Year	Disaster Name	Disaster Type	Disaster Cause	Disaster #	State Declaration #	Federal Declaration #
1950	1950 Floods	Flood	Flood	OCD 50-01	11/21/1950	–

Source: Cal OES, FEMA

This disaster history (combined FEMA and state) suggests that Sacramento County experiences a major event worthy of a disaster declaration every 1.25 years. The County has an 80.3 percent chance of receiving a federal or state disaster declaration in any given year.

Disasters since 2011

There has been one FEMA Emergency Management declaration for the Napa earthquake in 2014 since the 2011 plan. In addition, there have been 10 USDA Secretarial Disaster Declarations for drought (discussed in Section 4.2.7) since 2011.

4.2 Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

The hazards identified in Section 4.1 Hazard Identification Natural Hazards, are profiled individually in this section as it applies to both the Sacramento County Planning Area and the unincorporated County. In general, information provided by planning team members is integrated into this section with information from other data sources. These profiles set the stage for Section 4.3 Vulnerability Assessment, where the vulnerability is quantified, as data allows, for each of the priority hazards.

Each hazard is profiled in the following format:

- **Hazard/Problem Description**—This section gives a description of the hazard and associated issues followed by details on the hazard specific to the Sacramento County Planning Area and the unincorporated County. Where known, this includes information on the hazard extent, area, seasonal patterns, speed of onset/duration, and magnitude and/or any secondary effects.
- **Past Occurrences**—This section contains information on historical incidents, including impacts where known. The extent or location of the hazard within or near the Sacramento County Planning Area and the unincorporated County is also included here. Historical incident worksheets were used to capture information from participating jurisdictions on past occurrences.
- **Frequency/Likelihood of Future Occurrence**—The frequency of past events is used in this section to gauge the likelihood of future occurrences specific to the Sacramento County Planning Area and the unincorporated County. Where possible, frequency was calculated based on existing data. It was determined by dividing the number of events observed by the number of years on record and multiplying by 100. This gives the percent chance of the event happening in any given year (e.g., three droughts over a 30-year period equates to a 10 percent chance of a experiencing a drought in any given year). The likelihood of future occurrences is categorized into one of the following classifications:
  - ✓ **Highly Likely**—Near 100 percent chance of occurrence in next year or happens every year

- ✓ **Likely**—Between 10 and 100 percent chance of occurrence in next year or has a recurrence interval of 10 years or less
- ✓ **Occasional**—Between 1 and 10 percent chance of occurrence in the next year or has a recurrence interval of 11 to 100 years
- ✓ **Unlikely**—Less than 1 percent chance of occurrence in next 100 years or has a recurrence interval of greater than every 100 years.

- **Climate Change**—This section contains the effects or influence of climate change to that hazard (if applicable). The possible ramifications of climate change on the hazard are discussed.

Section 4.2.22 Natural Hazards Summary provides an initial assessment of the profiles and assigns an initial level of significance or priority to each hazard. Those hazards determined to be of high or medium significance are characterized as priority hazards that required further evaluation in Section 4.3 Vulnerability Assessment. Those hazards that occur infrequently or have little or no impact on the Planning Area, including unincorporated Sacramento County, were determined to be of low significance and not considered a priority hazard. Significance was determined based on the hazard profile, focusing on key criteria such as frequency and resulting damage, including deaths/injuries and property, crop, and economic damage. The ability of a community to reduce losses through implementation of existing and new mitigation measures was also considered as to the significance of a hazard. This assessment was used by the HMPC to prioritize those hazards of greatest significance to the Planning Area, enabling the County and participating jurisdictions to focus resources where they are most needed.

The following sections provide profiles of the natural hazards that the HMPC identified in Section 4.1 Hazard Identification. The severe weather hazards are discussed first because it provides an overview of climatological conditions in the Planning Area, it sets the stage for the types of natural hazards likely to occur, and it is often the secondary hazards generated by severe weather (e.g., flood and wildfire) that can result in the most significant losses. The other hazards follow alphabetically.

Data Sources

The following data sources formed the basis for this Hazard Profiles portion of the plan:

- 2013 State of California Multi-Hazard Mitigation Plan
- CALFED Levee System Integrity Program
- CAL FIRE Wildfire History Database
- California Climate Adaptation Strategy
- California Department of Water Resources Division of Safety of Dams
- California Department of Water Resources Best Available Maps
- California's Drought of 2007-2009, An Overview. State of California Natural Resources Agency, California Department of Water Resources. 2010.
- California Division of Mines and Geology
- California Natural Resources Report
- Delta Risk Management Strategy. June 2011.
- Federal Aviation Administration National Wildlife Database
- Federal Aviation Administration Wildlife Strike Database
- Federal Emergency Management Agency: Building Performance Assessment: Oklahoma and Kansas Tornadoes

- Federal Emergency Management Agency: Multi-Hazard Identification and Risk Assessment. 1997
- Federal Emergency Management Agency – Wind Zones in the United States
- Johnstone, J. and Dawson, T. Climatic context and ecological implications of summer fog decline in the coast redwood region. Proceedings of the National Academy of Sciences, January 7, 2010.
- Galloway, Jr Dr. Gerald E. Levees in History: The Levee Challenge. Water Policy Collaborative, University of Maryland, Visiting Scholar, USACE, IWR.
- Lighthouse Marina EIR/EIS. E D A W, Inc., November, 1985.
- Mount J, Twiss R. 2005. Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1 (March 2005), Article 5.
- National Aeronautics and Space Administration
- National Drought Mitigation Center
- National Flood Insurance Program
- National Integrated Drought Information System
- National Oceanic and Atmospheric Administration's National Climatic Data Center
- National Oceanic and Atmospheric Administration Storm Prediction Center
- National Performance of Dams Program
- National Weather Service Heat Index
- National Weather Service Sacramento – Climate of Sacramento, California, 2010
- National Weather Service Wind Chill Index
- North American Breeding Bird Survey
- Post Authorization Change Report for the Sacramento River Bank Protection Project Draft EIS
- Public Policy Institute of California. If drought continues: Environment and poor rural communities most likely to suffer. [press release]. 2015.
- Sacramento Bee
- Sacramento County Airport System
- Sacramento County Agricultural Commissioner's Reports, 2010-2014
- Sacramento County Flood Insurance Study, June 16, 2015
- Sacramento County Department of Water Resources – 2011 to 2015 Storm Reports
- Sacrament County 2035 General Plan
- Sacramento County General Plan Background Report
- Sacramento County Watershed Master Plan
- Sacramento County WMA Strategic Plan
- Some Significant Wildlife Strikes to Civil Aircraft in the United States, January 1990 – November 2015. U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services. December 3, 2015.
- State of California Department of Conservation Farmland Mapping and Monitoring Program
- Underwood, E. Models predict longer, deeper US droughts. Science, 347(6223) 707 DOI: 10.1126/science.347.6223.707. 2015.
- University of California Santa Barbara Department of Geology
- United State Geologic Survey. Earthquake Intensity Zonation and Quaternary Deposits, Miscellaneous Field Studies Map 9093, 1977.
- United States Geological Survey. Open File Report 2015-3009. 2015.
- USA TODAY
- US Department of the Interior. Fact Sheet 2014-3120. December 2014.
- US Army Corps of Engineers
- US Bureau of Reclamation

- US Drought Monitor
- US Geological Survey: Volcanic Ash: Effect & Mitigation Strategies.
- Ingebritsen, S.E. and Ikehara, M. Sacramento-San Joaquin Delta: The Sinking Heart of the State. US Geological Survey Report FS-005-00.
- USDA Secretarial Disasters Declarations
- Western Regional Climate Center
- Wildlife Strikes to Civil Aircraft in the United States 1990–2012. US Department of Transportation and Animal and Plant Health Inspection Services. September 2013.

4.2.1. Severe Weather: General

Severe weather is generally any destructive weather event, but usually occurs in the Sacramento County Planning Area as localized storms that bring heavy rain, hail, lightning, and strong winds.

The NOAA's National Climatic Data Center (NCDC) has been tracking severe weather since 1950. Their Storm Events Database contains data on the following: all weather events from 1993 to current (except from 6/1993-7/1993); and additional data from the Storm Prediction Center, which includes tornadoes (1950-1992), thunderstorm winds (1955-1992), and hail (1955-1992). This database contains 212 severe weather events that occurred in Sacramento County between January 1, 1950, and December 31, 2015. Table 4-4 summarizes these events.

*Table 4-4 NCDC Severe Weather Events for Sacramento County 1950-12/31/2015**

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Cold/Wind Chill	13	0	0	0	0	$0	$0
Dense Fog	6	6	1	38	0	$2,120,000	$0
Drought	19	0	0	0	0	$0	$0
Excessive Heat	1	0	0	0	0	$0	$0
Extreme Cold/Wind Chill	1	0	0	0	0	$0	$0
Flash Flood	4	1	0	0	0	$4,400,000	$0
Flood	29	1	0	0	0	$8,826,000	$7,800,000
Frost/Freeze	6	0	0	0	0	$200,000	$5,000,000
Funnel Cloud	6	0	0	0	0	$0	$0
Hail	7	0	0	0	0	$11,030	$0
Heat	31	0	1	30	1	$0	$0
Heavy Rain	18	0	0	1	0	$365,000	$50,000
Heavy Snow	1	0	0	0	0	$0	$0
High Surf	1	0	0	0	0	$0	$0
High Wind	36	1	0	0	0	$8,842,000	$39,000
Lightning	1	0	0	0	0	$150,000	$0
Strong Wind	9	0	1	0	2	$2,185,000	$0

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Thunderstorm Winds	7	0	0	0	0	$0	$0
Tornado	11	0	0	0	0	$1,455,000	$0
Wildfire	3	0	0	0	0	$3,000,000	$0
Winter Storm	2	0	0	0	0	$0	$0
Total	**212**	**9**	**3**	**69**	**3**	**$31,554,030**	**$12,889,000**

Source: NCDC

*Note: Losses reflect totals for all impacted areas

The NCDC table above summarizes severe weather events that occurred in Sacramento County. Only a few of the events actually resulted in state and federal disaster declarations. It is interesting to note that different data sources capture different events during the same time period, and often display different information specific to the same events. While the HMPC recognizes these inconsistencies, they see the value this data provides in depicting the County's "big picture" hazard environment.

As previously mentioned, most all of Sacramento County's state and federal disaster declarations have been a result of severe weather. For this plan, severe weather is discussed in the following subsections:

- Extreme Temperatures – Cold/Freeze
- Extreme Temperatures – Heat
- Fog
- Heavy Rains and Storms (Thunderstorms/Hail, Lightning)
- Wind and Tornadoes

Climate Change and Severe Weather

Climate change can have direct implications on almost every hazard addressed in the plan, with earthquake and bird strike being possible exceptions. Climate change has the potential to alter the nature and frequency of most hazards. The potential for climate change influences on hazards are further noted in the climate change hazard profile and in each of the hazard discussions.

4.2.2. Severe Weather: Extreme Temperatures – Cold and Freeze

Hazard/Problem Description

Extreme cold often accompanies a winter storm or is left in its wake. It is most likely to occur in the winter months of December, January, and February. Prolonged exposure to the cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat. Extreme cold can disrupt or impair communications facilities. Extreme cold can also affect the crops grown in Sacramento County.

In 2001, the National Weather Service (NWS) implemented an updated Wind Chill Temperature index, shown in Figure 4-1. This index was developed to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

Figure 4-1 Wind Chill Temperature Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill } (^\circ F) = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

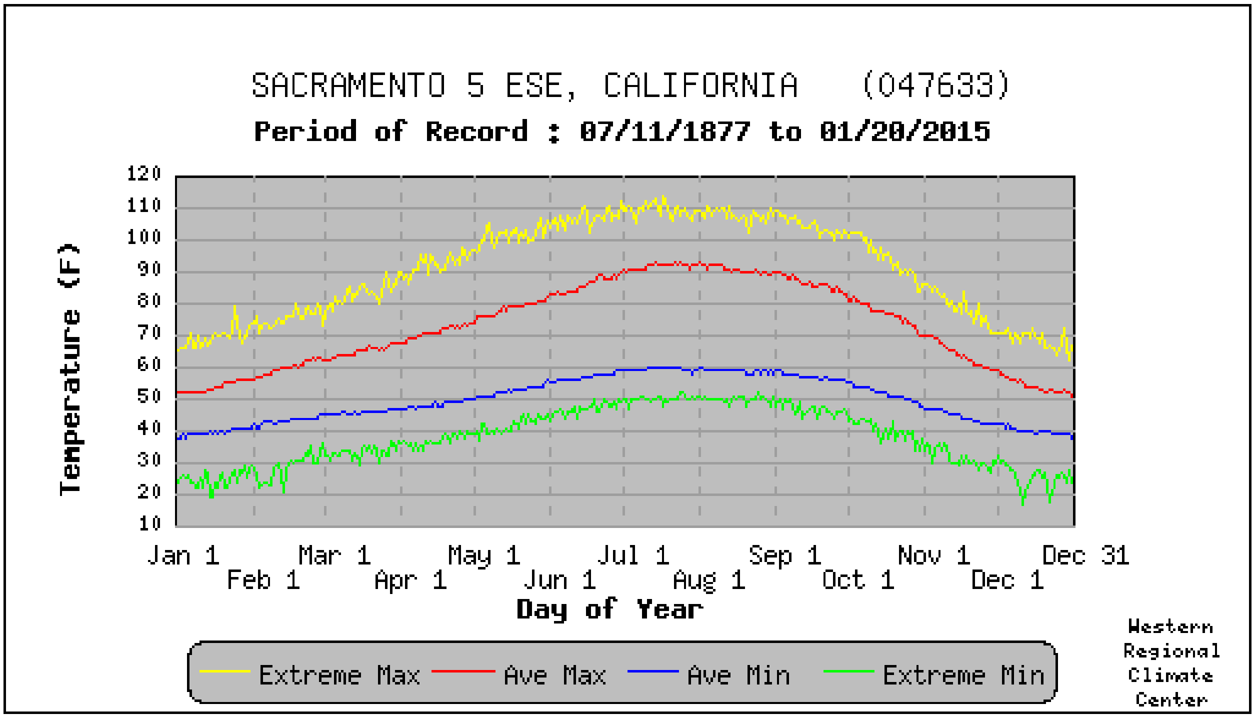
Source: National Weather Service

The effects of freezing temperatures on agriculture in Sacramento County are discussed further in Section 4.2.7 Agricultural Hazards. Information from the oldest continually reporting weather station in the County is summarized below and in Figure 4-2.

Sacramento County (5 ESE Weather Station, Period of Record 1877 to 2015)

According to the Western Regional Climate Center (WRCC), monthly average minimum temperatures in the County from November through April range from the upper-30s to the upper-50s. The lowest recorded daily extreme was 17°F on December 11, 1932. In a typical year, minimum temperatures fall below 32°F on 8.3 days with no days falling below 0°F.

Figure 4-2 Sacramento County—Daily Temperature Averages and Extremes



Source: Western Regional Climate Center

Past Occurrences

Disaster Declaration History

There have been no state or FEMA disaster declarations for Sacramento County associated with extreme cold or freeze. There have been three USDA secretarial disaster declarations for Sacramento County from cold and freeze, which can be found in Table 4-22 in the Section 4.2.7 Agriculture Hazards of this document.

NCDC Events

The NCDC data recorded 22 cold and freeze incidents for Sacramento County since 1993. A summary of these events are shown in Table 4-5. Specific events from the NCDC database that caused injuries, deaths, or damages in Sacramento County are discussed below the table.

Table 4-5 NCDC Winter Storms and Extreme Cold Events in Sacramento County 1993 to 12/31/2015

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Cold/Wind Chill	13	0	0	0	0	$0	$0
Extreme Cold/Wind Chill	1	0	0	0	0	$0	$0

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Frost/Freeze	6	0	0	0	0	$200,000	$5,000,000
Winter Storm	2	0	0	0	$0	$0	$0
Total	**22**	**0**	**0**	**0**	**$0.00**	**$200,000**	**$5,000,000**

Source: NCDC

*Deaths, injuries, and damages are for the entire event, and may not be exclusive to the County.

- **December 4, 1998** – A substantial freeze occurred as valley temperatures dropped into the middle to upper 20s.
- **December 6, 1998** – The second Arctic blast in a five-day period produced well below normal temperatures. The cold air not only affected the Northern Sacramento Valley, but also seeped south into the Northern San Joaquin Valley. Record low temperatures as well as low maximum temperatures were recorded at the Sacramento Executive Airport. The City of Sacramento reported a low of 27°.
- **December 29, 1998** – The third Arctic airmass of the month to spread into the Central California interior was the coldest of the three and produced large amounts of crop damage/loss. Downtown Sacramento experienced 6 consecutive days with low temperatures at or below freezing. The lowest temperature recorded downtown was 26°. $2.4 million in crop damages were reported in Sacramento and surrounding counties. A USDA disaster declaration was declared for the County.
- **December 6, 2005 –** Morning temperatures dropped into the 20s across the Sacramento and Northern San Joaquin Valleys. A record low temperature was tied in Sacramento. The temperature at Sacramento Executive Airport (SAC) dropped to 28°, which tied the record set in 1980.
- **November 30, 200**6 – Clear skies and a cold arctic airmass led to freezing temperatures across the Planning Area. Temperatures dropped to the mid to upper 20s, which was near record values for the date.
- **January 14-23, 2007** – A very cold arctic airmass settled over the region and temperatures in the Central Valley of California dropped sharply for a relatively prolonged period of time. Many temperature records were tied and broken during the episode and the damage to area crops was extensive.
- **April 20-24, 2008** – A cool and dry airmass coupled with light winds resulted in cold morning temperatures from April 20th to the 24th in the Planning Area. Record low temperatures were set in several locations. Frost and freezing temperatures caused significant damage to young walnuts, prunes, peaches, pears, and wine grapes across the area.
- **December 4, 2008** – High pressure over the area brought light winds and clear skies. This allowed the unusual case of a record minimum and a record maximum both being tied on the same day in the northern Sacramento Valley. Light winds and clear skies brought cold morning temperatures to the northern Sacramento Valley.
- **December 6-10, 2009** – A very cold airmass brought a hard freeze and record cold to the northern Central Valley. Many pipes in homes and businesses froze and burst, including those for fire sprinkler systems. Some crop damage in orchards was also reported. A hard freeze caused pipes and sprinkler systems to burst throughout the southern Sacramento Valley, causing water damage to homes and businesses. There were nine water main breaks reported in Sacramento, with eighty-two customers reporting problems with leaking pipes.

HMPC Events

The HMPC noted that extreme cold events continue to occur on an annual basis. They did not identify any specific additional events related to extreme cold temperatures in the Sacramento County Planning Area.

Western Regional Climate Center Data

The WRCC maintains data on extreme temperatures in the County. Past record lows from the Sacramento 5 ESE Coop Weather Station by month are shown in Table 4-6.

Table 4-6 Record Low Temperatures – Sacramento 5 ESE Weather Station (1877-2015)

Month	Temperature	Date	Month	Temperature	Date
January	19°	1/14/1888	July	47°	7/03/1901
February	21°	2/13/1884	August	48°	8/30/1887
March	29°	3/15/1880	September	44°	9/18/1882
April	34°	4/34/1927	October	34°	10/30/1935
May	37°	5/03/1950	November	27°	11/28/1880
June	43°	6/01/1929	December	17°	12/11/1932

Source: WRCC

Likelihood of Future Occurrence

Likely—Cold and freeze are likely to continue to occur annually in the Sacramento County Planning Area.

Climate Change and Freeze and Snow

According to the California Climate Adaptation Strategy (CAS), freezing spells are likely to become less frequent in California as climate temperatures increase. If emissions increase, freezing events could occur only once per decade in large portion of the state by the second half of the 21st century. According to a California Natural Resources Report in 2009, it was determined that while fewer freezing spells would decrease cold related health effects, too few freezes could lead to increased incidence of disease as vectors and pathogens do not die off.

Preliminary Draft – Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the 2016 Preliminary Draft CAP, which utilized Cal Adapt to model potential climate change impacts to Sacramento County, annual average low temperatures in Sacramento County of 49.8° F (from 1961-1990) would increase under the low admissions scenario by 1.6° F to 51.4° F. Under the high emissions scenario, the average annual low temperature is projected to increase by 6.0° F to 55.8° F by 2099.

4.2.3. Severe Weather: Extreme Temperatures – Heat

Hazard/Problem Description

According to information provided by FEMA, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980 more than 1,250 people died. Extreme heat can also affect the agricultural industry. Extreme heat as it affects agriculture in Sacramento County is discussed further in the section on agricultural hazards.

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds a level at which the body can remove it, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Elderly persons, small children, chronic invalids, those on certain medications or drugs, and persons with weight and alcohol problems are particularly susceptible to heat reactions.

Heat emergencies are often slower to develop, taking several days of continuous, oppressive heat before a significant or quantifiable impact is seen. Heat waves do not strike victims immediately, but rather their cumulative effects slowly take the lives of vulnerable populations. Heat waves do not cause damage or elicit the immediate response of floods, fires, earthquakes, or other more "typical" disaster scenarios. While heat waves are obviously less dramatic, they are potentially more deadly. According to the 2013 California State Hazard Mitigation Plan, the worst single heat wave event in California occurred in Southern California in 1955, when an eight-day heat wave resulted in 946 deaths.

The Western Regional Climate Center (WRCC) maintains data on weather normal and extremes in the western United States. WRCC data for the County is summarized below and in Figure 4-2 above.

Sacramento County (Sacramento 5 ESE Weather Station, Period of Record 1877 to 2015)

According to the WRCC, in the western portion of Sacramento County, monthly average maximum temperatures in the warmest months (May through October) range from the mid-70s to the low 90s. The highest recorded daily extreme was 114°F on July 17, 1925. In a typical year, maximum temperatures exceed 90°F on 65.4 days.

Figure 4-3 and Figure 4-4 show the Heat Index (HI) that the National Weather Service uses to show the relationship between heat and relative humidity. The Heat Index describes how hot the heat-humidity combination makes it feel. As relative humidity increases, the air seems warmer than it actually is because the body is less able to cool itself via evaporation of perspiration. As the HI rises, so do health risks.

- When the HI is 90°F, heat exhaustion is possible with prolonged exposure and/or physical activity.
- When it is 90°-105°F, heat exhaustion is probable with the possibility of sunstroke or heat cramps with prolonged exposure and/or physical activity.

- When it is 105°-129°F, sunstroke, heat cramps or heat exhaustion is likely, and heatstroke is possible with prolonged exposure and/or physical activity.
- When it is 130°F and higher, heatstroke and sunstroke are extremely likely with continued exposure. Physical activity and prolonged exposure to the heat increase the risks.

Figure 4-3 Heat Index

NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: National Weather Service

Note: Since HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Figure 4-4 Possible Heat Disorders by Heat Index Level

Heat Index	Category	Possible heat disorders for people in high risk groups
130°F or higher	Extreme Danger	Heatstroke risk extremely high with continued exposure.
105° - 129°F	Danger	Sunstroke, Heat Cramps and Heat Exhaustion likely, Heatstroke possible with prolonged exposure and/or physical activity.
90° - 105°F	*Extreme Caution*	*Sunstroke, Heat Cramps and Heat Exhaustion possible with prolonged exposure and/or physical activity.*
80° - 90 °F	Caution	Fatigue possible with prolonged exposure and/or physical activity.

Source: National Weather Service

The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime high is expected to equal or exceed 105°F and a nighttime minimum high of 80°F or above is expected for two or more consecutive days. The NWS office in Sacramento can issue the following heat-related advisory as conditions warrant.

- **Excessive Heat Outlook**: are issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to Heat Index forecast map for the contiguous United States those who need considerable lead time to prepare for the event, such as public utilities, emergency management and public health officials.
- **Excessive Heat Watch**: is issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A Watch is used when the risk of a heat wave has increased, but its occurrence and timing is still uncertain. A Watch provides enough lead time so those who need to prepare can do so, such as cities that have excessive heat event mitigation plans.
- **Excessive Heat Warning/Advisory**: are issued when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurring. The warning is used for conditions posing a threat to life or property. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.

Past Occurrences

Disaster Declaration History

There have been no state or FEMA disaster declarations associated with extreme heat. Two USDA Secretarial Disasters related to extreme heat have occurred in the County and can be found in Table 4-27 in Section 4.2.7.

NCDC Disasters

The NCDC data shows 32 extreme heat incidents for Sacramento County since 1993. These are shown in Table 4-7. Events that caused specific injuries or damage are discussed below the table.

Table 4-7 NCDC Extreme Heat Events in Sacramento County 1993 to 12/31/2015

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Excessive Heat	1	0	0	0	0	$0	$0
Heat	31	0	1	30	1	$0	$0
Total	**32**	**0**	**1**	**30**	**1**	**$0**	**$0**

Source: NCDC

- **July 11, 1999** – Afternoon high temperatures averaged 10 to 20 degrees above normal across the central and northern interior. No fatalities or severe heat related injuries were noted by area hospitals, although there was an increase in lesser heat related illnesses caused by prolonged dehydration. Area utilities indicated that facilities were stressed during the event and the voluntary brown out program had to be utilized. SMUD also indicated they broke an all-time record on the 12th for electrical production and distribution. No injuries or fatalities were reported.

- **May 21, 2000** – Daily maximum temperatures across the area reached record levels for three consecutive days and most official reporting sites were fifteen to twenty degrees above normal readings. Sacramento tied or broke records on one or more days. The normal maximum temperature for Sacramento for this period is 82°, yet temperatures reached 100°, 103°, and 99°, all new daily records. No injuries or fatalities were reported.
- **June 13, 2000 –** Very hot weather persisted across interior Northern California for three days, resulting in record and near record temperatures at most reporting sites. Sixteen people were treated for heat stroke in Sacramento and Solano counties and one, a 16-year-old male in West Sacramento, died. A heavily used portion of I-80 between Sacramento and San Francisco was closed for several hours to repair three lanes in which the asphalt had buckled due to the sustained heat. Power outages were suffered by more than 100,000 customers during the event. Maximum temperatures were fifteen to twenty degrees above normal throughout the valley and foothills, but what made the weather especially difficult to handle was that the minimum temperatures were also ten to twenty degrees above normal for the period. The hottest day across the area was the 14th, with maximum temperatures of 107°F in Sacramento. The maximum temperatures on the 8th, less than a week earlier, were 71°. Sacramento set a daily high minimum temperature record by dropping only to 68° on the 13th. No injuries or fatalities were reported.
- **July 29, 2000** – Excessive heat impacted the Sacramento and northern San Joaquin Valleys during the last few days of July. Temperatures reached and exceeded 100° in many areas before peaking on the 31st at 104° in Sacramento. No injuries or fatalities were reported.
- **September 18, 2000** – Daily maximum temperature records were tied and broken across the Sacramento and northern San Joaquin valleys. The Sacramento temperature reached 101°, which tied the record previously set in 1984. No injuries or fatalities were reported.
- **September 20, 2000** – The daily high maximum temperature record was set in Sacramento when it reached 102°, breaking the previous record of 101° set in 1994. No injuries or fatalities were reported.
- **July 1, 2005** – July 2005 set a new record for heat in Sacramento. The average temperature in Sacramento was 81.8° for the month. This was the hottest average temperature ever recorded in Sacramento. The old record was 81.6° set in July 2003. In addition, the average low temperature for the month of July was 65.2°, breaking the old record of 65.1° set in July 2003. However, the average high temperature record was not broken. The average for July 2005 was 98.4°, which is well below the record average high of 99.6° set in 1988.
- **July 4-5, 2007** – High pressure over the western United States brought record heat to Northern California on July 4th and 5th. New daily high temperature records were set today at the Downtown Sacramento and the Sacramento Executive Airport sites. At Downtown Sacramento, the temperature reached 108°, which broke the old record of 107° set in 1931. At Sacramento Executive Airport, the temperature reached 107°, which broke the old record of 105° set in 1968.
- **August 23, 2007** – High pressure over California resulted in hot conditions in the Planning Area. Temperatures in excess of 100° were recorded at many locations in the Planning Area.
- **May 15-18, 2008 –** A strong high pressure ridge over the region produced hot temperatures across interior Northern California from May 14th to May 17th, with many triple digit daily high temperature records set. Record daily high minimum temperatures were also set as clouds and northerly winds maintained the heat overnight. The hot temperatures lingered into the 19th, especially for the northern San Joaquin Valley.
- **July 9, 2008** – A strong upper level ridge brought hot weather to much of the Planning Area from July 6th to the 10th. High temperatures well over the century mark were recorded, with records tied or set

across the northern Central Valley on the 9th. Overnight temperatures also remained very warm, with several record high minimums set or tied.

- **August 15, 2008** – A strong high pressure ridge allowed high temperatures to reach triple digits across the northern Central Valley. In the Planning Area, temperatures of 102° to 108° were recorded.
- **August 26-29, 2008** – A strong upper level ridge brought hot weather to much of the area from the 26th to the 28th. High temperatures well over the century mark were recorded, with records tied or set across the northern Central Valley. A daily maximum temperature record of 104° was set at Sacramento Executive Airport. This broke the previous record of 103° set in 1950.

HMPC Events

The HMPC identified the following events related to extreme temperatures in the Sacramento County Planning Area.

- 2013 Jun7& 8 – 100°-112°F
- 2013 Jun 28-30, again Jul 1 – over 100°F for 7 days
- July 1-4, 2013 – A strong high pressure ridge built over Northern California, keeping max temperatures in the Central Valley above 100 for at least 7 days. Overnight temperatures failed to recover, reaching generally down to the mid 60s to 90. The heat wave felt warmer due to the moisture in the air from the previous rainfall on June 26th, as well as from the intrusion of subtropical moisture from the south.
- January 2014 – January was an abnormally dry and warm month for interior Northern California. Many record high temperatures were broken, and a state-wide drought was declared on January 17th.

Western Regional Climate Center Data

The WRCC maintains data on extreme temperatures in the County. Past record highs from the Sacramento 5 ESE Coop Weather Station by month are shown in Table 4-8.

Table 4-8 Record High Temperatures – Sacramento 5 ESE Weather Station (1877-2015)

Month	Temperature	Date	Month	Temperature	Date
January	74°	1/31/1976	July	114°	7/18/1925
February	80°	2/18/1899	August	111°	8/13/1933
March	90°	3/31/1966	September	109°	9/01/1950
April	98°	4/26/2004	October	102°	10/2/1952
May	107°	5/28/1984	November	86°	11/1/1966
June	112°	6/30/1934	December	72°	12/15/1958

Source: WRCC

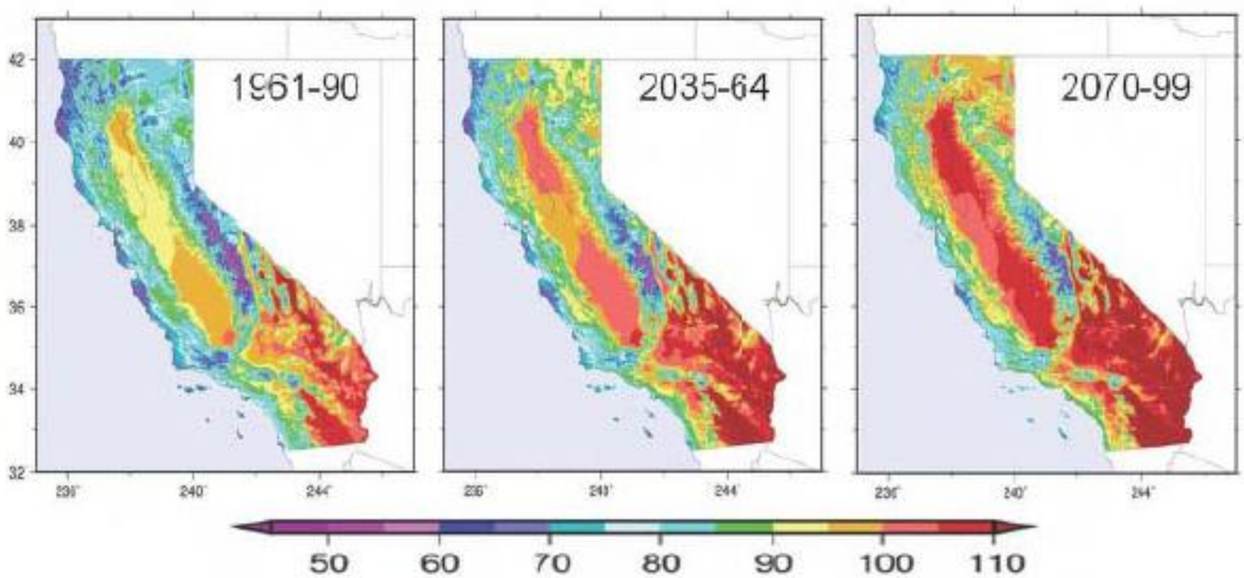
Likelihood of Future Occurrence

Highly Likely—Temperature extremes are likely to continue to occur annually in the Sacramento County Planning Area. Temperatures at or above 90°F are common most summer days in the County.

Climate Change and Extreme Heat

The CAS, citing a California Energy Commission study, states that "over the past 15 years, heat waves have claimed more lives in California than all other declared disaster events combined." This study shows that California is getting warmer, leading to an increased frequency, magnitude, and duration of heat waves. These factors may lead to increased mortality from excessive heat, as shown in Figure 4-5.

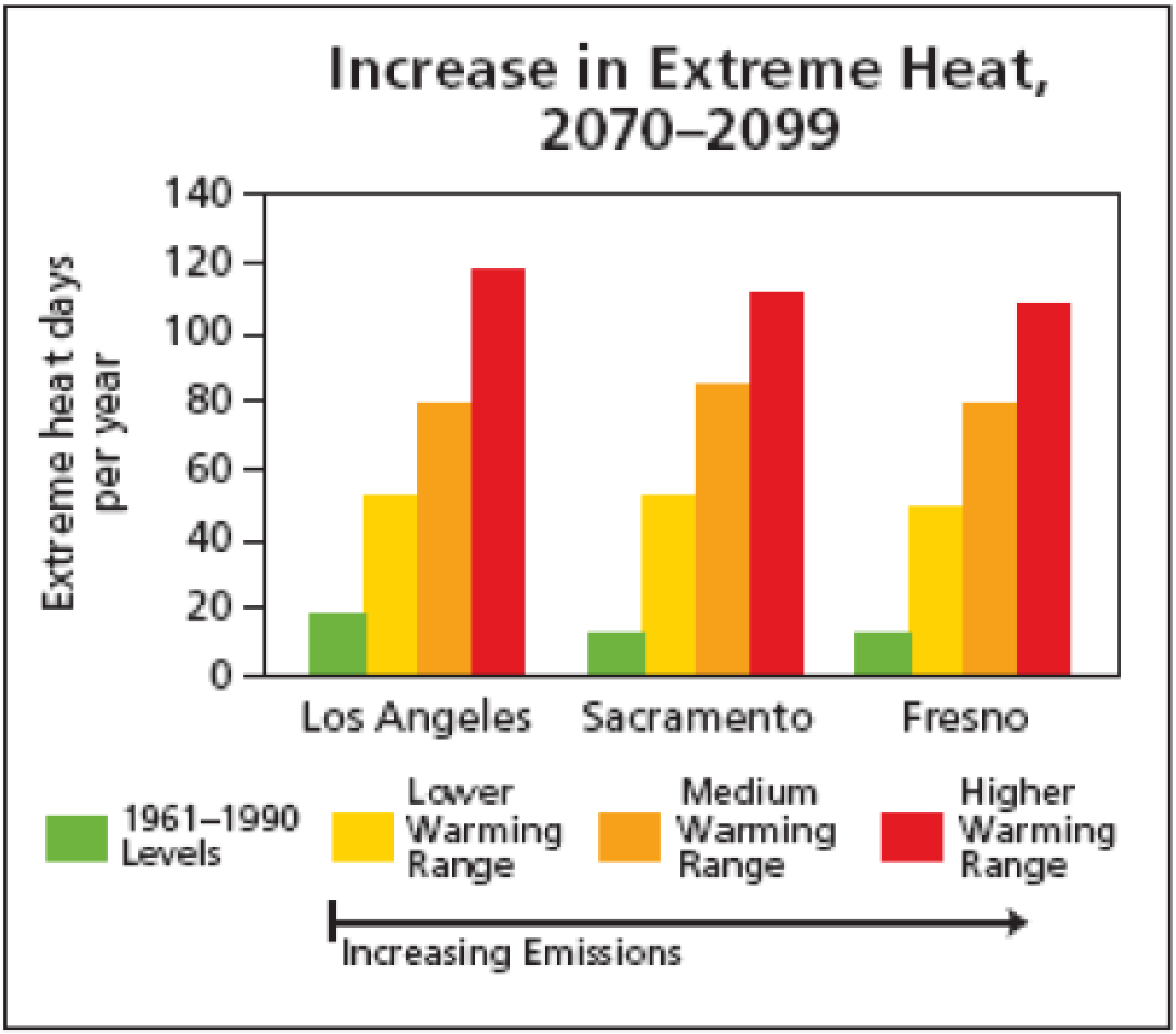
Figure 4-5 California Historical and Projected Temperature Increases - 1961 to 2099



Source: Dan Cayan; California Climate Adaptation Strategy

As temperatures increase, California and Sacramento County will face increased risk of death from dehydration, heat stroke, heat exhaustion, heart attack, stroke and respiratory distress caused by extreme heat. According to the CAS report and the 2010 State of California Hazard Mitigation Plan, by 2100, hotter temperatures are expected throughout the state, with projected increases of 3-5.5°F (under a lower emissions scenario) to 8-10.5°F (under a higher emissions scenario). If temperatures rise to the higher warming range, there could be 100 more days per year with temperatures above 95°F in the City of Sacramento (see Figure 4-6). These changes could lead to an increase in deaths related to extreme heat in Sacramento County.

Figure 4-6 Increase in Heat in Major California Cities from 2070 to 2099



Source: 2010 California State Hazard Mitigation Plan

Preliminary Draft - Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the Sacramento County Phase 1 Vulnerability Assessment, contained within the 2016 Preliminary Draft CAP, which utilized Cal Adapt to model potential climate change impacts to Sacramento County, it concluded that annual average high temperatures in Sacramento County of 73.1°F would increase under the low emissions scenario by 3.1°F to 76.2°F. Under the high emissions scenario, the average annual high temperature is projected to increase by 7.2°F to 80.3°F by 2099.

In addition, research published by California Environmental Protection Agency suggests that heat impacts are felt disproportionately in the northern portions of Sacramento County and the surrounding areas, due to prevailing wind patterns. This phenomenon is likely be exacerbated by climate change.

Extreme Heat Days. Extreme heat days are defined by Cal adapt for Sacramento County as 100 ºF or higher. From 1961 to 1990, Sacramento County has a historical average of four extreme heat days a year. From 2010 to 2016, extreme heat days increase in Sacramento County with a current average of 8 to 9 extreme heat days per year. Utilizing Cal-Adapt, the projected average annual number of extreme heat days under the low emissions scenario is approximately 15 days per year in 2050 and between 19 to 45 days per year at the end of the century. Under the high emissions scenario, Cal-Adapt predicts that Sacramento County will experience 25-31 extreme heat days per year in 2050 and 50 to 67 days per year by 2099. Also to be considered are warm nights. A warm night is defined as a day between April and October where the minimum temperature exceeds the historical minimum temperatures between 1961 and 1990. Historically, Sacramento County has an average of four warm nights a year, with a threshold of 65 ºF. Under the low- and high- emissions scenarios, the number of warm nights is expected to increase to an average of 12-33 nights by 2050 and 23 to 90 nights by 2099.

Frequency and Timing of Heat Waves. When these extreme temperatures are experienced over a period of several days or more, they are considered heat waves. Cal-Adapt defines a heat wave for Sacramento County as an event where the extreme heat day threshold of 100 ˚F is exceeded for five days or more. Based on this analysis, heat waves consisting of a five-day period have occurred in Sacramento County at a rate of about one to two heat waves per decade between 1950 and 2000. The Cal-Adapt model projects an increase in heat waves as the century progresses. Under the low emissions scenario, Sacramento County is expected to experience approximately three heat waves per year around 2050 and up to four per year by 2099. Under the high emissions scenario, an average of three to five heat waves per year by 2050 are projected and up to 12 per year by the end of the century. Also to be noted, as shown in both emissions scenarios, the model projects that the occurrence of these heat waves will occur both earlier and later in the season.

The HMPC noted that low income people and communities of color in urban neighborhoods are particularly vulnerable to heat waves, as they are often segregated and surrounded by heat trapping surfaces like asphalt and less likely to have air conditioning.

4.2.4. Severe Weather: Fog

Hazard/Problem Description

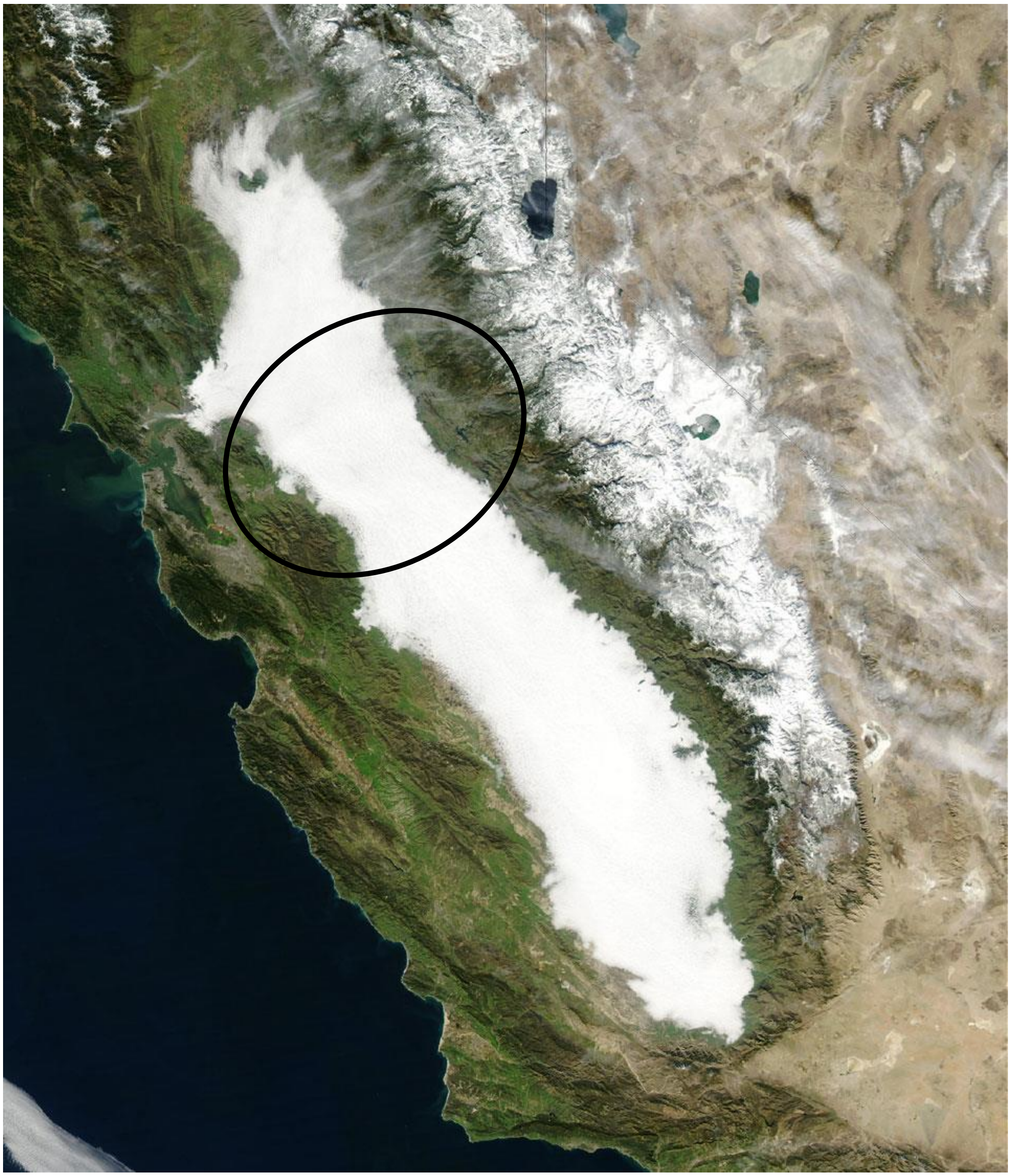
Fog is a collection of water droplets or ice crystals suspended in the air at or near the Earth's surface. Fog results from air being cooled to the point where it can no longer hold all of the water vapor it contains. Fog can form in a number of ways, depending on how the cooling that caused the condensation occurred. The most common types in the County are radiation and advection fog.

Radiation Fog

This type of fog forms at night under clear skies with calm winds when heat absorbed by the earth's surface during the day is radiated into space. As the earth's surface continues to cool, provided a deep enough layer of moist air is present near the ground, the humidity will reach 100% and fog will form. Radiation fog varies in depth from 3 feet to about 1,000 feet and is always found at ground level and usually remains stationary. This type of fog can reduce visibility to near zero at times and make driving very hazardous.

One of the most dangerous types of radiation fog unique to the planning is tule fog. It forms on clear nights when the ground is moist and the wind is near calm. On nights like this, the ground cools rapidly. In turn, the moist air above it cools and causes water vapor to condense. Once it has formed, the air must be heated enough to either evaporate the fog or lift it above the surface so that visibilities improve. It can cover large areas, as seen in Figure 4-7, with Sacramento County's location approximated with the black oval. The fog layer in tule fog often builds to several hundred feet thick, and can effectively block out incoming sunlight.

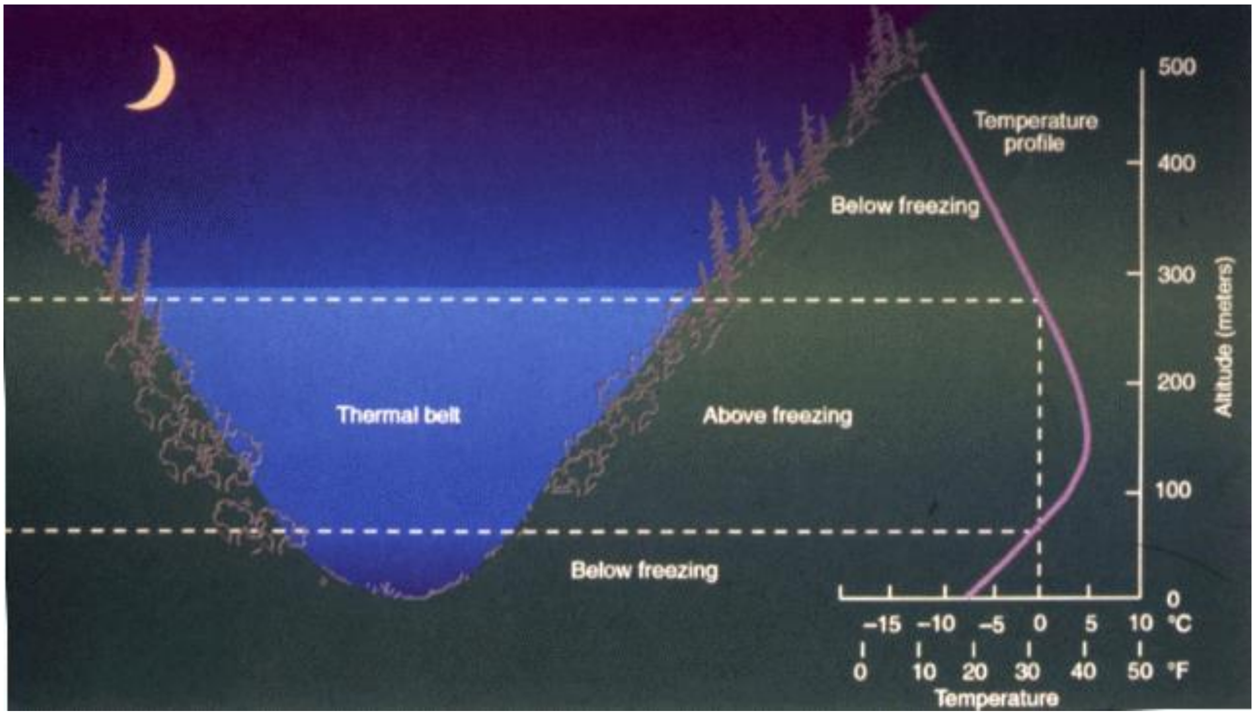
Figure 4-7 Tule Fog in the Central and San Joaquin Valley of California



Source: University of California Santa Barbara Department of Geology.

The Great Valley of California (the Sacramento and San Joaquin Valleys) is essentially a closed air basin. Therefore, the introduction of moisture is not removed from the valley air basin unless pushed or lifted out by atmospheric processes. By the late fall, cool season frontal passages begin to bring rain to the valley floor thereby adding low-level atmospheric moisture. High pressure building aloft behind frontal passages after a significant rain event provides moisture at low atmospheric levels, light wind, clear skies, and a temperature inversion aloft. This can be seen in Figure 4-8.

Figure 4-8 Temperature Inversion Affecting Fog in Valleys like Sacramento Valley



Source: University of California Santa Barbara Department of Geology.

This inversion limits vertical air movement from the valley air basin. Radiational cooling of the ground during the long nights cools the adjacent air and forms fog as temperatures reach dew points. The lack of strong sunshine during the fall and winter daytime hours does not provide sufficient incoming energy to always evaporate the overnight fog development. Thus, fog can and does last several days at a time until the atmosphere provides some form of additional drying or mixing. The combination of the previous mentioned parameters and circumstances provides for a rather dense fog where visibility is often limited to mere feet. It is situations like these that often lead to multi-car accidents where one car follows another into a fog bank. Another area prone to fatal accidents is intersections across major roads or heavily traveled roads, where the cross traffic does not have to stop.

Advection Fog

Advection fog often looks like radiation fog and is also the result of condensation. However, the condensation in this case is caused not by a reduction in surface temperature, but rather by the horizontal movement of warm moist air over a cold surface. This means that advection fog can sometimes be distinguished from radiation fog by its horizontal motion along the ground.

The fog season in Sacramento County is typically in the late fall and winter (November through March) but can occur as late as May. Fog typically forms rapidly in the early morning hours. Fog can have devastating effects on transportation corridors in the County. Severe fog incidents can close roads, cause accidents, and impair the effectiveness of emergency responders. These accidents can cause multiple injuries and deaths and can have serious implications for human health and the environment if a hazardous or nuclear waste shipment is involved.

Past Occurrences

Disaster Declaration History

There are no fog related FEMA federal or Cal OES state disaster declarations for Sacramento County. In addition, there are no USDA secretarial disaster declarations associated with fog.

NCDC Events

The NCDC data recorded 5 fog incidents for Sacramento County since 1993. A summary of these events is shown in Table 4-9, with details following the table.

Table 4-9 NCDC Fog Events in Sacramento County 1993 – 12/31/2014

Event	Date	Deaths (Direct)	Injuries (Direct)	Property Damage	Crop Damage	Injuries (Indirect)	Deaths (Indirect)
Dense Fog	12/11/1997	5	26	$1,500,000	$0	0	0
Dense Fog	12/18/1998	1	10	$500,000	$0	0	0
Dense Fog	12/20/1999	0	2	$120,000	$0	0	0
Dense Fog	1/3/2001	0	0	$0	$0	0	0
Dense Fog	1/3/2001	0	0	$0	$0	0	0
Dense Fog	12/8/2015	0	0	$0	$0	0	1
Total		**6**	**38**	**2,120,000**	**$0**	**0**	**1**

Source: NCDC

- **December 11, 1997** – Patchy dense fog was a main contributing factor in a major chain reaction collision on northbound Interstate 5 near Lambert, CA, 17 miles south of downtown Sacramento. The crash involved 8 tractor trailers, 1 tanker truck, and 28 automobiles and small trucks. The five fatalities were burn victims caught in the fires from exploding fuel tanks. 26 other people were injured, and damage of $1.5 million was attributed to the fog.
- **December 18, 1998** – Dense morning fog resulted in a 38-vehicle pileup 10 miles northwest of downtown Sacramento on Interstate 5. The crash involved 26 automobiles, 10 tractor trailers, and 2 motor homes. Interstate 5 was closed for more than 10 hours in both directions. 1 fatality and 10 injuries were recorded. $500,000 in damages was attributed to the fog.
- **December 20, 1999** – Dense fog was responsible for an 8-vehicle pileup on Highway 12 on Andrus Island in south Sacramento County. California Highway Patrol reported visibilities of 75 feet. Two big-rigs and 6 passenger vehicles were involved in the accident. 2 injuries and $120,000 were attributed to the fog. No fatalities occurred during this fog event.

- **January 3, 2001** – Dense fog affected morning travel between the Central Sacramento Valley and the Northern San Joaquin Valley. The Delta was also affected. The California Highway Patrol escorted travelers through Sacramento and Yolo Counties where visibilities lowered to 200 feet. They also reported that the combination of high speeds and dense fog tripled the average amount of minor accidents during the morning commute. Nearly one-third of the commercial flights originating from the Sacramento International Airport were cancelled. No injuries, fatalities, or damages were recorded.
- **December 8, 2015** – Light winds and wet ground allowed fog to develop overnight and in the early morning. Around 5:20 a.m., 42-year-old male was killed when he crossed Power Inn Road at Florin Road against the light and was struck by a northbound vehicle that had a green light, according to the CHP. Poor visibility from fog is believed to have been a factor. Speed and alcohol reportedly did not contribute to the crash.

HMPC Events

The HMPC noted that, in addition to these past occurrences, a report from the NWS Office in Sacramento titled "Climate of Sacramento, California" revised in 2010 listed the following data in Table 4-10 and Table 4-11 regarding dense fog in the Sacramento area. As can be seen by the tables, dense fog is a prominent natural hazard in Sacramento County.

Table 4-10 Greatest Number of Total Days in a Month with Dense Fog 1949 to 2010

Days	Period	Year		Days	Period	Year
17	December 12-28	1985		9	January 12-20	1965
14	December 23 - January 5	2000		9	9 January 17-25	1961
13	January 13-25	1975		9	November 25-December 3	1949
12	December 9-20	2004		9	February 3-11	1954
11	December 3-13	1962		8	February 3-10	1991
10	December 2-11	1977		8	December 23-30	1989
10	December 27 - January 5	1962		8	January 29-February 5	1962
9	December 23-31	2000		8	December 14-21	1956
9	January 6-14	1986		8	December 14-21	1954
9	February 6-14	1971				

Source: Climate of Sacramento California. 2010

*Table 4-11 Greatest Number of Consecutive Days with Dense Fog 1949 to 2010**

Days	Period		Days	Period
23	January 1961		16	January 1955
22	December 1989		15	January 1975
22	December 1985		15	January 1972
20	December 2000		15	January 1965
20	December 1962		14	December 1986
19	December 1963		14	January 1986
19	January 1958		14	January 1983
18	January 1985		14	January 1964
17	January 2003		14	January 1963
16	December 2004		14	January 1962
16	December 1977			

Source: Climate of Sacramento California. 2010
* Only periods with 14 or more days are tabulated.

Likelihood of Future Occurrence

Highly Likely – Based on input from the HMPC, it is likely that major fog events will continue to occur annually in Sacramento County; thus the future occurrence of severe fog is highly likely.

Climate Change and Fog

It is currently unclear if climate change will have any effect on fog issues in the future. Limited data and research performed for redwood regions in California suggests that the occurrence of summertime fog has declined by 33% over the course of the 20th century. These findings were presented by Johnstone and Dawson in the Proceedings of the National Academy of Sciences.

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

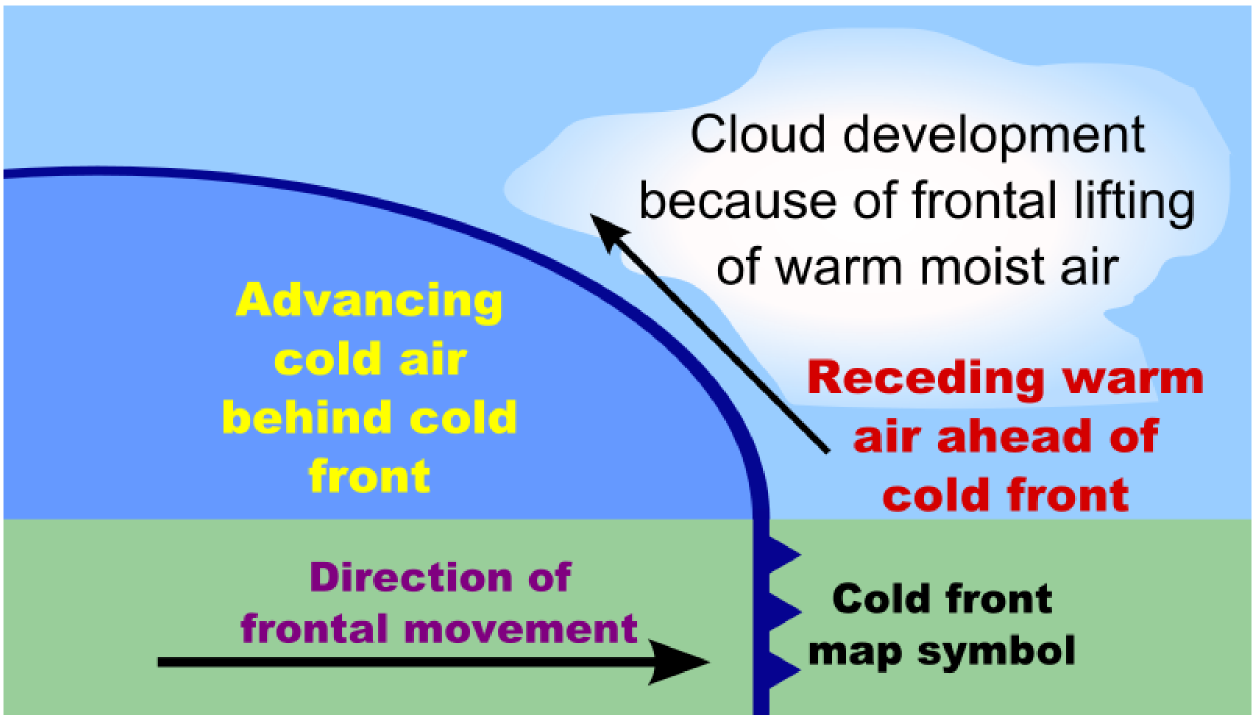
Hazard/Problem Description

Storms in the Sacramento County Planning Area 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 Sacramento County area falls mainly in the fall, winter, and spring months.

Heavy Rain and Thunderstorms

The NWS reports that thunderstorms result from the rapid upward movement of warm, moist air (see Figure 4-9). They can occur inside warm, moist air masses and at fronts. As the warm, moist air moves upward, it cools, condenses, and forms cumulonimbus clouds that can reach heights of greater than 35,000 ft. As the rising air reaches its dew point, water droplets and ice form and begin falling the long distance through the clouds towards earth's surface. As the droplets fall, they collide with other droplets and become larger. The falling droplets create a downdraft of air that spreads out at Earth's surface and causes strong winds associated with thunderstorms.

Figure 4-9 Formation of a Thunderstorm



Source: NASA.

According to the HMPC, short-term, heavy storms can cause both widespread flooding as well as extensive localized drainage issues. With the increased growth of the area, the lack of adequate drainage systems has become an increasingly important issue. In addition to the flooding that often occurs during these storms, strong winds, when combined with saturated ground conditions, can down very mature trees.

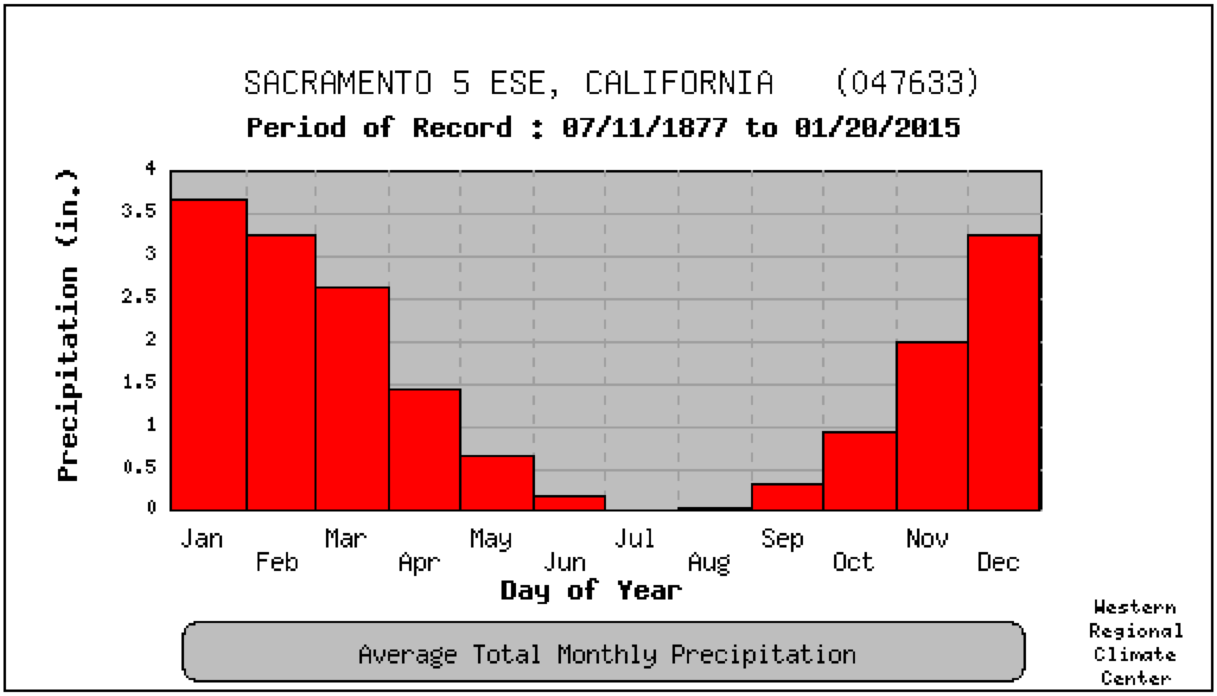
Information from the longest recording weather station in the County is summarized below.

Sacramento County (Sacramento 5 ESE Weather Station, Period of Record 1877 to 2015)

According to the WRCC, average annual precipitation in the County is 18.15 inches per year. The highest recorded annual precipitation is 37.62 inches in 1983; the highest recorded precipitation for a 24-hour period is 5.28 inches on April 20, 1962. The lowest recorded annual precipitation was 11.76 inches in 1976.

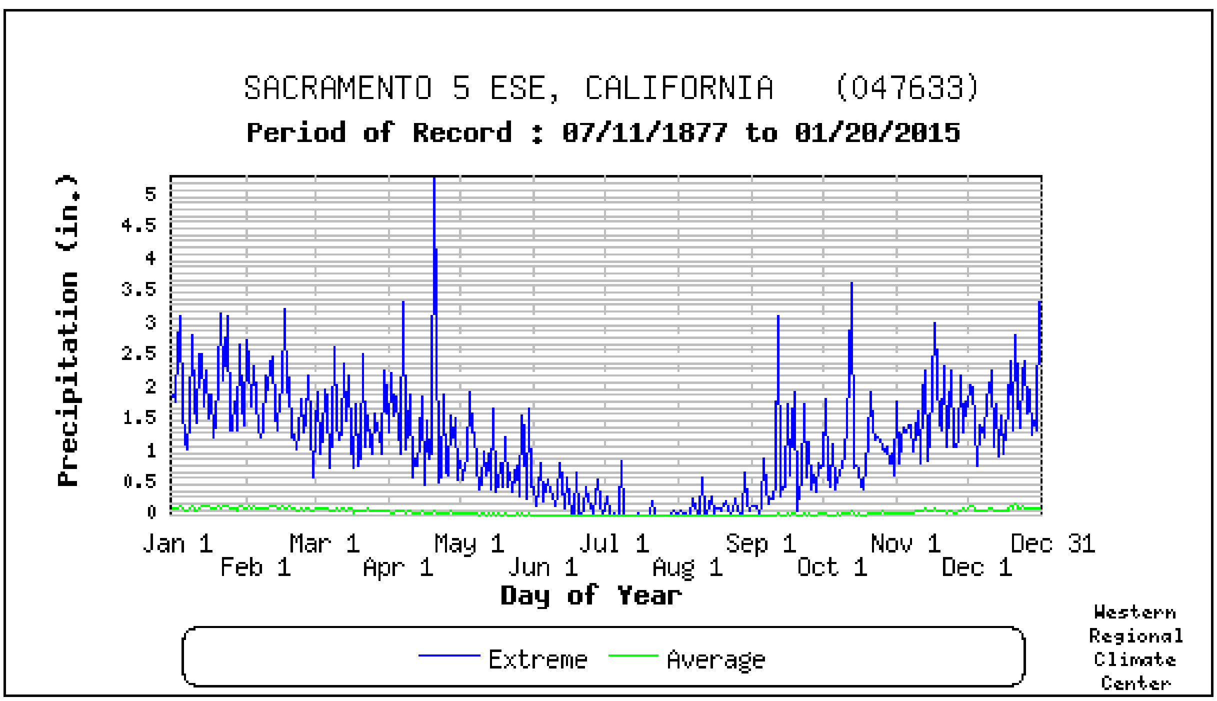
Average monthly precipitation for Sacramento County is shown in Figure 4-10. Daily average and extreme precipitations are shown in Figure 4-11.

Figure 4-10 Sacramento County Monthly Average Total Precipitation



Source: WRCC

Figure 4-11 Sacramento County Daily Precipitation Average and Extremes



Source: WRCC

Hail

Hail is formed when water droplets freeze and thaw as they are thrown high into the upper atmosphere by the violent internal forces of thunderstorms. Hail is sometimes associated with severe storms within the Sacramento County Planning Area. Hailstones are usually less than two inches in diameter and can fall at speeds of 120 miles per hour (mph). Severe hailstorms can be quite destructive, causing damage to roofs, buildings, automobiles, vegetation, and crops.

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4-12 indicates the hailstone measurements utilized by the National Weather Service.

Table 4-12 Hailstone Measurements

Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf-Ball
2.0 inch	Hen Egg
2.5 inch	Tennis Ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: NWS

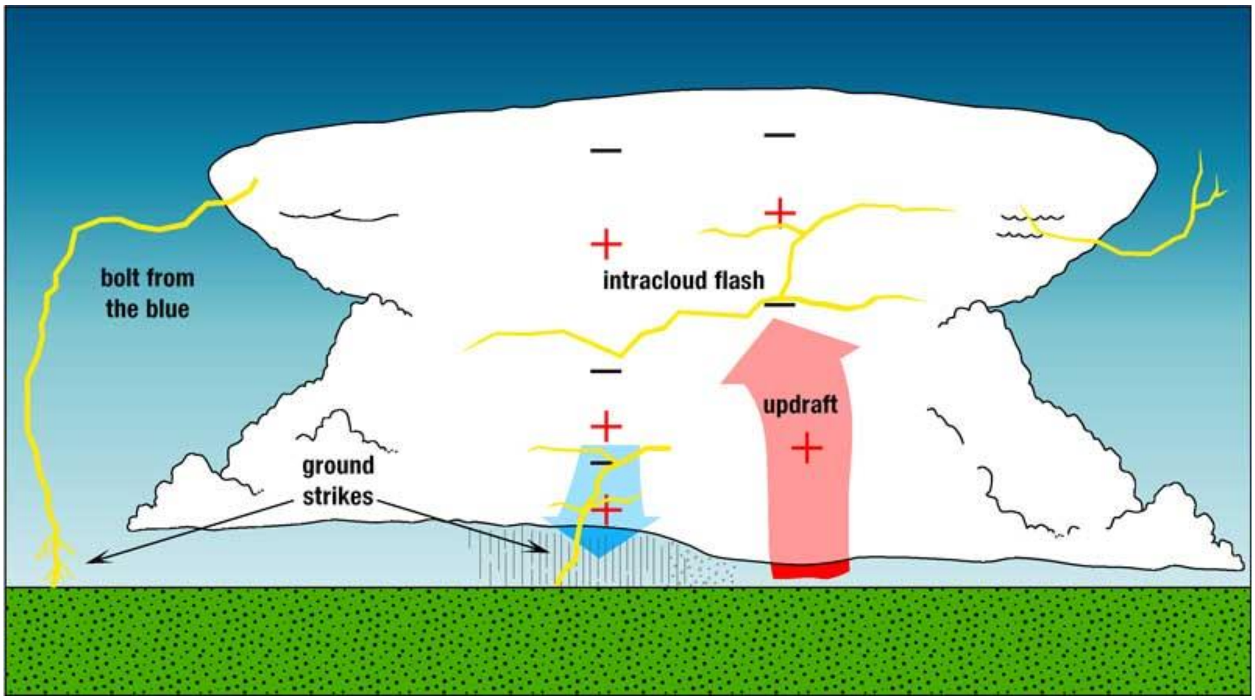
Lightning

Lightning is defined by the NWS as any and all of the various forms of visible electrical discharge caused by thunderstorms. Thunderstorms and lightning are usually (but not always) accompanied by rain. Cloud-to-ground lightning can kill or injure people by direct or indirect means. Objects can be struck directly, which may result in an explosion, burn, or total destruction. Or, damage may be indirect, when the current passes through or near an object, which generally results in less damage.

Intra-cloud lightning is the most common type of discharge. This occurs between oppositely charged centers within the same cloud. Usually it takes place inside the cloud and looks from the outside of the cloud like a diffuse brightening that flickers. However, the flash may exit the boundary of the cloud, and a bright channel, similar to a cloud-to-ground flash, can be visible for many miles.

Cloud-to-ground lightning is the most damaging and dangerous type of lightning, though it is also less common. Most flashes originate near the lower-negative charge center and deliver negative charge to earth. However, a large minority of flashes carry positive charge to earth. These positive flashes often occur during the dissipating stage of a thunderstorm's life. Positive flashes are also more common as a percentage of total ground strikes during the winter months. This type of lightning is particularly dangerous for several reasons. It frequently strikes away from the rain core, either ahead or behind the thunderstorm. It can strike as far as 5 or 10 miles from the storm in areas that most people do not consider to be a threat (see Figure 4-12). Positive lightning also has a longer duration, so fires are more easily ignited. And, when positive lightning strikes, it usually carries a high peak electrical current, potentially resulting in greater damage.

Figure 4-12 Cloud to Ground Lightning



Source: NWS

Past Occurrences

Disaster Declaration History

A search of FEMA and Cal OES disaster declarations turned up multiple events. FEMA federal disaster declarations occurred in 1950, 1955, 1958, 1963, 1969, 1983, 1986, 1989, 1995 (twice), 1997, 1998, 2006. State disaster declarations occurred in 1950, 1955, 1958 (twice), 1963, 1969, 1982 (twice), 1983, 1986, 1989, 1995 (twice), 1996, 1997, 1998, and 2008. More information can be found in Table 4-3 in Section 4.1.2. There have been no USDA secretarial declarations associated with severe storms.

NCDC Events

The NCDC data recorded 33 hail, heavy rain, lightning, and thunderstorm wind incidents for Sacramento County since 1950. A summary of these events is shown in Table 4-13 Specific events in the NCDC database showing damages, deaths, or injuries are detailed below the table; details on notable events follow

Table 4-13 NCDC Severe Weather Events in Sacramento County 1950-12/31/2015

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Hail	7	0	0	0	0	$11,030	$0
Heavy Rain	18	0	0	1	0	$365,000	$50,000
Lightning	1	0	0	0	0	$150,000	$0
Thunderstorm Wind	7	0	0	0	0	$0	$0
Total	**33**	**0**	**0**	**1**	**0**	**$526,030**	**$50,000**

Source: NCDC

- **March 24, 1994** – A strong upper low pressure system and cold front moved over the area, where rainfall amounts of 0.75 to 1.33 inches were common. Numerous reports of street flooding were reported.
- **January 22, 2000** – In about a 48-hour span, downtown Sacramento more than doubled its seasonal precipitation climbing from 3.91 inches to 8.21 inches. Officially for the event, downtown Sacramento received 4.30 inches. On the 24th, Sacramento easily established a new daily precipitation record with 3.11 inches. The previous record for the date was 1.76 inches. Saturated grounds along with breezy conditions were responsible for a tree's collapse which critically injured a Sacramento resident. The same uprooted tree damaged two passenger vehicles and a residence. SMUD reported that the extreme weather caused 1,871 customers to lose power. Over $15,000 in property damage was attributed to this storm.
- **February 11, 2000** – Heavy rain inundated a sewage pump along Greenback Lane in Folsom. This caused water and raw sewage to sweep downhill and into an impoundment on the American River. Over $100,000 in property damage was attributed to this storm.
- **October 9, 2000** – Lightning struck a television antenna, setting the roof ablaze in the City of Elk Grove. Over $150,000 was attributed to this lightning strike.
- **May 9, 2005** – Hail struck 10 miles north of the City of Sacramento. Hail accumulation on Highway 99 resulted in several accidents. Over $10,000 was attributed to this hail storm.
- **April 2, 2006** – Prolonged heavy precipitation with high snow levels resulted in excessive runoff into area river basins. Hardest hit was the San Joaquin River system and the Delta region. Many area reservoirs had minimal flood storage space as per seasonal norms and the large inflows had to be balanced very carefully with downstream releases to protect the fragile San Joaquin levee system. While the bulk of the flooding affected agricultural and rural properties, some local areas adjacent to waterways experienced flooding of homes and many roads were impassable. However, through the efforts of advance flood-fight measures, careful monitoring of levees, and critical water management coordination among federal, state, and local agencies, the system performed as designed and more serious flooding was averted. Over $250,000 in property damage and $50,000 in crop damage were attributed to this storm.

HMPC Events

The HMPC noted that the all-time record for rainfall during any 24-hour period in Sacramento is 7.24 inches on April 19-20, 1880. Streets were described as "having the appearance of miniature rivers." The rainstorm was also reported (colorfully) in such terms as "steady and business-like", "a perfect torrent", and "more like a cataract than an April shower."

The record maximum one-hour rainfall is 1.65 inches, which fell during the evening of April 7, 1935. Thunderstorms in the area were responsible for the downpour with considerable street flooding reported. (Note: Hourly rainfall records are only available after 1903).

January 1862, with 15.04 inches, is the wettest month on record. This took place before official government observations began. Precipitation records at that time were kept by two physicians, Dr. F.M. Hatch, a retired Army Surgeon, and his associate, Dr. T.M. Logan. Their records are believed to be reliable.

The most rainfall ever recorded in one season in Sacramento is 37.62 inches, set during the 1982-83 rainy season, under the influence of a strong El Niño. This followed the wet season of 1981-82 (32.65 inches), making it the wettest two-year period on record in Sacramento. The most recent El Niño outbreak to saturate the Sacramento area was the 1997-98 water year, which received a whopping 32.25 inches of precipitation. Since rainfall records began in 1849-50, only eight other water years have received more.

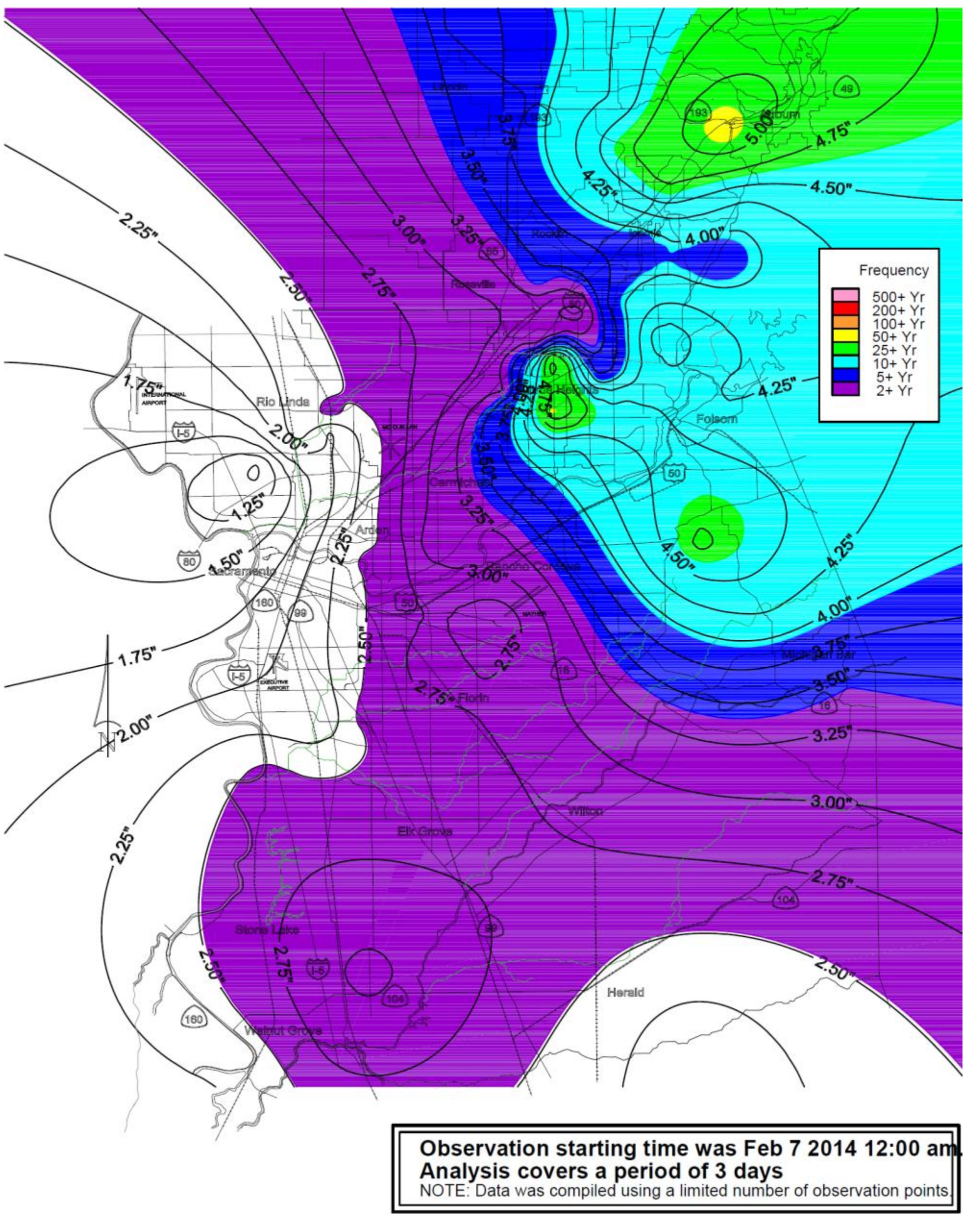
The HMPC also provided storm reports from 2011 to 2015. Reports are triggered for the following reasons:1) 75 drainage complaints Countywide, or 25 complaints in any one County Supervisor's District; 2) any structure flooding; and 3) coverage on the news about impending storms or during the storm. Information from those reports is included below.

- **March 2011** – Rain fell continually throughout the week, but the significant storm event began on the 24th. Rainfall totals only reached approximately 1" to 1.5" countywide on the 24th, but fell with high intensities at times on saturated watersheds which exacerbated impacts on stream levels. High winds helped dislodge debris to clog drain inlets. There were a total of 90 service request calls between 11 am on the 24th to 11 am on the 25th. Most calls were for plugged storm drains. There was one report of a flooded structure, but that was not confirmed.
- **December 2, 2012** – A series of consecutive heavy rainfall events caused creeks and streams to rise rapidly due to ground saturation. Reports of a trailer park flooded on Sunday due to rising creek levels along Arcade Creek. Winding Way (road) was reported as flooded in low lying areas as well. Damages included:
  - ✓ 12 homes (6 - homes confirmed, 6 - homes high probability)
  - ✓ 15 garages (8 - garages confirmed, 5 - garages high probability)
  - ✓ 4 duplexes (eight residences)
  - ✓ 29 apartments (2 within Auburn Villa MHP)
  - ✓ 4 mobile/manufactured homes within Auburn Villa MHP
  - ✓ 16 RVs within Auburn Villa MHP
  - ✓ 30 vehicles
- **May 5-6, 2013** – Redevelopment of thunderstorms that were producing torrential rainfall over the urban areas of Sacramento caused several instances of roadway flooding across the area. Law enforcement reported roadway flooding at Exposition Blvd and Heritage Lane with a vehicle stuck in the roadway,

two vehicles stuck in water near Arden and Hwy 160, roadway flooding near Watt Ave and Marconi Ave, as well as roadway flooding at H Street and 37th Street.

- **February 7-9, 2014** – A large storm occurred in the County. Rainfall totals of up to 3.5" occurred. Upstream of Folsom Dam, 5" fell in the City of Auburn in Placer County. Storm totals and an estimate frequency interval for the storm are shown on Figure 4-13. 73 calls were handled by the County for service requests.

Figure 4-13 February 7-9th Storm Rainfall Totals and Storm Interval



Source: Sacramento County Department of Water Resources 2014 Storm Report

- **February 5 to 9, 2015** – Countywide rainfall totaled approximately 1 inch to 3 inches and the rainfall intensity was equivalent to the 3-year storm event or less. The Department of Water Resources received 47 drainage service requests. The majority of calls were for localized street flooding and plugged drain inlets. No structure flooding was reported at this time. Three self-service sandbag sites were opened for the storm event, however no sandbags were distributed. Arcade Creek hit monitor stage at Winding Way near the American River College, Cosumnes River hit monitor stage at Michigan Bar (stages in the river are still raising but are not expected to reach flood stage), and the Natomas East Main Drain Canal hit monitor stage at pump station D15. Deer Creek hit flood stage at Scott Road.

- **December 21 and 22, 2015** – Countywide rainfall totaled approximately 0.1 inch to 0.95 inches, and the rainfall intensity was less than a 2-yr event. The Department of Water Resources received 12 drainage service requests. No structure flooding was reported at this time. Cosumnes River hit monitor stage at Michigan Bar and is receding. The Natomas East Main Drain Canal hit monitor stage at pump station D15. Deer Creek hit monitor stage at Scott Road.

Likelihood of Future Occurrence

Highly Likely – Heavy rains and storms are a well-documented seasonal occurrence that will continue to occur annually in the Sacramento County Planning Area.

Climate Change and Heavy Rains and Storms

According to the CAS, while average annual rainfall may increase or decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st century. This may bring stronger thunderstorm winds. It is unlikely that hail will become more common in the County. The amount of lightning is not projected to change.

Preliminary Draft - Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the 2016 Preliminary Draft CAP, which utilized Cal Adapt to model potential climate change impacts to Sacramento County, historic precipitation patterns could be altered. Depending on the location, precipitation events may increase or decrease in intensity and frequency. However, while the projections in California show little change in total annual precipitation, even modest changes could significantly affect California ecosystems that are conditioned to historical precipitation timing, intensities, and amounts. Also noted, reduced precipitation could lead to higher risk of drought and increased precipitation could cause flooding and soil erosion. Based on the Cal-Adapt model, the historical annual average rate of precipitation in Sacramento County is 18 inches. Under the high emission scenario, overall precipitation in Sacramento County is expected to decline over the next century, with annual averages decreasing more substantially under the high emissions scenario. Further, changes in weather patterns resulting from increases in global average temperature could result in a decrease in total amount of precipitation falling as snow. Based on historical data and modeling, under both low- and high-emissions scenarios, Cal DWR projects that the Sierra Nevada snowpack will decrease by 25-40 percent from its historic April 1st average of 28 inches of water content by 2050 and 48 to 65 percent by 2100, respectively.

4.2.6. Severe Weather: Wind and Tornadoes

Hazard/Problem Description

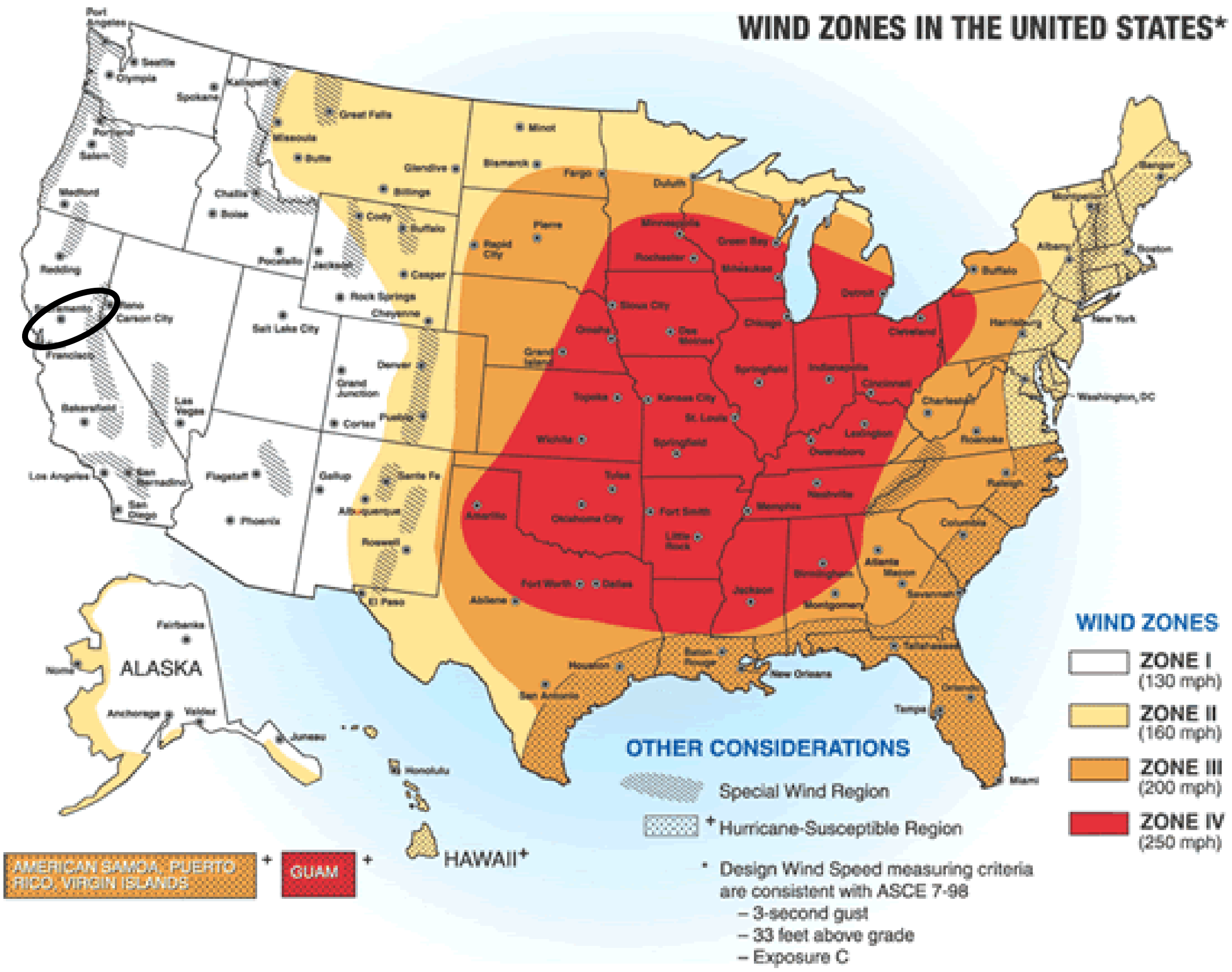
Winds

High winds, often accompanying severe thunderstorms, can cause significant property and crop damage, threaten public safety, and have adverse economic impacts from business closures and power loss.

The Planning Area is subject to significant, non-tornadic (straight-line), winds. 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. These winds may occur as part of a seasonal climate pattern or in relation to other severe weather events such as thunderstorms. Straight-line winds may also exacerbate existing weather conditions by increasing the effect on temperature and decreasing visibility due to the movement of particulate matters through the air, as in dust and snow storms. The winds may also exacerbate fire conditions by drying out the ground cover, propelling fuel around the region, and increasing the ferocity of exiting fires. These winds may damage crops, push automobiles off roads, damage roofs and structures, and cause secondary damage due to flying debris.

Figure 4-14 depicts wind zones for the United States. The map denotes that Sacramento County falls into Zone I, which is characterized by high winds of up to 130 mph. Portions of the County also fall into a Special Wind Region.

Figure 4-14 Wind Zones in the United States

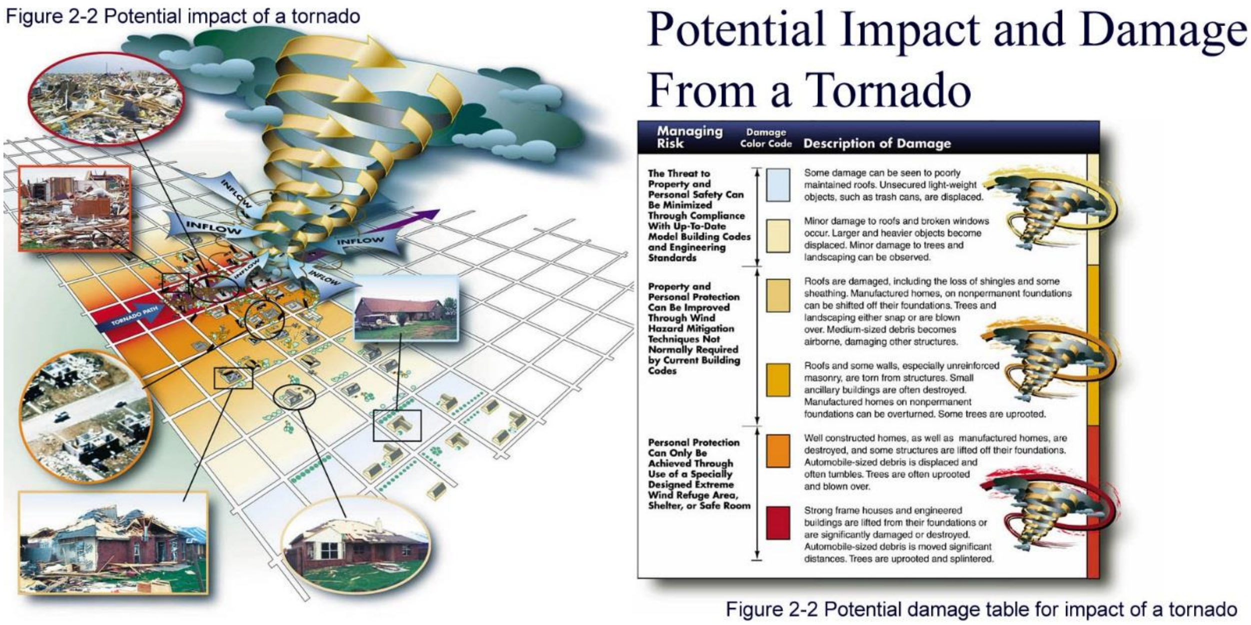


Source: FEMA

Tornadoes

Tornadoes and funnel clouds can also occur during these types of storms. Tornadoes are another severe weather hazard that can affect the Sacramento County Planning Area, primarily during the rainy season in the late fall and early spring. Tornadoes form when cool, dry air sits on top of warm, moist air. 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 are the most powerful storms that exist. They can have the same pressure differential across a path only 300 yards wide or less as 300-mile-wide hurricanes. Figure 4-15 illustrates the potential impact and damage from a tornado.

Figure 4-15 Potential Impact and Damage from a Tornado



Source: FEMA: Building Performance Assessment: Oklahoma and Kansas Tornadoes

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 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 takes into account the materials affected and the construction of structures damaged by a tornado. Table 4-14 shows the wind speeds associated with the original Fujita scale ratings and the damage that could result at different levels of intensity. Table 4-15 shows the wind speeds associated with the Enhanced Fujita Scale ratings.

Table 4-14 Original Fujita Scale

Fujita (F) Scale	Fujita Scale Wind Estimate (mph)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.

Fujita (F) Scale	Fujita Scale Wind Estimate (mph)	Typical Damage
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: NOAA Storm Prediction Center, www.spc.noaa.gov/faq/tornado/f-scale.html

Table 4-15 Enhanced Fujita Scale

Enhanced Fujita (EF) Scale	Enhanced Fujita Scale Wind Estimate (mph)
EF0	65-85
EF1	86-110
EF2	111-135
EF3	136-165
EF4	166-200
EF5	Over 200

Source: NOAA Storm Prediction Center, www.spc.noaa.gov/faq/tornado/ef-scale.html

Tornadoes can cause damage to property and loss of life. While most tornado damage is caused by violent winds, the majority of injuries and deaths generally result from flying debris. Property damage can include damage to buildings, fallen trees and power lines, broken gas lines, broken sewer and water mains, and the outbreak of fires. Agricultural crops and industries may also be damaged or destroyed. Access roads and streets may be blocked by debris, delaying necessary emergency response.

Past Occurrences

Disaster Declaration History

There have not been any FEMA federal or state disaster declarations in the Planning Area associated with high winds or tornadoes. There has been one USDA secretarial disaster declaration for wind/tornado in 2005, which is detailed in Table 4-21 in Section 4.2.7.

NCDC Events

Winds

The NCDC data shows 32 wind incidents for Sacramento County since 1993. These are shown in Table 4-16. Winds that resulted in damage, injuries, or deaths are discussed below the table.

Table 4-16 NCDC Wind Events in Sacramento County 1993 to 12/31/2015

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
High Wind	36	1	0	0	0	$8,842,000	$39,000
Strong Wind	9	0	1	0	2	$2,185,000	$0
Thunderstorm Wind	7	0	0	0	0	$0	$0

Event Type	Number of Events	Deaths	Deaths (indirect	Injuries	Injuries (indirect)	Property Damage	Crop Damage
Total	**52**	**1**	**1**	**0**	**2**	**$0**	**$0**

Source: NCDC

- **February 7, 1998** – Strong winds blew for a second day in a row in the Sacramento and Northern San Joaquin Valleys. The winds were strong enough to push a floating restaurant upstream on the swollen Sacramento River near Sacramento. Power outages left 60,000 customers in Sacramento and 15,000 Solano County customers in the dark for hours. 118 city trees were damaged in Sacramento. In total, $300,000 in property damage was attributed to this wind storm. No injuries or deaths were recorded.
- **November 7, 1998** – Post-frontal winds exceeding 50 mph downed over 400 power lines and trees. Over 125,000 SMUD and PG&E customers temporarily lost power with 90,000 of them in Sacramento County. In addition, $700,000 of damages were reported. No injuries or deaths were recorded.
- **April 3, 1999** – Pre-frontal winds of 40 mph disrupted electrical service for 3,500 PG&E customers. In addition, $59,000 of damages were reported. $20,000 of it was property damage, while $39,000 of crop damage was recorded. No injuries or deaths were recorded.
- **June 17, 2000 –** Sustained winds of 30-40 mph blew through the Carquinez Strait during the afternoon and early evening hours. A motorcyclist traveling on I-680 in nearby Solano County was pushed off the highway near Marshview Road by a stronger gust at approximately 5:25 pm and died of his injuries.
- **October 24, 2000 –** Strong north winds exceeded 40 mph across the interior valley and foothills. More than 20,000 Sacramento Metropolitan Utility District (SMUD) and Pacific Gas & Electric (PG&E) customers were temporarily without power. The winds uprooted trees damaging several homes and vehicles. $40,000 in property damage was attributed to this wind storm. No injuries or deaths were recorded.
- **January 4, 2008** – A 71 mph gust was measured 4 miles west northwest of Elk Grove. A 69 mph wind gust was measured at Sacramento Executive Airport and a 66 mph wind gust was measured at Sacramento International Airport. The State Legislature building had several windows broken and proceedings were forced to be suspended. Many trees were reported down, including an 80 foot oak tree near the intersection of Elm and Hazel in Sacramento. PG&E reported many power poles down throughout the area and thousands of residents and businesses were without power for up to seven days. Several big rigs were reported down by the California Highway Patrol (CHP), including one on I-5 south of River Rd. in Woodland, and another on I-80 east of State Route 113. $7.4 million in property damages were recorded, though not all of them occurred in Sacramento County. No injuries or deaths were recorded.
- **October 27, 2013** – Strong onshore winds brought down large trees for the Southern Sacramento Valley. Sacramento Executive AP peaked at 41mph, Sacramento International AP peaked at 46mph, and Vacaville/Nut Tree peaked at 36mph. Broadcast media reported several large trees down in Sacramento which hit houses, powerlines, and cars. A tree fell on a home near Sac State that caused significant roof damage. $50,000 in property damage was attributed to this wind storm. No injuries or deaths were recorded.
- **December 11, 2014** – Law enforcement, media, and the public reported numerous trees and large branches downed by winds in Sacramento and adjacent suburbs, such as Rosemont, Carmichael, and Florin. These caused local power outages spread across the area. There was a 38 mph gust measured at 7 am at Sacramento Executive Airport, a 40 mph gust at Sacramento International Airport. $500,000 in property damage was attributed to this wind storm. No injuries or deaths were recorded.

- **December 30, 2014 –** Multiple fallen trees caused damage to homes in the Motherlode foothills and in the Sacramento metro area. Trees were reported falling on homes and business in Sacramento, Elk Grove, and Folsom. Fallen trees and branches also caused power outages, with 344,000 customers across northern California impacted. $1,600,000 in property damage was attributed to this wind storm, though not all in Sacramento County. No injuries or deaths were recorded.

Tornado

During the rainy season, the Sacramento County Planning Area is prone to relatively strong thunderstorms, sometimes accompanied by funnel clouds and tornadoes. While tornadoes do occur occasionally, most often they are of F0 or F1 intensity. Documented incidents of tornadoes in the Sacramento County Planning Area from the NCDC Storm Events Database are listed in Table 4-17 and explained in further detail in the text below the table.

Table 4-17 Sacramento County Tornado Events from 1950 – 12/31/2015

Type	# of Events	Property Loss	Crop Loss	Deaths	Injuries
Funnel Cloud	6	$0	$0	0	0
F0	8	$706,000	$0	0	0
F1	3	$500,000	$0	0	0
F2	1	$250,000	$0	0	0
Total	**18**	**$1,456,000**	**$0**	**0**	**0**

Source: NCDC

- **February 7, 1978** – An F2 tornado was reported in Sacramento County. The tornado was 20 yards wide and was on the ground for approximately 1.9 miles. No deaths, no injuries, and $250,000 in damages were attributed to this tornado.
- **March 22, 1983** – An F1 tornado was reported in Sacramento County. The tornado was 50 yards wide and was on the ground for approximately 1 mile. No deaths, no injuries, and $250,000 in damages were attributed to this tornado.
- **April 9, 1988** – An F1 tornado was reported in Sacramento County. The tornado was 30 yards wide and was on the ground for approximately 1 mile. No deaths, no injuries, and $500,000 in damages were attributed to this tornado.
- **April 24, 1998** – A weak tornado (F0) touched down near a large mall in the Sacramento metro area, severely damaging a tree and damaging two cars. No deaths, no injuries, and $10,000 in damages were attributed to this tornado.
- **February 21, 2005** – On 21 February 2005 Presidents' Day, three tornadoes and several funnel clouds (see Figure 4-16) occurred in the Sacramento valley, including two weak (F0) tornadoes in the Sacramento, CA metropolitan area. The Southport, CA and Natomas, CA tornadoes caused nearly $1 million of damage to residential and commercial property. Amazingly, there were no fatalities or serious injuries despite the amount of flying debris, air-borne projectiles, toppled trees, and an over-turned semi-trailer truck.

Figure 4-16 Images from the President's Day Tornado Outbreak in Sacramento County

Source: Sacramento Bee

- **April 8, 2005** – An F0 made two brief touchdowns in Sacramento County, one 8 miles north of the City of Sacramento and another near the Sacramento Metro Airport. The brief touchdown north of the City caused damage to a church roof, residential property fences, and to tree branches. The brief touchdown near the airport was in an open field and caused no damages. In all, no deaths, no injuries, and $25,000 in damages were attributed to this tornado.
- **February 25, 2007** – Clearing skies over an unstable airmass left in the wake of a very cold winter storm provided an environment favorable for weak convective activity. A very weak tornado (EF0) skimmed a residential area just south of downtown Elk Grove shortly after noon. Damage was minimal but consistent in a narrow one mile path. Most of the damage was to small tree branches but also included two power lines tipped, a rooftop solar heating unit damaged, and there was minor damage to fence panels at two locations. No structural damage was noted. No deaths or injuries were attributed to this tornado.
- **February 25, 2011** – An EF0 tornado touched down at the Mather Field Industrial Park, immediately north of Mather Field. The maximum wind speed of the tornado was estimated at 75 mph with a damage path of one third of a mile. The damage path was in a northeast direction. No injuries nor fatalities have been reported. Damage was to a few trees including a large evergreen tree, broken road signs, and broken windows to multiple cars.
- **October 22, 2015** – A tornado touched down in the City of Elk Grove. Supercells developed behind the cold front along a north-south boundary in the middle of the Central Valley, where both instability and shear were large. Reports of tornado damage were at approximately 3:45pm (PST) near Waterman and Grand Line Roads. The estimated damage path length was about a mile with wind speeds estimated at 90-100mph. A sturdy metal roof was bent back, tree trunks that were several feet in diameter were snapped. Dozens of houses were mildly damaged.

HMPC Events

The Planning Team for the County noted the following events since 2011:

- 2012 – October 22nd @ 3:45 – A tornado occurred in Elk Grove, which caused winds of 90-100 mph.
- 2013 – April 8th and 9th – A strong trough that had brought rain and snow to interior northern California, had moved eastward of the area on Monday, April 8th. This brought strong, gusty northerly winds in its wake across the area, mainly the Central Valley, ridge tops, and wind prone mountain canyons. The strongest periods of winds were on Monday, April 8th from late morning into mid-afternoon. Breezy conditions occurred again on Tuesday, April 9th, though winds were not quite as strong. Sustained winds on Monday reached 25-35 mph with gusts as high as around 50 mph. Sustained winds on Tuesday

were 20-30 mph with gusts as high as around 40 mph. Over 20,000 people were reported to have lost power due to falling trees and wind (though not all in Sacramento County).

- 2013 – Oct 3rd & 27th – High winds occurred. Gusts of 35 – 50 mph.
- March 29th – A Pacific front moved through interior Northern California March 28-30th which brought rain and heavy snow to the area. A supercell strengthened in the Central Sacramento Valley that afternoon that eventually produced an EF0 tornado near Nord, CA that evening.
- 2014 – Dec 11th – Heavy rainfall & winds of about 50-60 mph.
- 2014 – Dec 30th – High winds occurred, causing a power outage to about 344,000 people.
- 2015 – December – there was a tornado that formed over Folsom Lake and impacted El Dorado County
- 2016 – January 19th – Part of a tree fell onto Saverien Drive, blocking the right turn lane. This was a result of rainfall and 40 mph winds.

Likelihood of Future Occurrence

Highly Likely – High winds are a well-documented seasonal occurrence that will continue to occur annually in the Sacramento County Planning Area, making future occurrence highly likely. While occasional, tornadoes do occur in the County as well. Combining the likelihoods results in a likelihood of future occurrence of likely.

Climate Change and High Winds/Tornadoes

According to the CAS, while average annual rainfall may increase or decrease slightly, the intensity of individual events is likely to increase during the 21st century. This may bring stronger thunderstorm winds. The number of tornadoes is not projected to change.

4.2.7. Agricultural Hazards

Hazard/Problem Description

Agricultural production in Sacramento County remains a significant contributor to the local economy. In addition to the almost $470 million in annual production value, there are hundreds of jobs directly tied to agricultural production and thousands more that are impacted indirectly in the production, processing, transportation, and marketing of those commodities. It is estimated that there is approximately a four to one ratio for crops grown in this region, so $470 million in production value is actually a $1.88 billion impact on the local economy.

Sacramento County is at risk from severe weather events and insects/pests that, under the right circumstances, can cause severe economic, environmental, or physical harm. Severe weather and insects affect crop production and can result in economic disasters. These hazards can have a major economic impact on farmers, farm workers, packers, and shippers of agricultural products. They can also cause significant increases in food prices to the consumer due to shortages.

Sacramento is also at risk to noxious weeds that can affect both waterways and agricultural crops. These hazards can have major impact on farmers, farm workers, packers, and shippers of products, as well as those who use waterways for recreation or for water supply.

Important Farmland

According to the California Department of Conservation's Farmland Mapping and Monitoring Program (FMPP), as of 2014, the County has approximately 91,568 acres of prime farmland, 43,105 acres of farmland of statewide importance, 15,125 acres of unique farmland, 58,852 acres of farmland of local importance, and 153,452 acres of grazing land. These numbers have been reduced since 2004 due to increased development in the County.

Sacramento County Agriculture Industry

According to the 2015 crop report, 2015 represented the fourth year of severe drought and that is finally demonstrated in the County's crop production value of $469,947,546 which represents a 6.4% decrease from the adjusted 2014 figure of $502,274,000 (a record high). Although the drought did negatively affect the yields of some crops, another major contributing factor to the lower farmgate was the decrease in prices for many commodities in 2015. It should be noted that many of the 2015 lower commodity prices had increased significantly in 2014 so this may be a re-adjustment to more of a normal price. Sacramento County agriculture demonstrated stability in 2015 as the top ten commodities remain the same and their proportion of the County's agricultural value remained stable as well. All but two of the top ten commodities had a decrease in value. The largest decreases were in milk and field corn. Field corn production dropped 25% and the price per ton dropped 12.7% and milk production dropped 8% and its price per unit dropped almost 30%. Pears also showed a significant decrease (-20%) with a drop in both production and price per ton but Sacramento still remains the top pear producing county in California. The top County commodity, wine grapes, increased in acreage but most likely due to the drought decreased a bit in yield and the price decreased slightly as well. Livestock was a bright spot in 2015 with a 60% increase in the value of aquaculture production and it remains in the top ten commodities. Although the price in cattle and calves remained strong and even increased, many cattlemen had already thinned their herds due to the drought (production was down almost 10%) and the cattle were not carrying the weight that they did in 2014 so producers were unable to take advantage of that strong price and turned in a 13% decrease for 2015. The rest of the livestock in the County showed increases in value so that overall, livestock values increased more than 12% over 2014.

A summation of crop values from 2010-2015 is shown in Table 4-18.

Table 4-18 Sacramento County Crop Values 2010 to 2015

INDUSTRY	2010 Value	2011 Value	2012 Value	2013 Value	2014 Value	2015 Value
Apiary Products	$3,000	$51,000	$50,000	$58,000	$230,000	$234,000
Field Crops	$58,543,000	$78,059,000	$81,030,000	$75,565,000	$80,600,000	$74,612,000
Fruit & Nut Crops	$144,270,000	$145,179,000	$198,334,000	$197,863,000	$196,923,000	$189,117,000
Livestock/Poultry	$43,467,000	$59,141,000	$74,804,586	$71,309,055	$89,953,000	$101,314,546
Livestock/Poultry Products	$50,149,000	$63,654,000	$58,884,000	$65,526,000	$76,994,000	$49,916,000
Nursery Products	$28,925,000	$26,457,000	$23,642,000	$24,916,000	$24,229,000	$23,778,000
Seed Crops	$2,275,000	$2,759,000	$5,511,000	$4,811,000	$4,254,000	$4,812,000

INDUSTRY	2010 Value	2011 Value	2012 Value	2013 Value	2014 Value	2015 Value
Vegetable Crops	$28,311,000	$29,911,000	$18,395,000	$18,909,000	$22,195,000	$26,614,000
GRAND TOTALS	**$355,943,000**	**$405,211,000**	**$460,650,586**	**$458,957,055**	**$495,378,000**	**$470,397,546**

Source: Sacramento County Agricultural Commissioner's Reports, 2010-2014

Natural Hazards and Sacramento County Agriculture

According to the HMPC, agricultural losses occur on an annual basis and are usually associated with severe weather events, including heavy rains, floods, heat, and drought. The 2013 State of California Multi-Hazard Mitigation Plan attributes most of the agricultural disasters statewide to drought, freeze, and insect infestations. Other agricultural hazards include fires, crop and livestock disease, and noxious weeds.

Insects and Sacramento County Agriculture

Sacramento County is threatened by a number of insects that, under the right circumstances, can cause severe economic and environmental harm to the agricultural industry. Insects of concern to plants and crops include the Asian citrus psyllid, Caribbean fruit fly, false codling moth, melon fruit fly, guava Fruit fly, gypsy moth, Japanese beetle, Light brown apple moth, Mediterranean fruit Fly, melon fruit fly, Mexican fruit fly, oriental fruit fly, peach fruit fly, red imported fire ant, and striped fruit fly. The Sacramento County Department of Agriculture traps and monitors all of these agricultural pests. Pest detection is a proactive program that seeks to identify exotic, invasive insects. These pests have a wide host ranges and are difficult and costly to manage once established. Early detection is essential for quick and efficient eradication. Public participation is critical to the success of this program, since staff relies on the goodwill of property owners who allow traps to be placed on their properties. The Agriculture Department deploys 7,800 traps annually between spring and fall.

The California Department of Food & Agriculture (CDFA) Pest Eradication staff with the assistance of the California Conservation Corp help to mitigate the impacts of insect pests by providing human resources to assist in state and local eradication efforts, including surveying private yards and business landscapes to detect the Glassy Winged Sharpshooter, stripping citrus fruit infected by the Mexican Fruitfly, removal of citrus trees which have been infected with Huanglongbing (HLB), also known as Citrus Greening, or cleaning and disinfecting backyards infected by the Exotic Newcastle Disease.

Weeds and Sacramento County Agriculture

Noxious weeds, defined as any plant that is or is liable to be troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate, are also of concern. Weeds of concern in the County from the California Invasive Plant Council (Cal IPC) are shown in Table 4-19 and Table 4-20.

Table 4-19 Sacramento County High Priority Weeds

Scientific Name	Common Name	Cal-IPC Rank/ CDFA Rating	Notes
Acroptilon repens	Russian knapweed	Mod/B	Few locations along roadsides and fields in Natomas Area

Scientific Name	Common Name	Cal-IPC Rank/ CDFA Rating	Notes
Arundo donax	Giant reed	High/B	Priority for management in riparian areas.
Centaurea solstitialis	Yellow starthistle	High/C	Management in high quality habitat and recreation areas.
Chondrilla juncea	Skeleton weed	MOD/A	Not a priority for mapping and control in Sacramento or foothill counties according to CDFA, weed of concern for counties around Sacramento
Cuscuta japonica	Japanese dodder	--/A	Active eradication program in place.
Cytisus scoparius	Scotch broom	High/C	Not much of this, keep on priority list, abundant in upstream watersheds.
Dittrichia graveolens	Stinkwort	MOD*/NL	Project priority. This weed is the subject of a mapping and eradication program started in 2009.
Eichornia crassipes	Water hyacinth	High*/C	Priority in Delta waterways, still actively sold in nurseries.
Genista monspessulana	French broom	HIGH/C	Scattered locations, sometimes sold in nursery trade, upstream of American River Parkway.
Lepidium latifolium	Perennial pepperweed	High/B	Heavy infestations in the southern part of the County, spreading along roadsides and through contaminated materials.
Ludwigia spp.	Water primrose	HIGH/NL	Project priority. Eradication target for mosquito and vector control work. Spreading in agricultural ditches and Laguna Creek
Sapium sebiferum	Chinese tallow	MOD*/NL	Starting to naturalize in the American River Parkway, Dry Creek and other riparian areas.
Sesbania punicea	Red sesbania	HIGH*/B	Project priority. Target of active eradication program in Dry Creek, abundant in Steelhead, Robla and Arcade creeks.
Spartium junceum	Spanish broom	High/C	Scattered locations in American River Parkway, sometimes sold in nursery trade.

Source: Sacramento WMA Strategic Plan

Status Definitions

Cal-IPC Ranks (Cal-IPC Inventory Categories):

High – These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

Moderate – These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

Limited – These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

CDFA Rating definitions:

"A" –A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. A-rated pests are prohibited from entering the state because, by virtue of their rating, they have been placed on the of Plant Health and Pest Prevention Services Director's list of organisms "detrimental to agriculture" in accordance with the FAC Sections 5261 and 6461. The only exception is for organisms accompanied by an approved CDFA or USDA live organism permit for contained exhibit or research purposes. If

found entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.
"B"–An pest of known economic or environmental detriment and, if present in California, it is of limited distribution. B-rated pests are eligible to enter the state if the receiving county has agreed to accept them. If found in the state, they are subject to state endorsed holding action and eradication only to provide for containment, as when found in a nursery. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.
"C"–A pest of known economic or environmental detriment and, if present in California, it is usually widespread. C-rated organisms are eligible to enter the state as long as the commodities with which they are associated conform to pest cleanliness standards when found in nursery stock shipments. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.
"Q"–An organism or disorder suspected to be of economic or environmental detriment, but whose status is uncertain because of incomplete identification or inadequate information.
"D"–An organism known to be of little or no economic or environmental detriment, to have an extremely low likelihood of weediness, or is known to be a parasite or predator. There is no state enforced action.

Table 4-20 Sacramento WMA Weed Watch List

Scientific Name	Common Name	Cal-IPC Rank/ CDFA Rating	Notes
Ailanthus altissima	Tree of Heaven	MOD/C	Concern in natural areas.
Centaurea calcitrapa	Purple starthistle	MOD/B	A few recorded locations, more abundant in Solano County.
Centaurea sulphurea	Sicilian starthistle	--/B	Expanding outside known location in Folsom.
Cynara cardunculus	Artichoke thistle	MOD/B	In southern Delta, could expand north.
Glyceria declinata	Manna grass	MOD/NL	Invading vernal pools.
Lythrum salicaria	Purple loosestrife	HIGH/B	Small populations are not being actively managed.
Robinia pseudoacacia	Black locust	LIMITED/NL	Concern in riparian areas.
Rubus (armeniacus) discolor	Himalaya blackberry	HIGH/NL	Concern in high-value habitats, widespread.
Taeniatherum caput-medusae	Medusahead	HIGH/C	Widespread, concern in high quality rangeland in eastern County.
Tamarisk sp.	Tamarisk	HIGH - VAR/B	Only a few populations on American River Parkway, could become more widespread.
Tribulus terrestris	Puncture vine	NL/C	Concern to bikers, abundant along Sacramento River bike trail.

Source: Sacramento WMA Strategic Plan. Cal-IPC and CDFA rankings are same as in previous table.

Noxious weeds have been introduced in the Planning Area by a variety of means, including through commercial nurseries. An absence of natural controls, combined with the aggressive growth characteristics and unpalatability of many of these weeds, allows these weeds to dominate and replace more desirable native vegetation. Negative effects of weeds include the following:

- Loss of wildlife habitat and reduced wildlife numbers;
- Loss of native plant species;
- Reduced livestock grazing capacity;
- Increased soil erosion and topsoil loss;
- Diminished water quality and fish habitat;

- Reduced cropland and farmland production; and
- Reduced land value and sale potential.

Disasters and Impacts to Sacramento County Agriculture

Economic Impacts

According to the HMPC, the consequences of agricultural disasters to the Planning Area include ruined plant crops, dead livestock, ruined feed and agricultural equipment, monetary loss, job loss, and possible multi-year effects (i.e., trees might not produce if damaged, loss of markets, food shortages, increased prices, possible spread of disease to people, and loss or contamination of animal products). When these hazards cause a mass die-off of livestock, other issues occur that include the disposal of animals, depopulation of affected herds, decontamination, and resource problems. Those disasters related to severe weather may also require the evacuation and sheltering of animal populations. Overall, any type of severe agricultural disaster can have significant economic impacts on both the agricultural community and the entire Planning Area.

According to the USDA, every year natural disasters, such as droughts, earthquakes, extreme heat and cold, floods, fires, earthquakes, hail, landslides, and tornadoes, challenge agricultural production. Because agriculture relies on the weather, climate, and water availability to thrive, it is easily impacted by natural events and disasters. Agricultural impacts from natural events and disasters most commonly include: contamination of water bodies, loss of harvest or livestock, increased susceptibility to disease, and destruction of irrigation systems and other agricultural infrastructure. These impacts can have long lasting effects on agricultural production including crops, forest growth, and arable lands, which require time to mature.

Impact to Waterways

Some of California's most serious weed problems occur in our waterways, lakes and streams. The aquatic plant hydrilla is considered one of the most serious aquatic weed problems in the world and CDFA maintains an intensive program to survey and eradicate this aquatic weed pest. It can quickly take over lakes and streams, crowding out native animals and plants and blocking hydroelectric plants, while impeding water flow and delivery. Its rapid growth and ease of spread by boats makes it critical to detect early and eradicate. Based on estimates from the USDA, the permanent establishment of hydrilla in the Sacramento/San Joaquin Delta would result in at least $200 million in annual losses.

Past Occurrences

USDA Disaster Declaration History

A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency. This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a major disaster declaration for counties designated major disaster areas and those that are contiguous to declared counties, including those that are across state lines. As part of an agreement with the USDA, the SBA offers low interest loans for eligible businesses that suffer economic losses in declared and contiguous counties that have been declared by the USDA. These loans are referred to as Economic Injury Disaster Loans.

Disaster declarations from 1982 through 2015 are shown in Table 4-21.

Table 4-21 Sacramento County USDA Designations: 1982-2015

Year	Disaster Name	Disaster Type	Disaster Cause	Disaster #	State Declaration #	Federal Declaration #
2015	–	Agricultural	Drought	S3797	–	2/25/2015
2015	–	Agricultural	Drought	S3784	–	2/4/2015
2014	–	Agricultural	Drought	S3743	–	9/17/2014
2014	–	Agricultural	Drought	S3637	–	1/23/2014
2013	–	Agricultural	Wildfire	S3626	–	8/17/2013
2013	–	Agricultural	Drought	S3569	–	8/1/2013
2013	–	Agricultural	Drought	S3558	–	7/31/2013
2012	–	Agricultural	Drought	S3452	–	12/29/2012
2012	–	Agricultural	Drought	S3379	–	9/5/2012
2009	–	Agricultural	Freezing Temperatures	S3109	–	11/25/2010
2008	–	Agricultural	Drought, Unseasonable Frost	S2708	–	7/29/2008
2007	–	Agricultural	Drought	S2563	-	8/9/2007
2007	–	Agricultural	Extremely low temperatures, freezing conditions	S2488	-	1/31/2007
2006	–	Agricultural	Excessive rain and hail	S2322	-	6/26/2006
2005	–	Agricultural	Cold wet weather	S2183	-	12/13/2005
2005	–	Agricultural	Unseasonable rain	S2120	-	8/25/2005
2005	–	Agricultural	Severe high temperatures, low humidity, strong winds	S2113	-	8/18/2005
2003	–	Agricultural	Extreme heat, unseasonable rainfall	S1855	-	12/19/2003
2003	–	Agricultural	Excessive rain, wheat stripe rust	S1812	-	10/23/2003
2002	–	Agricultural	Drought	S1769	-	4/28/2003

Year	Disaster Name	Disaster Type	Disaster Cause	Disaster #	State Declaration #	Federal Declaration #
1998	–	Agricultural	Severe Winter storms, flooding	S1242	-	10/1/1998
1998	–	Agricultural	Severe Winter storms, flooding	M1203 (precursor to DR-1203)	-	2/9/1998
1995	–	Agricultural	Flooding, landslides, mud & debris flows	M1044 (precursor to DR-1044)	-	1/12/1995
1989	–	Agricultural	Earthquake	M-845 (precursor to DR-845)	-	11/4/1989
1988	–	Agricultural	Drought	S401	-	8/1/1989
1982	Rains Causing Agricultural Losses	Agricultural	Storms	GP	10/26/1982	–

Source: USDA, Sacramento County Department of Agriculture

NCDC Events

The NCDC does not track agriculture events. It does note any crop damages that come from severe weather events. These were detailed in Table 4-4 in Section 4.2.1.

HMPC Events

Members of the HMPC noted that in the **1960s** there was a significant infestation of Japanese Beetle near the State Capitol in downtown Sacramento.

In the summer of **1983**, the Sacramento County Agriculture Department and the CDFA initiated a program to eradicate an infestation of the Japanese Beetle in Orangevale, California. One phase of the eradication program consisted of multiple applications of the pesticide carbaryl to foliage for each of the three summers for 1983, 1984, and 1985. The same materials and procedures were used on earlier gypsy moth infestations in the State. During the peak beetle flight season of the summer of 1984, a number of properties were sprayed every 4 to 9 days rather than the normal interval of 14+ days. Eradication efforts were completed in 1986.

In **1999**, in two Oriental Fruit Fly traps, approximately 1 mile apart, 2 Guava Fruit Flies were detected. In response to the finds, 359 additional Oriental Fruit Fly traps were deployed in an effort to pinpoint the source of the insects. These traps covered a 90-square mile area. Though no further Guava Fruit Flies were found, a 9-square mile area was treated in the core area of the find sites.

Since **2000**, Sacramento County has been under quarantine for the Glassy-winged Sharpshooter. The pest was first found in Rancho Cordova and then in Foothill Farms. The sharpshooter feeds by sucking juices from a wide variety of plants. For most plants this is not a problem, however, the sharpshooter may spread a lethal bacterial disease to grapes. Luckily the 2 quarantine areas were in urban settings and away from the 25,110 acres of grapes in the County. Since discovering the infestations, hundreds of residential and commercial landscapes were treated in an effort to kill the pest before it spread to the vineyards. After 2 years of negative finds in both Rancho Cordova and Foothill Farms, all quarantine designations were removed in 2009. Trapping and visual surveys continue throughout the county to ensure the pest does not return. Eradication efforts over the 10 year period totaled around $6 million

In **2000**, both Gypsy Moth and Japanese Beetle were both found. Gypsy Moth was found in the Carmichael area prompting crews to deploy 100 more traps in a 4 square mile area. No additional Gypsy moths were trapped, however increased trapping in that area continued into 2001. A single Japanese Beetle was recovered from a trap at the former Mather Air Force Base in Rancho Cordova. It is suspected that the beetle "hitch-hiked" on one of the many air cargo planes landing there. Additional traps were deployed, but no further beetles were found.

In **2001**, the Red Imported Fire Ant was detected at an RV area at Cal Expo, in Sacramento County. The discovery was made by an alert RV camper from Texas who recognized the ants and alerted officials. Additional ant colonies were found by the Cal Expo amphitheater. To eradicate the infestation, an attractive bait was applied to the infested areas for worker ants to take back to the colonies. This bait is designed to disrupt the queens' ability to reproduce, and also inhibit the ants' ability to absorb nutrients. This "one-two punch" approach targets the entire colony and not just the ants above ground.

In **2001**, a single Japanese Beetle was recovered from a trap at the former Mather Air Force Base in Rancho Cordova. It is suspected that the beetle "hitch-hiked" on one of the many air cargo planes landing there. Additional traps were deployed, but no further beetles were found.

In **2002**, five Japanese Beetles were trapped at the former Mather Air Force Base in Rancho Cordova. The old base is now used for air cargo planes; some originating in the eastern United States where Japanese beetles are well established. It is thought that the beetles may have "hitch- hiked" in the cargo holds, only to fly out when the planes were unloaded. In response to the discoveries, visual surveys were conducted and 370 additional traps were deployed. As a precaution against any possible low level infestation, limited pesticide treatments were carried out on the Mather property.

In **2003**, inspectors trapped 2 Oriental fruit flies in the Rosemont area of Sacramento. In response to the finds, additional traps were set in an 81 square mile area. Weekly monitoring of the traps revealed no further evidence of the fly. Although the additional traps were removed from the field in late spring 2004, monitoring traps continued to be inspected. Because a specific site could not be determined to be the source of the flies, no pesticide treatments were conducted.

In mid-summer **2004** a single female Japanese beetle was trapped by county ag personnel near the express carrier terminals at Mather Field in Rancho Cordova. The trap was one of over 500 Japanese beetle traps that are placed throughout the County to detect this destructive pest. As all airports are considered high risk sites, trapping levels at Mather Field remained high through the season. An introduced pest of the Eastern United states, Japanese beetles can be attracted to airport lights and fuel odors leading them to become stowaways in the cargo holds of California bound planes. Through a cooperative agreement with the CDFA, state inspectors will continue to inspect the cargo holds of planes coming from infested eastern states.

In **2005**, Asian Longhorned Beetles (ALB) were discovered in Sacramento. Three exotic tree destroying beetles were found at a warehouse specializing in imported stone products in Sacramento in 2005. Identified as Asian Longhorned Beetles, these insects were stowaways in wooden crating material originating from China. The beetles apparently started their journey in Asia as larvae in hardwood trees that were turned into crating lumber. In nature, ALB larvae bore deep into deciduous hardwood trees such as maple, birch, chestnut, poplar, willow, elm and ash – eventually killing them. Introductions of the beetle in New York, Chicago, and New Jersey have caused the destruction of thousands of trees in efforts to eradicate the pest. The discovery of this destructive pest in California presents a serious threat to the environment. In response to the Sacramento find, Sacramento County Ag Commissioner's staff, along with state and federal ag officials quickly implemented detection and eradication procedures:

- The warehouse and all suspect trace forward packing crates were fumigated
- Visual survey of host trees in 9 square mile area (to be continued through 2008)
- Trapping survey of 9 square mile area (1 season only)
- Systemic pesticide applied preventatively to host trees near find site (for 2 seasons)
- Baited "trap" trees used as detection lures deployed near warehouse (to be continued through 2008)

In **2009**, Sacramento County detection traps intercepted a single Oriental Fruit Fly in Citrus Heights, 3 Oriental Fruit Flies in Elk Grove, and a single Mexican Fruit Fly in the Meadowview area. In cooperation with CDFA and the USDA, three separate delimitation areas were set up and hundreds of additional traps were deployed to determine if full blown infestations existed. Pesticide bait stations were placed in a 9 square mile area in Elk Grove where the 3 Oriental Fruit flies were found. After many weeks of not finding additional fruit flies, the traps were removed from each delimitation area and the threat of quarantine declaration was averted.

In **2010**, the first find of Light Brown Apple Moth in the County (Epiphyas postivittana). While no eradication treatments are currently under way, there are concerns about the impacts of quarantine and growers are taking it upon themselves to make dormant treatments of susceptible plantings such as pears and cherries, to limit pest numbers in the spring.

In **2010**, a lone mated female Oriental Fruit Fly was found in a detection trap in the North Highlands area of Sacramento County in June of 2010. Because the find indicated that there was a breeding population present, a quarantine was imposed and pesticide treatments were prescribed. Properties close to the find site received a ground spray of spinosad while insecticide bait stations were distributed over a 9 square mile area. Though the area under quarantine was mostly urban residential properties, some smaller growers and farmers markets were affected. Growers of host fruit originating within the quarantine boundaries were required to treat their produce weekly for 30 days before it could leave the quarantine area. Farmer's Markets and outdoor vendors were required to safeguard fruit and vegetables while displayed with screens or plastic to avoid fruit fly eggs being laid in host fruit. Hundreds of additional traps were deployed in the area but no further fly finds were made. The quarantine was lifted from the area in November 2010.

In **2010**, one single female Japanese beetle was trapped at a residence in Fair Oaks in August 2010. In response, the California Department of Agriculture (CDFA) placed hundreds of additional traps in the area surrounding the find to determine if a breeding population existed. Japanese beetle is not native to the United States but was accidentally introduced to the eastern states from Japan around 1917. Increased trapping levels will continue for 2 more years to monitor the area.

In **2010**, one male Peach Fruit Fly was discovered in South Sacramento in a detection trap. Bactrocera zonata is known in India and Southeast Asia as a serious pest of tropical and subtropical fruits. It is one of the three most destructive flies in India, causing crop losses of 25 to 100 percent in peach, apricot, guava and figs. Damage to the fruit is similar to that caused by the Mediterranean fruit fly and the Melon fly. It has been reared from 33 different types of fruits, a number of which are important commercial crops. It lowers the yield and quality of such fruits as mango, guava, citrus, eggplant, tomato, apple, peach and loquat. In response to the find, hundreds of additional traps were deployed to determine if a breeding population exists. Traps were monitored until early summer 2011.

In **2011**, two more Japanese Beetles were detected in a Fair Oaks neighborhood just east of the Sunrise Mall. The beetles were caught in 2 of the 50 detection traps that blanketed the area in response to the discovery of a single beetle in 2010. Trap density was increased to 160 traps in an effort to pin down the source of the population.

In **2012**, The Japanese beetle (JB) eradication project in Fair Oaks continued into its third year in 2012 with over 700 detection traps monitoring a 49 square mile area just east of the Sunrise Mall. The infestation was first discovered in 2010 after county detection trappers found a lone JB in a trap at a residential property. Two more beetles were trapped in 2011 and an eradication project was triggered. Properties within 200 meters of each find site were treated twice using a foliar spray for the adult JB's and a soil treatment for the immature grubs. In 2012, officials from both state and county agriculture departments were disappointed to detect 4 more adult beetles in the same general area. 23 more properties were added to the treatment area as the quarantine boundaries expanded. Trap numbers were increased in an effort to pin down the infestation **-** many property owners had at least 2 traps placed in their yards. Pesticide applications were increased to 5 treatments –repeated every two weeks in hopes of getting a handle on the population.

In **2013**, over 700 Japanese beetle traps were redeployed over 49 square miles in the infested area of Fair Oaks and checked throughout the summer by California Department of Food and Agriculture employees. No Japanese beetles were found. In fact 2013 marks the first summer since 2010 that no Japanese beetles were detected in Fair Oaks.

In **2014**, Japanese beetle and Gypsy moth were detected in Sacramento County. Because of these limited detections, no official quarantines were enacted but continuous monitoring and treatment must occur until no further evidence of either pest is found. If the pests are found in additional areas, quarantine holds may be necessary.

In addition to these specific outbreaks, the HMPC noted that Apple Codling Moth is a recurrent pest problem in Sacramento County Orchards. The HMCP also noted that agriculture events occur yearly, though with varying levels of damages. Finally, members of the HMPC noted that many of the events in the drought section of this plan (Section 4.2.11) affected the agriculture industry in the County.

Likelihood of Future Occurrence

Highly Likely— Due to the high number of recent incidents of severe weather and pests harming agriculture, plants, and humans in the County, it is likely that future damages will occur in Sacramento County. Given the high value of crops in the County, and the high population in the County, agricultural hazards can have large impacts economically and socially.

Climate Change and Agricultural Hazards

According to the CAS, addressing climate change in agriculture will encompass reducing vulnerability through adapting to the ongoing and predicted impacts of climate. Agriculture in California is vulnerable to predicted impacts of climate change, including less reliable water supplies, reduced water quality, increased temperatures, decreased winter freezing, and increased new and existing species of pests and weeds.

4.2.8. Bird Strike

Hazard/Problem Description

The County of Sacramento operates five airports, which have a collective economic impact in excess of $3 billion annually (2008 dollars) and over 5,000 on-site jobs. Four airports comprise the Sacramento County Airport System (SCAS):

- Sacramento International – (SMF) is the region's primary air carrier passenger service airport, accommodating approximately 10 million annual passengers
- Sacramento Executive – (SAC) is a general aviation airport that also serves as a reliever airport for Sacramento International.
- Sacramento Mather – (MHR), formally Mather Air Force Base, serves as the region's primary air cargo airport.
- Franklin Field – (F72) is a small general aviation airport frequently used for flight training.

A fifth airport in the County, McClellan Field, is also operated and maintained by the SCAS. Additionally, there are a number of privately owned airports within Sacramento County, operated for both public and private use, which are not within the purview of the SCAS. The Sacramento airports are in the Pacific flyway for migratory birds and reports more bird strikes annually than any other airport in FAA's Western-Pacific Region (Arizona, California, Hawaii, Nevada).

Sharing both the sky and the airport environment with birds and other wildlife has been a safety and economic concern to aviation personnel since the days of the Wright Brothers. Orville Wright documented the first known bird strike during a flight over a corn field near Dayton, Ohio in 1905. Since Orville and Wilbur Wright's days to the present day, conflicts between wildlife and airplanes have caused damage to aircraft and loss of human life. These conflicts have increased in recent years.

Collisions between wildlife and aircraft (wildlife strikes) are a threat to civil and military aircraft, causing billions of dollars in aircraft damage. Globally, wildlife strikes killed 229 people and destroyed over 210 aircraft between 1988 and 2008. According to the Federal Aviation Administration (FAA) National

Wildlife Database (Wildlife Database), almost 90,000 reported wildlife strikes occurred in the United States 1990 through 2008, with 7,516 strikes in 2008 alone. Birds account for more than 97 percent of wildlife strikes. Most bird strikes happen fairly close to the ground, with sixty percent occurring within 100 feet or less above ground level (AGL), 73 percent at 500 feet AGL or less, and 92 percent at 3,000 feet AGL or less. Reporting of civil aircraft wildlife strikes to the Wildlife Database is voluntary but strongly encouraged. Strike reporting by airlines and airports has gradually increased. While it was historically assumed that only about 20 percent of strikes were reported, the FAA estimates that about 39 percent of the strikes at commercial service airports were reported to the Wildlife Database between 2004 and 2008.

Figure 4-17 Birds Surrounding a Plane after Takeoff

Source: FAA

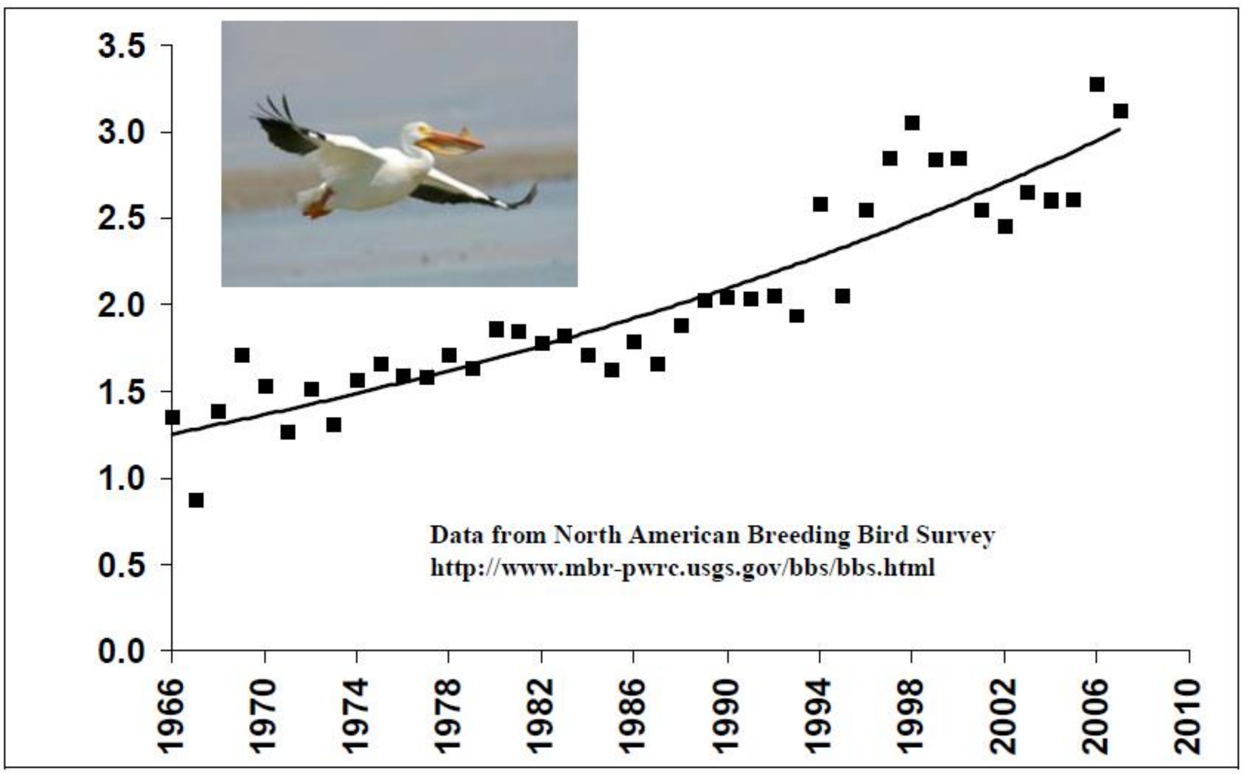
Presently, over $600 million dollars, and over 500,000 hours of aircraft down time, is annually lost due to wildlife strikes (both bird strikes and animal strikes) with civil aircraft in the United States alone. Although the economic costs of wildlife strikes are extreme, the cost in human lives lost when airplanes crash as a result of wildlife strikes is even greater than the economic losses.

Events in early 2009 amplified public awareness of wildlife strikes to aircraft. The dramatic "forced landing" of US Airways Flight 1549 in the Hudson River on January 15, 2009 after Canada geese were ingested in both engines on the Airbus 320 dramatically demonstrated to the public at large that bird strikes are a serious aviation safety issue.

There are many factors effecting today's concern about wildlife and aviation safety, three of these factors are:

- Many populations of wildlife species commonly involved in strikes have increased markedly in the last few decades and adapted to living in urban environments, including airports. For example, from 1980 to 2007, the resident (non-migratory) Canada goose population in the USA and Canada increased at a mean rate of 7.3 percent per year. Other species showing significant mean annual rates of increase included bald eagles (4.6 percent), wild turkeys (12.1 percent), turkey vultures (2.2 percent), American white pelicans (2.9 percent), double-crested cormorants (4.0 percent), and sandhill cranes (5.0 percent). Thirteen of the 14 bird species in North America with mean body masses greater than 8 lbs have shown significant population increases over the past three decades. An example of this is shown in Figure 4-18, which shows the American white pelican population in North America increased at a mean annual rate of 4.3 percent from 1966-2007.

Figure 4-18 American White Pelican Population from 1966-2007



Source: North American Breeding Bird Survey

- Concurrent with population increases of many large bird species, air traffic has increased substantially since 1980. In 2009, the Federal Aviation Administration reported that passenger enplanements in the US had increased from about 310 million in 1980 to 750 million in 2008 (3.2 percent per year), and commercial air traffic had increased from about 18 million aircraft movements in 1980 to 28 million in 2008 (1.6 percent per year). US commercial air traffic is predicted to continue growing at a rate of about 1.3 percent per year to 35 million movements by 2025.
- Commercial air carriers have replaced their older three- or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft. In 1965, about 90 percent of the 2,100 USA passenger aircraft had

three or four engines. In 2005, the USA passenger fleet had grown to about 8,200 aircraft, and only about 10 percent had three or four engines (U.S. Department of Transportation 2009). With the steady advances in technology over the past several decades, today's two-engine aircraft are more powerful than yesterday's three- and four-engine aircraft, and they are more reliable. However, in the event of a multiple ingestion event (e.g., the US Airways Flight 1549 incident on January 15, 2009), aircraft with two engines may have vulnerabilities not shared by their three or four engine-equipped counterparts. Additionally, previous research has indicated that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines than older aircraft with noisier engines.

These results in a majority of wildlife strikes occur within the immediate airport environment (FAA manual). As a result of these factors, experts within the FAA, USDA, and U.S. Navy and U.S. Air Force expect the risk, frequency, and potential severity of wildlife-aircraft collisions to grow over the next decade.

Land-use practices that attract or sustain hazardous wildlife populations on or near airports can significantly increase the potential for wildlife strikes. The FAA is looking to avoid potential facilities and areas that attract hazardous wildlife and threaten aviation safety. These facilities include:

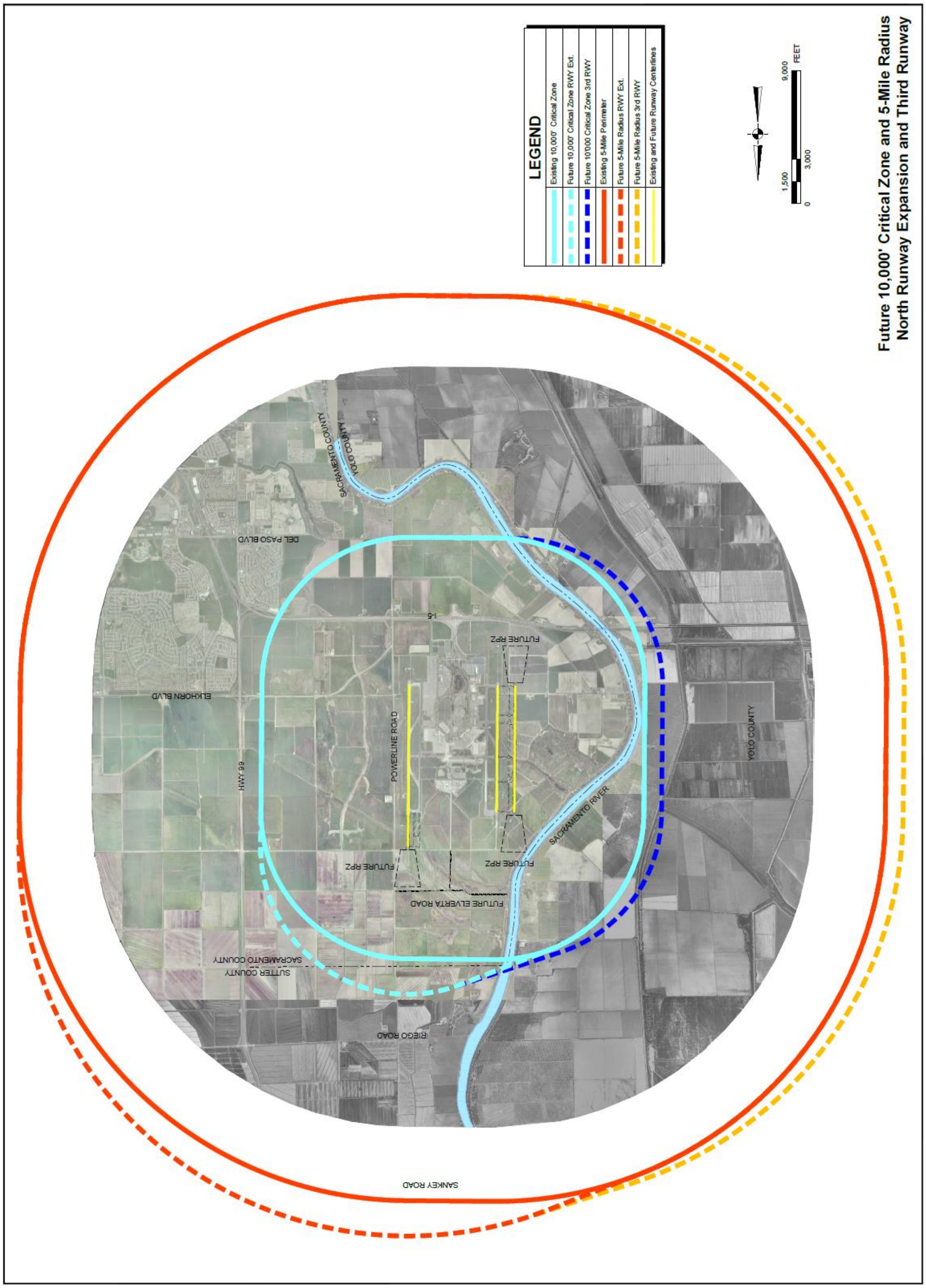
- Waste Disposal Operations
- Water Management Facilities
- Wetlands
- Dredge Spoil Containment Areas
- Agricultural Activities
- Golf Courses, Landscaping, and other Large Grassy Areas

These areas are all known to attract birds, both migratory and native species. Because of this, the FAA recommends the minimum separation criteria outlined below for land-use practices that attract hazardous wildlife to the vicinity of airports.

- Airports Serving Piston-Powered Aircraft – Notwithstanding more stringent requirements for specific land uses, the FAA recommends a separation distance of 5,000 feet at these airports for any of the hazardous wildlife attractant.
- Airports Serving Turbine-Powered Aircraft – Notwithstanding more stringent requirements for specific land uses, the FAA recommends a separation distance of 10,000 feet at these airports for any of the hazardous wildlife attractant.
- Protection of Approach, Departure, and Circling Airspace – For all airports, the FAA recommends a distance of 5 statute miles between the farthest edge of the airport's AOA and the hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace.

The County of Sacramento has mapped the minimum separation criteria areas for the Sacramento International Airport. The map can be found in Figure 4-19.

Figure 4-19 Sacramento International Airport Separation Distances



Source: Sacramento County Airport System

Past Occurrences

Disaster Declaration History

There have been no disasters related to bird strike in Sacramento County.

NCDC Events

The NCDC does not track bird strike events. They are tracked by the FAA.

FAA Events

The FAA data shows 2,812 bird strike incidents for Sacramento County since 1990. These are shown in Table 4-22. Significant strikes are discussed in greater detail below the table.

Table 4-22 Bird Strikes in Sacramento Airports between 1/1/1990 and 4/1/2015

Airport	Number of Bird Strikes
Sacramento International	2,607
Mather Field	129
Sacramento Executive	43
Franklin Field	1
McClellan Field	32
Total	**2,812**

Source: FAA Wildlife Strike Database

Many of these instances below were sourced from a report titled "Some Significant Wildlife Strikes To Civil Aircraft In The United States, January 1990 – November 2015" released by the USDA on November 10, 2010. Between 2010 and 2012 (the most recent publication available), instances of bird strike were sourced from "Wildlife Strikes to Civil Aircraft in the United States 1990–2012," released by the FAA in September 2013.

January 8, 1996 – Shortly after takeoff, a Boeing 737 ingested a bird in #2 engine during climb. Vibration increased and crew throttled back and returned to land. One fan blade separated and other blades were damaged by re-ingestion of broken blade fragments. The engine was replaced.

November 22, 1996 - Several gulls were ingested just after takeoff causing the engine on a McDonnell Douglas MD-80 to lose power. The engine was shut down and an emergency was declared. The plane was forced to land much heavier than usual because of a full fuel load. There were no injuries and passengers were transferred to a replacement jet. Fan blades and engine were damaged. Runway was closed for approximately ½ hour.

February 25, 2000 – During a takeoff run, a Boeing 737 struck an unknown bird. The aircraft returned to the airport after a bird strike on takeoff. The pilots heard a loud bang and the plane suddenly yawed. The air cooler was plugged and 7 fan blades were damaged.

December 8, 2004 – A McDonnell Douglas MD-80 struck a Northern Pintail while climbing after takeoff. Passengers reported seeing a flock of geese at time of strike. The radome was dented, and over 1/3 of surface and wing was punctured and dented. Identification of the bird was performed by the Smithsonian, Division of Birds. Cost of repairs estimated at $200,000.

December 28, 2005 – While climbing after takeoff, a Boeing 737 struck an unknown bird. The pilot saw a large white bird fly by, heard a loud pop, then the left engine began vibrating. The aircraft returned to the airport. All fan blades were replaced. Passengers were put on other flights. Cost of repairs was $210,400.

December 22, 2009 – Four bird strikes in 14 hours were recorded at the Sacramento Airport. The weekend may have been the bumpiest on record at the Sacramento International Airport. Each of the strikes hit four different airline carriers, and two of the planes had to be grounded for repairs. Sacramento has a staff of wildlife biologists that try to prevent strikes, even shooting birds when necessary in accordance with the provisions of a depredation permit issued by the United States Fish and Wildlife Service, but many of the strikes happened beyond the airport's property. All of the weekend's strikes occurred while pilots were on their approach for landing; one plane was five miles out, another was nine miles out, and a third was 13 miles out. The California Fish and Game states that every year at this time, roughly four million birds fly through the skies surrounding the Sacramento Airport.

January 5, 2010 - Two bird-aircraft strikes were reported at the Sacramento airport. Airport officials in Sacramento say birds hit two passenger jets in separate incidents but caused no damage to the planes. The first bird strike was reported around noon Tuesday after birds hit the nose of a Southwest Airlines flight during landing. The plane arrived safely. The second incident happened around 1 p.m. after birds flew into the windshield of another Southwest Airlines flight en route to Las Vegas. The plane returned to Sacramento for inspection. A windshield wiper was replaced and the plane departed.

January 14, 2010 - A US Airways flight leaving from Sacramento International Airport struck a bird while departing Thursday. An airport spokeswoman said two fan blades on the plane were damaged as the plane was departing to Phoenix. No passengers were injured and the plane landed safely in Sacramento.

February 18, 2010 – A Cessna 208 hit a large bird during approach. The aircraft briefly rolled to the right but landed safely. Significant damage was done to the leading edge of right wing. The landing light housing and skin of the wing showed damage. Some control loss due to the aileron control cables being pushed out of position. The aircraft was taken out of service for 80 hours and the cost of repairs was $80,000.

September 1, 2010 – An Airbus A-320 was struck by a bird immediately after takeoff. A great blue heron was ingested in #1 engine at rotation and aircraft returned to land. A piece of plastic from the engine was found on the runway. The runway was closed for full sweep for foreign object damage (FOD). Only small pieces of bird were found. Engine had damage to two fan blades.

January 21, 2012 – Two engines of a Boeing 737 were damaged when geese were struck during climb out. The aircraft returned to land after declaring an emergency. Fan blades were damaged in both engines Passengers were rebooked on other flights.

January 24, 2013 – The aircraft had multiple strikes on climb-out, declared an emergency due to vibration in the #2 engine. They returned to land safely. The #2 engine had significant fan blade damage and the #1 engine had bird remains. ID by Smithsonian, Division of Birds. Time out of service was 24 hours. Cost of repairs reported as $20,000 and other costs $25,000.

November 22, 2014 – Pilot saw a flock of large birds on seven mile final. Strike occurred on right side of the radome just below the First Officer causing a 2- foot dent. Engine ingestion. Aircraft was out of service for one day.

December 3, 2014 – Major bird strike while on approach. Blood smears, feathers and bird remains were visible on the nose, windshield, leading edge of both wings, flaps and in both engines. Remains were embedded in the nose. Time out of service was 8 days.

December 12, 2014 – Hit a flock of birds on approach. Ingested at least one bird into the #2 engine. Emergency declared due to compressor stalls, asymmetrical thrust and flames coming from back of engine.

HMPC Events

The HMPC noted that since 2011 Sacramento County Department of Airports facilities have recorded 868 wildlife strikes in the FAA Wildlife Strike Database. Sacramento International Airport had 779 wildlife strikes and 51 have been damaging. Sacramento Executive Airport had 10 wildlife strikes and three were damaging. Mather Airport had 63 wildlife strikes and one was damaging. McClellan Airfield had 16 wildlife strikes and one was damaging. Franklin Field has not had a wildlife strike since 2011.

There have been no injuries reported from the strikes and no deaths have occurred.

Department of Airports estimates the cost to repair damaged aircraft during that period has been in the tens of millions of dollars, mostly due to damage caused to commercial aircraft engines. Those costs are borne entirely by the aircraft operators and are not customarily reported to the department.

Likelihood of Future Occurrence

Highly Likely— Based on FAA data, 2,812 bird strike incidents over a 26-year period (1990-2015) equates to 108.2 reported bird strikes in Sacramento County each year. This equates to a 100 percent chance of a bird strike event in any given year.

Climate Change and Bird Strike

According to the US Fish and Wildlife Service (FWS), changes in climate shift bird migratory patterns. According to the Office of Environmental Health Hazard Assessment's Indicators of Climate Change Report in California, climate change is shifting the timing of bird migration in California, with some bird species arriving earlier in the springtime. Sacramento is currently in the Pacific Flyway bird migration route.

4.2.9. Climate Change

Hazard/Problem Description

Climate change is the distinct change in measures of weather patterns over a long period of time, ranging from decades to millions of years. More specifically, it may be a change in average weather conditions such as temperature, rainfall, snow, ocean and atmospheric circulation, or in the distribution of weather around the average. While the Earth's climate has cycled over its 4.5 billion year age, these natural cycles have taken place gradually over millennia, and the Holocene, the most recent epoch in which human civilization developed, has been characterized by a highly stable climate – until recently.

This LHMP is concerned with human-induced climate change that has been rapidly warming the Earth at rates unprecedented in the last 1,000 years. Since industrialization began in the 19th century, the burning of fossil fuels (coal, oil, and natural gas) at escalating quantities has released vast amounts of carbon dioxide and other greenhouse gases responsible for trapping heat in the atmosphere, increasing the average temperature of the Earth. Secondary impacts include changes in precipitation patterns, the global water cycle, melting glaciers and ice caps, and rising sea levels. According to the Intergovernmental Panel on Climate Change (IPCC), climate change will "increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems" if unchecked.

Through changes to oceanic and atmospheric circulation cycles and increasing heat, climate change affects weather systems around the world. Climate change increases the likelihood and exacerbates the severity of extreme weather – more frequent or intense storms, floods, droughts, and heat waves. Consequences for human society include loss of life and injury, damaged infrastructure, long-term health effects, loss of agricultural crops, disrupted transport and freight, and more. Climate change is not a discrete event but a long-term hazard, the effects of which communities are already experiencing.

Climate change adaptation is a key priority of the State of California. The 2013 State of California Multi-Hazard Mitigation Plan stated that climate change is already affecting California. Sea levels have risen by as much as seven inches along the California coast over the last century, increasing erosion and pressure on the state's infrastructure, water supplies, and natural resources. The State has also seen increased average temperatures, more extreme hot days, fewer cold nights, a lengthening of the growing season, shifts in the water cycle with less winter precipitation falling as snow, and earlier runoff of both snowmelt and rainwater in the year. In addition to changes in average temperatures, sea level, and precipitation patterns, the intensity of extreme weather events is also changing. Data suggests that the effects of climate change have already been felt in the Sacramento region.

Past Occurrences

Disaster Declaration History

Climate change has never been directly linked for any declared disasters.

NCDC Events

The NCDC does not track climate change events

HMPC Events

Past flooding, wildfire, levee failure, and drought disasters may have been exacerbated by climate change, but it is impossible to make direct connections to individual events. Unlike earthquake and floods that occur over a finite time period, climate change is a slow onset, long term hazard, the effects of which some communities may already be already experiencing, but for which little empirical data exists. Further, given the science, it is likely that measurable effects may not be seriously experienced for years, decades, or may be avoided altogether by mitigation actions taken today.

However, the 2013 State of California Multi-Hazard Mitigation Plan stated that climate change is already affecting California. Sea levels have risen by as much as seven inches along the California coast over the last century, increasing erosion and pressure on the state's infrastructure, water supplies, and natural resources. The State has also seen increased average temperatures, more extreme hot days, fewer cold nights, a lengthening of the growing season, shifts in the water cycle with less winter precipitation falling as snow, and both snowmelt and rainwater running off sooner in the year. In addition to changes in average temperatures, sea level, and precipitation patterns, the intensity of extreme weather events is also changing. This data suggests that the effects of climate change has been occurring in the Sacramento region.

Likelihood of Future Occurrence

Highly Likely – Climate change is virtually certain to continue without immediate and effective global action. According to NASA, 2016 is on track to be the hottest year on record, and 15 of the 17 hottest years ever have occurred since 2000. Without significant global action to reduce greenhouse gas emissions, the Intergovernmental Panel on Climate Change (IPCC) concludes in its Fifth Assessment Synthesis Report (2014) that average global temperatures is likely to exceed 1.5 C by the end of the 21st century, with consequences for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges.

Climate Scenarios

The United Nations IPCC developed several greenhouse gas (GHG) emissions scenarios based on differing sets of assumptions about future economic growth, population growth, fossil fuel use, and other factors. The emissions scenarios range from "business-as-usual" (i.e., minimal change in the current emissions trends) to more progressive (i.e., international leaders implement aggressive emissions reductions policies). Each of these scenarios leads to a corresponding GHG concentration, which is then used in climate models to examine how the climate may react to varying levels of GHGs. Climate researchers use many global climate models to assess the potential changes in climate due to increased GHGs.

Key Uncertainties Associated with Climate Projections

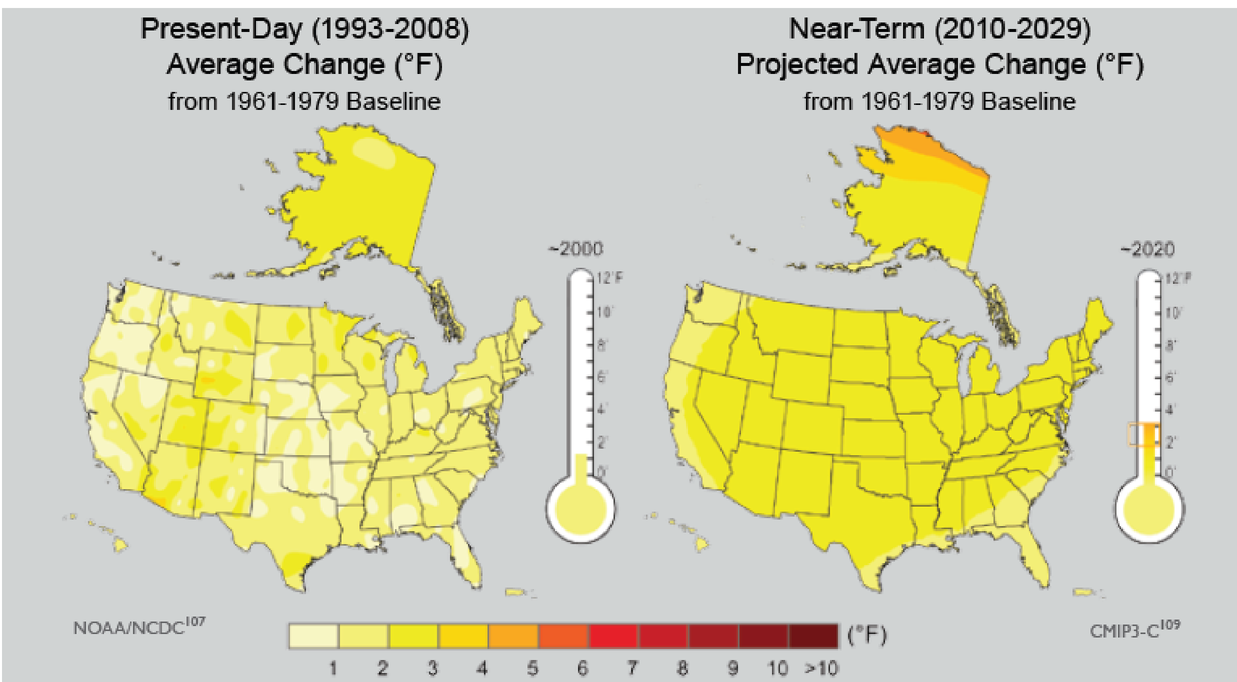
- Climate projections and impacts, like other types of research about future conditions, are characterized by uncertainty. Climate projection uncertainties include but are not limited to:
  - ✓ Levels of future greenhouse gas concentrations and other radiatively important gases and aerosols,
  - ✓ Sensitivity of the climate system to greenhouse gas concentrations and other radiatively important gases and aerosols,

- ✓ Inherent climate variability, and
- ✓ Changes in local physical processes (such as afternoon sea breezes) that are not captured by global climate models.

Even though precise quantitative climate projections at the local scale are characterized by uncertainties, the information provided can help identify the potential risks associated with climate variability/climate change and support long term mitigation and adaptation planning.

The following maps (shown in Figure 4-20 and Figure 4-21) are excerpts from the Global Climate Change Impacts report that show the magnitude of the observed and projected changes in annual average temperature. It is important to discuss these projected temperature changes, as heat is a major driver of climate and climate related phenomena. The map for the period around 2000 shows that most areas of the United States have warmed 1 to 2°F compared to the 1960s and 1970s. Although not reflected in these maps of annual average temperature, this warming has generally resulted in longer warm seasons and shorter, less intense cold seasons. The average warming for the country as a whole is shown on the thermometers adjacent to each map. By the end of the century, the average U.S. temperature is projected to increase by approximately 7 to 11°F under the higher emissions scenario and by approximately 4 to 6.5°F under the lower emissions scenario.

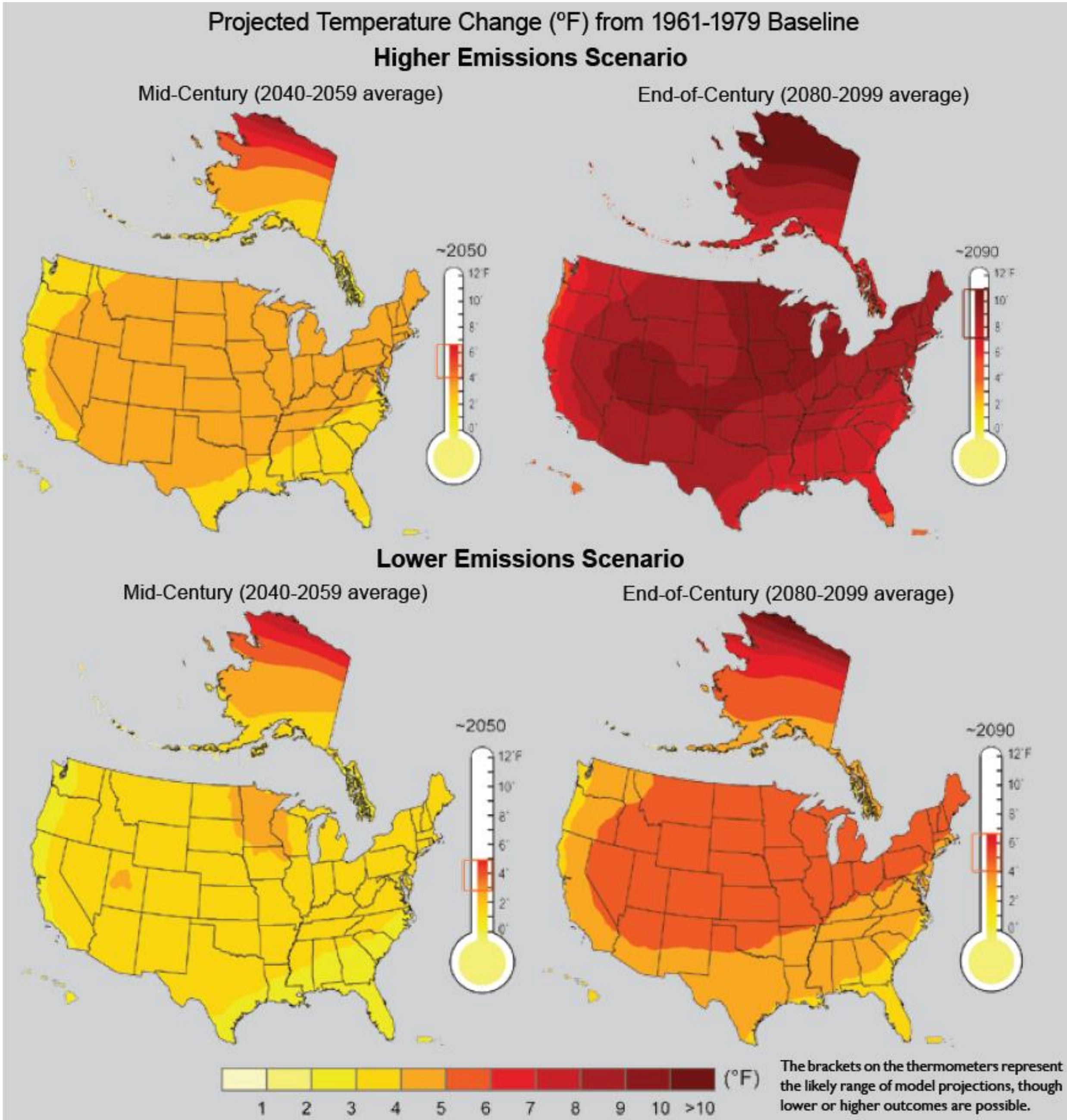
Figure 4-20 Present and Near Term Average Temperature Changes



The maps and thermometers on this page and the next page show temperature differences (either measured or projected) from conditions as they existed during the period from 1961-1979. Comparisons to this period are made because the influence on climate from increasing greenhouse gas emissions has been greatest during the past five decades. The present-day map is based on the average observed temperatures from 1993-2008 minus the average from 1961-1979. Projected temperatures are based on results from 16 climate models for the periods 2010-2029, 2040-2059, and 2080-2099. The brackets on the thermometers represent the likely range of model projections, though lower or higher outcomes are possible. The mid-century and end-of-century maps show projections for both the higher and lower emission scenarios.[91] The projection for the near-term is the average of the higher and lower emission scenarios[91] because there is little difference in that timeframe.

Source: Source: USGCRP (2009). Global Climate Change Impacts in the United States

Figure 4-21 Projected Average Temperature Changes



Source: (USGCRP (2009). Global Climate Change Impacts in the United States

Local Climate Change Projections

According to the California Natural Resource Agency (CNRA), Climate change is already affecting California and is projected to continue to do so well into the foreseeable future. Current and projected changes include increased temperatures, seal level rise, a reduced winter snowpack altered precipitation patterns, and more frequent storm events. Over the long term, reducing greenhouse gases can help make these changes less severe, but the changes cannot be avoided entirely. Unavoidable climate impacts can result in a variety of secondary consequences including detrimental impacts on human health and safety, economic continuity, ecosystem integrity and provision of basic services.

The CNRA's 2009 Climate Adaptation Strategy (CAS) delineated how climate change may impact and exacerbate natural hazards in the future, including wildfires, extreme heat, floods, drought, and levee failure:

- Climate change is expected to lead to increases in the frequency, intensity, and duration of extreme heat events and heat waves in Sacramento and the rest of California, which are likely to increase the risk of mortality and morbidity due to heat-related illness and exacerbation of existing chronic health conditions. Those most at risk and vulnerable to climate-related illness are the elderly, individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses, infants, the socially or economically disadvantaged, and those who work outdoors.
- Higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher, resulting in less snowpack to supply water to California users.
- Droughts are likely to become more frequent and persistent in the 21st century.
- Intense rainfall events, periodically ones with larger than historical runoff, will continue to affect California with more frequent and/or more extensive flooding.
- Storms and snowmelt may coincide and produce higher winter runoff from the landward side, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, these changes may increase the probability of floods and levee and dam failures in the Sacramento-San Joaquin Delta, along with creating issues related to salt water intrusion.
- Warmer weather, reduced snowpack, and earlier snowmelt can be expected to increase wildfire through fuel hazards and ignition risks. These changes can also increase plant moisture stress and insect populations, both of which affect forest health and reduce forest resilience to wildfires. An increase in wildfire intensity and extent will increase public safety risks, property damage, fire suppression and emergency response costs to government, watershed and water quality impacts, vegetation conversions and habitat fragmentation.
- Sea-level rise will increase erosion, threatening public and private property and structures and causing social, economic, and resource losses.

The California Adaptation Planning Guide (APG) prepared by California OES and CNRA was developed to provide guidance and support for local governments and regional collaboratives to address the unavoidable consequences of climate change. The APG: Understanding Regional Characteristics provides environmental and socioeconomic information for 11 climate impact regions. The Sacramento County Planning Area falls within the northern portion of the Bay-Delta Region. Cal-Adapt Projections for the Bay Delta Region are shown in Table 4-23.

Table 4-23 Summary of Cal-Adapt Climate Projections for the Bay-Delta Regions

Effect	Ranges
Temperature Change 1990 - 2100	Winter: 6° to 7°F increase in average temperatures Summer: 7° to 9°F increase in average temperatures (Modeled high temperatures – average of all models; high carbon emissions scenario)

Effect	Ranges
Precipitation	Precipitation across the region is projected to decline by approximately 3 to 5”. The most dramatic decline of 5” is projected around Richmond while most other areas are projected to experience a decline of 4”, although Stockton may only experience a 3” decline in precipitation. (CCSM3 climate model; high carbon emissions scenario)
Sea Level Rise	The portions of the Delta Region in close proximity of the San Francisco Bay are projected to be increasingly susceptible to 1.4--‐meter sea level rise. Solano County is anticipated to experience a 13% increase in estimated acreage of land vulnerable to a 100--‐year flood event. This indicator rises to 40% in Contra Costa County and 59% in Sacramento Count. Most flooding is projected to occur in areas around Suisun City, Pittsburg, Benicia, Richmond, and Vallejo.
Wildfire Risk	Portions of western and northern Yolo County, north western Solano, southern Contra Costa and eastern San Joaquin and Sacramento Counties are projected to experience limited increases in potential area burned by wildfire. There are moderately high increases projected for the far eastern areas of San Joaquin County. (GFDL model, high carbon emissions scenario)

Source: Public Interest Energy Research (2011). Cal--‐Adapt. Retrieved from: http://cal--‐adapt.org]

The Preliminary Draft – Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP) developed by Ascent Environmental, utilized Cal Adapt a climate change scenario planning tool developed by the California Energy Commission (CEC) and the University of California Berkeley Geospatial Innovation Facility. Cal-Adapt downscales global climate stimulation model data to local and regional resolution under two emissions scenarios: the A-2 scenario represents a high, future GHG emissions scenario, and the B-1 scenario represents a lower future GHG emissions scenario. This CAP includes information on both emissions scenarios in developing a vulnerability assessment for the Sacramento County Planning Area. Climate Change vulnerability data from the vulnerability assessment conducted by Ascent Environmental is included in each of the hazard specific sections, where applicable.

4.2.10. Dam Failure

Hazard/Problem Description

Dams are manmade structures built for a variety of uses including flood protection, power generation, agriculture, water supply, and recreation. When dams are constructed for flood protection, they are usually engineered to withstand a flood with a computed risk of occurrence. For example, a dam may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If prolonged periods of rainfall and flooding occur that exceed the design requirements, that structure may be overtopped and fail. Overtopping is the primary cause of earthen dam failure in the United States.

Dam failures can also result from any one or a combination of the following causes:

- Earthquake;
- Inadequate spillway capacity resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage, or piping or rodent activity;
- Improper design;
- Improper maintenance;
- Negligent operation; and/or
- Failure of upstream dams on the same waterway.

Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major loss of life could result as well as potentially catastrophic effects to roads, bridges, and homes. Electric generating facilities and transmission lines could also be damaged and affect life support systems in communities outside the immediate hazard area. Associated water supply, water quality and health concerns could also be an issue. Factors that influence the potential severity of a full or partial dam failure are the amount of water impounded; the density, type, and value of development and infrastructure located downstream; and the speed of failure.

In general, there are three types of dams: concrete arch or hydraulic fill, earth and rockfill, and concrete gravity. Each type of dam has different failure characteristics. A concrete arch or hydraulic fill dam can fail almost instantaneously; the flood wave builds up rapidly to a peak then gradually declines. An earth-rockfill dam fails gradually due to erosion of the breach; a flood wave will build gradually to a peak and then decline until the reservoir is empty. And, a concrete gravity dam can fail instantaneously or gradually with a corresponding buildup and decline of the flood wave.

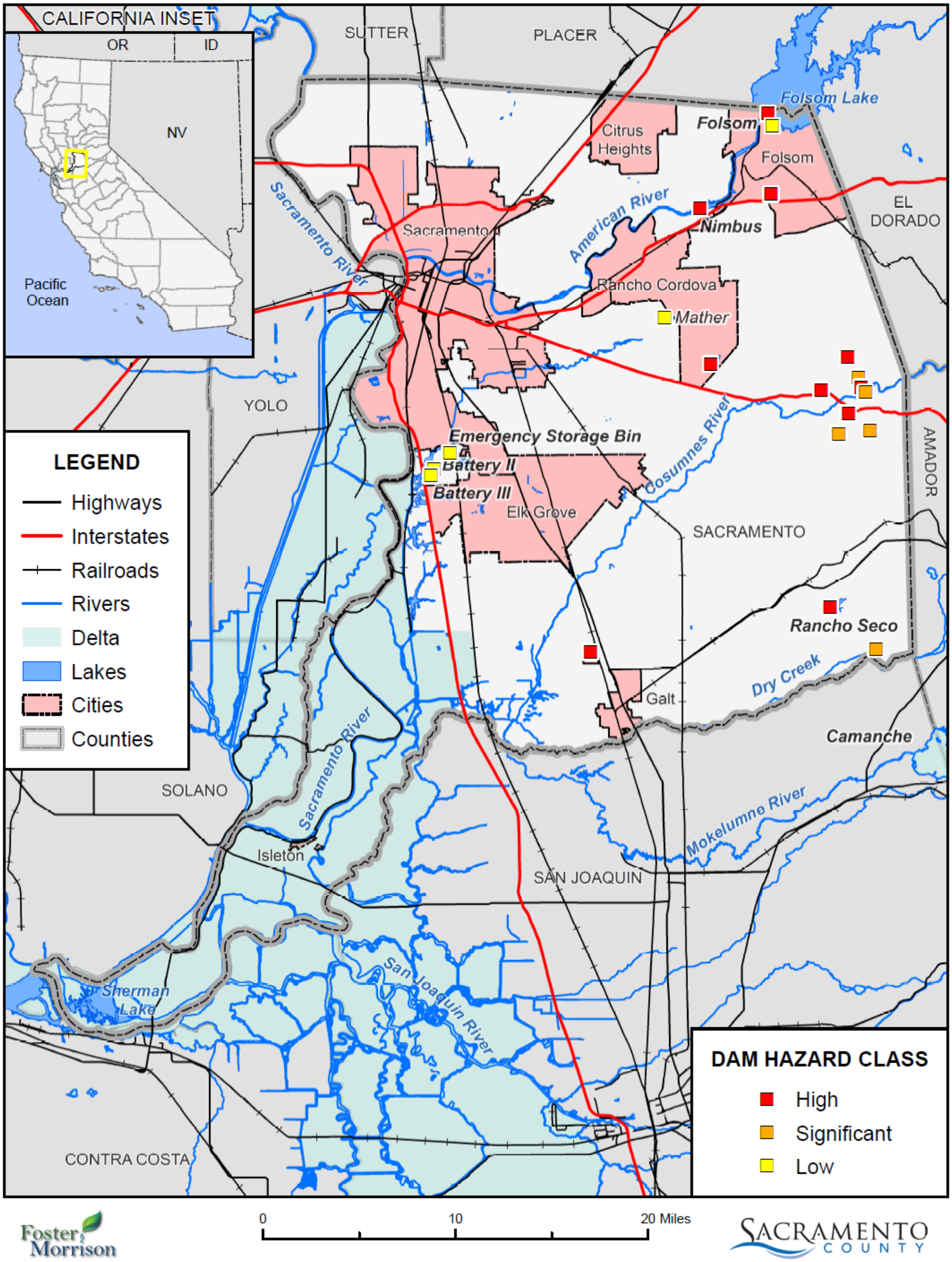
The California Department of Water Resources Division of Safety of Dams (DSOD) has jurisdiction over impoundments that meet certain capacity and height criteria. Embankments that are less than six feet high and impoundments that can store less than 15 acre-feet are non-jurisdictional. Additionally, dams that are less than 25 feet high can impound up to 50 acre-feet without being jurisdictional. The Cal DWR DSOD assigns hazard ratings to large dams within the State. The following two factors are considered when assigning hazard ratings: existing land use and land use controls (zoning) downstream of the dam. Dams are classified in three categories that identify the potential hazard to life and property:

- High hazard indicates that a failure would most probably result in the loss of life
- Significant hazard indicates that a failure could result in appreciable property damage
- Low hazard indicates that failure would result in only minimal property damage and loss of life is unlikely

According to data provided by Sacramento County, Cal DWR, and Cal OES, there are 27 dams in Sacramento County constructed for flood control, storage, electrical generation, and recreational purposes. Of the 27 dams, 16 are rated as High Hazard, 5 as Significant Hazard, 5 as Low Hazard, and 1 was not rated.

Table 4-24 identifies the 27 dams located in the Sacramento County Planning Area. Figure 4-22 illustrates the locations of identified dams.

Figure 4-22 Sacramento County Dam Inventory



Data Source: Sacramento County GIS, Cal-Atlas, National Inventory of Dams; Map Date: 05/2016.

Table 4-24 Sacramento County Dam Inventory

Name	Significance	Owner	River	Nearest City/ Distance (mi)	Mapped	Structural Height (ft)	Maximum Storage (acre-ft)
Battery I	Low	Sacramento Regional County Sanitation District	Unnamed	N/A	Y	N/A	N/A
Battery II	Low	Sacramento Regional County Sanitation District	Unnamed	N/A	Y	15	315
Battery III	Low	Sacramento Regional County Sanitation District	Unnamed	N/A	Y	12	847
Blodgett	High	Private	Laguna Creek	Mather AFB 2 miles	Y	24	599
Calero	High	Private	Crevis Creek	Rancho Murieta 3 miles	Y	55	3,375
Chesbro	Significant	Private	Consumnes River	Rancho Murieta 2 miles	Y	79	1,500
Clementia	High	Private	Tributary of Consumnes River	Rancho Murieta 0 miles	Y	33	1,510
Emergency Storage Basin	Low	Sacramento Regional County Sanitation District	Laguna Creek	N/A	Y	13	629
Folsom	High	Department of Interior	American River	Folsom 1 mile	Y	340	1,120,000
Folsom Mormon Island Auxiliary Dam	High	Department of Interior	Blue Ravine	Folsom 2 miles	N	110	1,120,000
Folsom Dike 7	High	Department of Interior	Green Valley	Folsom 1 mile	N	25	1,120,000
Folsom Dike 8	High	Department of Interior	Green Valley	Folsom 1 mile	N	15	1,120,000
Folsom Left Wing	High	Department of Interior	American River	Folsom 1 mile	N	145	1,120,000

Name	Significance	Owner	River	Nearest City/ Distance (mi)	Mapped	Structural Height (ft)	Maximum Storage (acre-ft)
Folsom Right Wing	High	Department of Interior	American River	Folsom 1 mile	N	145	1,120,000
Galt	High	City of Galt	Consumnes River	Rancho Murieta 2 miles	Y	16	155
Granlees	Significant	Consumnes Irrigation Association	Tributary of Dry Creek	N/A	Y	17	75
Hamel	Significant	Private	Morrison Creek	N/A	Y	26	350
Mather	Low	USAF	Tributary of Consumnes River	Rancho Murieta 2 miles	Y	N/A	N/A
Michigan Bar No. 1	High	Private	Tributary of Consumnes River	Rancho Murieta 2 miles	Y	17	897
Michigan Bar No. 2	High	Private	Consumnes River	Rancho Murieta 1 miles	Y	36	56
Mills	High	Private	Consumnes River	Rancho Murieta 2 miles	Y	23	315
Mount Stoneman	Low	Folsom Prison	Tributary of American River	Folsom 2 miles	Y	73	40
Nimbus	High	Department of Interior	American River	Fair Oaks 3 miles	Y	87	8,800
Rancho Seco	High	Sacramento Municipal Utilities	Hadselville Creek	Clay 4 miles	Y	58	4,350
Schneider	Significant	Private	Tributary of Arkansas Creek	Rancho Murieta 4 miles	Y	22	226
Van Vleck	Significant	Private	Arkansas Creek	Rancho Murieta 7 miles	Y	30	2,600
Willow Hill	High	City of Folsom	American River	Folsom 3 miles	Y	24	175

Source: Cal OES and the National Performance of Dams Program
*One Acre Foot=326,000 gallons

There are 25 additional facilities located outside of Sacramento County, shown in Table 4-25, classified as high or significant hazard dams. Of these, there are 8 high hazard dams located in neighboring counties with the potential to impact the Sacramento County Planning Area.

Table 4-25 High and Significant Hazard Dams Outside Sacramento County

Dam Name Dam ID County	Hazard Class	Owner	Dam Height	Storage (acre-feet)*	Stream	Nearest Community/Distance
Oroville CA00035 Butte	High	California Department of Water Resources	770	3,540,000	Feather River	Oroville 3 miles
Miner's Ranch CA00275 Butte	High	Oroville Wyandotte Irrigation District	90	815	Kelly Ridge Canal	Kelly Ridge 1 mile
Camanche Main CA00 73 San Joaquin	High	East Bay Municipal Utility District	171	431,000	Mokelumne River	Clements 4 miles
Shasta CA10186 Shasta	High	Department of the Interior	602	4,661,860	Sacramento River	Redding 9 miles
Pardee CA00164 Border of Calaveras and Amador Counties	High	East Bay Municipal Utility District	350	198,000	Mokelumne River	Jackson 8 miles
CSP Mule Creek CA01195 Amador	High	State Department of Corrections	51	630	Offstream	Ione 2 miles
Jackson Creek CA00867 Amador	High	Jackson Valley Irrigation District	168	24,000	Jackson Creek	Buena Vista 1 mile
Camp Far West CA00227 Yuba	High	South Sutter Water District	185	104,000	Bear River	Sheridan 5 miles
Preston CA00012 Amador	Significant	Amador Reg. Sanit. Authority	40	37	Tributary of Mule Creek	Ione 1 mile
Preston Forebay CA00006 Amador	Significant	Amador Reg. Sanit. Authority	40	37	Offstream	Ione 2 miles
Wallace CA01314 Calaveras	Significant	Private	19	700	Tributary of Bear Creek	Wallace 0 miles
Ferrario CA00626 Calaveras	Significant	Private	25	384	Tributary of Bear Creek	Wallace 4 miles

Dam Name Dam ID County	Hazard Class	Owner	Dam Height	Storage (acre-feet)*	Stream	Nearest Community/Distance
Cameron Park CA01199 El Dorado	Significant	Cameron Park Community Services District	29	880	Deer Creek	Cameron Park 1 mile
Barnett CA00998 El Dorado	Significant	Private	18	187	Barnett Creek	Shingle Springs 2 miles
Williamson #1 CA00608 El Dorado	Significant	Private	42	260	Tributary of Weber Creek	Shingle Springs 6 miles
Holiday Lake CA00910 El Dorado	Significant	Holiday Lake Community Service District	39	220	Sawmill Creek	Frenchtown 2 miles
Crystal Lake CA01282 El Dorado	Significant	Private	32	296	Tributary of Deer Creek	Shingle Springs 4 miles
Schubin CA01045 El Dorado	Significant	Private	55	315	Tributary of Webber Creek	Shingle Springs 7 miles
Indian Creek CA00997 El Dorado	Significant	Private	36	757	Indian Creek	Rescue 4 miles
Hinkle CA01192 Placer	Significant	San Juan Suburban Water District	20	200	Tributary of American River	Orangevale 2 miles
Kokila CA00544 Placer	Significant	Pacific Gas and Electric	42.5	1,520	Tributary of South Yuba River	Washington 25 miles
Vicini CA01093 Amador	Significant	Private	19	290	Tributary of Willow Creek	Indian Hill 8 miles
Woodbridge CA00285 San Joaquin	Significant	Woodbridge Irrigation District	35	5,064	Mokelumne River	Woodbridge 0 miles
Davis #2 CA00656 San Joaquin	Significant	Private	26	2,220	Tributary of Calaveras River	Linden 4 miles

Source: National Performance of Dams Database

*One Acre Foot=326,000 gallons

Cal OES provides local jurisdictions with hazard information based on data from the U.S. Bureau of Reclamation and the Department of Water Resources. Included in this information is a series of dam inundation maps for Sacramento County. Detailed inundation maps from Cal OES and County mapping projects are available at the Sacramento County Department of Water Resources

The American River Flood Control System and Folsom Dam

The American River Flood Control System consists of the Folsom Dam, Nimbus Dam, an auxiliary dam at Mormon Island, eight earth-filled dikes, and four miles of levees on the north bank of the American River (from Howe Avenue to Arden Way). The System receives runoff from the American River Watershed which contains about 2,100 square miles of the western slope in the Sierra Nevada. Since its completion in 1956, Folsom Dam has stopped three potentially catastrophic floods from occurring. The Flood of 1986 exceeded Folsom's design for flooding by almost 20 percent. An initial reconnaissance report, "American River Investigation, January 1988" concluded that Folsom Dam and the American River levees are only capable of handling a 70-year flood event. Recommendations were to increase the carrying capacity of the American River below Nimbus Dam, modifying the Folsom Dam spillage, increasing storage capacity at Folsom Lake and for greatest protection (200-year level) construct a new upstream storage facility. Work on that project is underway, and is actually ahead of the scheduled 2020 completion. This is primarily due to the drought conditions that lowered lake levels during construction.

Mercury and Dams

In addition, the HMPC noted that a problem with methylated mercury that could be tied to dam failure in Sacramento County. Of note was the Alder Creek Miners Dam. This dam was built in about 1890-1910 in Alder Creek upstream of Folsom Blvd and is owned by the City of Folsom enveloped by property now owned by AeroJet. In order to develop upstream, the dam must be refurbished or removed. The dam is considered to be below certification standards. While not a high or medium significance dam, the Alder Creek dam would pose risk to downstream communities should it fail. More information on mercury can be found in Section 4.2.14.

Past Occurrences

Disaster Declaration History

There have been no disasters declarations related to dam failure in Sacramento County.

NCDC Events

There have been no NCDC dam failure events in Sacramento County.

HMPC Events

Based on input provided by the HMPC, a search of the National Performance of Dams database data shows two dam failure incidents for Sacramento County since 1994, both related to the Folsom Dam. However, these incidents were not actually dam failures, were quite limited in scope, and since the incidents occurred, improvements to the Folsom Dam system have been made and are continuing. These two events are further described below:

July 17, 1995 – At the Folsom Dam, a spillway gate (gate #3 – see Figure 4-23) of Folsom Dam failed, increasing flows into the American River significantly. The spillway was repaired and the U.S. Bureau of Reclamation carried out an investigation of the water flow patterns around the spillway using numerical modeling. No flooding occurred as a result of the partial failure, but due to the location of the dam in proximity to the City of Folsom, possible flooding was a major concern.

Figure 4-23 July 17, 1995 Folsom Dam Incident

Source: US Bureau of Reclamation

May 15, 1997 – Cavitation damage to river outlet works occurred at Folsom Dam. Damage was discovered just downstream of gate #3. The damage consisted of a hole in the floor of the conduit measuring approximately 42 feet long, 15 feet wide, and 6 feet deep. Subsequent inspections of the other conduits revealed similar damage downstream of gate #4. Also, the beginning of cavitation damage was found downstream of gate #2. Minor damage was found in the other five conduits. No flooding was associated with this damage.

Likelihood of Future Occurrence

Unlikely—The County remains at risk to dam breaches/failures from numerous dams under a variety of ownership and control and of varying ages and conditions. Given the number and types of dams in the County, the potential exists for future dam issues in the Sacramento County Planning Area.

Climate Change and Dam Failure

Increases in the volume and intensity of precipitation, as well as warmer and earlier springs accelerating the timing and rate of snow melt, could increase the potential for dam failure and uncontrolled releases in Sacramento County.

4.2.11. Drought and Water Shortage

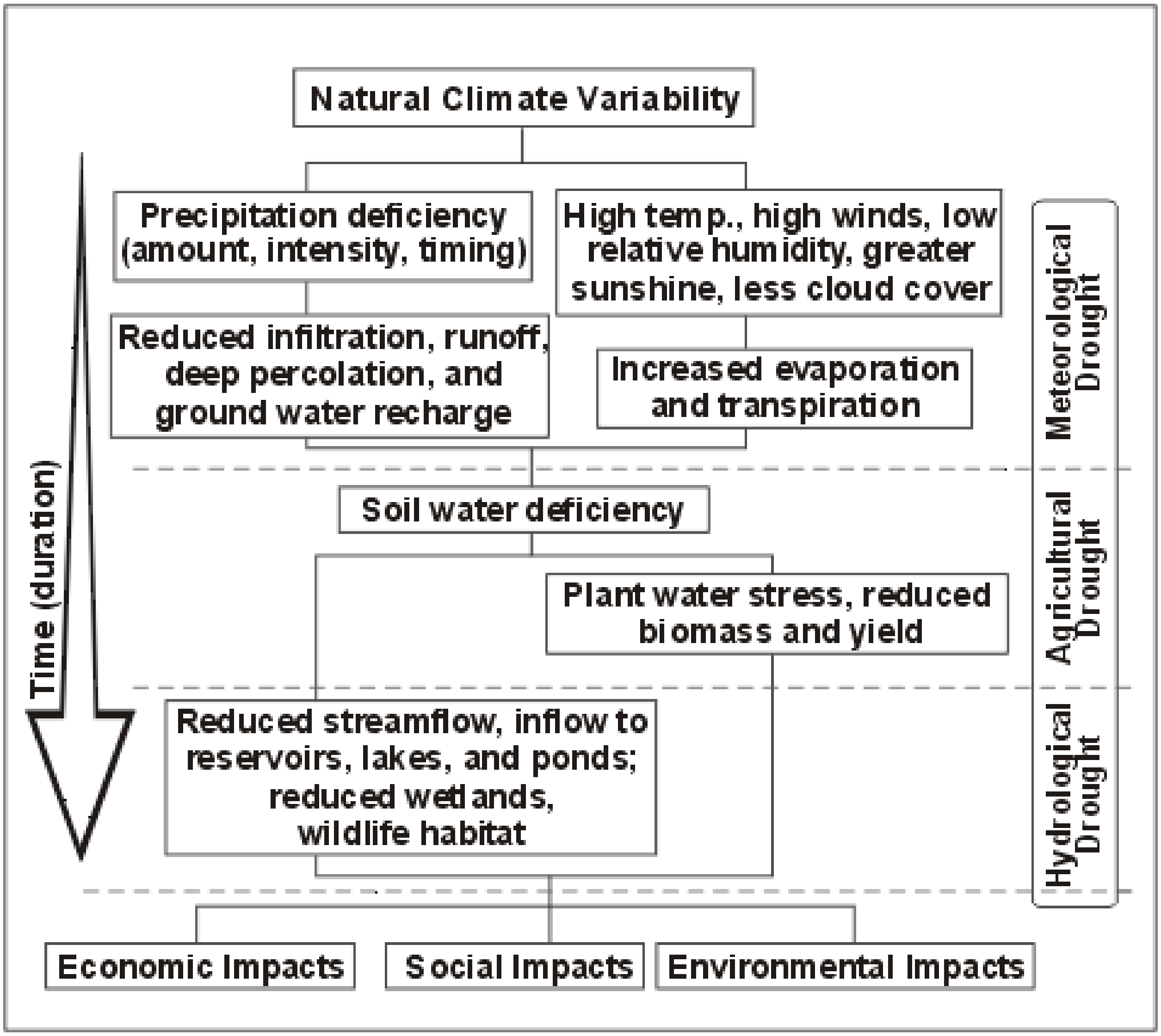
Hazard/Problem Description

Drought is a gradual phenomenon. Although droughts are sometimes characterized as emergencies, they differ from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a multi-year period, and it is often not obvious or easy to quantify when a drought begins and ends. Water districts normally require at least a 10-year planning horizon to implement a multiagency improvement project to mitigate the effects of a drought and water supply shortage.

Drought is a complex issue involving (see Figure 4-24) many factors—it occurs when a normal amount of precipitation and snow is not available to satisfy an area's usual water-consuming activities. Drought can often be defined regionally based on its effects:

- Meteorological drought is usually defined by a period of below average water supply.
- Agricultural drought occurs when there is an inadequate water supply to meet the needs of the state's crops and other agricultural operations such as livestock.
- Hydrological drought is defined as deficiencies in surface and subsurface water supplies. It is generally measured as streamflow, snowpack, and as lake, reservoir, and groundwater levels.
- Socioeconomic drought occurs when a drought impacts health, well-being, and quality of life, or when a drought starts to have an adverse economic impact on a region.

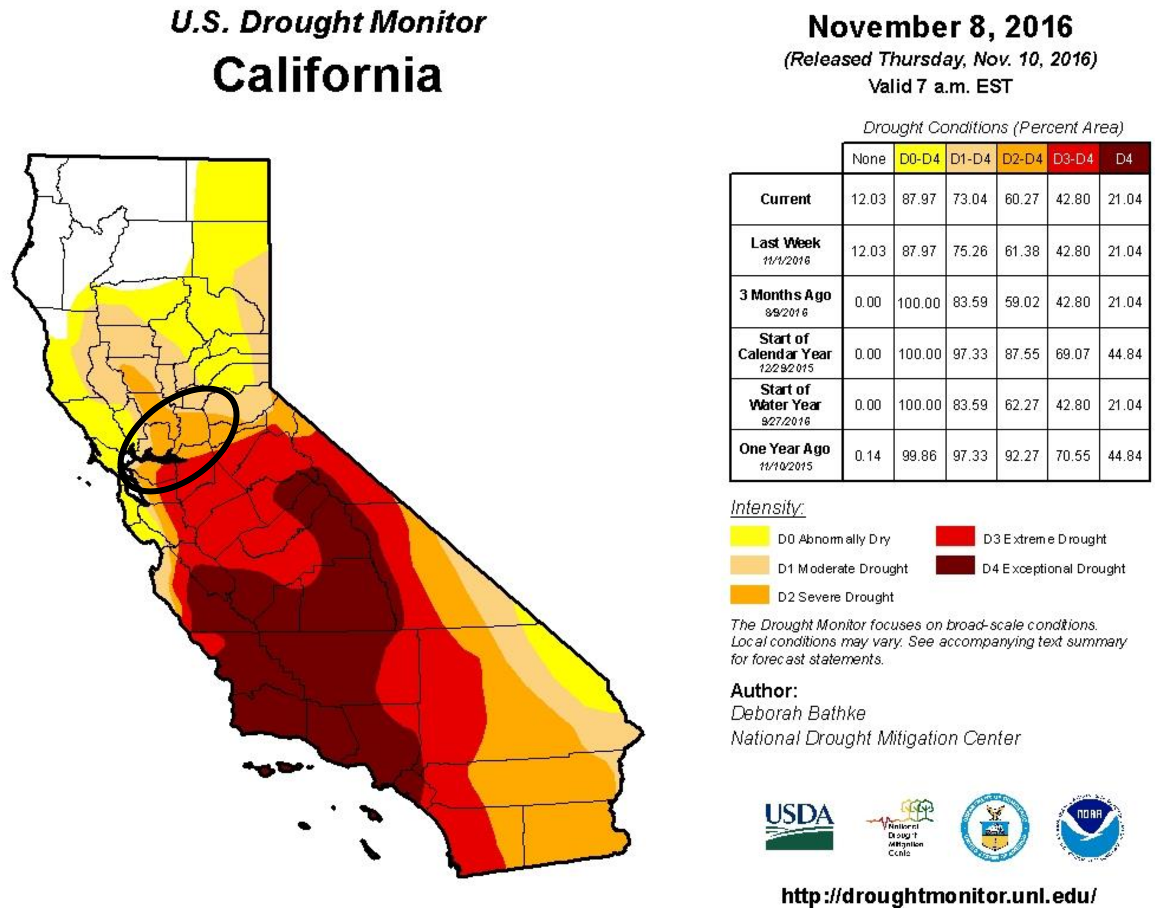
Figure 4-24 Causes and Impact of Drought



Source: National Drought Mitigation Center (NDMC)

Drought in the United States is monitored by the National Integrated Drought Information System (NIDIS). A major component of this portal is the U.S. Drought Monitor. The Drought Monitor concept was developed jointly by the NOAA's Climate Prediction Center, the NDMC, and the USDA's Joint Agricultural Weather Facility in the late 1990s as a process that synthesizes multiple indices, outlooks and local impacts, into an assessment that best represents current drought conditions. The final outcome of each Drought Monitor is a consensus of federal, state, and academic scientists who are intimately familiar with the conditions in their respective regions. A snapshot of the drought conditions in California and the Planning Area can be found in Figure 4-25. Drought snapshots in 2015 and early 2016 are shown in Figure 4-26.

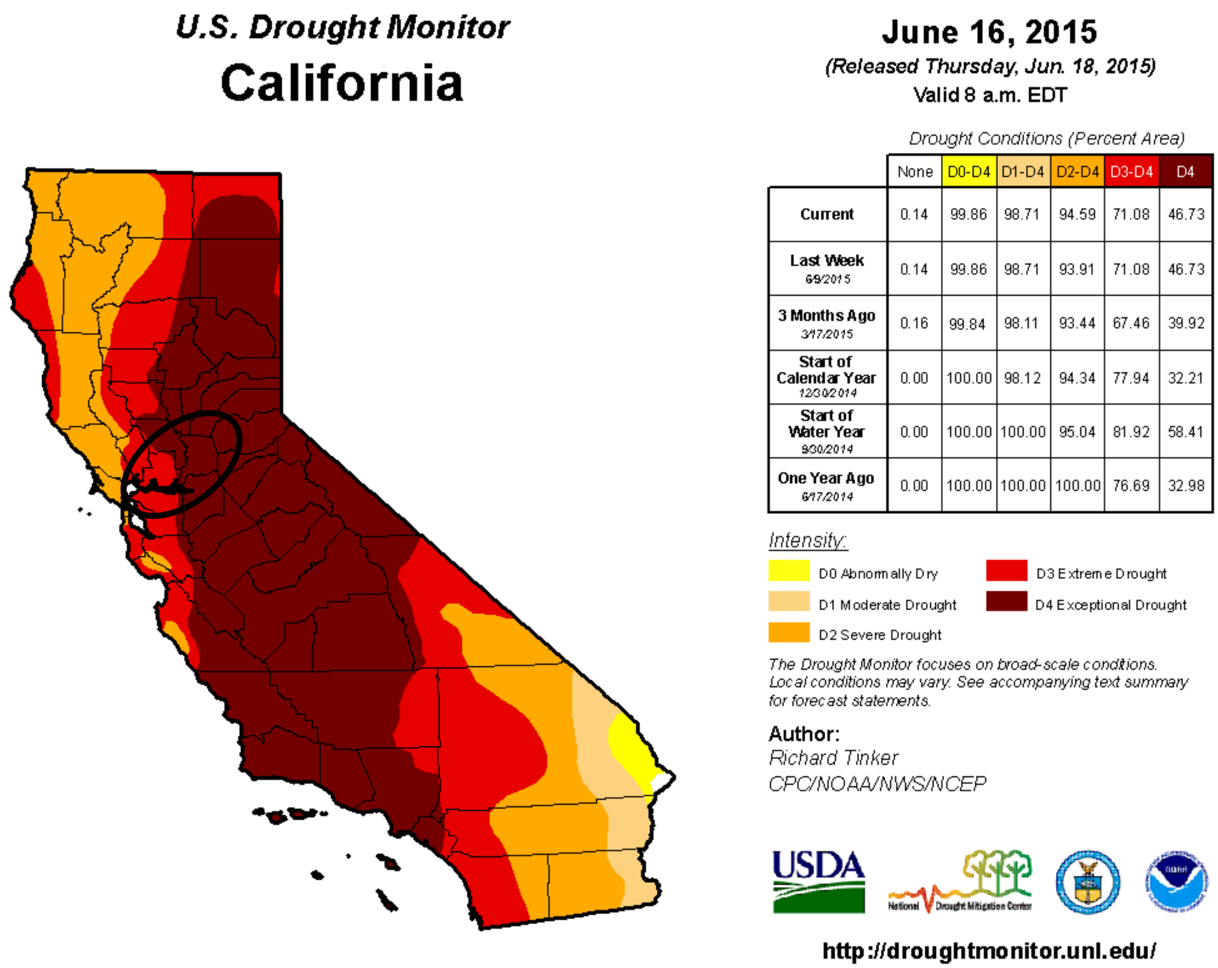
Figure 4-25 Current Drought Status in Sacramento County



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	12.03	87.97	73.04	60.27	42.80	21.04
Last Week 11/1/2016	12.03	87.97	75.26	61.38	42.80	21.04
3 Months Ago 8/9/2016	0.00	100.00	83.59	59.02	42.80	21.04
Start of Calendar Year 12/29/2015	0.00	100.00	97.33	87.55	69.07	44.84
Start of Water Year 9/27/2016	0.00	100.00	83.59	62.27	42.80	21.04
One Year Ago 11/10/2015	0.14	99.86	97.33	92.27	70.55	44.84

Source: US Drought Monitor

Figure 4-26 Previous Drought Status in California



Source: US Drought Monitor

Cal DWR says the following about drought:

> *One dry year does not normally constitute a drought in California. California's extensive system of water supply infrastructure—its reservoirs, groundwater basins, and inter-regional conveyance facilities—mitigates the effect of short-term dry periods for most water users. Defining when a drought begins is a function of drought impacts to water users. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users elsewhere, or for water users having a different water supply. Individual water suppliers may use criteria such as rainfall/runoff, amount of water in storage, or expected supply from a water wholesaler to define their water supply conditions.*

The drought issue in California is further compounded by water rights. Water is a commodity possessed under a variety of legal doctrines. The prioritization of water rights between farming and federally protected fish habitats in California contributes to this issue

Drought is not initially recognized as a problem because it normally originates in what is considered good weather, which typically includes a dry late spring and summer in Mediterranean climates, such as in California. This is particularly true in Northern California where drought impacts are delayed for most of the population by the wealth of stored surface and ground water. The drought complications normally appear more than a year after a drought begins. In most areas of California, ranchers that rely on rainfall to support forage for their livestock are the earliest and most affected by drought. Even below normal water years could affect ranchers depending on the timing and duration of precipitation events. It is difficult to quantitatively assess drought impacts to Sacramento County because not many county-specific studies have been conducted. Some factors to consider include the impacts of fallowed agricultural land, habitat loss and associated effects on wildlife, and the drawdown of the groundwater table. The most direct and likely most difficult drought impact to quantify is to local economies, especially agricultural economies. The State has conducted some empirical studies on the economic effects of fallowed lands with regard to water purchased by the State's Water Bank; but these studies do not quantitatively address the situation in Sacramento County. It can be assumed, however, that the loss of production in one sector of the economy would affect other sectors.

The drawdown of the groundwater table is one factor that has been recognized to occur during repeated dry years. Lowering of groundwater levels results in the need to deepen wells, which subsequently lead to increased pumping costs. These costs are a major consideration for residents relying on domestic wells and agricultural producers that irrigate with groundwater and/or use it for frost protection. Some communities in higher elevations with shallow bedrock do not have a significant source of groundwater.

Drought impacts are wide-reaching and may be economic, environmental, and/or societal. The most significant impacts associated with drought in the Planning Area are those related to water intensive activities such as agriculture, wildfire protection, municipal usage, commerce, tourism, recreation, and wildlife preservation. Also, during a drought, allocations go down and water costs increase, which results in reduced water availability. Voluntary conservation measures are a normal and ongoing part of system operations and actively implemented during extended droughts. A reduction of electric power generation and water quality deterioration are also potential problems. Drought conditions can also cause soil to compact and not absorb water well, potentially making an area more susceptible to flooding and erosion.

Water Shortage

Sacramento County relies on a combination of surface and groundwater for their water supply. Snowmelt originating from the Sierra Nevada Mountains is a key source of surface water for the Sacramento Planning Area. The Sacramento, American, Consumnes, and Mokelumne rivers provide municipal, agricultural, and recreational uses to Sacramento County and depend on the spring and summer snowmelt in the Sierra Nevada for their flows. The network of dams constructed in Northern California to support the State Water Project and the Central Valley Project help provide California and Sacramento with water security during droughts. Sacramento County also sits over the north central portion of the California's Great Valley Groundwater Basin, which provides approximately 50 percent of all municipal and agricultural water supply in the County. Groundwater recharge occurs primarily from the American and Cosumnes rivers, with additional recharge from the Sacramento River and local streams. Groundwater stores are directly linked to surface water in the County and snowmelt in the Sierra Nevada.

Thus, Sacramento County, generally has sufficient groundwater and surface water supplies to mitigate even the severest droughts of the past century. Many other areas of the State, however, also place demands on these water resources during severe drought. For example, Northern California agencies, including those from Sacramento County, were major participants in the Governor's Drought Water Bank of 1991, 1992 and 1994.

Past Occurrences

Drought Disaster Declaration History

There has been one state declaration and one federal declaration related to drought and water shortage in Sacramento County since 1950.

- Drought State of Emergency – Governor's Proclamation January 17, 2014 (details below)
- 2008 Central Valley Drought (California State Declaration GP 2008-03)
- 1977 Drought (Federal Emergency Management Declaration EM-3023)

There have also been 12 USDA Secretarial Disaster Declarations since 1982. The USDA declarations are included in Table 4-21 in Section 4.2.7.

2014 Governor's Drought Declaration

California's ongoing response to its five-year drought has been guided by a series of executive orders issued by Governor Edmund G. Brown Jr. that are listed below beginning with the most recent and continuing in reverse chronological order:

- **Executive Order B-37-16, May 9, 2016**: The Governor's latest drought-related executive order established a new water use efficiency framework for California. The order bolstered the state's drought resilience and preparedness by establishing longer-term water conservation measures that include permanent monthly water use reporting, new urban water use targets, reducing system leaks and eliminating clearly wasteful practices, strengthening urban drought contingency plans and improving agricultural water management and drought plans.
- **Executive Order B-36-15, November 13, 2015**: This executive order called for additional actions to build on the State's ongoing response to record dry conditions and assist recovery efforts from 2015's devastating wildfires.
- **Executive Order B-29-15, April 1, 2015**: Key provisions included ordering the State Water Resources Control Board (Board) to impose restrictions to achieve a 25-percent reduction in potable urban water usage through February 28, 2016; directing the California Department of Water Resources (DWR) to lead a statewide initiative, in partnership with local agencies, to collectively replace 50 million square feet of lawns and ornamental turf with drought tolerant landscapes, and directing the California Energy Commission to implement a statewide appliance rebate program to provide monetary incentives for the replacement of inefficient household devices.
- **Executive Order B-28-14, December 22, 2014**: The order cited paragraph 9 of the January 17, 2014 Proclamation and paragraph 19 of the April 25, 2014 Proclamation (both are linked below) and extended the operation of the provisions in these paragraphs through May 31, 2016.
- **Executive Order B-27-14, October 6, 2014**: The order directed State agencies to assist local governments in their response to wildfires during California's drought conditions.

- **Executive Order B-26-14, September 18, 2014**: The order facilitated efforts to provide water to families in dire need as extreme drought continued throughout California.
- Proclamation of a **Continued State of Emergency, April 25, 2014**: The order strengthened the State's ability to manage water and habitat effectively in drought conditions and called on all Californians to redouble their efforts to conserve water.
- **Drought State of Emergency, January 17, 2014**: The Governor proclaimed a State of Emergency and directed State officials to take all necessary actions to make water immediately available. Key measures in the proclamation included:
  - ✓ Asking all Californians to reduce water consumption by 20 percent and referring residents and water agencies to the Save Our Water campaign – www.saveourwater.com – for practical advice on how to do so;
  - ✓ Directing local water suppliers to immediately implement local water shortage contingency plans;
  - ✓ Ordering the Board to consider petitions for consolidation of places of use for the State Water Project and Central Valley Project, which could streamline water transfers and exchanges between water users;
  - ✓ Directing DWR and the Board to accelerate funding for projects that could break ground in 2014 and enhance water supplies;
  - ✓ Ordering the Board to put water rights holders across the state on notice that they may be directed to cease or reduce water diversions based on water shortages;
  - ✓ Asking the Board to consider modifying requirements for releases of water from reservoirs or diversion limitations so that water may be conserved in reservoirs to protect cold water supplies for salmon, maintain water supplies and improve water quality.

NCDC Drought Events

There has been 19 NCDC drought events in Sacramento County. These are shown on Table 4-26. All of these events were from January 2014 to the end of 2015.

Table 4-26 Sacramento County Drought Events, 1993 to 12/31/2015

Date	Event Type	Deaths Direct	Injuries Direct	Property Damage	Crop Damage	Injuries Indirect	Deaths Indirect
1/1/2014	Drought	0	0	0	0	0	0
3/1/2015	Drought	0	0	0	0	0	0
4/1/2015	Drought	0	0	0	0	0	0
5/1/2015	Drought	0	0	0	0	0	0
5/1/2015	Drought	0	0	0	0	0	0
6/1/2015	Drought	0	0	0	0	0	0
6/1/2015	Drought	0	0	0	0	0	0
7/1/2015	Drought	0	0	0	0	0	0
7/1/2015	Drought	0	0	0	0	0	0
8/1/2015	Drought	0	0	0	0	0	0
8/1/2015	Drought	0	0	0	0	0	0

Date	Event Type	Deaths Direct	Injuries Direct	Property Damage	Crop Damage	Injuries Indirect	Deaths Indirect
9/1/2015	Drought	0	0	0	0	0	0
9/1/2015	Drought	0	0	0	0	0	0
10/1/2015	Drought	0	0	0	0	0	0
10/1/2015	Drought	0	0	0	0	0	0
11/1/2015	Drought	0	0	0	0	0	0
11/1/2015	Drought	0	0	0	0	0	0
12/1/2015	Drought	0	0	0	0	0	0
12/1/2015	Drought	0	0	0	0	0	0

Source: NCDC

HMPC Drought Events

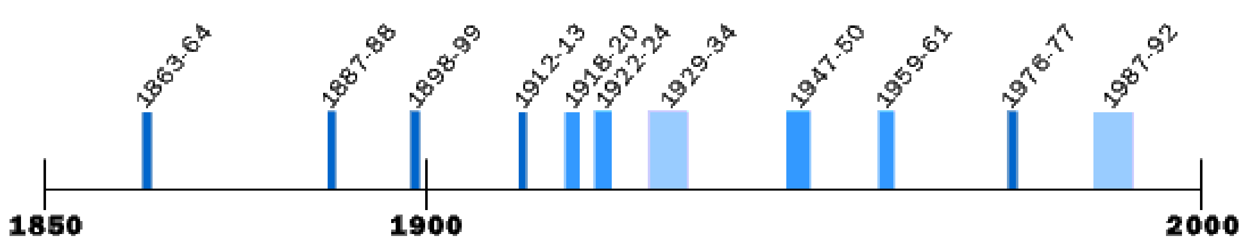
Historically, California has experienced multiple severe droughts. According to Cal DWR, droughts exceeding three years are relatively rare in Northern California, the source of much of the State's developed water supply. The 1929-34 drought established the criteria commonly used in designing storage capacity and yield of large northern California reservoirs. Table 4-27 compares the 1929-34 drought in the Sacramento and San Joaquin Valleys to the 1976-77, 1987-92, and 2007-09 droughts. Figure 4-27 depicts California's Multi-Year Historical Dry Periods, 1850-2000. Figure 4-28 depicts runoff for the State from 1900 to 2015. This gives a historical context for the 2014-2015 drought to past droughts.

Table 4-27 Severity of Extreme Droughts in the Sacramento and San Joaquin Valleys

Drought Period	Sacramento Valley Runoff		San Joaquin Valley Runoff	
	(maf*/yr)	(percent Average 1901-96)	(maf*/yr)	(percent Average 1906-96)
1929-34	9.8	55	3.3	57
1976-77	6.6	37	1.5	26
1987-92	10.0	56	2.8	47
2007-09	11.2	64	3.7	61

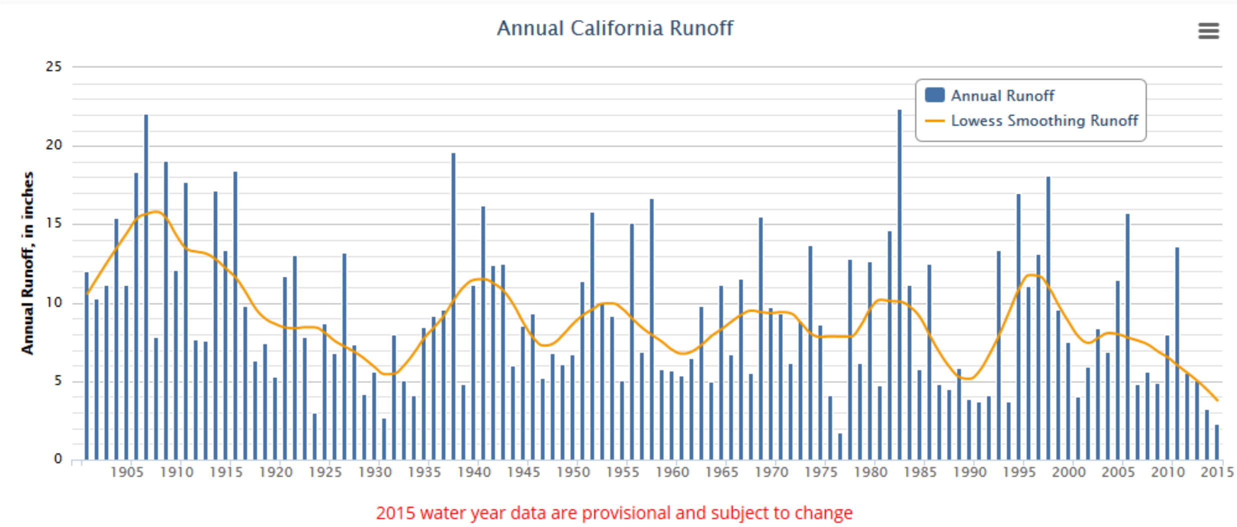
Source: California's Drought of 2007-2009, An Overview. State of California Natural Resources Agency, California Department of Water Resources. Available at: http://www.water.ca.gov/drought/docs/DroughtReport2010.pdf
*maf=million acre feet

Figure 4-27 California's Multi-Year Historical Dry Periods, 1850-2000



Source: California Department of Water Resources, www.water.ca.gov/
Notes: Dry periods prior to 1900 estimated from limited data; covers dry periods of statewide or major regional extent

Figure 4-28 Annual California Runoff –1900 to 2015



Source: California DWR

The HMPC identified the following droughts as having significant impacts on the Planning Area:

- **2011 through to current.** Significant crop loss and loss of jobs related to agriculture. See agriculture hazards for specific information on damages.
- Construction of a $40 million temporary barrier at West False River in the Sac-San Joaquin Delta was installed to keep salt water from contaminating drinking water to Bay Area residents.
- **2014** – On January 17, 2014 the governor declared a State of Emergency for drought throughout California. This declaration came on the heels of a report that stated that California had the least amount of rainfall in its 163-year history. Californians were asked to voluntarily reduce their water consumption by 20 percent. Drought conditions worsened through 2014 and into 2015. On April 1, 2015, following the lowest snowpack ever recorded, Governor Brown announced actions that will save water, increase enforcement to prevent wasteful water use, streamline the State's drought response, and invest in new technologies that will make California more drought resilient. The Governor directed the State Water Resources Control Board to implement mandatory water reductions in cities and towns across California to reduce water usage by 25 percent. This savings amounts to approximately 1.5 million acre-feet of water through the end of 2015.
- **March 2015 –** An extremely dry March followed a below normal February for most areas. This continued the 4th consecutive year of drought for the region. Mountain snowfall was very limited for the month. This along with record warmth over the area resulted in the lowest snow pack levels on record for the time of year. By the end of March, the snow pack was only about 5 percent of normal levels. Melting snow pack supplies about a third of the annual water supply for California. Reservoirs across the area by the end of March were already well below normal levels.
- **April 2015** – The long-term drought continues as April was yet another below normal month for precipitation for much of the area. There was some mountain snowfall, but this did little to improve the snow pack, which remained at the lowest levels on record. By the end of April, the snow pack was only about 4 percent of normal levels. As a result, reservoirs across the area by the end of April remained well below normal levels with little or no spring rise, due to the lack of snow melt.

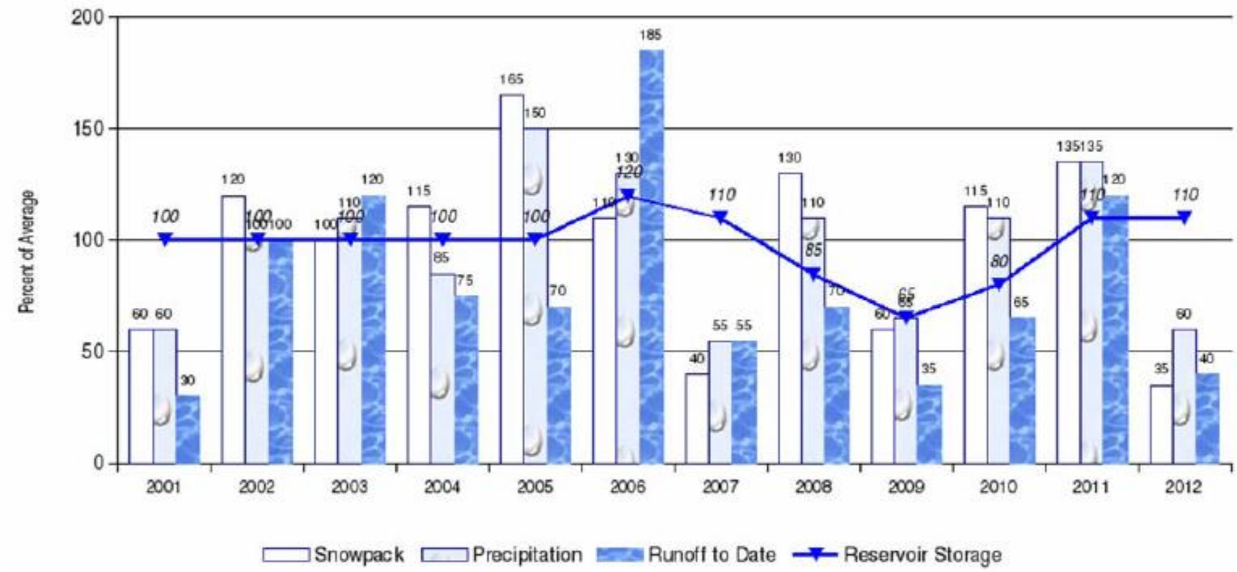
- **May 2015** – The long-term drought continues as May was yet another below normal month for precipitation for much of the area. There was some mountain precipitation in the form of rain, but much of it was focused along and east of the crest. Snow pack was at the lowest levels on record and by the end of the month was virtually nonexistent. As a result, reservoirs across the area by the end of the month were at well below normal levels and were already beginning to drop.
- **June 2015** – The long-term drought continued through June with yet another below normal month for precipitation for much of the area. There was some mountain rain, but much of it was focused along and east of the crest. Without a snow pack, reservoirs across the area by the end of the month were at well below normal levels and were continuing to drop. NOAA – As a result of continuing drought, emergency legislation appropriated over $1 Billion in additional funds for drought related projects".
- **July 2015** – The long-term drought continued through July. While quite a few mountain locations received greater than normal precipitation due to moisture from the monsoon and from ex-hurricane Dolores, this made little impact on the drought overall. The main affects were in decreasing fire activity in areas where locally heavy rain fell. Without a snow pack, reservoirs across the area by the end of the month were continuing to drop well below normal levels.
- **August 2015** – The long-term drought continued through August with little change. Without a snow pack for late spring/early summer, reservoirs across the area by the end of the month were continuing to drop well below normal levels. All major reservoirs across the state were less than 40% of capacity by the end of the month. Folsom Lake was down to 20% of capacity, approaching near-record low levels for August, seen last in 1977. A UC Davis Center for Watershed Sciences report – (due to drought) showed statewide drought impact in 2015 at $2.7 Billion and loss of more than 21,000 jobs. Approx. 743,642 boxes of food distributed to 300k households that suffered unemployment from the drought.
- **September 2015** – The long-term drought continued through September with little change. Reservoirs across the area were continuing to drop well below normal levels. All major reservoirs across the state were less than 40% of capacity. Folsom Lake was down to 18% of capacity, approaching near-record low levels for September, seen last in 1977.
- **October 2015** – The long-term drought continued through October with little change. Reservoirs across the area were continuing to drop well below normal levels. All major reservoirs across the state were less than 40% of capacity. Folsom Lake was down to 16% of capacity, approaching near all-time record low levels, set in 1977.
- **November 2015** – The long-term drought continued through November. Widespread precipitation returned to the area with several events, but reservoirs across the area continued to drop well below normal levels. All major reservoirs across the state were 30% or less of capacity. Folsom Lake was down to 14% of capacity, breaking the all-time record low set in 1977. Lake Oroville came close to a record low, but did not reach it.
- **December 2015** – The long-term drought continued through December, though there was near normal precipitation in the mountains and above normal snow pack by the end of the month. Reservoirs across the area began to slowly fill but continued to be well below normal levels.
- **January 2016** – The long-term drought continued through January, though precipitation amounts for the month were much better than in recent years, about 150-200% of normal. This built an above normal snow pack for the northern Sierra and southern Cascades by the end of the month. Reservoirs across the area continued to increase but generally remained below normal levels. Folsom Lake was an exception to this, rising to 104% by the end of January after a record low late in the fall. The Department of Water Resources increased water delivery projections from 10 percent early in the month to 15 percent of full water allotments by the end of the month, due to the increased reservoir levels.

- **February 2016 –** Long term drought continued through the month of February. After a relatively wet January, a period of extremely dry and warm conditions returned for most of February. This prevented the snow pack for the northern Sierra and southern Cascades from growing much, and actually decreased it in some locations by the end of the month, down to around 90% of normal, 85% for the whole state. Reservoirs across the area continued to increase but generally remained below normal levels. Folsom Lake was an exception to this, rising to 111% by the end of February. The Department of Water Resources increased water delivery projections to 30% of requests, up from a 15% estimate in late January. However, the dry conditions through the month prevented a larger anticipated increase.
- **March 2016 –** Long term drought continued through the month of March, but with significant improvements in mountain snow pack and most reservoir levels. After a period of extremely dry and warm conditions for most of February, a pattern of moist westerly flow brought a series of unusually wet storms in March. This added significantly to the snow pack for the northern Sierra and southern Cascades. Snow pack increased to around 97% of normal for those areas, while on average the whole state was 86%. Reservoirs across interior northern California continued to increase, with the two largest rising to above normal levels. Lake Shasta was 109% of normal by the end of the month, Lake Oroville was 114%. Folsom Lake was 110% of normal and had to make flood control releases. In contrast, Don Pedro and New Melones remained below normal. The Department of Water Resources increased water delivery projections to 45% of requests, up from a 30% estimate in late February.
- **April 2016 –** Long term drought impacts continued through the month of April, but near seasonal values for Northern and Central Sierra mountain snow pack and the "Big 3" northern reservoir levels meant some good news. The very active March resulted in much above average precipitation numbers which helped top off the reservoirs. In fact, they had to do some flood control releases on Folsom as it was above historical levels. Reservoirs across interior northern California continued to increase, with the three largest rising to above normal levels. Lake Shasta was 108% of normal by the end of the month, Lake Oroville was 118% and Folsom Lake was 113% of normal. In contrast, Don Pedro and New Melones remained below normal at 67% and 26% respectively. On April 21st, the Department of Water Resources increased water delivery projections to the State Water Project to 60%, up from a 45% estimate in late March.
- **May 2016** – Long term drought impacts continued through the month of May, though the largest of the reservoirs in northern interior California were at or above normal levels due to a significant mountain snowpack melting. Lake Shasta was 107% of normal by the end of the month, Lake Oroville was 111%, Folsom Lake was 101%, and Don Pedro was 99%. New Melones continued to lag behind the other significant area reservoirs and was only 41% of normal. On April 21st, the Department of Water Resources increased water delivery projections to the State Water Project to 60%, up from the 45% estimate in late March. Groundwater aquifers recharged much more slowly than the surface reservoirs, with many in the Central Valley still falling toward record levels.

Water Shortage Events

Figure 4-29 illustrates several indicators commonly used to evaluate water conditions in California. The percent of average values are determined by measurements made in each of the ten major hydrologic regions. The chart describes water conditions in California between 2001 and 2012. The chart illustrates the cyclical nature of weather patterns in California. Snow pack and precipitation increased between 2005 and 2006, began decreasing in late 2006, and began to show signs of recovery in 2009.

Figure 4-29 Water Supply Conditions, 2001 to 2012



Source: 2013 State of California Hazard Mitigation Plan

Since 2012, snowpack levels in California have dropped dramatically. 2015 estimates place snowpack as 5 percent of normal levels. Snowpack measurements have been kept in California since 1950 and nothing in the historic record comes close to 2015's severely depleted level. The previous record for the lowest snowpack level in California, 25 percent of normal, was set both in 1976-77 and 2013-2014. In "normal" years, the snowpack supplies about 30 percent of California's water needs, according to the California Department of Water Resources.

With a reduction in water, water supply issues based on water rights becomes more evident. Some agricultural uses, such as grapes and walnuts, are severely impacted through limited water supply. Drought and water supply issues will continue to be a concern to the Planning Area. Irrigation of agricultural lands continues to be a concern in the Planning Area.

Likelihood of Future Occurrence

Drought

Likely—Historical drought data for the Sacramento County Planning Area and region indicate there have been 6 significant droughts in the last 89 years. This equates to a drought every 14.8 years on average or a 6.7 percent chance of a drought in any given year. However, based on this data and given the multi-year length of droughts, the HMPC determined that future drought occurrence in the Planning Area are likely.

Water Shortage

Occasional – Recent historical data for water shortage indicates that Sacramento County may at some time be at risk to both short and prolonged periods of water shortage. Based on this it is possible that water shortages will affect the County in the future should extreme drought conditions continue. However, to date, most of Northern California and Sacramento County have continued to have good, consistent water supply. Most of the Planning Area's supply comes from surface water, with groundwater resources also being used in some areas.

Climate Change and Drought and Water Shortage

Climate scientists studying California find that drought conditions are likely to become more frequent and persistent over the 21st century due to climate change. The experiences of California during recent years underscore the need to examine more closely the state's water storage, distribution, management, conservation, and use policies. The CAS stresses the need for public policy development addressing long term climate change impacts on water supplies. The CAS notes that climate change is likely to significantly diminish California's future water supply, stating that:

> *California must change its water management and uses because climate change will likely create greater competition for limited water supplies needed by the environment, agriculture, and cities.*

The regional implications of declining water supplies as a long-term public policy issue are recognized in a Southern California Association of Governments July 2009 publication of essays examining climate change topics. In one essay, Dan Cayan observes:

> *In one form or another, many of Southern California's climate concerns radiate from efforts to secure an adequate fresh water supply…Of all the areas of North America, Southern California's annual receipt of precipitation is the most volatile – we only occasionally see a "normal" year, and in the last few we have swung from very wet in 2005 to very dry in 2007 and 2008….Southern California has special challenges because it is the most urban of the California water user regions and, regionwide, we import more than two-thirds of the water that we consume.*

Members of the HMPC noted a report published in Science magazine in 2015 that stated:

> *Given current greenhouse gas emissions, the chances of a 35+ year "megadrought" striking the Southwest by 2100 are above 80 percent.*

The HMPC also noted a report from the Public Policy Institute of California that thousands of Californians – mostly in rural, small, disadvantaged communities – already face acute water scarcity, contaminated groundwater, or complete water loss. Climate change would make these effects worse.

Preliminary Draft - Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the 2016 Preliminary Draft Sacramento County CAP, based on historical data and modeling, under the low- and high-emissions scenarios, Cal DWR projects that the Sierra Nevada snowpack will decrease by 25-40 percent from its historic April 1st average of 28 inches of water content by 2050 and 48 to 65 percent by 2100, respectively. With a projected decrease in overall precipitation, including precipitation falling as snow and increased average temperatures, drought conditions may increase and both groundwater and surface water supplies may be impacted.

4.2.12. Earthquake

Hazard/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. 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. One of the first was the Richter Scale, developed in 1932 by the late Dr. Charles F. Richter of the California Institute of Technology. The Richter Magnitude Scale is used to quantify the magnitude or strength of the seismic energy released by an earthquake. Another measure of earthquake severity is intensity. Intensity is an expression of the amount of shaking at any given location on the ground surface (see Table 4-28). Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4-28 Modified Mercalli Intensity (MMI) Scale

MMI	Felt Intensity
I	Not felt except by a very few people under special conditions. Detected mostly by instruments.
II	Felt by a few people, especially those on upper floors of buildings. Suspended objects may swing.
III	Felt noticeably indoors. Standing automobiles may rock slightly.
IV	Felt by many people indoors; by a few outdoors. At night, some people are awakened. Dishes, windows, and doors rattle.
V	Felt by nearly everyone. Many people are awakened. Some dishes and windows are broken. Unstable objects are overturned.
VI	Felt by everyone. Many people become frightened and run outdoors. Some heavy furniture is moved. Some plaster falls.
VII	Most people are alarmed and run outside. Damage is negligible in buildings of good construction, considerable in buildings of poor construction.
VIII	Damage is slight in specially designed structures, considerable in ordinary buildings, and great in poorly built structures. Heavy furniture is overturned.
IX	Damage is considerable in specially designed buildings. Buildings shift from their foundations and partly collapse. Underground pipes are broken.

MMI	Felt Intensity
X	Some well-built wooden structures are destroyed. Most masonry structures are destroyed. The ground is badly cracked. Considerable landslides occur on steep slopes.
XI	Few, if any, masonry structures remain standing. Rails are bent. Broad fissures appear in the ground.
XII	Virtually total destruction. Waves are seen on the ground surface. Objects are thrown in the air.

Source: Multi-Hazard Identification and Risk Assessment, FEMA 1997

California is seismically active because it sits on the boundary between two of the earth's tectonic plates. Most of the state - everything east of the San Andreas Fault - is on the North American Plate. The cities of Monterey, Santa Barbara, Los Angeles, and San Diego are on the Pacific Plate, which is constantly moving northwest past the North American Plate. The relative rate of movement is about two inches per year. The San Andreas Fault is considered the boundary between the two plates, although some of the motion is taken up on faults as far away as central Utah.

Earthquake Hazards

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, hazmat incidents, fires, 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. This section briefly discusses issues related to types of seismic hazards.

Ground Shaking

Groundshaking is motion that occurs as a result of energy released during faulting. The damage or collapse of buildings and other structures caused by groundshaking is among the most serious seismic hazards. Damage to structures from this vibration, or groundshaking, is caused by the transmission of earthquake vibrations from the ground to the structure. The intensity of shaking and its potential impact on buildings is determined by the physical characteristics of the underlying soil and rock, building materials and workmanship, earthquake magnitude and location of epicenter, and the character and duration of ground motion. Much of the County is located on alluvium which increases the amplitude of the earthquake wave. Ground motion lasts longer and waves are amplified on loose, water-saturated materials than on solid rock. As a result, structures located on alluvium typically suffer greater damage than those located on solid rock.

Seismic Structural Safety

Older buildings constructed before building codes were established, and even newer buildings constructed before earthquake-resistance provisions were included in the codes, are the most likely to be damaged during an earthquake. Buildings one or two stories high of wood-frame construction are considered to be the most structurally resistant to earthquake damage. Older masonry buildings without seismic reinforcement (unreinforced masonry) are the most susceptible to the type of structural failure that causes injury or death.

The susceptibility of a structure to damage from ground shaking is also related to the underlying foundation material. A foundation of rock or very firm material can intensify short-period motions which affect low-rise buildings more than tall, flexible ones. A deep layer of water-logged soft alluvium can cushion low-rise buildings, but it can also accentuate the motion in tall buildings. The amplified motion resulting from softer alluvial soils can also severely damage older masonry buildings.

Other potentially dangerous conditions include, but are not limited to: building architectural features that are not firmly anchored, such as parapets and cornices; roadways, including column and pile bents and abutments for bridges and overcrossings; and above-ground storage tanks and their mounting devices. Such features could be damaged or destroyed during strong or sustained ground shaking.

Liquefaction Potential

Liquefaction is a process whereby soil is temporarily transformed to a fluid form during intense and prolonged ground shaking. Due to the damage liquefaction poses to the levees in Sacramento County, a separate, more detailed discussion of liquefaction can be found in Section 4.2.13.

Settlement

Settlement can occur in poorly consolidated soils during ground shaking. During settlement, the soil materials are physically rearranged by the shaking to result in a less stable alignment of the individual minerals. Settlement of sufficient magnitude to cause significant structural damage is normally associated with rapidly deposited alluvial soils or improperly founded or poorly compacted fill. These areas are known to undergo extensive settling with the addition of irrigation water, but evidence due to ground shaking is not available.

Other Hazards

Earthquakes can also cause seiches, landslides, and dam and levee failures. A seiche is a periodic oscillation of a body of water resulting from seismic shaking or other factors that could cause flooding. Earthquakes may cause landslides, particularly during the wet season, in areas of high water or saturated soils. Finally, earthquakes can cause dams and levees to fail (see Section 4.2.9 Dam Failure and Section 4.2.17 Levee Failure).

Faults

A fault is defined as "a fracture or fracture zone in the earth's crust along which there has been displacement of the sides relative to one another." For the purpose of planning there are two types of faults, active and inactive. Active faults have experienced displacement in historic time, suggesting that future displacement may be expected. Inactive faults show no evidence of movement in recent geologic time, suggesting that these faults are dormant.

Two types of fault movement represent possible hazards to structures in the immediate vicinity of the fault: fault creep and sudden fault displacement. Fault creep, a slow movement of one side of a fault relative to the other, can cause cracking and buckling of sidewalks and foundations even without perceptible ground shaking. Sudden fault displacement occurs during an earthquake event and may result in the collapse of buildings or other structures that are found along the fault zone when fault displacement exceeds an inch or two. The only protection against damage caused directly by fault displacement is to prohibit construction in the fault zone.

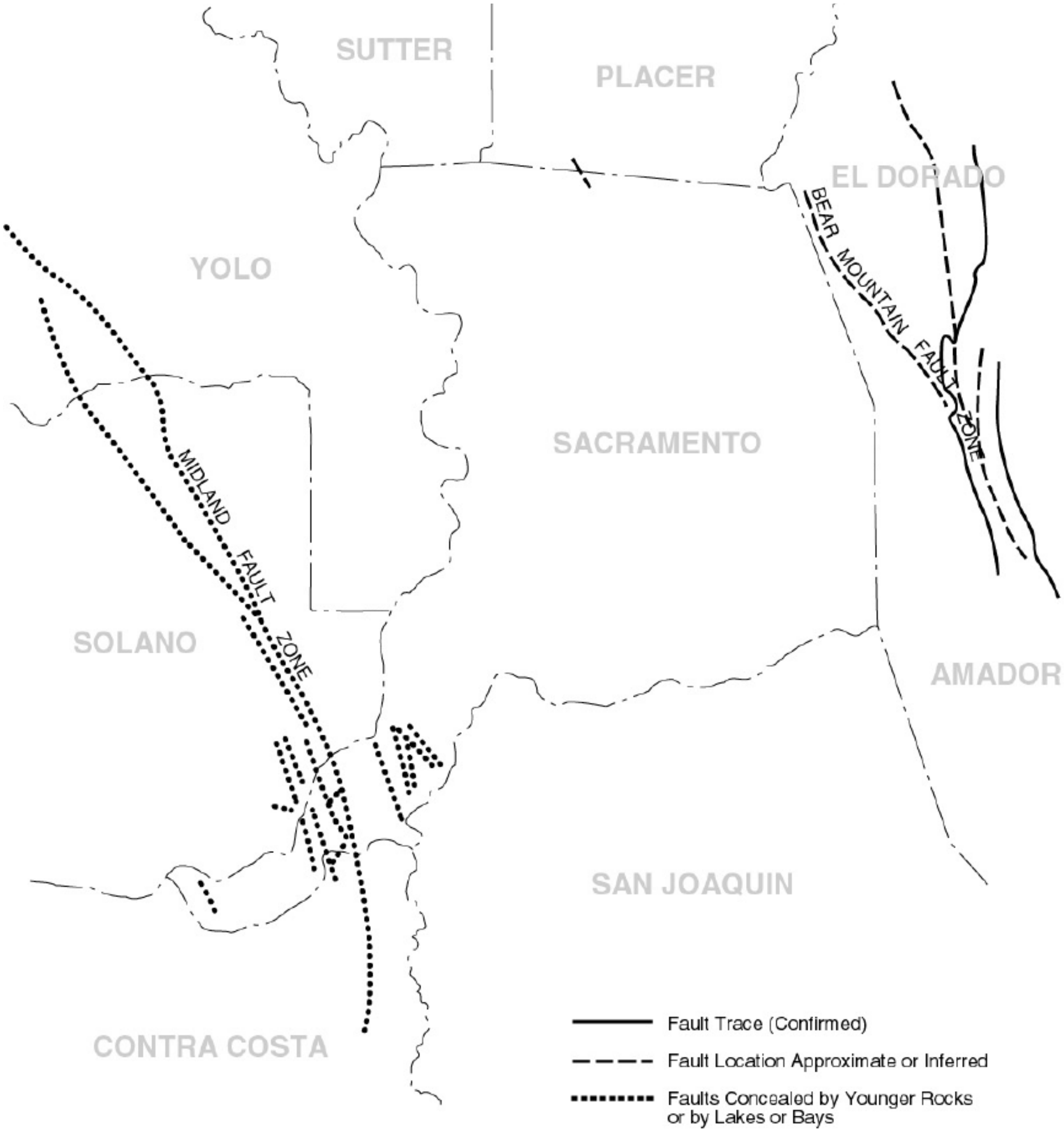
Geological literature indicates that no major active faults transect the County; however, there are several subsurface faults in the Delta. The Midland fault, buried under alluvium, extends north of Bethel Island in the Delta to the east of Lake Berryessa and is considered inactive but possibly capable of generating a near 7.0 (Richter Scale) earthquake. This figure is speculative based on a 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. Table 4-29 and Figure 4-30 identify the faults in close proximity to Sacramento County.

Table 4-29 Historically Active Faults in the Vicinity of Sacramento County

Maximum Richter Scale Reading	Approximate Distance from West Sacramento (Miles)	Historical Seismicity	Probable Intensity
San Andreas	80	1906 (8.25)*	7.5
Vaca	35	1892 (6.5-7)	6.0
Hayward	60	1836, 1868 (7.25)	6.5-7
Calaveras	50	1861 (6.5-7)	6.5-7
Concord-Green Valley	45	1955 (5.4; small events on Green Valley; creep on Concord)	6.0
Midland	20	Possible source of major historic earthquake (1895?)	6.9
Dunnigan Hills	18	Unknown	6.0
Foothill Fault System	25	Oroville 1975	6.0

Source: Lighthouse Marina EIR/EIS, by E D A W, Inc., November, 1985.

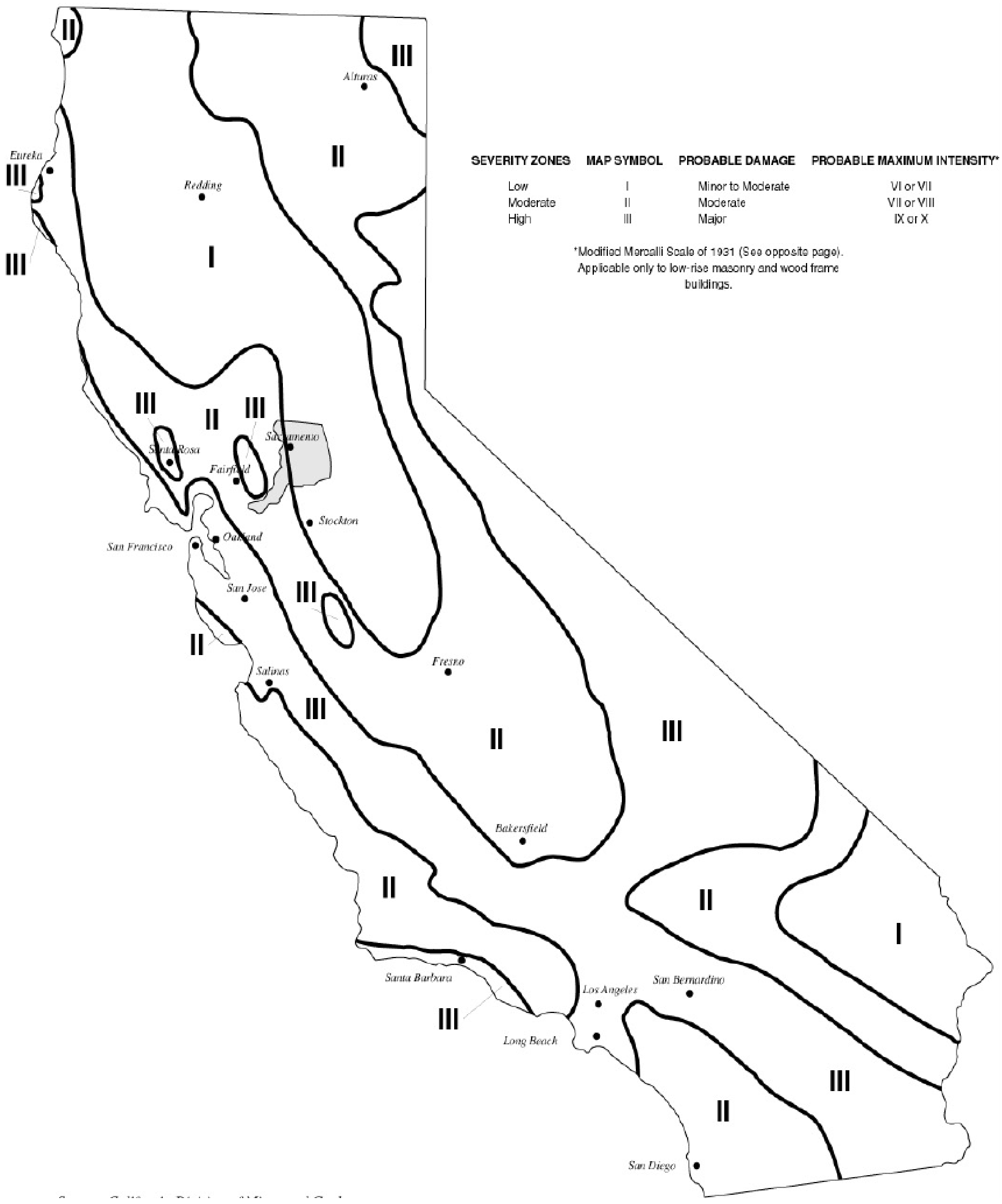
Figure 4-30 Faults in the Vicinity of Sacramento County



Source: Sacramento County General Plan Background Report

Maps indicating the maximum expectable intensity of groundshaking for the County are available through several sources. The California Division of Mines and Geology has prepared a map of the state showing the eastern and central portions of the County in a relatively low intensity groundshaking zone while the western portion of the County is in a relatively moderate groundshaking zone (Figure 4-31). More information on groundshaking can be found in the vulnerability discussion of earthquake in Section 4.3.8.

Figure 4-31 Maximum Expectable Earthquake Intensity



Source: California Division of Mines and Geology

The HMPC noted that Lake County's earthquake was on a previously unknown fault. While fault maps developed by the California Geological Survey (CGS) and the US Geological Survey (USGS) are thorough, a chance remains of an earthquake on an unknown fault in the County.

Past Occurrences

Disaster Declaration History

There have been two disaster declarations in the County related to earthquake:

- 2014 Earthquake (Federal Emergency Management Disaster Declaration EM 4193)
- 1989 Loma Prieta Earthquake (Federal Disaster Declaration DR-845; USDA Disaster Declaration M-845)

NCDC Events

Earthquake events are not tracked by the NCDC database.

USGS Events

The USGS National Earthquake Information Center database contains data on earthquakes in the Sacramento County area. Table 4-30 shows the approximate distances earthquakes can be felt away from the epicenter. According to the table, a magnitude 5.0 earthquake could be felt up to 90 miles away. The USGS database was searched for magnitude 5.0 or greater on the Richter Scale within 90 miles of the City of Sacramento. These results are detailed in Table 4-31.

Table 4-30 Approximate Relationships between Earthquake Magnitude and Intensity

Richter Scale Magnitude	Maximum Expected Intensity (MM)*	Distance Felt (miles)
2.0 - 2.9	I – II	0
3.0 - 3.9	II – III	10
4.0 - 4.9	IV – V	50
5.0 - 5.9	VI – VII	90
6.0 - 6.9	VII – VIII	135
7.0 - 7.9	IX – X	240
8.0 - 8.9	XI – XII	365

*Modified Mercalli Intensity Scale.

Source: United State Geologic Survey, Earthquake Intensity Zonation and Quaternary Deposits, Miscellaneous Field Studies Map 9093, 1977.

*Table 4-31 Magnitude 5.0 Earthquakes within 90 Miles of Sacramento County**

Date	Richter Magnitude	Location
8/1/1975	5.8	59 miles
8/2/1975	5.1	59 miles

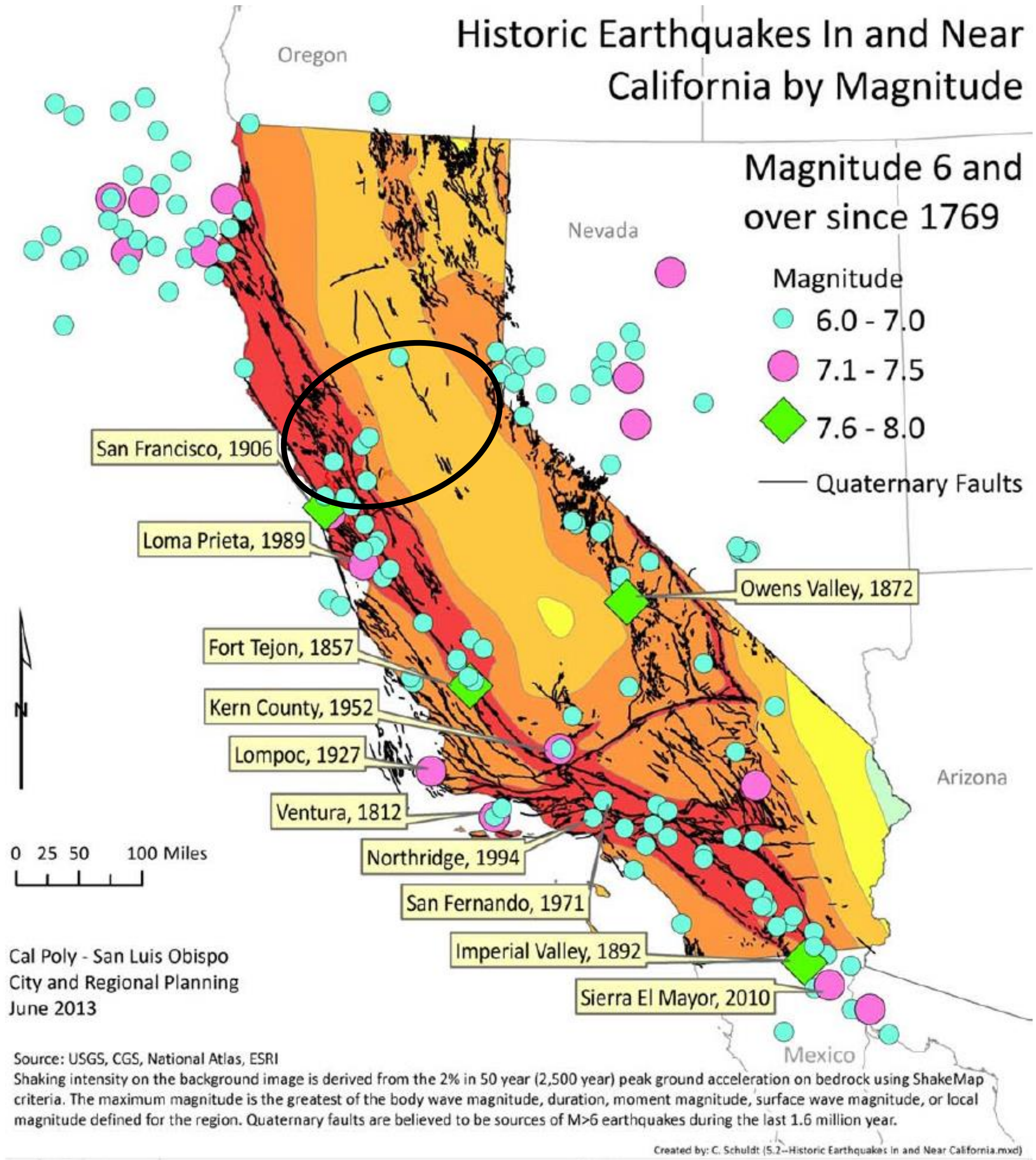
Date	Richter Magnitude	Location
8/2/1975	5.1	58 miles
9/4/1978	5.2	88 miles
1/24/1980	5.8	51 miles
1/27/1980	5.8	57 miles
11/28/1980	5.2	73 miles
4/24/1984	6.2	85 miles
3/31/1986	5.7	73 miles
6/13/1988	5.4	81 miles
9/3/2000	5.0	51 miles
10/31/2007	5.6	78 miles
8/24/2014	6.0	51 miles

Source: USGS

*Search dates 1/1/1950- May 1, 2016

Figure 4-32 shows major historical earthquakes in California from 1769 to 2013.

Figure 4-32 Historic Earthquakes in California and Sacramento County



	MMI	Damage	Effects
	X	Very Heavy	Some well-built, wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
	IX	Heavy	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
	VIII	Moderate to Heavy	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
	VII	Moderate	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly-built or badly designed structures; some chimneys broken.
	VI	Light	Felt by all, many frightened. Some heavy furniture moved; a few instance of fallen plaster. Damage slight.
	V	Very Light	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.

Source: 2013 State of California Multi-Hazard Mitigation Plan

HMPC Events

Historically, major earthquakes have not been an issue for Sacramento County. However, minor earthquakes have occurred in or near the County in the past. The HMPC has identified several earthquakes that were felt by area residents and/or caused damaging shaking in the County. Details on some of these events follow.

- The greatest amount of groundshaking experienced in the County occurred on **April 21, 1892**, when an earthquake shook Yolo County between Winters and Vacaville. While the damage in Yolo County was severe, the damage in Sacramento County was substantially less. Damage to buildings in Sacramento was limited to statuary falling from building tops and cracks in chimneys.
- The **1906** San Francisco earthquake generated little shaking in Sacramento County and damage locally was limited to minor cracks in a local post office and jail.
- A **December 16, 1954** earthquake near Fairview Peak, Nevada measured 7.1 on the Richter Scale. The earthquake caused some damage in Sacramento, while virtually no damage occurred in Reno, Nevada.
- On **August 1, 1975**, a moderate earthquake (magnitude 5.7) occurred near Oroville on the Cleveland Hills fault. This earthquake was felt in Sacramento County, although no direct damage was reported.
- Sacramento County suffered little damage from the **October 17, 1989** Loma Prieta earthquake, which was felt over an area covering 400,000 square miles from Los Angeles to the California-Oregon border. The earthquake measured 7.1 on the Richter Scale; the epicenter was located along the San Andreas fault beneath the Santa Cruz Mountains, about 60 miles southeast of San Francisco. In contrast to Sacramento County, the San Francisco Bay region suffered over $6 billion in property damage and 62 lives were lost. The Loma Prieta earthquake resulted in a federal disaster declaration (DR-845) for the area around San Francisco, including Sacramento County.
- **2014 Napa Earthquake** – A magnitude 6.0 earthquake occurred 51.1 miles west/southwest of the City of Sacramento. Damage estimates in the County were negligible. The County was included in a disaster declaration for this earthquake.

There have been many earthquakes in Northern California since 2011. Most were at a magnitude of 1.5 – 3.0. those closest to Sacramento Valley were; 1.8 magnitude in Antioch, 2.4 in Rio Vista and 6.0 magnitude in American Canyon.

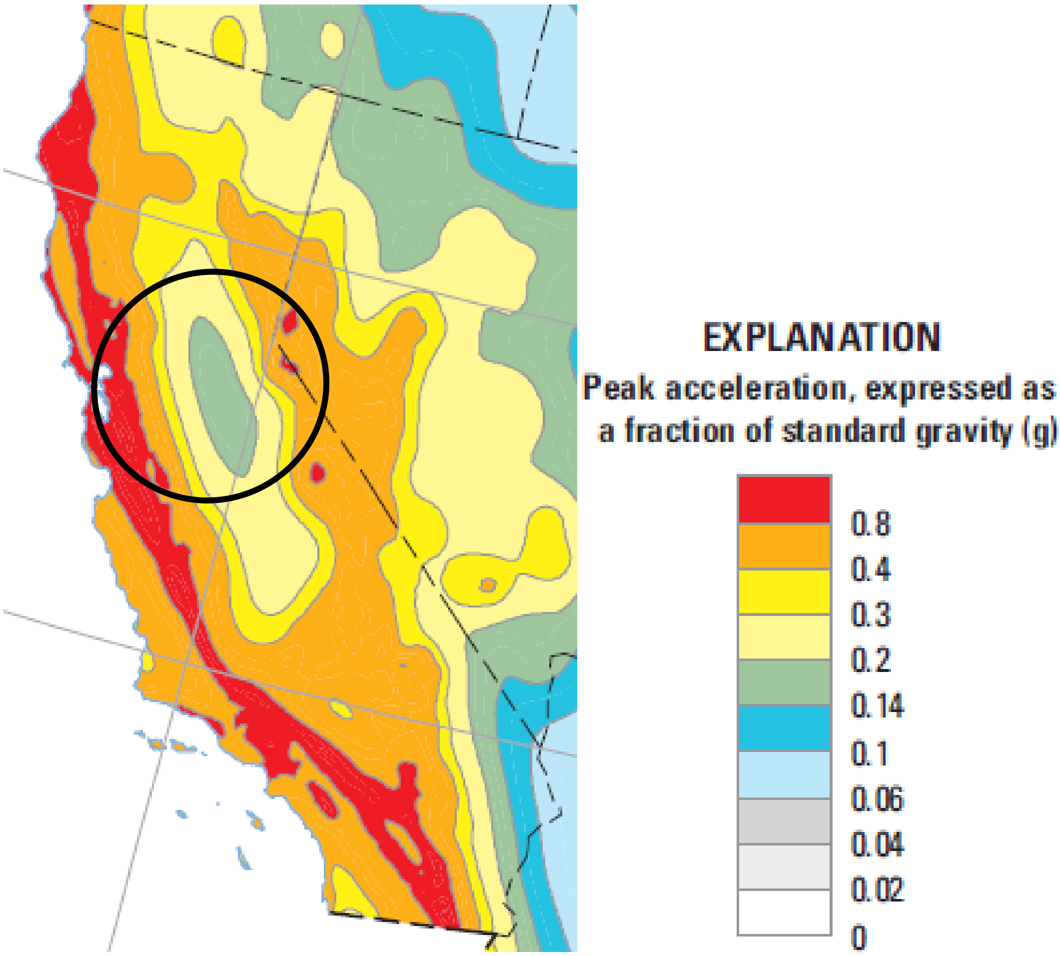
Likelihood of Future Occurrence

Occasional—No major earthquakes have been recorded within the county; although the county has felt ground shaking from earthquakes with epicenters located elsewhere. Based on historical data and the location of the Sacramento County Planning Area relative to active and potentially active faults, the Planning Area will experience an earthquake occasionally.

Mapping of Future Occurrences

Maps indicating the maximum expectable intensity of groundshaking for the County are available through several sources. The USGS issues National Seismic Hazard Maps as reports every few years. These maps provide various acceleration and probabilities for time periods. Figure 4-33 depicts the peak horizontal acceleration (%g) with 10% probability of exceedance in 50 years (a 500-year event) for the planning region. The figure demonstrates that the County falls in the 14%g (grey) to 20%g area. This data indicates that the expected severity of earthquakes in the region is somewhat limited, as damage from earthquakes typically occurs at peak accelerations of 30%g or greater.

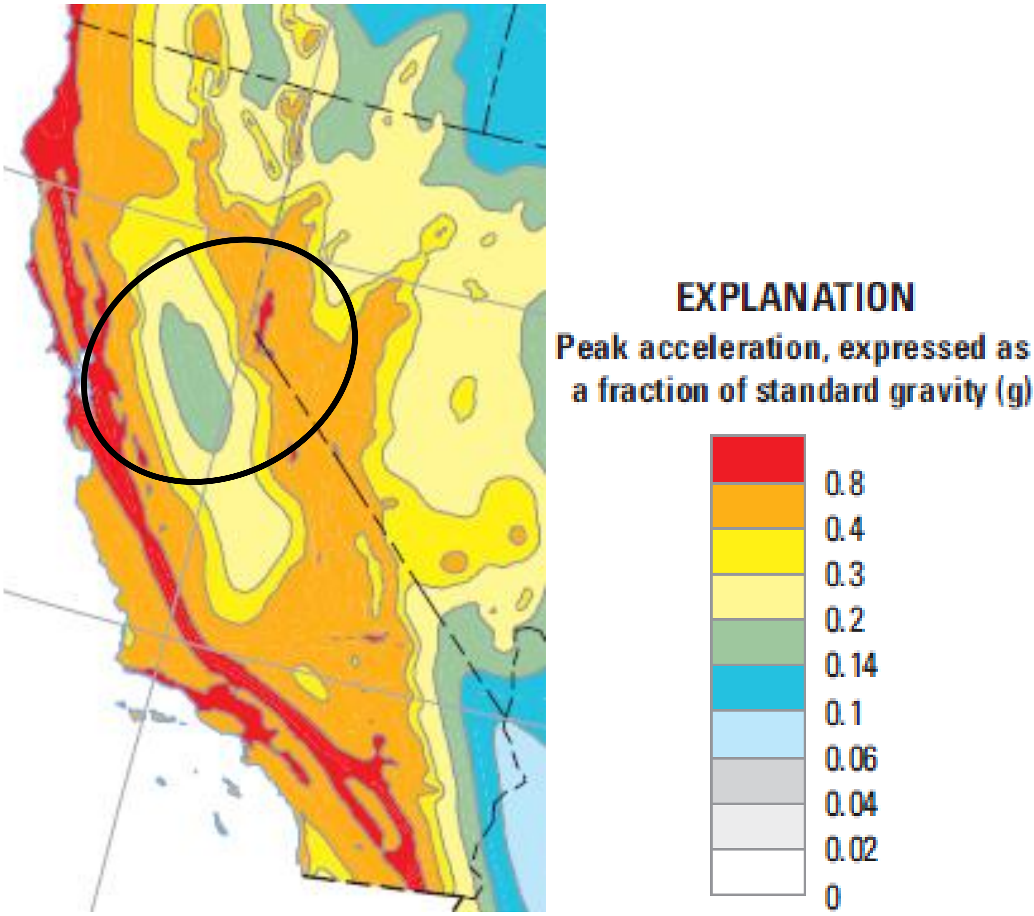
Figure 4-33 Peak Horizontal Acceleration with 10% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps

Figure 4-34 depicts the peak horizontal acceleration (%g) with 2% probability of exceedance in 50 years (a 2,500-year event) for the County. The figure demonstrates that the County falls in the 14%g (grey) to 20%g area. This data indicates that the expected severity of earthquakes in the region is moderate, as damage from earthquakes typically occurs at peak accelerations of 30%g or greater.

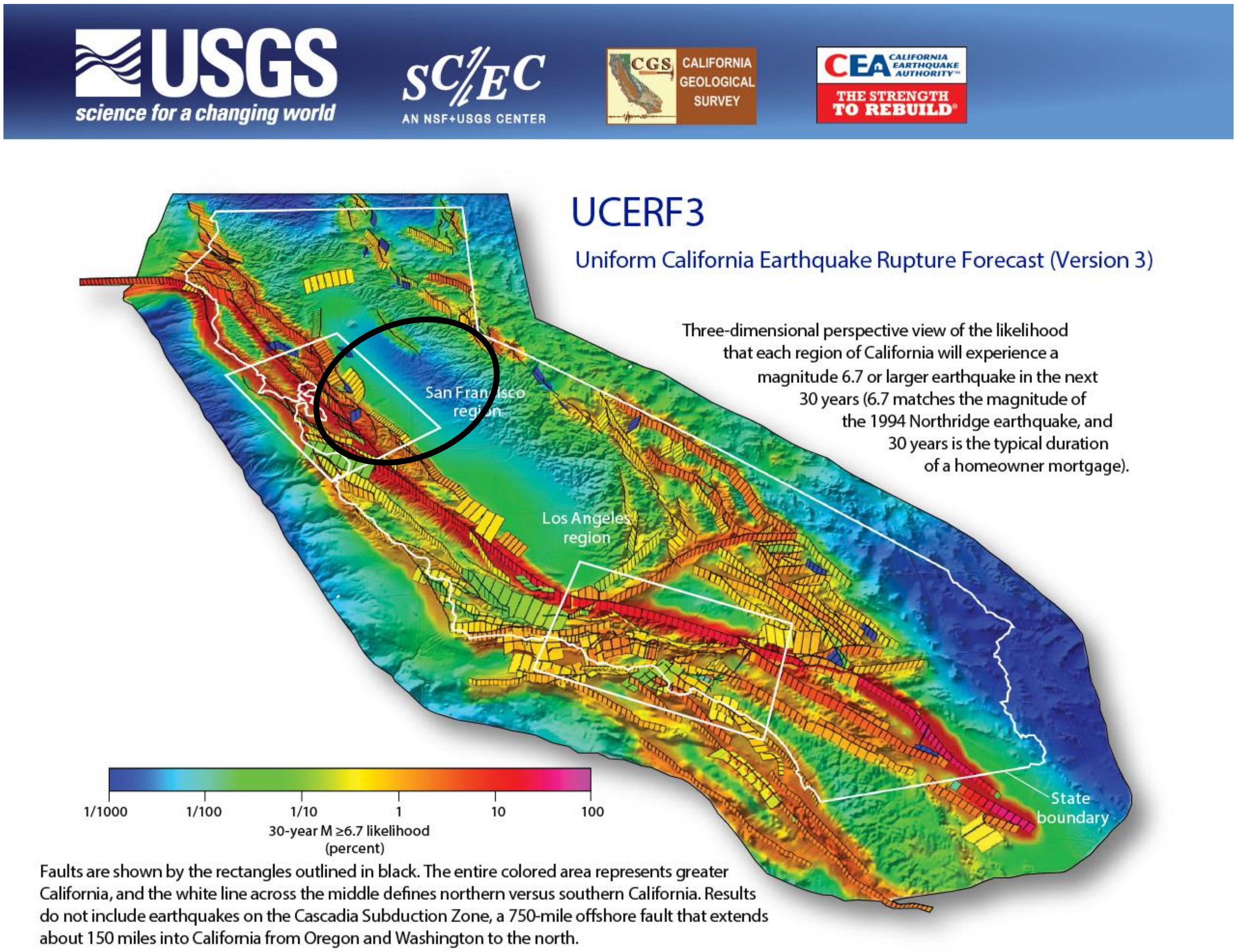
Figure 4-34 Peak Horizontal Acceleration with 2% Probability of Occurrence in 50 Years



Source: USGS National Seismic Hazard Maps

In 2014, the USGS and the CGS released the time-dependent version of the Uniform California Earthquake Rupture Forecast (UCERF III) model. The UCERF III results have helped to reduce the uncertainty in estimated 30-year probabilities of strong ground motions in California. The UCERF map is shown in Figure 4-35 and indicates that Sacramento County has a low to moderate risk of earthquake occurrence, which coincides with the likelihood of future occurrence rating of occasional.

Figure 4-35 Probability of Earthquake Magnitudes Occurring in 30 Year Time Frame



Source: United States Geological Survey Open File Report 2015-3009

Climate Change and Earthquake

Climate change is unlikely to increase earthquake frequency or strength.

4.2.13. Earthquake: Liquefaction

Hazard/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.

Liquefaction during major earthquakes has caused severe damage to structures on level ground as a result of settling, titling, or floating. Such damage occurred in San Francisco on bay-filled areas during the 1989 Loma Prieta earthquake, even though the epicenter was several miles away. If liquefaction occurs in or under a sloping soil mass, the entire mass may flow toward a lower elevation. Also of particular concern in terms of developed and newly developing areas are fill areas that have been poorly compacted.

Typical effects of liquefaction include:

- Loss of bearing strength—the ground can liquefy and lose its ability to support structures.
- Lateral spreading—the ground can slide down very gentle slopes or toward stream banks riding on a buried liquefied layer.
- Sand boils—sand-laden water can be ejected from a buried liquefied layer and erupt at the surface to form sand volcanoes; the surrounding ground often fractures and settles.
- Flow failures—earth moves down steep slope with large displacement and much internal disruption of material.
- Ground oscillation—the surface layer, riding on a buried liquefied layer, is thrown back and forth by the shaking and can be severely deformed.
- Flotation—light structures that are buried in the ground (like pipelines, sewers and nearly empty fuel tanks) can float to the surface when they are surrounded by liquefied soil.
- Settlement—when liquefied ground re-consolidates following an earthquake, the ground surface may settle or subside as shaking decreases and the underlying liquefied soil becomes more dense.

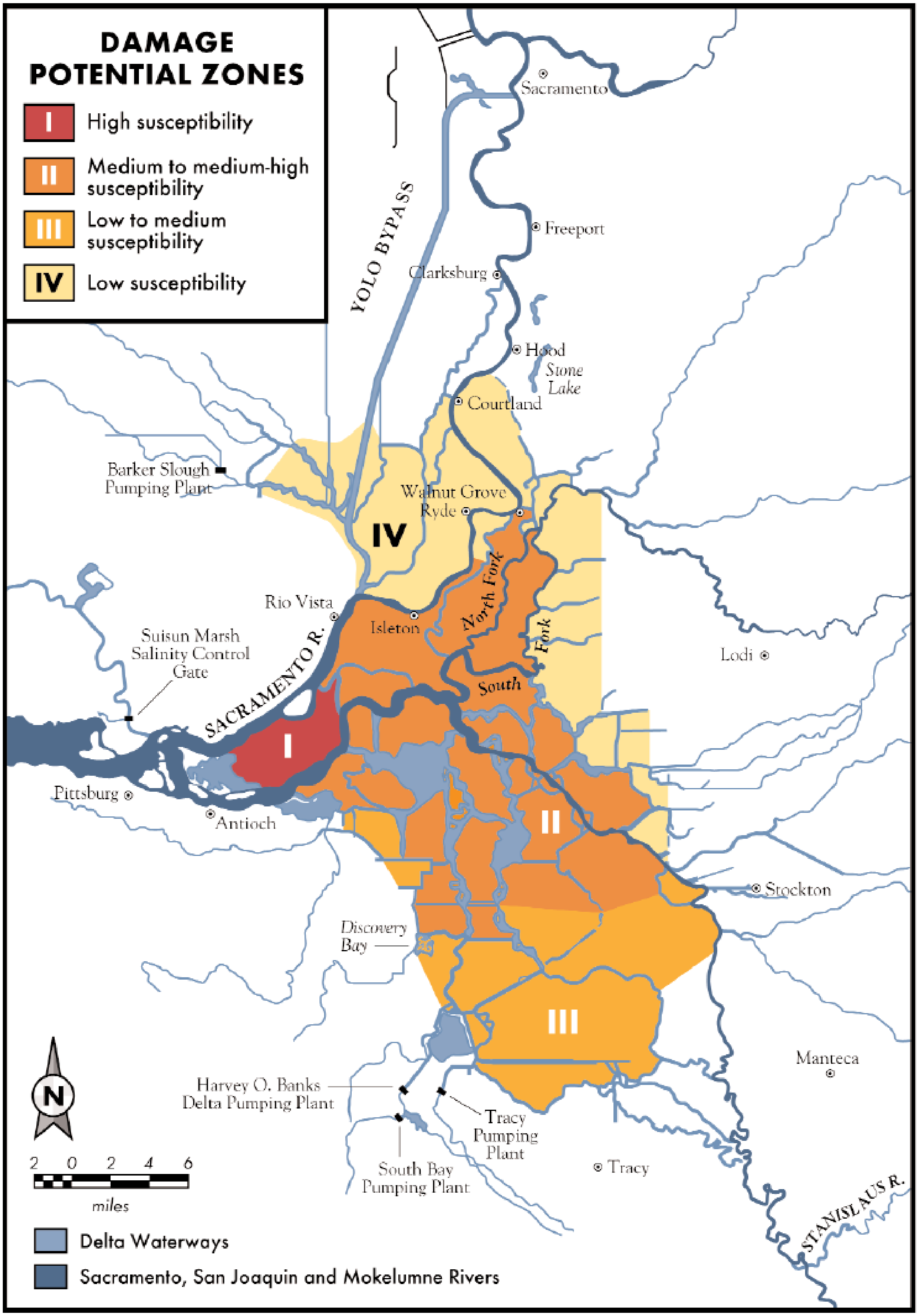
In Sacramento County, the Delta and areas of downtown Sacramento are at risk to liquefaction. The Delta sits atop a blind fault system on the western edge of the Central Valley. Moderate earthquakes in 1892 near Vacaville and in 1983 near Coalinga demonstrate the seismic potential of this structural 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.

Although there have been no significant quakes in or closely adjacent to the Delta since high levees were originally constructed, there are at least five major faults within the vicinity of the Delta capable of generating peak ground acceleration values that would likely lead to levee failures. More information on earthquakes and the faults affecting the Sacramento County area can be found in Section 4.2.12.

A preliminary analysis of the risk of levee failure due to seismicity was prepared for the CALFED Levee System Integrity Program. Based on standard methods and local expertise, it was estimated the magnitude and recurrence intervals of peak ground accelerations throughout the Delta. Two competing fault models were evaluated for this study, producing a wide range of potential accelerations. Then, based on local knowledge and limited geotechnical information, Damage Potential Zones were established for the Delta

(Figure 4-36). The zones of highest risk lie in the central and west Delta where tall levees are constructed on unstable soils that are at high risk of settling or liquefaction during an earthquake.

Figure 4-36 Delta Area - Potential Damage Due to Liquefaction and Levee Collapse



This report estimated recurrence intervals for ground accelerations and the number of potential levee failures in each Damage Potential Zone. It is useful to examine their estimates of the number of failures that might occur during a 100-year event, or an event with a 0.01 probability of being equaled or exceeded in any given year. Based on their estimates, it is a roughly 50-50 chance that 5 to 20 levee segments will fail during a 100-year event in the Delta. This does not imply that 5 to 20 islands will flood, but just that 5 to 20 levee segments will fail. The loss of 5 to 20 levee segments in the Delta constitutes considerable and abrupt landscape change, since island flooding is likely to be widespread and persistent for a long period of time.

In sum, liquefaction may pose a serious threat to levees, especially as levees are built larger and higher to deal with continuing island subsidence. Levee failure, depending on the extent, could have disastrous effects on agriculture, natural gas supply, fisheries, and salt water intrusion of the San Francisco Bay. Water supply to California could be affected for years. A greater discussion of levee failure can be found in Section 4.2.15.

Past Occurrences

Disaster Declarations

There have been no disaster declarations due to earthquake based liquefaction.

NCDC Events

The NCDC does not track earthquakes.

HMPC Events

Sacramento County has two areas that have been suggested as posing potential liquefaction problems - the downtown area and the Delta. While there is little published geologic information on the liquefaction potential of Delta soils, a geological and seismological study in 1972 indicated that the Housing and Redevelopment Agency building site located downtown at the intersection of 7th and I Streets has a potential for liquefaction. This study also concluded that potential liquefaction problems may exist throughout the downtown area where loose sands and silts are present below the ground water table.

Although no historic examples of seismically induced levee failure are known in the Delta, the modern levee network has not been subjected to strong shaking. Levees were either smaller or non-existent in 1906 when the region was strongly shaken by the great San Francisco earthquake.

Likelihood of Future Occurrences

Occasional – Due to the presence of faults in the area, and the ever increasing height of levees protecting the Delta, there is concern that liquefaction could be a cause of levee failure. Embankment and foundation materials for most Delta levees are substandard, adding to the risk of failure during seismic events. The U.S. Geological Survey estimates that an earthquake of magnitude 6.7 or greater has a 62 percent probability of occurring in the San Francisco Bay Area between 2003 and 2032. Such an earthquake is capable of causing multiple levee failures in the Delta Region which could result in fatalities, extensive property damage and the interruption of water exports from the Delta for an extended period of time.

4.2.14. Flood: 100/200/500-year

Hazard/Problem Description

Flooding is the rising and overflowing of a body of water onto normally dry land. History clearly highlights floods as one of the most frequent natural hazards impacting Sacramento County. Floods are among the most costly 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. A car will float in less than two feet of moving water and can be swept downstream into deeper waters. This is one reason floods kill more people trapped in vehicles than anywhere else. 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, such as dam spillways. 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. Where flooding occurs in populated areas, warning and evacuation will be of critical importance to reduce life and safety impacts from any type of flooding.

Health Hazards from Flooding

Certain health hazards are also common to flood events. While such problems are often not reported, three general types of health hazards accompany floods. The first comes from the water itself. Floodwaters carry anything that was on the ground that the upstream runoff picked up, including dirt, oil, animal waste, and lawn, farm and industrial chemicals. Pastures and areas where cattle and other livestock are kept or their wastes are stored can contribute polluted waters to the receiving streams.

Floodwaters also saturate the ground, which leads to infiltration into sanitary sewer lines. When wastewater treatment plants are flooded, there is nowhere for the sewage to flow. Infiltration and lack of treatment can lead to overloaded sewer lines that can back up into low-lying areas and homes. Even when it is diluted by flood waters, raw sewage can be a breeding ground for bacteria such as e. coli and other disease causing agents.

The second type of health problem arises after most of the water has gone. Stagnant pools can become breeding grounds for mosquitoes, and wet areas of a building that have not been properly cleaned breed mold and mildew. A building that is not thoroughly cleaned becomes a health hazard, especially for small children and the elderly.

Another health hazard occurs when heating ducts in a forced air system are not properly cleaned after inundation. When the furnace or air conditioner is turned on, the sediments left in the ducts are circulated throughout the building and breathed in by the occupants. If a city or county water system loses pressure, a boil order may be issued to protect people and animals from contaminated water.

The third problem is the long-term psychological impact of having been through a flood and seeing one's home damaged and irreplaceable keepsakes destroyed. The cost and labor needed to repair a flood-damaged home puts a severe strain on people, especially the unprepared and uninsured. There is also a long-term problem for those who know that their homes can be flooded again. The resulting stress on floodplain residents takes its toll in the form of aggravated physical and mental health problems.

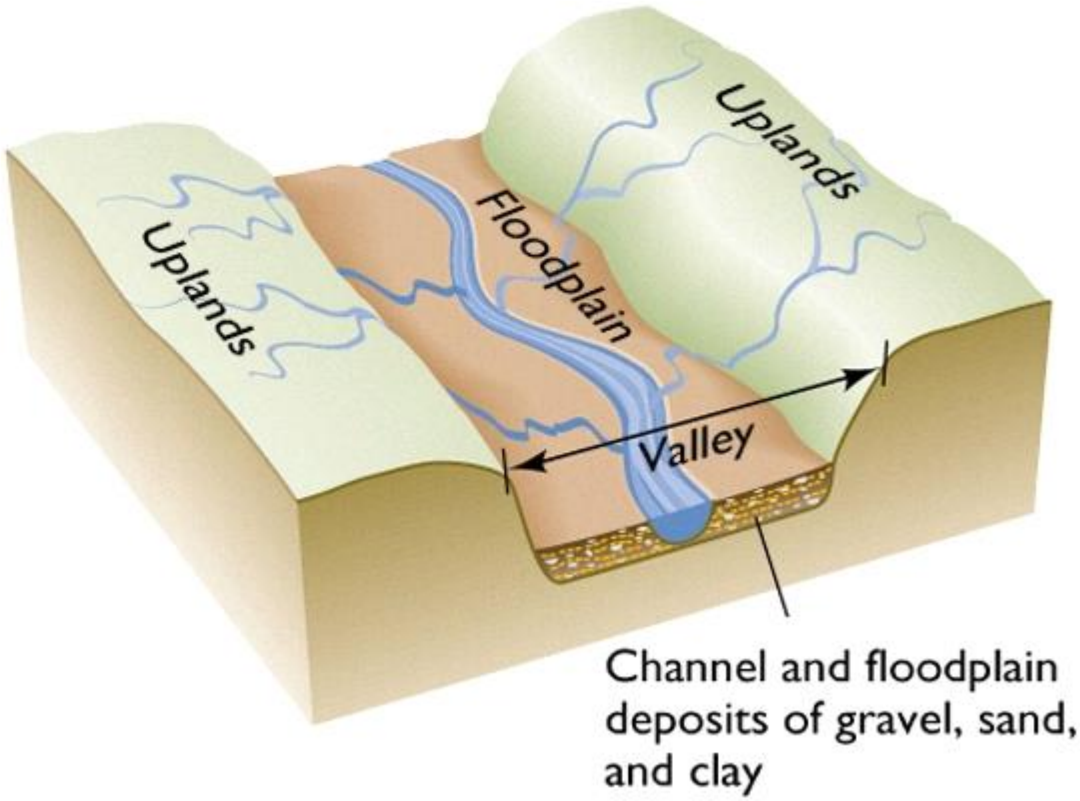
Warning and Evacuation Procedures

Sacramento County and its incorporated communities have a variety of systems and procedures established to protect its residents and visitors to plan for, avoid, and respond to a hazard event including those associated with floods and wildfires. This includes Pre-Disaster Public Awareness and Education information which is major component in successfully reducing loss of life and property in a community when faced with a potentially catastrophic incident. Much of this information is not specific to a given hazard event and is always accessible to the public on local County and City websites. Specific warning and evacuation systems and procedures include information relative to: Flood Forecasting (e.g., California Data Exchange Center), ALERT System, Warning Systems, dam protocols, evacuation procedures, and sheltering in place. Additional information on these warning and evacuation procedures as well as post-disaster mitigation policies and procedures can be found in Section 4.4, Capabilities, of this Risk Assessment and in the Emergency Management discussions in Appendix C.

Floodplains

The area adjacent to a channel is the floodplain (see Figure 4-37). Floodplains are illustrated on inundation maps, which show areas of potential flooding and water depths. In its common usage, the floodplain most often refers to that area that is inundated by the 100-year flood, the flood that has a one percent chance in any given year of being equaled or exceeded. The 100-year flood is the national minimum standard to which communities regulate their floodplains through the National Flood Insurance Program. The 200-year flood is one that has 0.5% chance of being equaled or exceeded each year. The 500-year flood is the flood that has a 0.2 percent chance of being equaled or exceeded in any given year. The potential for flooding can change and increase through various land use changes and changes to land surface, which result in a change to the floodplain. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

Figure 4-37 Floodplain Schematic



Source: FEMA

The Sacramento County Planning Area is susceptible to various types of flood events as described below.

- **Riverine flooding** – Riverine flooding, defined as when a watercourse exceeds its "bank-full" capacity, generally occurs as a result of prolonged rainfall, or rainfall that is combined with snowmelt and/or already saturated soils from previous rain events. This type of flood occurs in river systems whose tributaries may drain large geographic areas and include one or more independent river basins. The onset and duration of riverine floods may vary from a few hours to many days and is often characterized by high peak flows combined with a large volume of runoff. Factors that directly affect the amount of flood runoff include precipitation amount, intensity and distribution, the amount of soil moisture, seasonal variation in vegetation, snow depth, and water-resistance of the surface due to urbanization. In the Sacramento County Planning Area, riverine flooding can occur anytime from November through April and is largely caused by heavy and continued rains, sometimes combined with snowmelt, increased outflows from upstream dams, and heavy flow from tributary streams. These intense storms can overwhelm the local waterways as well as the integrity of flood control structures. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions. The warning time associated with slow rise riverine floods assists in life and property protection
- **Flash flooding** – Flash flooding describes localized floods of great volume and short duration. This type of flood usually results from a heavy rainfall on a relatively small drainage area. Precipitation of this sort usually occurs in the winter and spring. Flash floods often require immediate evacuation within the hour and thus early threat identification and warning is critical for saving lives.

- **Localized/Stormwater flooding** – Localized flooding problems are often caused by flash flooding, severe weather, or an unusual amount of rainfall. Flooding from these intense weather events usually occurs in areas experiencing an increase in runoff from impervious surfaces associated with development and urbanization as well as inadequate storm drainage systems.

The area is also at risk to flooding resulting from levee failures and dam failures. Dam failure flooding is discussed separately in Section 4.2.9 of this document; Levee failure flooding are discussed separately in Section 4.2.17 of this document. Regardless of the type of flood, the cause is often the result of severe weather and excessive rainfall, either in the flood area or upstream reach.

Mercury in Waterways in Sacramento County

As a result of historical releases of mercury associated with gold mining in Sacramento County, as well as in areas throughout watersheds upstream of Sacramento County, mercury contamination is a significant hazard to County residents and visitors, as well as wildlife. The State Resources Agency, as well as Cal EPA and US EPA, have recognized this contamination. The Sacramento-San Joaquin Delta, the American River, Lake Natoma, and numerous water bodies that are tributaries to them, are designated through the Clean Water Act 303d listing process as impaired water bodies due to mercury levels found in fish that so high that they are hazardous both to the human population and to wildlife. Additional water bodies in and near Sacramento are likely to be added to the 303d list in the future due to mercury contamination. Fish consumption advisories developed by the State Dept. of Public Health and the Office of Environmental and Health Hazard Assessment warn people not to eat certain types of fish caught in these waters.

Various factors in the Sacramento region can affect the amount of mercury that enters the food chain and poses a hazard to human health and the environment. Some of these factors may be subject to some level of influence by human activity. Factors that affect the hazard caused by mercury include but are not limited nutrient levels, sediment transport, streambed modification, food chain and ecological effects, fish consumption practices, management of water levels, water exports and diversions, irrigation practices, salinity, oxygen concentrations, wetland restoration and management practices, flooding of Delta islands, dredging, reservoir management, stormwater and wastewater discharges and treatment processes, source control and pollution prevention activities, and levels of mercury in sediments, water bodies, and discharges.

Major Sources of Flooding

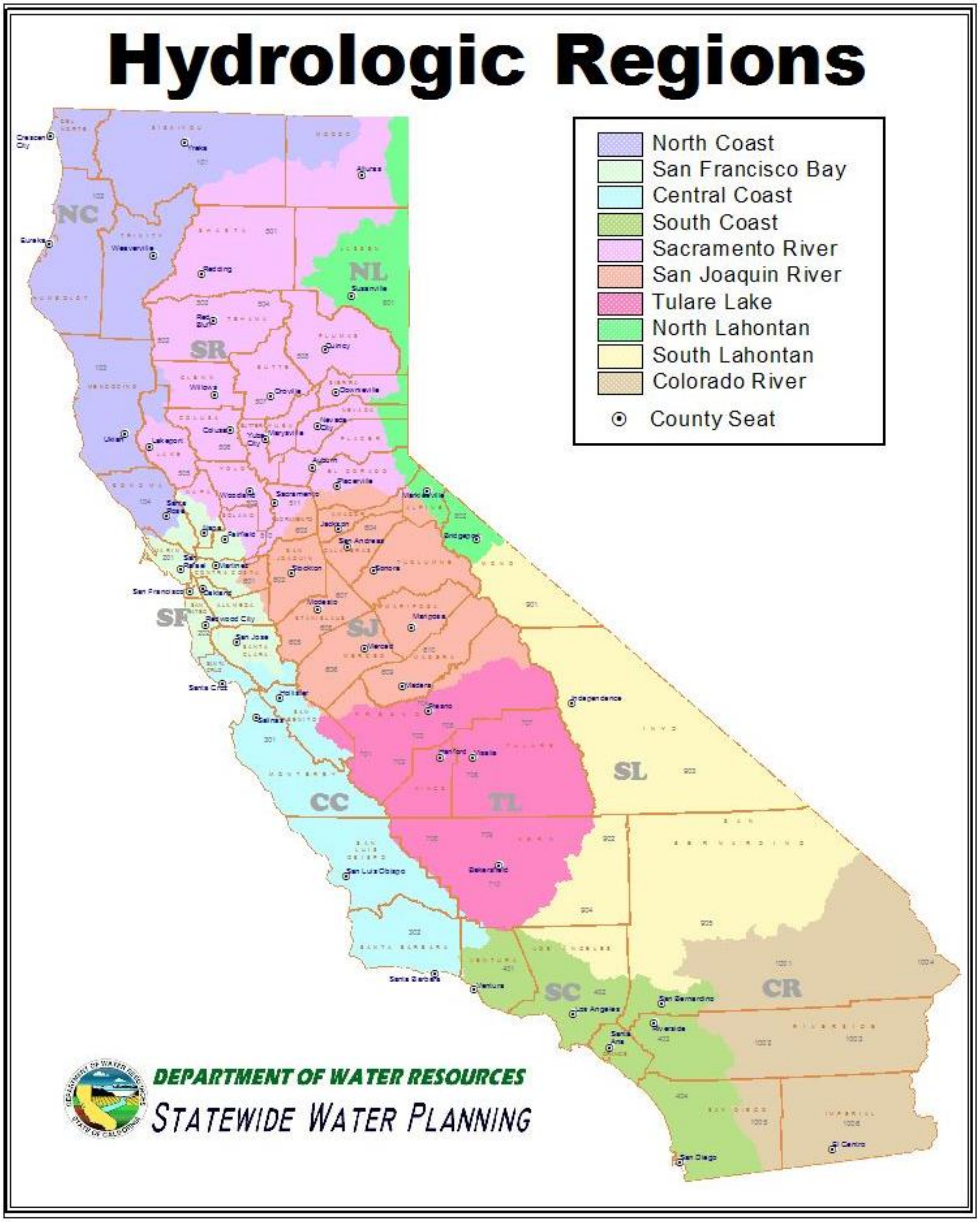
California has 10 hydrologic regions. Sacramento County sits in the Sacramento and San Joaquin hydrologic region.

- The Sacramento River hydrologic region covers approximately 17.4 million acres (27,200 square miles). The region includes all or large portions of Modoc, Siskiyou, Lassen, Shasta, Tehama, Glenn, Plumas, Butte, Colusa, Sutter, Yuba, Sierra, Nevada, Placer, Sacramento, El Dorado, Yolo, Solano, Lake, and Napa counties. Small areas of Alpine and Amador counties are also within the region. Geographically, the region extends south from the Modoc Plateau and Cascade Range at the Oregon border, to the Sacramento-San Joaquin Delta. The Sacramento Valley, which forms the core of the region, is bounded to the east by the crest of the Sierra Nevada and southern Cascades and to the west by the crest of the Coast Range and Klamath Mountains. The Sacramento metropolitan area and surrounding communities form the major population center of the region. With the exception of Redding, cities and towns to the north, while steadily increasing in size, are more rural than urban in nature, being based in major agricultural areas.

- The San Joaquin River hydrologic region covers approximately 9.7 million acres (15,200 square miles) and includes all of Calaveras, Tuolumne, Mariposa, Madera, San Joaquin, and Stanislaus counties, most of Merced and Amador counties, and parts of Alpine, Fresno, Alameda, Contra Costa, Sacramento, El Dorado, and San Benito counties. Significant geographic features include the northern half of the San Joaquin Valley, the southern part of the Sacramento-San Joaquin Delta, the Sierra Nevada and Diablo Range. The region is home to about 1.6 million people.

A map of the California's hydrological regions is provided in Figure 4-38.

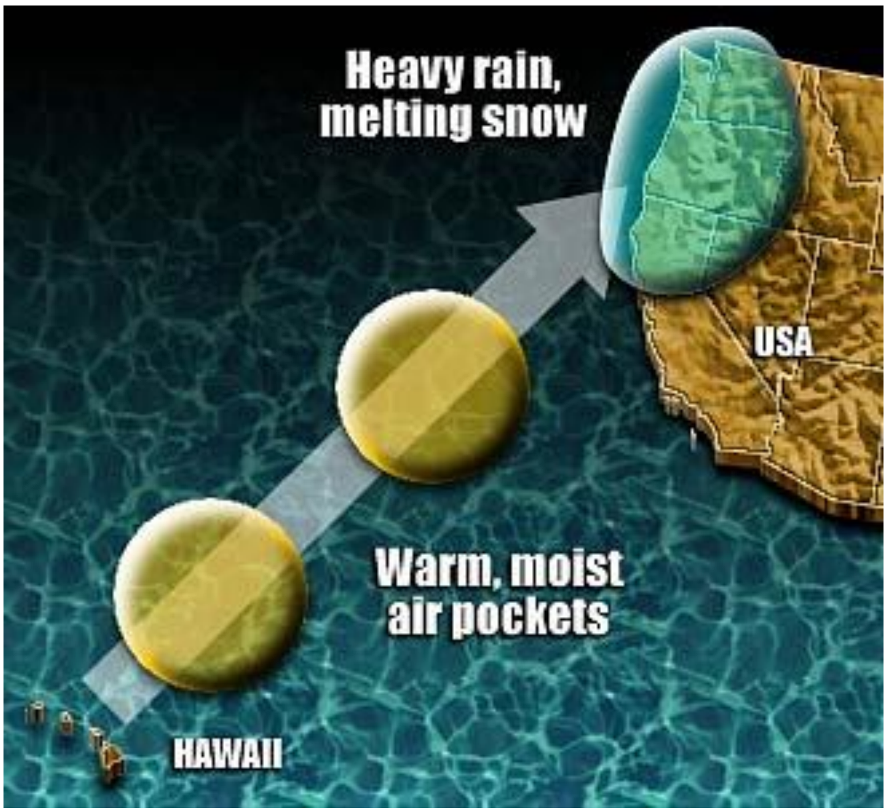
Figure 4-38 California Hydrologic Regions



Source: California Department of Water Resources

A weather pattern called the "Pineapple Express" contributes to the flooding potential of the area. A pineapple express brings warm air and rain to West. A relatively common weather pattern brings southwest winds to the Pacific Northwest or California, along with warm, moist air. The moisture sometimes produces many days of heavy rain, which can cause extensive flooding. The warm air also can melt the snow pack in the mountains, which further aggravates the flooding potential. In the colder parts of the year, the warm air can be cooled enough to produce heavy, upslope snow as it rises into the higher elevations of the Sierra Nevada or Cascades. Forecasters and others on the West Coast often refer to this warm, moist air as the "Pineapple Express" because it comes from around Hawaii where pineapples are grown. This is shown in Figure 4-39.

Figure 4-39 Pineapple Express Weather Pattern



Source: USA TODAY research by Chad Palmer http://www.usatoday.com/weatherwpinappl.htm

The Sacramento County Waterway System

In the Sierra Nevada Mountains, small creeks and high streams are fed by underground springs, storm run-off, and melting snow. Descending from the upper watershed, these creeks and streams form large rivers such as the Sacramento, American, Feather, Yuba, San Joaquin, Mokelumne, and Consumnes. These waterways are characterized by: small river beds conveying normal flow from the mountains and wide overbank floodplains carrying flood flows cause by heavy mountain rainfall. The Sacramento River Watershed, which includes the American River, encompasses some 27,000 square miles and drains most of Northern California.

The watersheds of Sacramento County include numerous watersheds contained within the County as well as several watersheds that drain into Sacramento County from Placer, El Dorado, or Amador Counties. Figure 4-40 illustrates the watersheds of Sacramento County. Table 4-32 details the watersheds in Sacramento County.

Figure 4-40 Sacramento County Watersheds

Table 4-32 Watersheds in Sacramento County

Watershed Name	Area (acres)	Watershed Name	Area (acres)
Alder Creek	7,226	Hadselville Creek	11,759
Antelope Creek	973	Hagginbottom	2,571
Arcade Creek	6,508	Hagginwood Creek	885
Arcade Creek South Branch	1,657	Hen Creek	4,759
Arkansas Creek	4,768	Laguna Creek	21,176
Badger Creek	11,109	Laguna Creek (South)	32,471
Beach-Stone Lake	40,118	Linda Creek	3,580
Bear Slough	2,699	Little Deer Creek	1,040
Boyd Creek	2,201	Magpie Creek	3,789
Brooktree Creek	1,180	Manlove	1,987
Browns Creek	8,077	Mariposa Creek	812
Buffalo Creek	9,167	Mayhew Slough	2,954
Carmichael Creek	2,726	Minnesota Creek	1,095
Carson Creek	6,811	Morrison Creek	34,502
Chicken Ranch Slough	3,722	Natomas Basin	26,449
Cordova/Coloma Stream Group	1,728	Negro Slough	285
Cosumnes River	45,130	NEMDC Trib 1	865
Courtland	3,099	NEMDC Trib 2	2,744
Coyle Creek	987	NEMDC Trib 3	1,567
Coyote Creek	4,625	North Delta	100,143
Crevis Creek	5,940	North Fork Badger Creek	10,423
Cripple Creek	4,327	Robla Creek	5,141
Date Creek	694	Rolling Draw Creek	1,128
Deadmans Gulch	8,641	San Juan Creek	1,334
Deer Creek	26,125	Sierra Branch	978
Diablo Creek	893	Sierra Creek	1,743
Dry Creek	4,138	Skunk Creek	6,744
Dry Creek (South)	20,158	Slate Creek	510
East Antelope	1,118	Strawberry Creek	5,588
East Natomas	1,816	Strong Ranch Slough	4,573
Elder Creek	7,632	Sunrise Creek	636
Elk Grove Creek	4,019	Unionhouse Creek	2,194
Fair Oaks Stream Group	7,819	Unnamed	51,157
Florin Creek	2,857	Verde Cruz Creek	1,226
Frye Creek	1,286	Whitehouse Creek	1,585

Watershed Name	Area (acres)	Watershed Name	Area (acres)
Gerber Creek	2,579	Willow Creek	15,207
Griffith Creek	4,806	Willow Creek (Middle)	359
Grizzly Slough	1,374	Willow Creek (South)	3,843

Source: Sacramento County GIS

Sacramento County encompasses multiple rivers, streams, creeks, and associated watersheds. Figure 4-41 illustrates the major waterways of Sacramento County. The following streams in Table 4-33, listed by stream groups, are found in Sacramento County.

Figure 4-41 Sacramento County Major Waterways

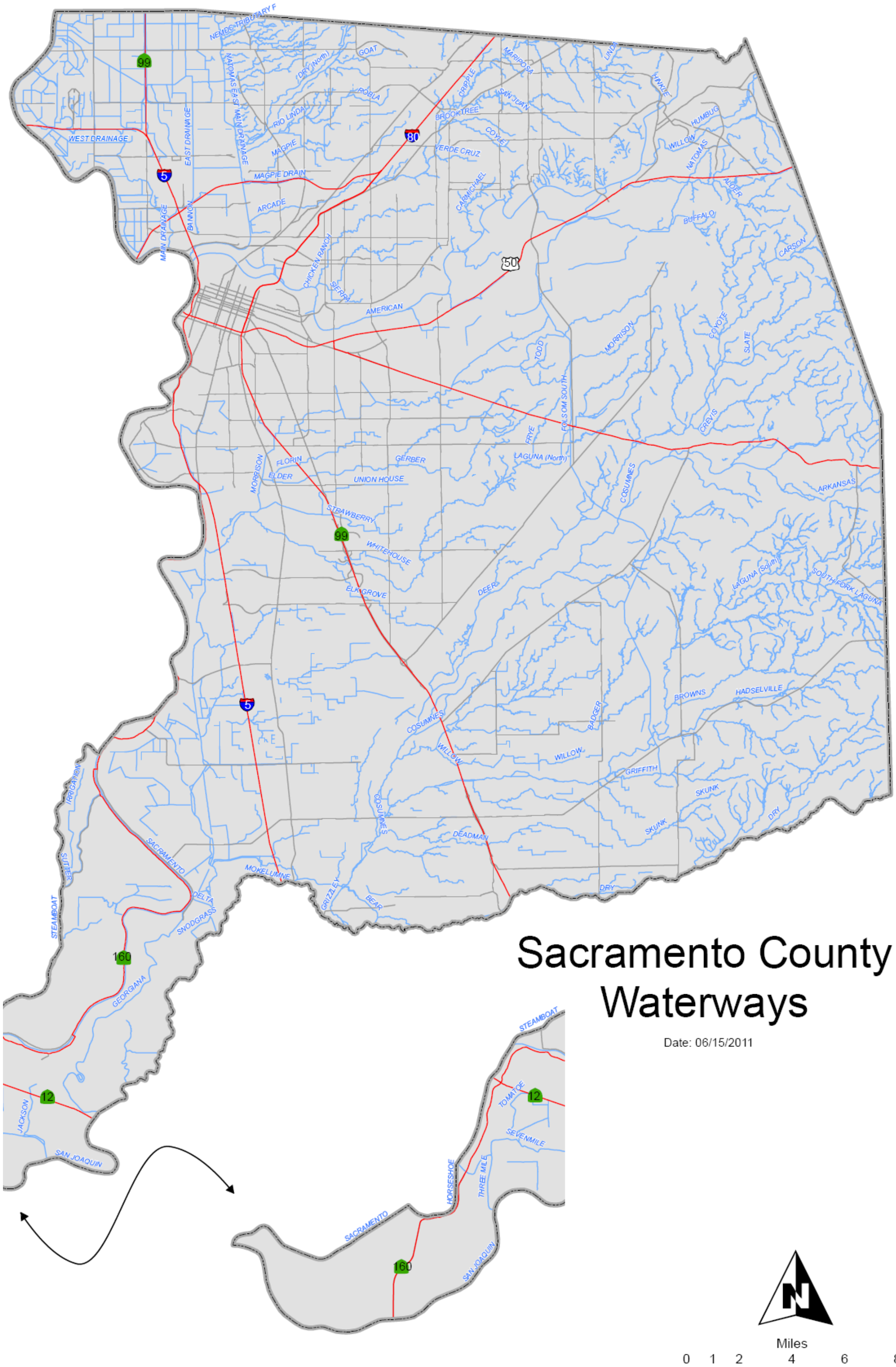


Table 4-33 Waterways and Streams in Sacramento County

Stream Group and Stream	
American River Stream Group	
American River	Magpie Creek
Arcade Creek	Mariposa Creek
Arcade Creek (South Branch)	Natomas East Main Drainage Canal
Brooktree Creek	Natomas East Main Drainage Canal Tributary 1
Carmichael Creek	Natomas East Main Drainage Canal Tributary 2
Chicken Ranch Slough	Natomas East Main Drainage Canal Tributary 3
Cripple Creek	Robla Creek
Coyle Creek	San Juan Creek
Dry Creek	Sierra Creek
Dry Creek (North Branch)	Strong Ranch Slough
Linda Creek	Verde Cruz Creek
Morrison Creek Stream Group	
Elder Creek	Morrison Creek
Elk Grove Creek	North Fork Laguna Creek
Florin Creek	Strawberry Creek
Gerber Creek	Unionhouse Creek
Laguna Creek	Whitehouse Creek
Laguna Creek Tributary 1	
Sacramento River And Delta Slough Group	
Georgiana Slough	Steamboat Slough
Sacramento River	Sutter Slough
Sevenmile Slough	Three Mile Slough
San Joaquin River Stream Group	
Delta Cross Canal	San Joaquin River
Mokelumne River	Snodgrass Slough
North Mokelumne River	
Natomas Area Stream Group	
Natomas East Drainage Canal	Deer Creek
Natomas Main Drainage Canal	Dry Creek
Natomas North Drainage Canal	Hadselville Creek
Natomas West Drainage Canal	Hen Creek
Arkansas Creek	Laguna Creek
Badger Creek	North Fork Badger Creek
Browns Creek	North Stone Lake Tributary

Stream Group and Stream	
Carson Creek	Skunk Creek
Cosumnes River	South Stone Lake-North Tributary
Cosumnes River Overflow	South Stone Lake-South Tributary
Crevis Creek	Willow Creek
Deadman Gulch	

Source: Sacramento County Flood Insurance Study, 2008

In Sacramento County, there are three main rivers, the Sacramento, American and Cosumnes Rivers. The Sacramento and American Rivers and several tributaries to the east, north, and west all flow toward the City of Sacramento. The watersheds of these two main rivers drain most of northern California and part of southern Oregon for a total of some 26,000 square miles. The third, the Cosumnes River, flows southwesterly through the southern portion of the County and into the Delta.

The Sacramento River extends north to Mount Shasta and the Shasta Reservoir. Many other rivers are tributary to the Sacramento, including (immediately north of Sacramento) the Bear and Feather Rivers. The American River extends to the Sierra Nevada foothills in three branches (South, North and Middle). Folsom Reservoir is at the eastern boundary of Sacramento County and serves to control the American River.

The Cosumnes River is a wild and natural river originating in the Sierra Nevada foothills, flowing into southern Sacramento County. This area is mostly rural farmland. Levees were constructed by agricultural interests, and they are inadequate for containing record storm flows such as those experienced in February 1986 and again in January 1997. These two storms left the levee system sorely damaged. Each time, the levee breaks were repaired, but the overall system sits in wait of another flood event.

Another river, the Mokelumne River is the southernmost river in the County and is controlled by a dam in the neighboring county and a series of levees.

All of the watersheds converge at the Sacramento River Delta, the flood issues in the Delta are of concern as the agricultural interests continue to farm the land which is subsiding annually, making the levee systems more vulnerable to breaching.

When the Sacramento River reaches its peak capacity, the American River and other tributaries that flow into the Sacramento River, cannot flow at a normal rate. These conditions result in "backflows' which cause tributaries to overflow and flood local areas. The Sacramento River is also affected by ocean tides that periodically raise and lower the water level. High tides that occur simultaneously with flooding conditions could increase the rate of flooding.

All surface water originating in or passing through Sacramento County discharges to the ocean via the Sacramento and San Joaquin Rivers, which join at the head of Suisun Bay, the easternmost arm of San Francisco Bay. With a combined tributary drainage area of approximately 60,000 square miles, these rivers provide most of the freshwater inflow to San Francisco Bay.

High water levels along the Sacramento and American Rivers are a common occurrence in the winter and early spring months due to increased flow from storm runoff and snowmelt. An extensive system of dams, levees, overflow weirs, drainage pumping plants, and flood control bypass channels strategically located on the Sacramento and American Rivers has been established to protect the area from flooding. These facilities control floodwaters by regulating the amount of water passing through a particular reach of the river. The amount of water flowing through the levee system can be controlled by Folsom Dam on the American River and the reserve overflow area of the Yolo Bypass on the Sacramento River. However, flood problems in Sacramento County are still quite a concern, especially since the flood of 1986. Numerous areas of the county are still subject to flooding by the overtopping of rivers and creeks, levee failures, and the failure of urban drainage systems that cannot accommodate large volumes of water during severe rainstorms. However, with the implementation of multiple improvements to the area's flood control structures, including those designed to provide a 200+ level of flood protection, flood risk is being reduced including the potential for devastating floods in the Planning Area.

High flows on the Cosumnes River are less frequent, as the river is essentially dam free and has little in the way of flow regulation. Flooding along the river, such as in 1997, has been due to high water coupled with the failure of non-standard, poorly constructed private levees.

The Sacramento County Flood Control System and Associated Flood Issues

Sacramento County is protected from the American River and Sacramento River by a comprehensive system of dams, levees, overflow weirs, and flood bypasses. Local creeks are often controlled by detention basins that attenuate peak flow by allowing flood water to spill over a weir, detained, and released when the creek subsides. Sacramento County maintains a system of ALERT Flood Warning gages throughout the County that provide real time monitoring information on current flood conditions (www.stormready.org).

In the aftermath of the 1986 and 1997 floods, multiple flood control projects were identified to address flood risks in the Sacramento area. Many of these projects were designed to correct structural deficiencies, others to address levee conditions, while additional projects were intended to increase the level of flood protection provided by the system. The Sacramento River improvements would focus predominantly on rehabilitating the existing system, while the American River required a significant increase in the system's flood control capacity.

Established in 1989, Sacramento Area Flood Contol Agency (SAFCA) is a regional joint-exercise-of-powers agency consisting of Sacramento and Sutter counties, the City of Sacramento, Reclamation District 1000, and the American River Flood Control District. SAFCA's long-term goal is to provide the urbanized portions of Sacramento with a minimum 200-year level of flood protection in order to reduce the risk of catastrophic damages and loss of life associated with a failure of the flood control system in the Sacramento area. SAFCA initiated a number of studies to determine the best implementable approach to address the area's flood problems. These flood control projects are in various stages of implementation; some have been completed, others are under construction, and a number are still being planned.

American River Flood Control System

The American River flood control system consists of the Folsom Dam, an auxiliary dam at Mormon Island, eight earth-filled dikes, Nimbus Dam, and levees on either side of the downstream river. The system receives runoff from the American River watershed, which contains about 2,100 square miles of the western slope in the Sierra Nevada.

An initial reconnaissance report, "American River Investigation, January 1988" concluded that Folsom Dam and the American River levees were only capable of handling a 70-year flood event. Recommendations were to increase the carrying capacity of the American River below Nimbus Dam, modifying the Folsom Dam spillage, increasing storage capacity at Folsom Lake, and for greatest protection (200-year level), construct a new upstream storage facility. Immediately after the Folsom Dam was completed in 1956, a huge flood filled the reservoir, saving Sacramento. Recently, the dam protected the county from at least four potentially catastrophic floods in 1986, 1995, 1997, and 2005.

American River Common Features and Folsom Dam

SAFCA and the Central Valley Flood Protection Board (CVFPB), working with US Army Corp of Engineers (USACE), identified an American River project to address the low level of flood protection provided by the existing system. Unable to gain support for construction of an expandable flood control dam near Auburn, SAFCA identified a series of American River Common Features and Folsom Dam improvement projects. The Common Features projects focused on the identification of features that were "common" to any project associated with controlling flood flows at Folsom Dam. These projects focused on the conveyance of higher flood flows through the leveed portion of the American River. Once completed, these improvements, along with additional American River improvement projects described below, allow passage of 160,000 cfs through the American River levee system. The Folsom Dam Raise and Auxiliary Spillway Project identified an auxiliary spillway alternative with a 3.5 foot dam raise that would provide at least a 200-year level of protection for the community.

American River-Related Projects

Additional projects have significantly improved the capacity and flows of the American River levee system. These include:

- Mayhew levee Improvements – This entailed raising and widening the levee and constructing a slurry wall, providing for 160,000 cfs to pass and providing 100-year level of protection. The Mayhew Drain Closure Structure project completed in 2009 prevents water from the American River from backing up the drain and putting additional strain on drain levees.
- Upper Levee Slope Protection – Levee slope protection measures were implemented in the area between Cal Expo to Rio Americano High School, the narrowest portion of the American River Parkway to prevent high scour velocities on the upper face of the levee during flood events.
- Slurry Wall Construction – Approximately 23 miles of slurry walls were constructed to prevent underseepage from affecting the levee foundation due to sand layers under the levee.
- Bank Protection – Portions of the American River are subject to extremely high velocities during a major flood event, eroding banks and levee toes, leading to levee failure. Several projects have been completed preserving levee integrity and providing additional protection during floods.
- Regional Sanitation Perimeter Levee – In order to protect the regional sanitation plan from flooding, a perimeter levee was required.

The Sacramento River Flood Control System

The Sacramento River flood control system consists of the several dams including Shasta and Oroville (on the Feather River), the Fremont Weir, Sacramento Weir, Yolo Bypass, and levees along the Sacramento River, and the Sacramento Bypass Channels. The Corps report "Sacramento River System Evaluation, June 1988" revealed that levees on both the Sacramento and American Rivers have inadequate freeboard and/or stability problems.

Sacramento River Projects

Several projects have been identified to rehabilitate the existing flood control system and work towards providing a minimum of 200-year level of flood protection in the urbanized portions of the Sacramento County Planning Area. Key projects include:

- Sacramento Urban Area Levee Reconstruction Project (SUALRP) – This project addressed through-levee seepage problems (i.e., landside sloughing of the levee in Natomas and seepage boils along the landside toe in the Pocket) within the Sacramento River Flood Control System (SRFCS) due to porous levee materials and poor compaction. This project improved flood protection but did not increase the design level of flood protection.
- The Sacramento Riverwall - A project feature of the SRFCS, is a concrete floodwall adjacent to old Sacramento. Due to erosion issues on the waterside toe and design deficiencies found with original construction, reconstruction of the Riverwall was addressed and improves flood protection to Old Sacramento, downtown, and portions of Interstate 5.
- Levee Slump on Garden Highway south of I-6 – To correct settling in an area of the levee near an agricultural well, a Slurry cutoff wall was constructed to prevent levee seepage and to raise the levee back to its original height. This seepage fix was designed to provide 200-year level of protection.
- Little Pocket and Sump 132 Underseepage Remediation – This project entailed construction of an approximately 2,400 feet of a levee underseepage cutoff wall in the Little Pocket area and 400-feet of levee underseepage cutoff wall construction at Sump 132 in the Pocket area. To address know underseepage problems. The project was designed to protect against the 200-year storm event.
- Pocket Underseepage – Reach 2 and Reach 9 – This project entailed construction of an approximately 2,500 feet of cutoff wall to address underseepage issues. Completion of this project along with erosion repairs provided a minimum of 100-year level of flood protection.
- Sacramento River Bank Protection Program (Sac bank) – this is an ongoing effort to address systematic erosion issues along the Sacramento River and its tributaries, including the American River. Erosion, primarily caused by high water events, which lead to scour and high bank erosion and summer boat traffic, which creates wave induced erosion at the levee toe.
- Pioneer Reservoir – Pioneer Reservoir is located along the Sacramento River just upstream of the California Auto Museum. This project constructed a seepage berm and six relief wells to address high seepage pressures in the area.

South Sacramento Streams Group (SSSG)

USACE, in cooperation with SAFCA and the City and County of Sacramento completed a study of alternatives, including both upstream detention and modifications to the downstream levee system. Results of the study supported work to be done to the existing Morrison Creek levees as well as to the Unionhouse, Florin, and Elder Creek levees. The County is also collecting development impact fees from upstream developers, which will be used to build detention basins to hold the additional run-off generated as new development occurs.

The Morrison Creek System

In 1987, the USACE in a study concluded that the levees and channels lacked adequate capacity to handle the 100-year storm. In 2005, USACE completed construction of nearly four miles of levee from Freeport Boulevard/Sacramento River Levee on the west to the Union Pacific Railroad to the east, raising the existing levee system to protect against a 200-year storm. USACE also constructed floodwalls along the four creeks (Elder, Unionhouse Florin, and Morrison) up to Franklin Boulevard.

Unionhouse Creek Channel Improvements

Channel improvements completed in 2012 increased the amount of water that can be contained I the channel, resulting in 100-year flood protection.

Florin Creek Improvements

Channel improvements in this area, combined with plans to construct a detention basin along Florin Creek will provide FEMA level of flood protection along much of Florin Creek.

The Natomas Area

After the 1986 flood demonstrated the inadequacy of the levee system in this area, efforts ensued to implement a series of levee improvements and other flood control improvements designed to address through-levee seepage and work in tandem with increased storage on the American River to provide affected areas with increased flood protection. This project provided a minimum 100-year level of flood protection to the Natomas Basin and to the lower Dry and Arcade Creek watersheds, including portions of Rio Linda and North Sacramento.

A huge development effort followed including residential in the incorporated City and commercial/industrial in the unincorporated County of Sacramento. The Natomas area includes about 70,000 residents, both Interstates 5 and 80, Sacramento Airport, and significant commercial and industrial development. Natomas is protected from flooding by levees on all sides. Some believe Natomas to be threatened by high probability flood events, but the fact remains that the area has never suffered a levee breach.

December 2008, FEMA remapped the Natomas Area as not having protection from the 1% annual recurrence flood event, and SAFCA kicked off a massive effort to improve the levees. SAFCA's efforts have been to restore at a minimum a 100-year level of protection, while working toward 200-year level of protection.

The Delta Region

The Delta Region lies within a floodplain and is faced with a major flooding problem because of inadequate levee construction and maintenance, subsidence, seepage, erosion and seismicity. Flood fighting has occurred in some part of the Delta on the average of once every four years. While most of the Delta levees in Sacramento County have stood the test of time, they defy engineering logic. Their foundations are soft and uncertain, they have a great deal of vegetation including large trees, and they suffer erosion and sloughing due to river velocity and wind wave wash. Nevertheless, they have served the county very well over many years.

The Delta Islands are subsiding due to lower groundwater, aeration of peat soils, and loss of soil to wind. While some believe the rate has been curbed over the past years due to conservation protocols, the fact is that some islands are 15' below sea level. The levees work much harder than they did a hundred years ago.

Some of the Delta levees essentially serve as a dam repressing hydrostatic pressure every day of the year. This leads some researchers to conclude that the potential for catastrophic failure of the Delta levees due to a seismic event has a concerning probability.

Ongoing and Planned Improvements to the Existing Flood Control Systems

There are currently six federally authorized projects that are being implemented to reduce flood risk to the Sacramento area:

- Natomas Levee Improvement Project
- American River Common Features
- Folsom Dam Modifications/Join Federal Project
- Folsom Dam Raise project
- South Sacramento Streams Group Project
- Sacramento River Bank Protection Program

Other ongoing projects include:

- SAFCA levee accreditation for FEMA level of protection
- Regional planning as part of the Central Valley Flood Protection Plan
- USACE-CVFPB-SAFCA General Reevaluation Report (GRR) planning for 200-year flood protection for Sacramento area
- SAFCA and local community plan development for 200-year flood protection to meet state requirements for urban Level of Protection and Urban Levee Design Criteria.

Details on these projects are provided in Section 4.4.1, Capabilities.

Sacramento County Flood Mapping and Flood Protection Measures

As part of the County's ongoing efforts to identify and manage their flood prone areas, Sacramento County relies on a variety of different mapping efforts. What follows is a brief description of FEMA and State of California DWR mapping efforts and related flood protection measures covering the Sacramento County Planning Area.

FEMA Floodplain Mapping

FEMA established standards for floodplain mapping studies as part of the National Flood Insurance Program (NFIP). The NFIP makes flood insurance available to property owners in participating communities adopting FEMA-approved local floodplain studies, maps, and regulations. Floodplain studies that may be approved by FEMA include federally funded studies; studies developed by state, city, and regional public agencies; and technical studies generated by private interests as part of property annexation and land development efforts. Such studies may include entire stream reaches or limited stream sections depending on the nature and scope of a study. A general overview of floodplain mapping is provided in the following paragraphs. Details on the NFIP and mapping specific to the County and participating jurisdictions are in Section 4.3 Vulnerability Assessment and in the jurisdictional annexes.

Flood Insurance Study (FIS)

The FIS develops flood-risk data for various areas of the community that will be used to establish flood insurance rates and to assist the community in its efforts to promote sound floodplain management. The current Sacramento County FIS is dated June 16, 2015. This study covers both the unincorporated and incorporated areas of the County.

Flood Insurance Rate Map (FIRM)

The FIRM is designed for flood insurance and floodplain management applications. For flood insurance, the FIRM designates flood insurance rate zones to assign premium rates for flood insurance policies. For floodplain management, the FIRM delineates 100- and 500-year floodplains, floodways, and the locations of selected cross sections used in the hydraulic analysis and local floodplain regulation. The County FIRMs have been replaced by digital flood insurance rate maps (DFIRMs) as part of FEMA's Map Modernization program, which is discussed further below.

Letter of Map Revision (LOMR) and Map Amendment (LOMA)

LOMRs and LOMAs represent separate floodplain studies dealing with individual properties or limited stream segments that update the FIS and FIRM data between periodic FEMA publications of the FIS and FIRM.

Digital Flood Insurance Rate Maps (DFIRM)

As part of its Map Modernization program, FEMA is converting paper FIRMS to digital FIRMs, DFIRMS. These digital maps:

- Incorporate the latest updates (LOMRs and LOMAs);
- Utilize community supplied data;
- Verify the currency of the floodplains and refit them to community supplied basemaps;
- Upgrade the FIRMs to a GIS database format to set the stage for future updates and to enable support for GIS analyses and other digital applications; and
- Solicit community participation.

DFIRMs for Sacramento County have been developed. The most recent DFIRMs, dated June 16, 2015, was used for the flood analysis for this LHMP Update.

Mapping of Levees

Also as part of FEMA's Map Modernization program, FEMA is mapping levees within communities, with a primary focus on maps determined to provide a 100-year level of flood protection.

In August of 2005, FEMA Headquarters' issued Memo 34 Interim Guidance for Studies Including Levees. This memo recognizes the risk and vulnerability of communities with levees. The memo mandates the inclusion of levee evaluations for those communities that are undergoing map changes such as the conversion to DFIRMs. No maps can become effective without an evaluation of all levees within a community against the criteria set forth in 44 CFR 65.10 Mapping of Areas Protected by Levee Systems. Generally, these levee certification requirements include evaluations of freeboard, geotechnical stability and seepage, bank erosion potential due to currents and waves, closure structures, operations and maintenance, and wind wet and wave run-up. In short, these guidelines require certification of levees before crediting any levee with providing protection from the 1 percent annual event (e.g., the 100-year flood).

In Sacramento County, similar to other locations in California, levees and flood control facilities have been built and are maintained variously by public and private entities, including water, irrigation and flood control districts, other state and local agencies, and private interests. Some of these facilities were constructed with flood control as secondary or incidental to their primary purpose, so are not considered as providing protection from the 100-year or greater flood. Levees in the County are discussed in Section 4.2.17 of this plan.

Other Floodplain Maps and Measures: Department of Water Resources

Also to be considered when evaluating the flood risks in Sacramento County are various floodplain maps and measures implemented by Cal DWR for various areas throughout California, and in the Sacramento-San Joaquin Valley cities and counties.

DWR Flood Awareness Maps

The Flood Awareness Maps, developed under the Flood Awareness Mapping Project, are designed to identify all pertinent flood hazard areas by 2015 for areas that are not mapped under the FEMA NFIP and to provide the community and residents an additional tool in understanding potential flood hazards currently not mapped as a regulated floodplain. The awareness maps identify the 100-year flood hazard areas using approximate assessment procedures. The floodplains are shown on these maps simply as flood prone areas without specific depths and other flood hazard data. The Flood Awareness Maps can be accessed online at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fes/awareness_floodplain_maps/. These maps are included in the levee profile in Section 4.2.17.

State Flood Protection Measures

Senate Bills (SB) 5 and 17 and Assembly Bills (AB) 5, 70, 156, and 162 (Legislation) were signed into law in 2007 to address flood problems, direct use of bond funds, and support local land-use planning. As part of this Legislation, DWR was required to develop a Central Valley Flood Protection Plan (CVFPP). The CVFPP was adopted in 2012 and will be updated every 5 years. In 2012, SB1278 and AB1965 were enacted, revising provisions related to planning and zoning for flood protection.

In accordance with this legislation, communities will be required to make findings related to an urban level of flood protection as stipulated in California Government Code Sections 65865.5, 65962, and 66474.5, using criteria consistent with, or developed by DWR after July 2016. DWR has developed draft criteria, Urban Level of Flood Protection (ULOP) (November 2013).

The ULOP requires a minimum urban level of 200-year flood protection before a community can issue a building permit or approve a parcel map. This requirement affects areas in the Sacramento-San Joaquin Valley where flood depths are anticipated to exceed three feet and are in a watershed greater than 10 square miles for the 200-year flood event. If a ULOP plan is in place to reach 200-year flood protection and adequate progress is shown annually, then these requirements can be delayed until 2025.

The Legislation also requires DWR to propose updated requirements to the California Building Standards Code for adoption and approval by the California Building Standards Commission. These requirements apply to construction in the Sacramento and San Joaquin valleys, where flood levels are anticipated to exceed three feet for a 200-year flood event.

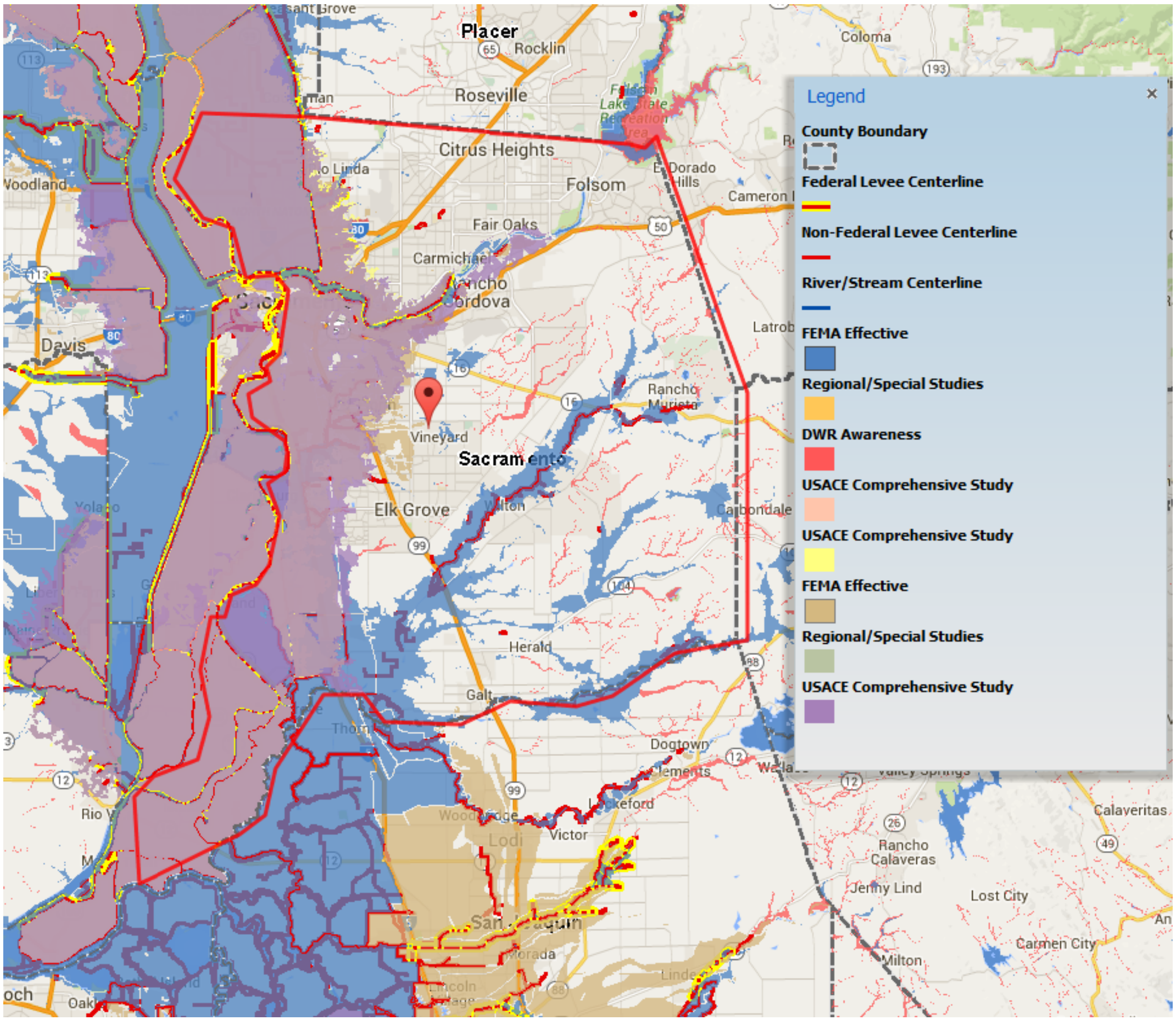
California Department of Water Resources Best Available Maps (BAM)

The FEMA regulatory maps provide just one perspective on flood risks in Sacramento County. Senate Bill 5 (SB 5), enacted in 2007, authorized the California DWR to develop the Best Available Maps (BAM) displaying 100- and 200-year floodplains for areas located within the Sacramento-San Joaquin (SAC-SJ) Valley watershed. SB 5 requires that these maps contain the best available information on flood hazards and be provided to cities and counties in the SAC-SJ Valley watershed. This effort was completed by DWR in 2008. DWR has expanded the BAM to cover all counties in the State and to include 500-year floodplains.

Different than the FEMA DFIRMs which have been prepared to support the NFIP and reflect only the 100-year event risk, the BAMs are provided for informational purposes and are intended to reflect current 100-, 200-, and 500-year event risks using the best available data. The 100-year floodplain limits on the BAM are a composite of multiple 100-year floodplain mapping sources. It is intended to show all currently identified areas at risk for a 100-year flood event, including FEMA's 100-year floodplains. The BAM are comprised of different engineering studies performed by FEMA, Corps, and DWR for assessment of potential 100-, 200-, and 500-year floodplain areas. These studies are used for different planning and/or regulatory applications. They are for the same flood frequency; however, they may use varied analytical and quality control criteria depending on the study type requirements.

The value in the BAMs is that they provide a bigger picture view of potential flood risk to the Sacramento County Planning Area than that provided in the FEMA DFIRMs. This provides the community and residents with an additional tool for understanding potential flood hazards not currently mapped as a regulated floodplain. Improved awareness of flood risk can reduce exposure to flooding for new structures and promote increased protection for existing development. Informed land use planning will also assist in identifying levee maintenance needs and levels of protection. By including the FEMA 100-year floodplain, it also supports identification of the need and requirement for flood insurance. Figure 4-42 shows the BAM for the Sacramento County Planning Area. BAM maps for each jurisdiction are included in their respective annexes.

Figure 4-42 Sacramento County Planning Area – Flood Awareness (Best Available) Map



Source: California DWR

Legend explanation: Blue - FEMA 100-Year, Orange – Local 100-Year (developed from local agencies), Red – DWR 100-year (Awareness floodplains identify the 100-year flood hazard areas using approximate assessment procedures.), Pink – USACE 100-Year (2002 Sac and San Joaquin River Basins Comp Study), Yellow – USACE 200-Year (2002 Sac and San Joaquin River Basins Comp Study), Tan – FEMA 500-Year, Grey – Local 500-Year (developed from local agencies), Purple – USACE 500-Year (2002 Sac and San Joaquin River Basins Comp Study).

Past Occurrences

Disaster Declaration History

A search of FEMA and Cal OES disaster declarations turned up multiple events. Most of the disaster declarations in the County have been related to flooding. Of the 17 federal declarations in the County, 12 were for flood. Of the 11 remaining state declarations, 8 were for flood. Many disasters in the Severe Weather: Heavy Rains profile in Section 4.2.5 also resulted in flood declarations.

NCDC Events

The NCDC tracks flooding events for the County. Events have been tracked for flooding since 1993. Table 4-34 shows events in Sacramento County since 1993. Events with damages, deaths, or injuries are detailed below the table. USDA Secretarial Disaster Declarations associated with drought are included in Table 4-21 in Section 4.2.7.

Table 4-34 NCDC Flood Events in Sacramento County 1993 to 12/31/2015

Date	Event	Deaths (direct)	Injuries (direct)	Property Damage	Crop Damage	Injuries (indirect)	Deaths (indirect)
1/2/1997	Flash Flood	1	0	$2,400,000	$0	0	0
1/22/1997	Flash Flood	0	0	$1,500,000	$0	0	0
1/26/1997	Flash Flood	0	0	$500,000	$0	0	0
1/26/1997	Flash Flood	0	0	$0	$0	0	0
12/12/1996	Flood	0	0	$0	$0	0	0
1/1/1997	Flood	0	0	$0	$0	0	0
1/1/1997	Flood	0	0	$0	$0	0	0
2/2/1998	Flood	0	0	$0	$0	0	0
2/2/1998	Flood	0	0	$0	$0	0	0
2/2/1998	Flood	0	0	$4,300,000	$7,800,000	0	0
2/2/1998	Flood	1	0	$0	$0	0	0
2/7/1999	Flood	0	0	$0	$0	0	0
2/9/1999	Flood	0	0	$0	$0	0	0
1/23/2000	Flood	0	0	$25,000	$0	0	0
1/23/2000	Flood	0	0	$0	$0	0	0
1/23/2000	Flood	0	0	$0	$0	0	0
1/23/2000	Flood	0	0	$0	$0	0	0
1/23/2000	Flood	0	0	$0	$0	0	0
1/23/2000	Flood	0	0	$0	$0	0	0
1/30/2000	Flood	0	0	$0	$0	0	0
2/10/2000	Flood	0	0	$0	$0	0	0
2/11/2000	Flood	0	0	$0	$0	0	0

Date	Event	Deaths (direct)	Injuries (direct)	Property Damage	Crop Damage	Injuries (indirect)	Deaths (indirect)
2/11/2000	Flood	0	0	$0	$0	0	0
2/11/2000	Flood	0	0	$0	$0	0	0
2/22/2000	Flood	0	0	$0	$0	0	0
2/26/2000	Flood	0	0	$0	$0	0	0
1/1/2006	Flood	0	0	$4,500,000	$0	0	0
12/2/2012	Flood	0	0	$0	$0	0	0
5/6/2013	Flood	0	0	$0	$0	0	0
12/3/2014	Flood	0	0	$1,000	$0	0	0
12/3/2014	Flood	0	0	$0	$0	0	0
12/3/2014	Flood	0	0	$0	$0	0	0
12/3/2014	Flood	0	0	$0	$0	0	0
Totals		**2**	**0**	**$13,326,000**	**$7,800,000**	**0**	**0**

Source: NCDC

January 2, 1997 – The heavy rains brought the Cosumnes River to record flows above designed limits for the protective levees. Twenty breaks occurred, with the largest near the town of Wilton in the southern end of the County. The surging floodwaters inundated 33,000 acres of cropland and 84 homes. Emergency workers effected several roof-top and car-top rescues by boat and helicopter. The single death occurred at the Cosumnes River bridge near the town of McConnel.

January 22, 1997 – Localized heavy rain brought Chicken Ranch Slough out of its banks, flooding the Arden-Arcade area of the city. At least 1,000 homes and apartment buildings were flooded.

January 26, 1997 – Heavy showers and thunderstorms moved over the metro area, re-flooding the neighborhoods surrounding Chicken Ranch Slough, which had just experienced flooding the previous 22nd. The flooding was higher and caused additional damage to 500 more homes.

February 2, 1998 – In Sacramento County, the Consumnes River threatened the town of Wilton, where levees broken by the January, 1997, flooding had not been repaired. Fortunately, flooding impact was minor.

January 23, 2000 – Persistent rains which measured for 34 continuous hours swelled Dry Creek over its banks in Rio Linda. Cherry Lane, 6th Street, as well as Curved Bridge Road were flooded. Twelve homeowners had water over their property. Two of them sustained interior flooding while another five sustained flooded garages. The Grant Joint Union High School District closed Rio Linda junior and senior high schools in fear that students wouldn't get home safely. Approximately 2,500 students were sent home early

January 1, 2006 – A series of warm winter storms brought heavy rain, mudslides, flooding, and high winds to Northern California. Levee overtopping, breaching, and river flooding occurred along the Feather and Sacramento mainstem rivers as well as along numerous smaller rivers, creeks, and streams. Several urban areas had significant street flooding. The Sacramento weir was opened for the first time since 1997 with twenty gates opened. Transportation throughout the area was difficult during the course of the storms as airports were closed due to the high winds and major road closures resulted from flooding and mudslides. Interstate 80...the main artery between Sacramento and the San Francisco Bay area...was closed near Fairfield in Solano County for several hours due to severe flooding. Additionally, Interstate 80 eastbound between Sacramento and Reno, NV, was closed for more than a day due to a massive mudslide, as was both directions of U.S. Highway 50 between Sacramento and South Lake Tahoe.

December 3, 2014 – Heavy rain showers and thunderstorms brought record rainfall and flooding issues to portions of the Central Valley and foothills. There were 2 berm levees which failed in Tehama County, flooding over 200 homes and damaging farms and orchards. Significant traffic delays were caused by road flooding across interior Northern California. Snow levels remained above 7500 feet, so snowfall was limited to higher Sierra peaks and Lassen Peak. Watt Ave. and Roseville Rd. number 1 lane flooded with 2 feet of water due to clogged drain.

FIS Events

The latest Flood Insurance Study for Sacramento County was released on June 16, 2015. The following discussion is sourced from this discussion.

In urbanizing areas, flood problems are intensified because rooftops of homes and other structures, streets, driveways, parking lots, and other paved areas all decrease the amount of open land available to absorb rainfall and runoff, thus increasing the volume of water that must be carried away by streams. As indicated earlier, the northern portion of the county is urbanizing at a fairly rapid rate.

Native American legends and historical records indicate that at least nine major floods occurred in the Sacramento River basin during the 19th century. A great flood (described in Native American legend as having swamped the entire Sacramento River basin) occurred in 1805. Indians also described floods that occurred in 1825 and 1826 as widespread in the basin. Extensive flooding in northern California took place in 1839, 1840, 1847, 1849-1850, 1852, 1861-1862, 1881, and 1890. The flood of 1861-1862 was the largest known flood in Sacramento County.

One of the earliest reports of flooding in Sacramento County was the graphic account of Professor William H. Brewer of Yale University, who described the floods of January-March 1862 in the Sacramento area:

> *"Nearly every house and farm over this immense region is gone. There is such a body of water-250 to 300 miles long and 20 to 60 miles wide, the water ice cold and muddy--that the winds high waves which beat the farm houses in pieces… The new Capitol is far out in the water—the Governor's house stands as in a lake—churches, public buildings, private buildings, everything is wet or in water. Not a road leading from the city is passable, business is at a dead standstill,"*

Substantial flooding in the County also occurred in 1928, 1937, 1938, 1940, 1943, 1945, 1950, 1952, 1955, 1956, 1958, 1962, 1963, 1964-1965, 1967 and 1969, 1972, 1980, 1982, 1983 and 1997. Newspaper accounts, rainfall and stream gage records and previous studies, indicate that the City of Sacramento has experienced significant flooding in 1928, 1950, 1962, 1967, 1986 and 1997.

American River Stream Group Flooding

The American River near the City of Sacramento overflowed in 1928, causing extensive flooding in the River Park and Industrial Park areas on the south bank. In 1950, the American River inundated extensive areas on the north bank, including the area in the vicinity of Fulton Avenue and Fair Oaks Boulevard.

Floods on Dry Creek (American River Stream Group) have occurred with regularity since 1937. Flooding also occurred on Dry and Robla Creeks near the Natomas East Main Drainage Canal. The October 1962 floods on Dry and Robla Creeks spread from approximately 800 feet to approximately 1 mile wide. The flood of October 1962, was the largest that has been recorded at the Roseville gaging station, located on Dry Creek upstream of Sacramento County. Damage in the October 1962 flood, was on the order of approximately $50,000. The resultant high water was within 2 feet of the top of the levee on the southern side of Robla Creek and along the Magpie Creek diversion channel. Floodwaters from Magpie Creek bypassed the upper portion of the diversion levee and flowed into lower Magpie Creek. Similar, less-severe floods, occurred in 1955, 1958, February 1962, 1967, 1969, 1970 and 1973.

Other creeks in the American River Stream Group have floodplain boundaries similar to that of Dry Creek. In December 1955, Arcade Creek overflowed its banks, inundating portions of Del Paso Park as well as areas upstream along Winding Way and portions of the Hagginwood District downstream.

Floods occurred twice in 1962. The largest recent floods on Strong Ranch and Chicken Ranch Sloughs occurred in February 1962.The February 1962 floods caused inundation along Arcade Creek in the vicinity of Del Paso Park. The park and the Haggin Golf Course were flooded, and the floodwaters forced the closing of Roseville Road. Dry and Robla Creeks caused flooding in the vicinity of the Natomas East Main Drainage Canal where Rio Linda Boulevard was threatened. Laguna Creek spread out over its floodplain. No damage estimates are available; however, runoff was too large for the channels and bridges, resulting in local flooding. The capacity of the American River pumping plant was exceeded for a short time, and floodwaters backed up and inundated areas in the vicinity of the nearby sewage treatment plant.

The largest flood on Arcade and Cripple Creeks occurred in October 1962. A severe, early season rainstorm occurred in October 1962, resulting in widespread flooding in the City of Sacramento. Arcade Creek overflowed from Marysville Road to past Del Paso Park. Six families on Verno Street had to evacuate because the flood threat was particularly severe in this area. Damages were estimated at $10,000 along Arcade Creek. Excess floodwaters from Dry Creek flowed southerly along the eastern side of the Western Pacific Railroad to Robla Creek and the Magpie Creek Diversion. The resultant high water was within 2 feet of the top of the southern levee of the diversion. Portions of floodwaters from Magpie Creek bypassed the upper portion of the diversion’s levee and flowed into Lower Magpie Creek, causing flooding in the area between Dry Creek Road and Raley Boulevard. Dry and Robla Creeks again spread out over their common floodplain near the Natomas East Main Drainage Canal. An estimated $50,000 in flood-related damages was caused by the flood on Dry Creek. Many of these damages were caused in areas along Dry Creek upstream of the City of Sacramento.

Flooding in January 1967 was less severe than flooding in 1962. Arcade Creek overflowed its banks upstream of the City of Sacramento and flooding in the city was restricted to minor inundation in Del Paso

Park. Flooding that occurred in February 1973 on Arcade Creek had a recurrence interval of approximately 10-percent annual chance flood. Dry and Robla Creeks, however, overflowed inside the city.

The most recent flooding on the American River occurred in February 1986. The peak flow during this flood has been estimated to exceed the current 1-percent annual chance flood peak of 115,000 cubic feet per second (cfs).

Morrison Stream Group Flooding

Large portions of the Morrison Creek Stream Group area in Sacramento County were flooded in 1952, 1955, 1958, 1962-64, 1966-67 and 1969. During the 1955 flood, overflow from the Cosumnes and Mokelumne Rivers caused inundation of the Beach-Stone Lake area, thus creating high backwater conditions on streams of the Morrison Creek Stream Group. Damage was estimated at $213,000 in the Morrison Creek Stream Group area as a result of the 1955 floods and at $204,000 from the 1958 flood.

In October 1962, the Morrison Creek Basin was again flooded. A local newspaper called the Fruitridge-Florin area "the worst hit," with water "up to the tops of doors on cars" (Sacramento Bee, 1962). Floodwaters escaped from Morrison Creek near the Sacramento Army Depot. This overflow, along with other overflows from Morrison Creek upstream of Stockton Boulevard, caused widespread inundation of a primarily residential area east of Stockton Boulevard from the City of Sacramento corporate limits north to Fruitridge Road. The Glen Elder section east of Stockton Boulevard and south of Elder Creek Road, was the most severely flooded portion in the Morrison Creek Stream Group area. Laguna, Elder, Florin and Unionhouse Creeks, also overflowed their banks during this flood, adding to the flood problems in the area. A total of $161,000 in flood related damages was estimated to have occurred in the entire Morrison Creek Stream Group area during the October 1962 flood.

In 1964, Morrison Creek flooded a large region west of the Western Pacific Railroad tracks and south of Meadowview Road. Laguna Creek flooded an area adjacent to the stream that extended for about six miles from near the City of Elk Grove westerly to the Union Pacific Railroad tracks. The 1964 flooding in the basin inundated about 7,700 acres and caused an estimated $156,000 in damages. The majority of flooding in January 1969, occurred on agricultural lands in the City of Sacramento, predominantly on lands that lay west of the Union Pacific Railroad (UPRR) tracks in the Beach-Stone Lakes area. Minor flood losses (principally to farmland, crops, and improvements) were incurred east of the Union Pacific Railroad tracks. Floodwaters covered approximately 10,500 acres, and damages were estimated at $159,000.

The Morrison Creek Stream Group experienced lesser flooding in 1967 and 1969. The estimated damage for 1969 was $159,000. Moderate agricultural damages estimated at $104,000 were caused by the 1966-67 flooding, even though more acres were flooded (approximately 8,070 acres), particularly on Laguna Creek which again overflowed into its floodplain, than during the flooding of 1963 and 1964.

In the Morrison Creek Stream Group Basin in Sacramento County, the most recent flooding occurred in February 1986. That flood had the largest peak flow recorded on Morrison Creek (slightly higher than the January 1982 peak flow). Both the 1982 and 1986 floods have recurrence intervals of approximately a 4-percent annual chance flood. The estimated damage for 1982 was $500,000. Flooding had also occurred in February 1973 and has a recurrence interval of approximately a 10-percent annual chance flood.

Detailed flood damage surveys were not conducted after the 1973, 1983, 1986 and 1997 floods. However, it is estimated that approximately $500,000 in damages occurred in 1983. Only negligible damages occurred during the February 1986 flood. Peak flows in the last ten years may have been higher partly because of channel improvement work, enlarged channel capacity, and levee construction by local interests in that period.

The severity of flooding on all the streams studied during the July 6, 1998, restudy in the City of Sacramento, is intensified by backwater conditions between stream systems. Floodwater elevations are increased in the lower portions of tributary streams due to the backwater effect from main streams reducing hydraulic gradients and flow-storage areas. During this time, there will be a high degree of coincidental 1-percent annual chance flood flows on all the study area waterways.

San Joaquin River Stream Group Flooding

Historically, flooding along the Mokelumne River has been caused by general rainstorms in late fall and winter, and by snowmelt runoff in spring and early summer. The effects of cloudburst storms on an area as large as the Mokelumne River basin is negligible.

Flooding on the detailed study reach of the Mokelumne River has occurred in 1907, 1909, 1911, 1914, 1921, 1925, 1928, 1937, 1950, 1952, 1955-1956, 1963, 1964, 1967, 1969 and 1970. The most disastrous flood was that of November 1950, which caused about $1.1 million in damages. The December 1955-January 1956 floodwaters caused an estimated $750,000 in damages. The flood of December 1964 is the largest of record on the Mokelumne River. However, due to the completion of Camanche Dam in April 1964, most damages in the later flood had been prevented. Contemporary accounts of floods on the Mokelumne River are essentially nonexistent. Streamflow recorded for the study reach of the Mokelumne River were begun in 1904.

Delta Flooding

The lower reaches/delta of the Sacramento and San Joaquin Rivers are under the influence of the tides. The most severe flood conditions in the delta would result when very high tides and large volume of stream outflow occur coincidentally, and strong onshore winds generate wave action. It should be noted that precipitation over the delta does not materially affect local flood conditions. More information about past occurrences of flooding in the Delta can be found in the levee failure discussion in Section 4.2.17.

Natomas Area Stream Group Flooding

Floods on the Cosumnes River occurred in 1950, 1955, 1958, 1962 and 1964, with the events of 1955, 1958 and 1964, being most severe. In 1958, an estimated 38,000 acres of land were inundated along the Cosumnes River and the lower portions of Dry, Deer, and Laguna Creeks. In 1964, an estimated 30,000 acres of land were inundated.

The higher elevation tributary area of the Dry Creek watershed, near the City of Galt, subject to snowfall is too small to generate snowmelt flooding. Snowmelt during a flood-producing rainstorm would not increase runoff significantly. Due to the largely rural nature of the Dry Creek floodplain, and because flood damage has been predominantly agricultural, historical floods have not been documented in much detail.

The earliest major flood flow of record, 13,200 cubic feet per second (cfs), approximately an 11.1-percent annual chance (9-year) flood, occurred on February 2, 1945. From high-water marks known to long-time residents of the area, an estimated flood flow of 18,700 cfs (approximately a 5.8-percent annual chance [17-year] flood) occurred in February 1936 and a flood flow estimated to be approximately 24,000 cfs (approximately a 2.9-percent annual chance [35-year] flood) occurred in March 1907.

In December 1955, a 17,000 cfs flow (approximately a 7.1-percent annual chance [14-year] flood) on Dry Creek resulted from approximately 7 inches of antecedent rainfall over the tributary drainage. Although there was no Dry Creek overflow into the City of Galt, there was flooding from Hen Creek in the west-central part of the city where water was nearly knee deep along Lois Avenue, and at the Myrtle Avenue-Palin Street and Myrtle Avenue-Oak Avenue intersections. Damage, however, was minor and floodwater receded within 1 day. On April 3, 1958, the largest flood of record, 24,000 cfs (approximately a 2.9-percent annual chance flood), occurred on Dry Creek. Although approximately 9,000 acres of land were flooded along the creek, there was no overflow into the City of Galt. Antecedent rainfall, which was 12.5 inches over a period of several days, had created very wet ground conditions that influenced the magnitude of runoff. Rainfall on January 31 and February 1, 1963, a total of approximately 32 percent of the normal annual precipitation over the Dry Creek drainage, resulted in a flow of 9,800 cfs (approximately a 20-percent annual chance [5-year] flood) on Dry Creek. A small dam at one end of the golf course, which was under construction on the south side of the City of Galt, was breached, and part of the facility was inundated for a short time. During the height of the storm, many streets in the City of Galt were submerged due to lack of adequate storm drainage. In December 1964, approximately 8,200 acres were flooded by Dry Creek; however, overflow near the City of Galt was limited to a portion of the golf course, which was caused when a low levee was overtopped. The flow recorded at the Dry Creek stream gage was 14,500 cfs (approximately a 10-percent annual chance flood). Antecedent rainfall was not significant.

The severity of two areas within the unincorporated areas where the high flow of floodwaters on some channels has a great impact (causing backwater conditions) on the hydraulic regimen of other channels. High flows on the Sacramento River generate backwater conditions on the lower reaches of the American River and the Cross Canal. The American River peak 1-percent annual chance flows induce backwater conditions in the lower reach of the Natomas East Main Drainage Canal. Coincidentally, high flows on the Natomas East Main Drainage Canal cause backwater conditions on the lower reaches of Arcade and Dry Creeks.

Other Flooding

The floodplain areas of Willow, Humbug, and Hinkle Creeks near the City of Folsom have little existing structural development. The current and past land uses have been agricultural and open space. A thorough search of records has not uncovered any record of past floods. No records have been kept due to the past and current land uses and short duration of flood flows. The flooding events have not been considered significant problems, and the flood damages have not been recorded.

HMPC Events

The HMPC noted an event in February of 1986. A resident in the area noted that flooding occurred in South Sacramento County. A 35-year flood event flooded 15,000 acres, including areas around I-5. I-5 was closed for 4 weeks and was under 3' of water in areas. Substantial damages to homes and businesses in the area. No deaths or injuries were reported.

Likelihood of Future Occurrence

Riverine flooding is the most significant natural hazard that Sacramento County faces. The Sacramento area has a good working knowledge of the 100-year flood, however, the statistical outlier flood is not as well quantified. Sacramento is not just at high risk of flooding, but is at low risk of catastrophic flooding.

In addition, there are many urban streams, channels, canals, and creeks that serve the drainage needs of the County. There is significant threat of flooding in large areas of the County from several of these streams. Many of these streams are prone to rapid flooding with little notice.

100-Year Flood

Occasional—The term "100-year flood" is misleading. It is not the flood that will occur once every 100 years. Rather, it is the flood that has a 1- percent chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time.

200/500-Year Flood

Unlikely—The 200- and 500-year flood is the flood that has a 0.5 and 0.2 percent chance of being equaled or exceeded in any given year respectively.

Climate Change and Flood

According to the CAS, climate change may affect flooding in Sacramento County. While average annual rainfall may decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st century. It is possible that average soil moisture and runoff could decline, however, due to increasing temperature, evapotranspiration rates, and spacing between rainfall events.

Preliminary Draft - Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the 2016 Preliminary Draft CAP, climate change is likely to lead to changes in frequency, intensity, and duration of extreme precipitation events. Increases in annual temperature may result in earlier and more rapid melting of the Sierra Nevada snowpack, which could lead to increased surface water flow rates and flood magnitude and frequency in Sacramento County.

Sea Level Rise. Another climate change issue is sea-level rise. The average global sea level rose approximately seven inches during the last century. Assuming that sea-level changes along the California coast reflects global trends, sea levels along the coastline could rise by 10-18 inches from its 2000 levels by 2050 and 31 to 55 inches higher by the end of the Century. The Cal-Adapt tool depicts sea level rise projections and existing storm-related flooding events using a "bathtub model", which shows the consequences of a 100-year flood event combined with up to 55 inches of sea level rise without taking into account protective flood control structures and levees or the increased flood risk from wave run-up. Based on this model a small portion of Sacramento County near the Delta is vulnerable to the influences of sea-level rise. Under current conditions, Cal-Adapt shows 171 acres inundated by the 100-year flood, with a 240 percent increase of up to 411 acres under a 55-inch sea level rise scenario. The area affected by sea level rise projections is determined to constitute only 0.1% of the County, which is largely undeveloped land containing wetlands on Delta islands. Although by land mass, Sacramento County is not predicted to be directly affected by sea-level rise, rising sea levels in the Sacramento-San Joaquin Delta may result in indirect effects associated with saltwater intrusion to the lower reaches of the Sacramento River. The level of salinity of the Delta and Sacramento River is dependent on several variables and fluctuates depending on the season, snowpack, tides, temperature, weather conditions, and human-related demand, thus it is difficult to predict the severity of saltwater intrusion into the Sacramento River as a result of sea-level rise. However, it would be expected that rising sea levels would introduce saltwater further upstream the Sacramento River reducing the quality of fresh water supply. It is further expected that the salt water intrusion from sea level rise would be limited to the lower reaches of the Sacramento River and would not affect the water quality of the Mokelumne, American, and Cosumnes rivers.

4.2.15. Flood: Localized Flooding

Hazard/Problem Description

Localized, stormwater flooding also occurs throughout the County. Urban storm drainpipes and pump station have a finite capacity. When rainfall exceeds this capacity, or the system is clogged, water accumulates in the street until it reaches a level of overland release. This type of flooding may occur when intense storms occur over areas of development.

According to Sacramento County, numerous parcels and roads throughout the County not included in the FEMA 100- and 500-year floodplains are subject to flooding in heavy rains. In addition to flooding, damage to these areas during heavy storms includes pavement deterioration, washouts, mudslides, debris areas, and downed trees. The frequency and type of damage or flooding that occurs varies from year to year, depending on the quantity of runoff.

Table 4-35 identifies the number of parcels and roads by watersheds affected by localized flooding throughout the unincorporated County. Parcels were identified by the County based on those parcels historically affected by localized flooding issues. Affected roads are estimated based on those roads fully within 50 feet of a parcel with historical flooding problems. Maps of these localized flooding areas are still under development by the County. The Watershed Master Plan included as Appendix H to this LHMP Update also addresses these flood prone areas falling outside of the established 100- and 500-year floodplains.

Table 4-35 Unincorporated Sacramento County Localized Flooding Areas

Watershed	# of Parcels Affected	# of Road Segments Affected
Buffalo Creek	63	686
Morrison Creek	1,102	366
Chicken Ranch Slough	421	221

Watershed	# of Parcels Affected	# of Road Segments Affected
Cosumnes River	335	211
Laguna Creek	1042	202
North Delta	769	199
Linda Creek	379	199
Florin Creek	715	191
Arcade Creek	347	182
Fair Oaks Stream Group	197	172
Dry Creek	308	166
Strong Ranch Slough	196	153
Sierra Creek	93	149
Carmichael Creek	176	128
Robla Creek	320	126
Antelope Creek	187	107
Minnesota Creek	212	105
Deadmans Gulch	223	102
Alder Creek	19	88
North Fork Badger Creek	232	86
NEMDC Trib 3	137	78
East Natomas	158	69
Badger Creek	194	62
Elder Creek	149	58
Arcade Creek South Branch	83	58
Magpie Creek	56	58
Diablo Creek	11	49
Sierra Branch	70	48
NEMDC Trib 2	118	47
Strawberry Creek	168	46
East Antelope	111	46
Unionhouse Creek	47	46
Skunk Creek	81	45
Laguna Creek (South)	52	45
Beach-Stone Lake	123	44
Hen Creek	94	44
Gerber Creek	75	42
Cripple Creek	38	39
Hagginbottom	38	38
Verde Cruz Creek	19	38

Watershed	# of Parcels Affected	# of Road Segments Affected
Dry Creek (South)	66	37
Hagginwood Creek	49	37
Courtland	157	31
Griffith Creek	125	29
Mayhew Slough	18	25
Date Creek	48	23
Deer Creek	61	21
Boyd Creek	40	20
Willow Creek (South)	64	19
NEMDC Trib 1	41	17
San Juan Creek	24	16
Hadselville Creek	43	15
Frye Creek	22	12
Manlove	13	12
Negro Slough	11	12
Rolling Draw Creek	10	11
Willow Creek	15	8
Coyle Creek	9	7
Natomas Basin	0	5
Crevis Creek	4	4
Coyote Creek	26	3
Arkansas Creek	4	3
Carson Creek	13	2
Bear Slough	3	2
Brooktree Creek	3	2
Browns Creek	6	1
Cordova/Coloma Stream Group	1	1
Elk Grove Creek	0	1
Little Deer Creek	0	1
Grizzly Slough	0	0
Mariposa Creek	0	0
Slate Creek	0	0
Sunrise Creek	0	0
Whitehouse Creek	0	0
Willow Creek (Middle)	0	0
Total	**10,034**	**5,216**

Source: Sacramento County

Past Occurrences

Disaster Declaration History

There have been no disasters declarations related specifically to localized flooding in Sacramento County, beyond those identified in the 100/200/500-year flood hazard section above.

NCDC Events

There have been no NCDC localized flooding events in Sacramento County, beyond those identified in the 100/200/500-year Flood Hazard section above.

HMPC Events

The Planning Team for the County noted the following localized flooding events that have occurred in the County since 2011.

- 2011 Mar 24 – High winds & 1 – 1.5" rain. 90 service calls, most for plugged drains. 1 structure flooded.
- 2012 Nov 30 – Dec 3. – High winds & 4" -6" rain. 800 service calls w/ 474 drainage service requests. 24 Mobile homes flooded at Auburn Blvd. & 15 other structures Countywide.
- 2014 Feb 10 - 2.5" – 4.5" rain. 72 drainage service calls.
- 2014 Dec 2 – 4 – 1.1 -5.5" rain. 321 drainage service calls. No structural flooding. Watt Ave. and Roseville Rd. number 1 lane flooded with 2 feet of water due to clogged drain. Roadway flooding in Sacramento on southbound Highway 99 near Sutterville Rd. Water was as deep as car doors and traffic was backed up. I-80 at Watt Ave. Eastbound Underpass had significant flooding due to heavy rain and pump failure. This resulted in major traffic backup, lasting several hours during evening rush hour.
- 2014 Dec 11 -12 – 2.3" – 3.5" rain. 179 drainage service calls.
- 2015 Feb 5 -9 – 1"-3" rain. 47 drainage service calls.
- January 5th & 19th, 2016 – A cool winter storm brought moderate rain, 1-2 inches across the Valley, with ponding on roads and small stream rises. There was roadway flooding with partial lane blockage reported on I80 and also on US Highway 50.

Likelihood of Future Occurrence

Highly Likely— With respect to the localized, stormwater flood issues, the potential for flooding may increase as storm water is channelized due to land development. Such changes can create localized flooding problems in and outside of natural floodplains by altering or confining natural drainage channels. Urban storm drainage systems have a finite capacity. When rainfall exceeds this capacity or systems clog, water accumulates in the street until it reaches a level of overland release. With increasing urbanization of the Sacramento County Planning Area, combined with older infrastructure, this type of flooding will continue to occur during heavy rains. Based on historical data, localized, stormwater flooding events less severe than a 100-year flood and those outside of the 100-year floodplain occur frequently (on an annual basis) during periods of heavy rains.

Climate Change and Localized Flood

While average annual rainfall may decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st century, increasing the likelihood of overwhelming stormwater systems built to historical rainfall averages. This makes localized flooding more likely.

4.2.16. Landslides and Debris Flows

Hazard/Problem Description

Landslides refer to a wide variety of processes that result in the perceptible downward and outward movement of soil, rock, and vegetation under gravitational influence. Common names for landslide types include slump, rockslide, debris slide, lateral spreading, debris avalanche, earth flow, and soil creep. Landslides may be triggered by both natural and human-induced changes in the environment that result in slope instability.

A landslide is the breaking away and gravity-driven downward movement of hill slope materials, which can travel at speeds ranging from fractions of an inch per year to tens of miles per hour depending on the slope steepness and water content of the rock/soil mass. Landslides range from the size of an automobile to a mile or more in length and width and, due to their sheer weight and speed, can cause serious damage and loss of life. Their secondary effects can be far-reaching; such as catastrophic flooding due to the sudden release of river water impounded by landslide debris or slope failure of an earthen dam.

Landslide problems can be caused by land mismanagement, particularly in mountain, canyon, and coastal regions. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Land-use zoning, professional inspections, and proper design can minimize many landslide, mudflow, and debris flow problems.

The susceptibility of an area to landslides depends on many variables including steepness of slope, type of slope material, structure and physical properties of materials, water content, amount of vegetation, and proximity to areas undergoing rapid erosion or changes caused by human activities. These activities include mining, construction, and changes to surface drainage areas.

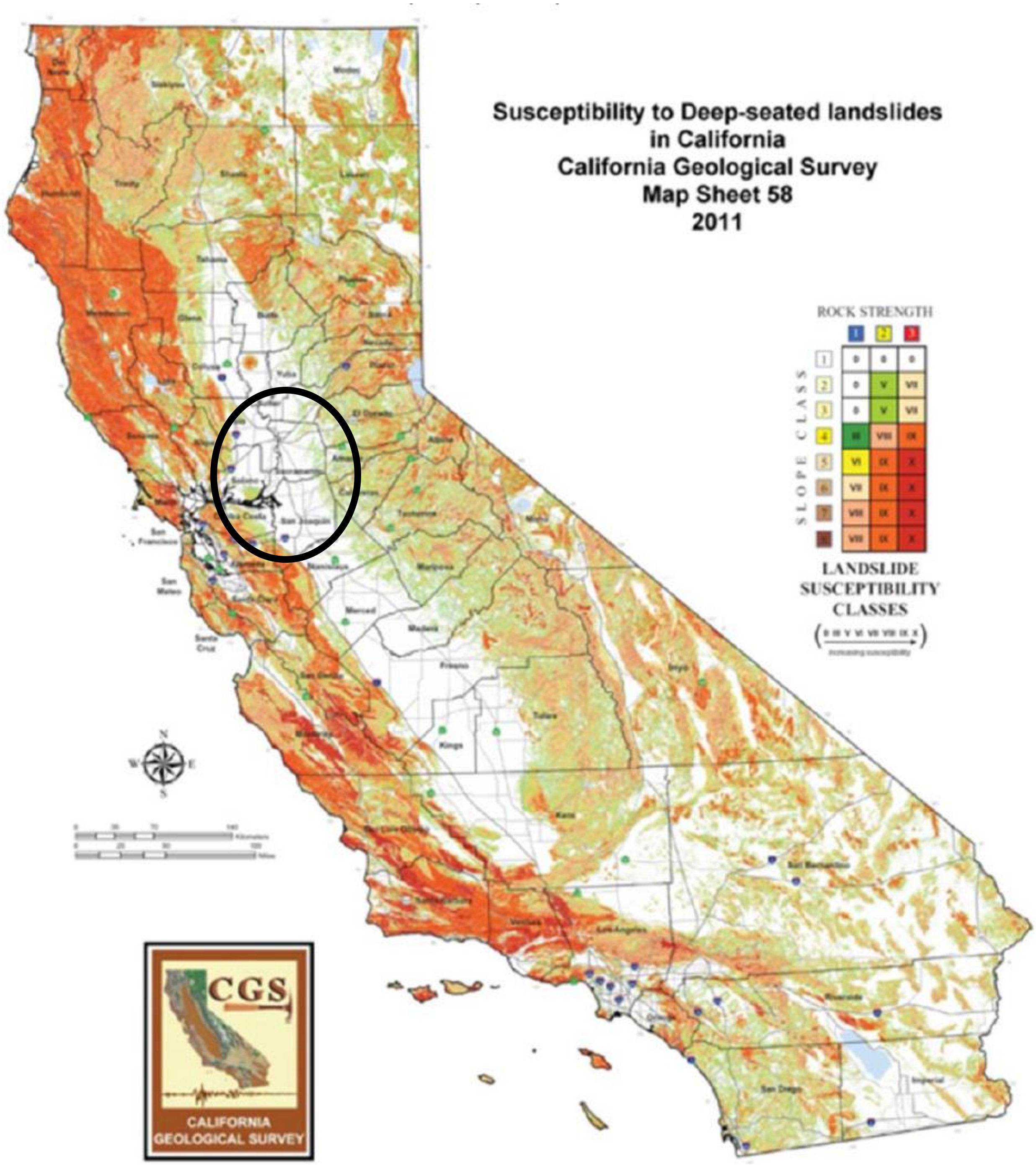
Landslides often accompany other natural hazard events, such as floods, wildfires, or earthquakes. Landslides can occur slowly or very suddenly and can damage and destroy structures, roads, utilities, and forested areas, and can cause injuries and death.

Landslides directly damage buildings in two general ways: 1) disruption of structural foundations caused by differential movement and deformation of the ground upon which the structure sits; and 2) physical impact of debris moving down slope against structures located in the travel path. In addition to buildings, other types of engineered structures are vulnerable to the impact and ground deformation caused by slope failures, particularly utilities and transportation structures. These belong to a category of structures called lifelines. Transmission lines such as telephone lines, electric power, gas, water, sewage, roadways, etc., are necessary for today's functioning society. They present a particular vulnerability because of their geographic extent and susceptibility to physical distress. Lifelines are generally linear structures that, because of their geographic extent, have a greater opportunity for impact by ground failure.

The Sacramento County General Plan Background Report describes areas in the County that are particularly prone to landslides. In Sacramento County, only a narrow strip along the eastern boundary, from the Placer County line to the Cosumnes River, is considered to have landslide potential. However, future slides on these slopes are expected to be minor in nature and do not pose a large-scale threat to life or property. The American River Bluffs downstream from Folsom and in Fair Oaks and Carmichael are considered stable and are generally not subject to fracture or landslides.

Figure 4-43 was developed for the 2013 State of California Multi-Hazard Mitigation Plan. It indicates that most areas throughout Sacramento County are at low risk for landslides, with areas in the eastern portion of the County is at low to medium risk for landslides.

Figure 4-43 Landslide Risk Zones



Source: 2013 State of California Multi-Hazard Mitigation Plan

Past Occurrences

Disaster Declaration History

There have been no disaster declarations associated with landslides in Sacramento County.

NCDC Events

The NCDC contains no records of landslides in the County.

HMPC Events

The HMPC did not identify any landslide incidents since the 2011 plan.

Likelihood of Future Occurrence

Unlikely – The topography of the majority of Sacramento County is relatively flat and not subject to landslide. In Sacramento County, only a narrow strip along the eastern boundary, from the Placer County line to the Cosumnes River, is considered to have landslide potential. However, future slides on these slopes are expected to be minor in nature and do not pose a large-scale threat to life or property. The American River Bluffs downstream from Folsom and in Fair Oaks and Carmichael are considered stable and are generally not subject to fracture or landslides; most land movement in this area is attributed to natural processes. This small portion, coupled with a lack of previous occurrences, equates to a likelihood of future occurrence of unlikely.

Climate Change and Landslide and Debris Flows

According to the CAS, climate change may result in precipitation extremes (i.e., wetter wet periods and drier dry periods). While total average annual rainfall may decrease only slightly, rainfall is predicted to occur in fewer, more intense precipitation events. The combination of a generally drier climate in the future, which will increase the chance of drought and wildfires, and the occasional extreme downpour is likely to cause more mudslides and landslides.

4.2.17. Levee Failure

Hazard/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. A natural levee is formed when sediment settles on the stream bank, raising the level of the land around the stream. To construct a man-made levee, workers place dirt or concrete along the stream banks, creating an embankment. This embankment is flat at the top, and slopes at an angle down to the water. For added strength, sandbags are sometimes placed over dirt embankments.

Approximately 150 years ago, the levees of the Sacramento-San Joaquin Delta were raised to prevent flooding on what remains some of the most fertile farmland in the nation. While the peat soils were excellent for agriculture, they were not the best choice to create strong foundations for levee barriers meant to contain a constant flow of river water. Nevertheless, it was these native soils that were primarily used to create the levee system.

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. Levees reduce, not eliminate, the risk to individuals and structures located behind them.

The time of year of a failure is an important factor in determining risk. Overtopping is most likely to occur during high water events in the winter. Multiple failures during large floods would generally not pose an immediate threat to water supplies outside the Delta. In contrast, a structural failure during a period of low inflow, such as summer, can draw ocean salinity into the Delta. The saline water could cause a multi-year disruption to statewide water use. Large-scale disruptions could cost hundreds of billions of dollars annually.

A levee system failure or overtopping can create severe flooding and high water velocities. It's important to remember that 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.

There are three primary risks to levee integrity in Sacramento County:

- Earthquake failure
- High water failure
- Dry weather failure

Earthquake Failure

Seismic risk in the Delta Region is characterized as moderate-to-high because of many active faults in the San Francisco Bay Area. Figure 4-30 in Section 4.2.12 Earthquake, illustrates the locations of faults in and near the San Francisco Bay Area and the Delta Region. Area seismic activity during the last 100 years is significantly less than what was experienced during the 1800s and the first part of the 1900s. Seismic experts predict increased seismic activity in the future similar to that which occurred up to the first part of the 1900s. Seismic risk to levees stems from the risk of liquefaction. Liquefaction is discussed as a stand-alone hazard in Section 4.2.13. A more in depth discussion may be found there.

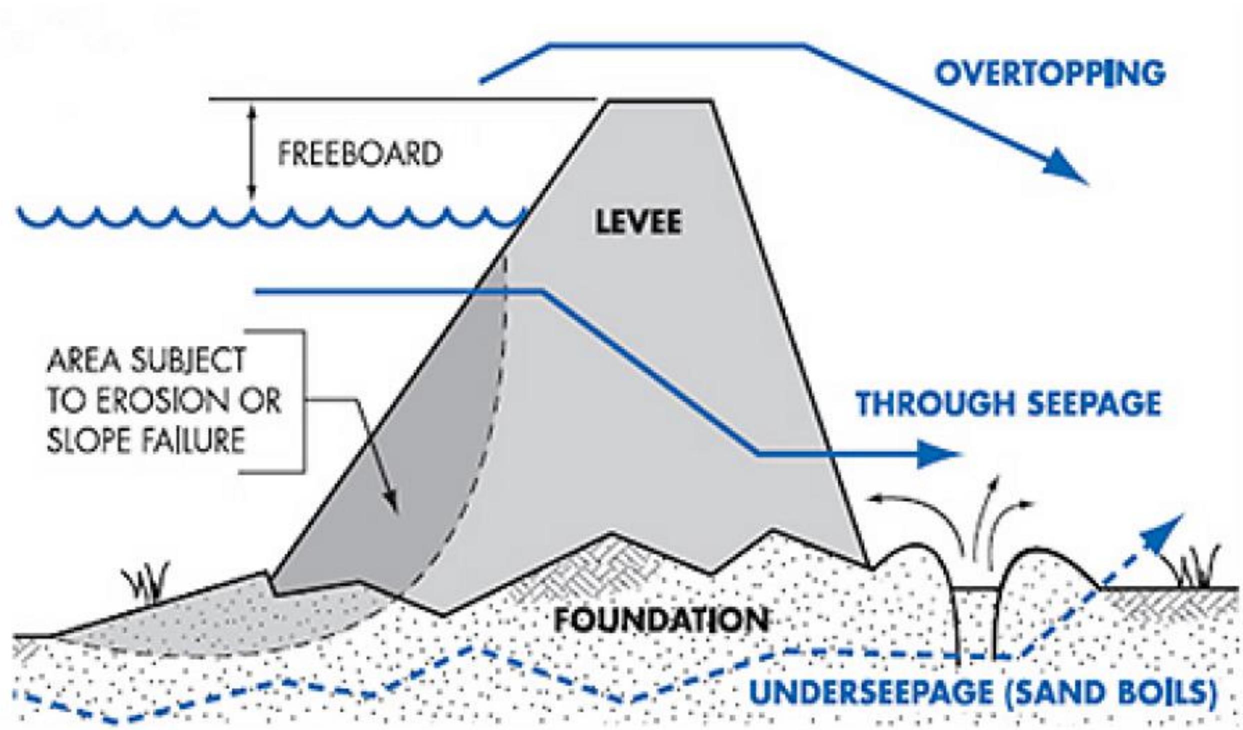
High Water Failure

Although earthquakes pose the greatest single risk to Delta Region levees, winter storms and related high water conditions are also a serious risk to all levees in the Sacramento County Planning Area. High water events can overtop levees. High water also increases the hydrostatic pressure on levees and their foundations, causing instability. The risk of through-levee and under-levee seepage failures increases as well.

Under-seepage refers to water flowing under the levee through the levee foundation materials, often emanating from the bottom of the landside slope and ground surface and extending landward from the landside toe of the levee. Through-seepage refers to water flowing through the levee prism directly, often emanating from the landside slope of the levee. Both conditions can lead to failure by several mechanisms, including excessive water pressures causing foundation heave and slope instabilities, slow progressing internal erosion, and piping leading to levee slumping.

Rodents burrowing into and compromising the levee system is a significant issue in the Planning Area. Erosion can also lead to levee failure. More information on erosion can be found in Section 4.2.18. Figure 4-44 depicts many causes of levee failure.

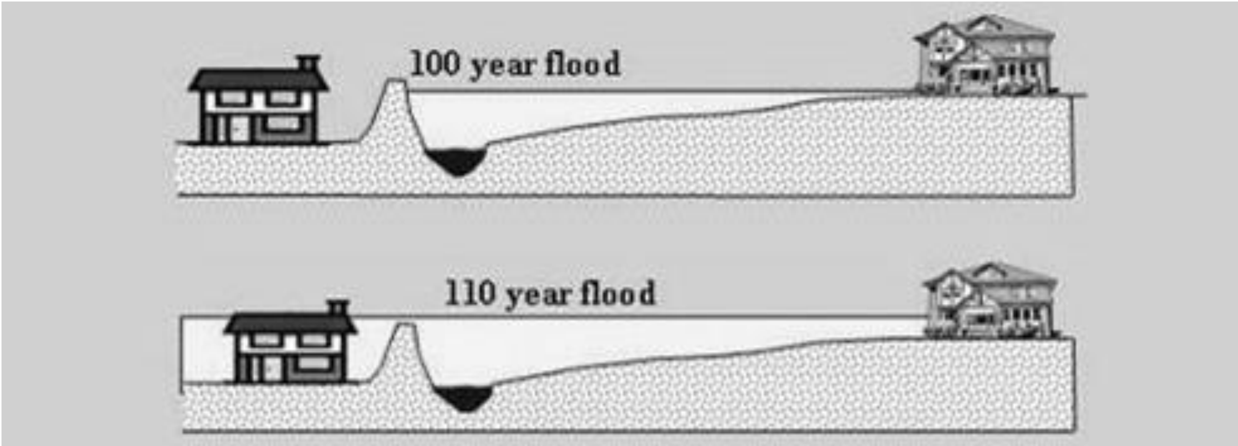
Figure 4-44 Potential Causes of Levee Failure



Source: USACE

Overtopping failure occurs when the flood water level rises above the crest of a levee. As shown in Figure 4-45, overtopping of levees can cause greater damage than a traditional flood due to the often lower topography behind the levee.

Figure 4-45 Flooding from Levee Overtopping



Source: Levees in History: The Levee Challenge. Dr. Gerald E. Galloway, Jr., P.E., Ph.D., Water Policy Collaborative, University of Maryland, Visiting Scholar, USACE, IWR.

Most levee failures in the Delta Region have occurred during winter storms and related high water conditions, often in conjunction with high tides and strong winds.

Dry Weather Failures

Dry weather, or sunny-day, failures are levee breaches that are not flood or seismic related. These failures typically occur between the end of the late snowmelt from the Sierras, in late May, and the beginning of the rainy season, in early October. Sunny-day failures are addressed separately from flood-induced failures to differentiate between winter and summer events. Aside from seismic events, factors that can cause levee failures in the Sacramento–San Joaquin River Delta (Delta) in the summer period are different than the factors that can cause winter failures.

Burrowing animal activities and pre-existing weaknesses in the levees and foundation are the key weak links leading to levee failures. This is the case regardless of whether the failures occur during a high-tide condition or not. Most practicing engineers, scientists, and maintenance personnel in the Delta and Suisun Marsh believe that rodents are prolific in the Delta and use levees for burrowing. As a result, they cause undue weaknesses by creating a maze of internal and interconnected galleries of tunnels.

Under-seepage and through-levee seepage are slow processes that tend to work through time by removing fines from levee and foundation material during episodes of high river levels. Cumulative deterioration through the years can lead to foundations ultimately failing in dry weather by means of uncontrollable internal erosion that leads to slumping and cracking of levees.

Accredited and Provisionally Accredited Levees (PAL)

It is important that community officials and citizens have the most accurate and up-to-date information to make decisions based on the flood risk that exists in levee-impacted areas. Accredited levees are those levees meeting the criteria set forth in 44 CFR 65.10 Mapping of Areas Protected by Levee Systems and certified as providing a 100-year level of flood protection. The PAL designation is used for a levee system when FEMA has previously accredited the levee system on an effective FIRM or DFIRM and FEMA is awaiting data and/or documentation that will demonstrate the levee system's compliance with Section 65.10 of the NFIP regulations.

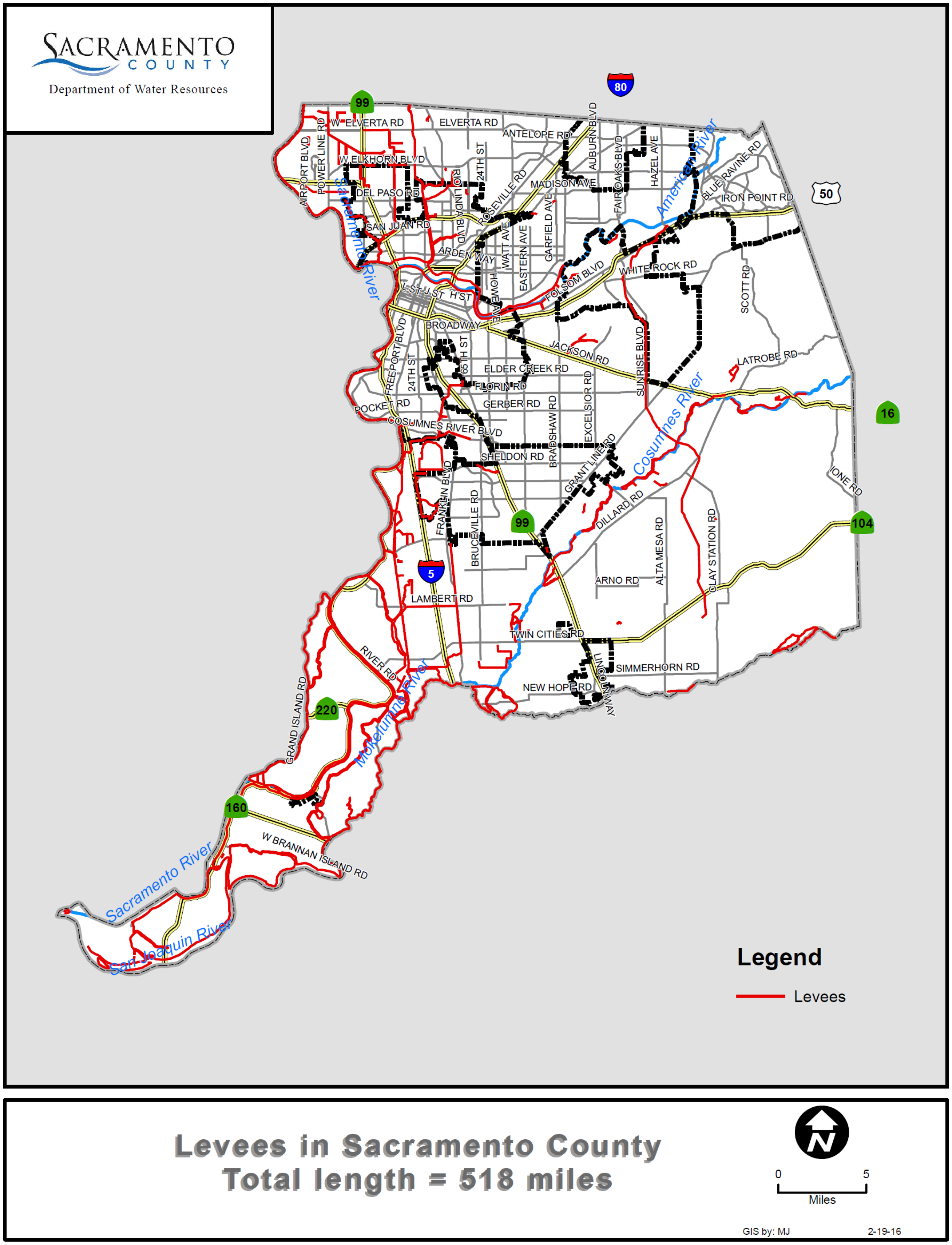
To be eligible for the PAL designation, the levee system must be shown as accredited on the effective FIRM. For levee systems that meet the PAL requirement, FEMA will place a note on the DFIRM panel landward of the levee system to indicate FEMA has provisionally accredited the levee system and the designation of any existing Zone X (shaded) area is provisional. The area impacted by the PAL system is shown as Zone X (shaded) except for areas of residual flooding, such as ponding areas, which are shown as SFHAs, areas subject to inundation by the base (1-percent annual chance) flood.

Current Accredited Levee and PAL Status in Sacramento County

There are over 1,100 miles of levees in Sacramento County; including over 500 miles of project levees. Currently, there are no accredited levees or PALs within the Sacramento County Planning Area. However, the current 2015 DFIRMs still reflect the presence of some levees as providing 100-year level of flood protection. As described throughout this LHMP Update, there are numerous planned and ongoing flood control system improvements, including levee improvement projects, that will result in establishing increased flood protection levels. Increased flood protection levels will include a minimum of 100-year level of protection to meet FEMA NFIP accreditation requirements and 200-year level of protection to meet the State of California's legislation resulting from Senate bill 5 and associated ULOP requirements and Urban Levee Design Criteria (ULDC).

Sacramento County's levee system can be seen in Figure 4-46.

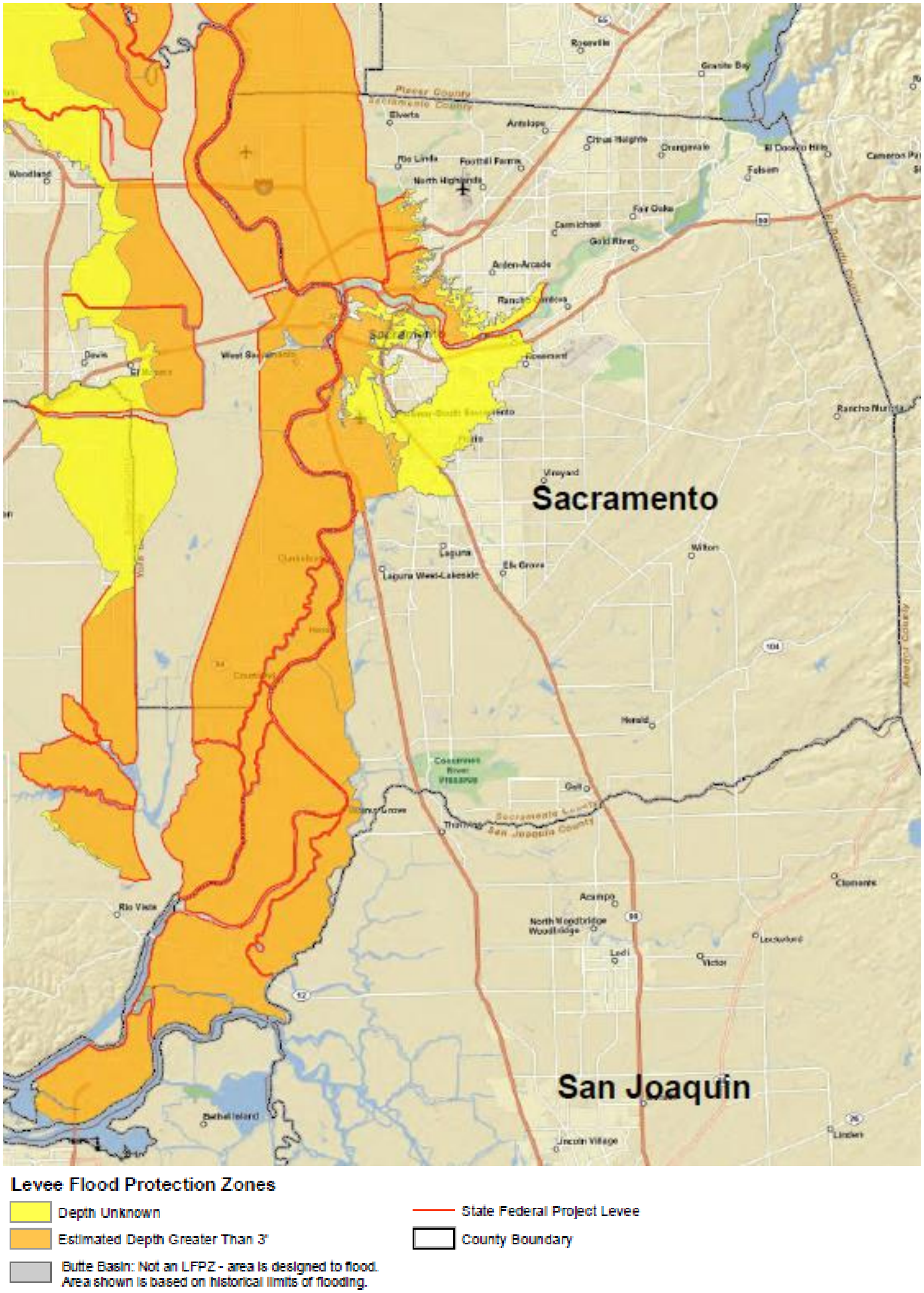
Figure 4-46 Sacramento Planning Area – Levee Map



Levee Flood Protection Zones (LFPZ) Maps

LFPZ maps represent floodplain areas protected by Central Valley State-Federal Project Levees. Under Water Code Section 9110(b), "LFPZ" means the area, as determined by the Central Valley Flood Protection Board or DWR, that is protected by a project levee. These maps were developed based on the best available information as required by Assembly Bill 156. This Bill requires DWR to prepare LFPZ maps to identify the areas where flood levels would be more than three feet deep if a project levee were to fail. DWR delineated the LFPZs by estimating the maximum area that may be flooded if a project levee fails with flows at maximum capacity that may reasonably be conveyed. DWR is using information from several sources, including FEMA floodplain maps, FEMA Q3 data, USACE's 2002 Sacramento and San Joaquin River Basins Comprehensive Study, and local project levee studies. Using this data, DWR is implementing a multi-year program to evaluate and delineate detailed floodplains for areas protected by project levees. This effort includes new topography, hydrology, hydraulic models, and floodplain maps. This information will be used to update the initial LFPZ maps. LPFZ maps can be accessed at: http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fes/levee_protection_zones/LFPZ_maps.cfm. Figure 4-47 is the most recent LFPZ map for the Sacramento County Planning Area.

Figure 4-47 Sacramento County - Levee Flood Protection Zones



Source: California Department of Water

Past Occurrences

Disaster Declaration History

There have been two FEMA disaster declarations in Sacramento County related to levee failure. Both were federal and state declared disasters.

- 1980 Delta Levee Break (Disaster EM-3078 declared on 1/23/1980)
- 1972 Andrus Island Levee Break (Disaster DR-342 declared on 6/21/1972)

NCDC Events

The NCDC does not track levee failure events.

FIS Events

The FIS reported the following regarding levee failure flooding.

Past flooding in the City of Isleton area has been due to levee failures caused by the separate or coincidental occurrence of very high tides and high stream outflow through the delta region, or from unexplained levee failures apparently not related from high tides and/or high stream outflow can reasonably be expected, such failures cannot be reliably predicted. A detailed field inspection of levees protecting Andrus, Brannan and Twitchell Islands, was made to determine levee conditions insofar as it is possible to do so without subsurface exploration. The report on the inspection identifies problem areas susceptible to failure and requires exploratory borings and testing of core materials to definitively determine levee stability (USACE, 1976). Because 2-percent annual chance flooding would overtop levees, stability analysis was deemed unnecessary, and this study is concerned only with levee overtopping and disintegration of levee sections subsequent to overtoppings.

The Delta has a long history of flooding, but little definitive data on specific flood events are available. Andrus, Brannan and Twitchell Islands, have all experienced historical floods. Large areas of the delta were inundated during floods, and it is probable that the City of Isleton was damaged or seriously threatened.

The 1950 and 1955 floods were outstanding in peak outflows through the delta and several islands were flooded. The City of Isleton, however, was not affected. In December 1965 and January 1965, the coincidental occurrence of very high tides and heavy inflow resulted in unusually high stages on all delta waterways. Concurrent strong onshore winds generated high waves that created very perilous conditions for many islands. Levees protecting Twitchell Island were seriously threatened by erosion and overtopping, but a massive flood fighting effort prevented overflow, destruction of levees and inundation of the City of Isleton.

In December 1964 and January 1965, the coincidental occurrence of very high tides and heavy inflow resulted in unusually high stages on all delta waterways. Concurrent strong onshore winds generated high waves that created very perilous conditions for many islands. Several hundred acres were flooded and damages, mainly flood fighting and repair of levees and levee roads, were a little less than $1 million. In January and February 1969, high tides and adverse wave action in the delta, combined with large river inflow and rain-soaked levees, caused the flooding of several islands and the endangerment of many other islands. Approximately 11,400 acres were inundated and flood damages amounted to about $9.2 million. The levee separating Andrus Island and the San Joaquin River failed from unknown causes in June 1972, resulting in the flooding of Andrus and Brannan Islands (including the City of Isleton). High winds had occurred prior to the break, but there had been no antecedent rainfall and the tidal cycle was not on the higher side. About 15,000 acres were inundated and flood damages for the event approximated $30 million.

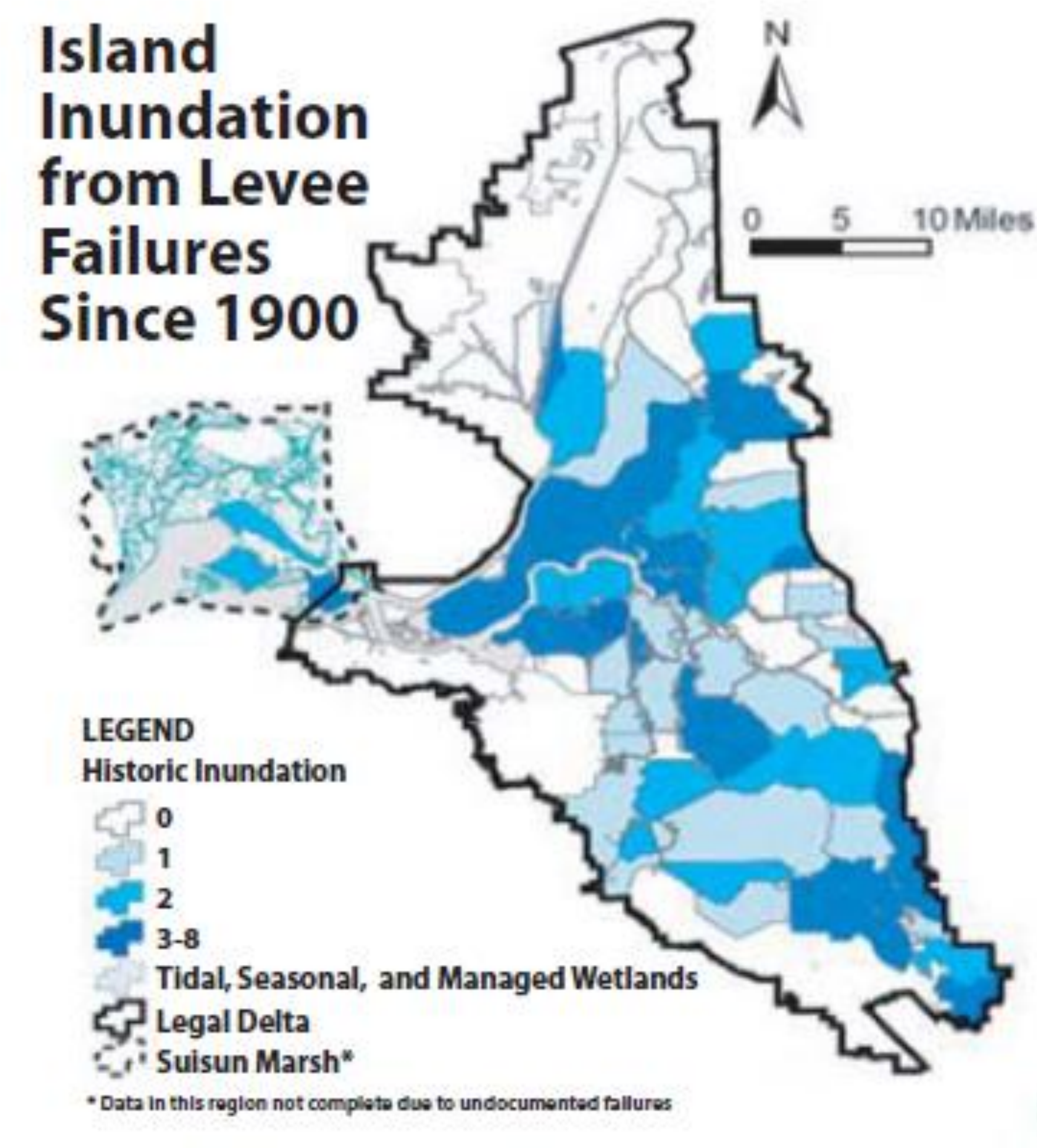
The most devastating and recent flooding of the City of Isleton resulted from failure of a levee at the southern end of Andrus Island. The levee failed from unknown causes during the night of June 21, 1972. There had not been any antecedent rainfall and the tidal cycle was not on the higher side, but high winds had been occurring prior to the break. Approximately 200,000 acre-feet of water from the San Joaquin River inundated Andrus and Brannan Islands. Activities to fight floods to protect the City of Isleton proved to be a losing battle, and almost all of the city was flooded. The entire population was evacuated, with some residents not being able to return to their homes for 4 months. Approximately one-half of the housing units in the city were damaged or destroyed. Damage from the flood event on the islands and in the City of Isleton totaled approximately $30 million.

Due to the size of the delta region, and the complexity of its stream and tidal regimen, flood frequency varies from location to location. In general, the 1950, 1955 and 1964 tidal stages in the central delta, had frequencies of 10, 30 and 5 years, respectively. Stage during the 1955 and 1964 flood periods was strongly influenced by onshore winds. The 1972 flood event cannot be assigned a frequency because the levee failure that caused the flooding cannot be attributed to tidal stage or streamflow conditions.

HMPC Events

There have been about 100 levee failures and 163 levee breaches since the early 1900. However, most of these failures occurred in the Delta area and are not specific to portions of the Delta located inside of Sacramento County. Only 14 failures and 17 breaches occurred after 1990 due to overall improvements in the levee systems throughout the Delta. These historic numbers are not representative of future occurrences within the County. Figure 4-48 shows the levee failures since 1900.

Figure 4-48 Island Inundation from Levee Failures from 1900-Present



Some islands have been flooded and recovered multiple times. A few islands, such as Franks Tract in San Joaquin County, have never been recovered. Some of the more major levee breaks in Sacramento County are detailed below.

June 21, 1972 – A levee in the Brannan-Andrus Levee Maintenance District broke. 35% of the City of Isleton was inundated. A national disaster was declared June 27, and the breach was closed on July 26. Estimated damages in 2011 dollars were $234 million. The USACE repaired the break.

February 19, 1986 – Heavy rains and flooding affected Sacramento County and the surrounding area. 6 months of precipitation fell in 10 days in mid-February. High water content caused multiple levee failures. Two levee breaks in the same general area occurred on the 8,800 acre Tyler Island in Sacramento County. These two levee breaks were approximately 300 feet in length (see Figure 4-49). A FEMA disaster declaration was declared on February 21. The approximate cost to repair the breaks was $6 million in 2011 dollars. Details on damages to structures and crops on the islands was not available.

Figure 4-49 1986 Tyler Island Levee Breach

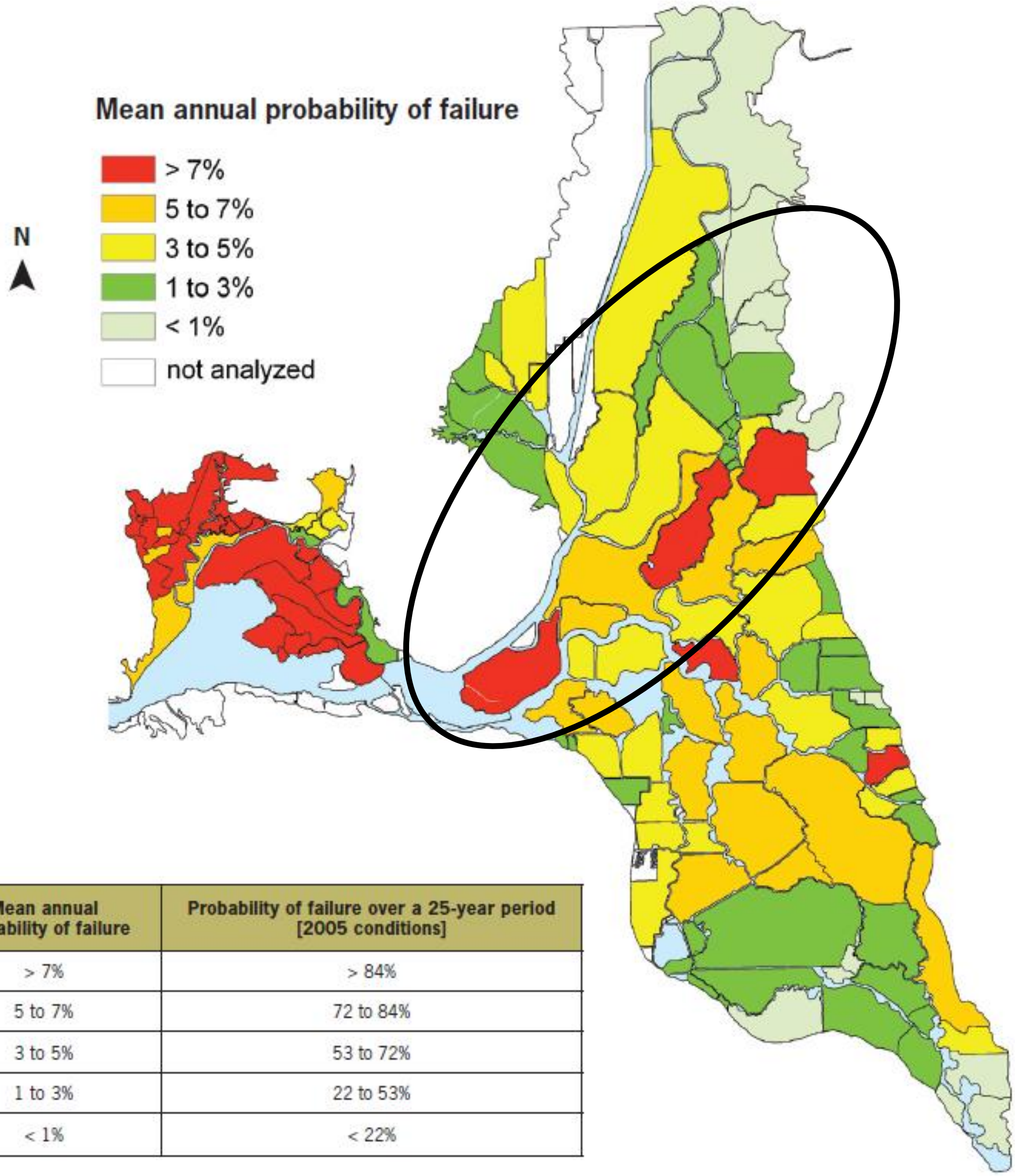
Source: California Department of Water Resources

December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and Early January 1997. The third and most severe of these storms lasted from December 31, 1996 through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. Levee failures due to breaks or overtopping in the Sacramento River Basin resulted in extensive damages. In the San Joaquin River Basin, dozens of levees failed throughout the river system and produced widespread flooding. The Sacramento-San Joaquin River Delta also experienced several levee breaks and levee overtopping. Affected Delta islands within Sacramento County included McCormack-Williamson Tract, Dead Horse Island and Glanville Tract.

Likelihood of Future Occurrence

Occasional – Due to the high number of past events, increasing subsidence, and the deteriorating conditions of the levees in Sacramento, future levee failures will occur occasionally. This can be seen for the Delta area in Figure 4-50.

Figure 4-50 Estimated Frequency of Levee Overtopping Under Current Conditions



Mean annual probability of failure	Probability of failure over a 25-year period [2005 conditions]
> 7%	> 84%
5 to 7%	72 to 84%
3 to 5%	53 to 72%
1 to 3%	22 to 53%
< 1%	< 22%

Source: Delta Risk Management Strategy

Climate Change and Levee Failure

Increased flood frequency in California is a predicted consequence of climate change. Mechanisms whereby climate change leads to an elevated flood risk include more extreme precipitation events and shifts in the seasonal timing of river flows. This threat may be particularly significant because recent estimates indicate the additional force exerted upon the levees is equivalent to the square of the water level rise.

These extremes are most likely to occur during storm events, leading to more severe damage from waves and floods.

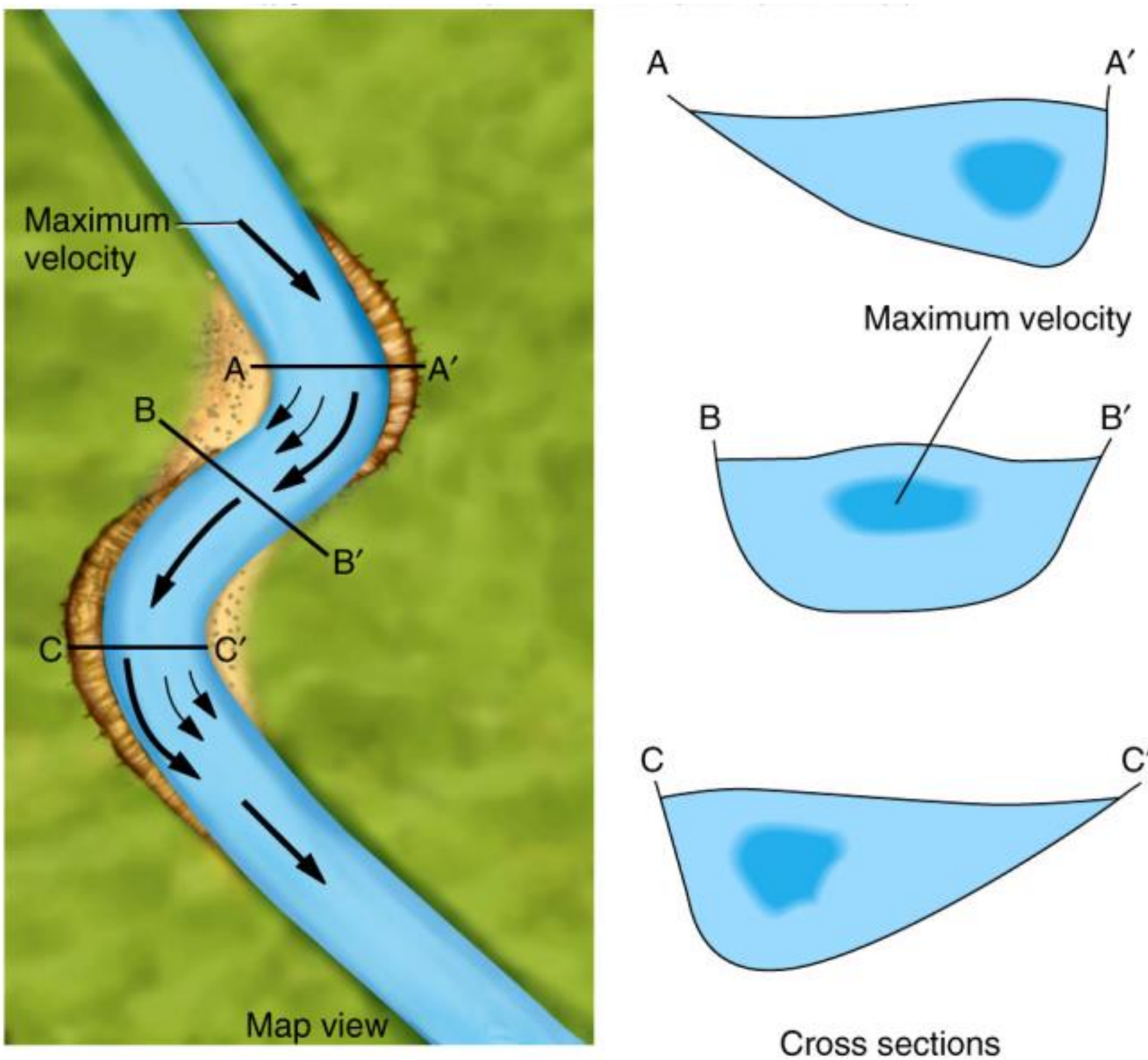
4.2.18. River/Stream/Creek Bank Erosion

Hazard/Problem Description

Any flowing body of water (brook, creek, stream, river) is a stream. Stream flow is expressed as volume per unit time, usually cubic meters per second, cubic feet per second, sometimes cubic kilometers per second, or acre-feet per second or day. Stream flow varies tremendously with time. Short term controls include rainfall, snowmelt, and evaporation conditions. Long term controls include land use, soil, groundwater state, and rock type.

Streams erode by a combination of direct stream processes, like down cutting and lateral erosion, and indirect processes, like mass-wasting accompanied by transportation. Water tends to move downstream in slugs that extend all the way across a channel as shown in Figure 4-51. When the channel bends, water on the outside of the bend (the cut-bank) flows faster and water on the inside of the bend (the point) flows slower. This distribution of velocity results in erosion occurring on the outside of the bend (cut) and deposition occurring on the inside of the bend.

Figure 4-51 Meanders and Streamflows



Stream bank erosion is a natural process, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Stream bank erosion processes, although complex, are driven by two major components: stream bank characteristics (erodibility) and hydraulic/gravitational forces. Many land use activities can affect both of these components and lead to accelerated bank erosion. The vegetation rooting characteristics can protect banks from fluvial entrainment and collapse, and also provide internal bank strength. When riparian vegetation is changed from woody species to annual grasses and/or forbs, the internal strength is weakened, causing acceleration of mass wasting processes. Stream bank aggradation or degradation is often a response to stream channel instability. Since bank erosion is often a symptom of a larger, more complex problem, the long-term solutions often involve much more than just bank stabilization. Numerous studies have demonstrated that stream bank erosion contributes a large portion of the annual sediment yield.

Determining the cause of accelerated streambank erosion is the first step in solving the problem. When a stream is straightened or widened, streambank erosion increases. Accelerated streambank erosion is part of the process as the stream seeks to re-establish a stable size and pattern. Damaging or removing streamside vegetation to the point where it no longer provides for bank stability can cause a dramatic increase in bank erosion. A degrading streambed results in higher and often unstable, eroding banks. When land use changes occur in a watershed, such as clearing land for agriculture or development, runoff increases. With this increase in runoff the stream channel will adjust to accommodate the additional flow, increasing streambank erosion. Addressing the problem of streambank erosion requires an understanding of both stream dynamics and the management of streamside vegetation.

Approximately 150 years ago, the levees of the Sacramento-San Joaquin Delta were raised to prevent flooding on what remains some of the most fertile farmland in the nation. While the peat soils were excellent for agriculture, they were not the best choice to create strong foundations for levee barriers meant to contain a constant flow of river water. Nevertheless, it was these native soils that were primarily used to create the levee system.

As farmers settled the valleys, the Gold Rush drew prospectors to the hills. As mining in the Sierra Nevada turned to the more "efficient" methods of hydraulic mining, the use of environmentally destructive high-pressure water jets washed entire mountainsides into local streams and rivers. Hydraulic gold mining in the northern Sierra Nevada foothills produced 1.1 billion cubic meters of sediment. As a result, the enormous amounts of silt deposited in the riverbeds of the Central Valley increased flood risk. As a remedy to these rising riverbeds, levees were built very close to the river channels to keep water velocity high and thereby scour away the sediment.

However, the design of these narrow channels has been too successful. While the Gold Rush silt is long gone, the erosive force of the constrained river continues to eat away at the levee system. In addition, the peat soils of the Delta have subsided, gradually lowering the elevations of Delta islands. As a result, some of these parcels are now more than 20 feet below sea level.

Erosion and deposition are occurring continually at varying rates over the Planning Area. Swiftly moving floodwaters cause rapid local erosion as the water carries away earth materials. Severe erosion removes the earth from beneath bridges, roads and foundations of structures adjacent to streams. By undercutting it can lead to increased rockfall and landslide hazard. The deposition of material can block culverts, aggravate flooding, destroy crops and lawns by burying them, and reduce the capacity of water reservoirs as the deposited materials displace water.

Streambank erosion increases the sediment that a stream must carry, results in the loss of fertile bottomland and causes a decline in the quality of habitat on land and in the stream. High velocity flows can erode material from the streambank. Erosion may also occur on the outboard or waterside of the levee (see Section 4.2.17), which may lead to instability and failure. Erosion can occur at once or over time as a function of the storm cycle and the scale of the peak storms.

Past Occurrences

Disaster Declaration History

There have been no disasters declarations in Sacramento County for erosion activity.

NCDC Events

The NCDC does not track erosion events.

USACE Events

The USACE began an annual erosion inventory of the Sacramento River in 1997, following the large flood event in the winter of 1996 and 1997. This flood event caused a levee failure and required numerous flood fighting efforts throughout the Sacramento River System. The original goal of the inventory was to identify the weak spots in the levee system caused by streambank erosion and repair them. However, concerns for the environment and endangered species limited the repair work to mainly emergency work (PL84-99) and local maintenance efforts. Under the SRBPP project, one site on the Sacramento River and a few sites on the American River were repaired prior to 2006.

In 2006, after the City of New Orleans was flooded, concern was raised for the threat of flooding to the Sacramento Valley. The Sacramento River Levee System has a lower level of flood protection than that of New Orleans. In February 2006, the governor of California declared a state of emergency for the Central Valley levees. Soon after, all the sites that were defined as "critical" in the 2005 inventory were repaired. Repairs have continued every year since and over 100 sites have been repaired since the declaration through the combined efforts of the USACE and Cal DWR.

While sites are currently being repaired, more sites enter the erosion inventory every year. The number of erosion sites within the system is large and even with repairs being completed every year, the number of stream bank erosion sites shows little decline year over year. With the large number of sites, a ranking system was developed to help determine which sites should be considered the highest priority for repair. Based on a 2010 field investigation, the total number of erosion sites within the Sacramento River Flood Control System is 185 sites, of which 3 are critical, 13 are new, 7 are minor, 11 were repaired, and 1 was removed. In 2010, none of these critical sites were located in Sacramento County.

In 2009, there were 221,582 linear feet of erosion within the system. In 2010, there is a total of 233,697 linear feet of erosion in the system. The total linear feet added in 2010 was 14,311 ft, of which 9,220 came from adding Wadsworth Canal into the inventory. The total linear feet repaired in 2009 was 5,497 ft. Data for specific linear feet in Sacramento County was unavailable for this plan.

During the 2011 annual erosion inventory, the following was added:

- There are currently 205 erosion sites in the inventory, or approximately 261,192 linear feet of eroding sites within the system.
- There are 48 new erosion sites and 47,113 linear feet of eroding bank were added this year.

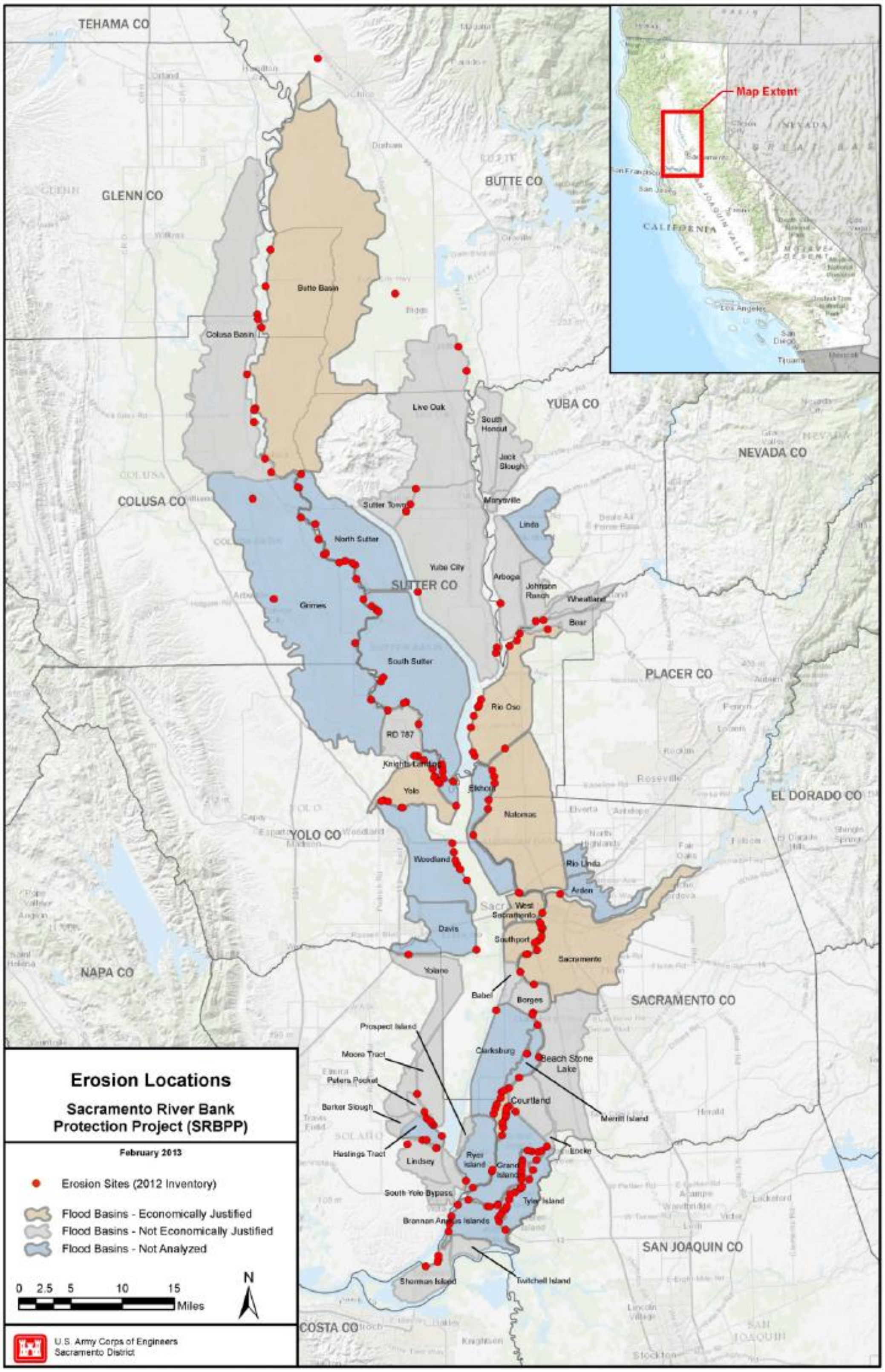
- There are 13 critical erosion sites: three on Cache Creek, five on Georgiana Slough, three on the Sacramento River, and two on Steamboat Slough. Ten of these critical erosion sites were upgraded to critical this year.

Following the 2012 annual erosion inventory the following was added:

- There are currently 201 erosion sites in the inventory, or approximately 265,625 linear feet of eroding sites within the system.
- There are 4 new erosion sites and 7,654 linear feet of eroding bank which were added this year.
- There are 14 critical erosion sites: three on Cache Creek, four on Georgiana Slough, six on the Sacramento River, and one on Steamboat Slough. Three of these erosion sites were upgraded to critical this year.

The 2012 Sacramento River Protection Project report (the most recent report available), done by the US Army Corps of Engineers, identified erosion spots of concern on the Sacramento River. These sites are shown on Figure 4-52.

Figure 4-52 2012 Identified Erosion Sites within the Sacramento River Flood Control Project



Source: Post Authorization Change Report for the Sacramento River Bank Protection Project Draft EIS

HMPC Events

The HMPC confirmed that erosion is an ongoing issue throughout the County.

Likelihood of Future Occurrence

Highly Likely – Due to the high number of linear feet in need of repair and the continuing number of linear feet that enter the USACE inventory, the likelihood of future occurrences of streambank erosion in Sacramento County is highly likely.

Climate Change and Soil Bank Erosion

Climate change may affect flooding in Sacramento County, which in turn may affect erosion rates. While average annual rainfall may increase or decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st century. High water associated with these heavy rains and flooding can contribute to increased erosion to stream and creek banks. It is possible that average soil moisture and runoff could decline, however, due to increasing temperature, evapotranspiration rates, and spacing between rainfall events.

4.2.19. Subsidence

Hazard/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. 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.

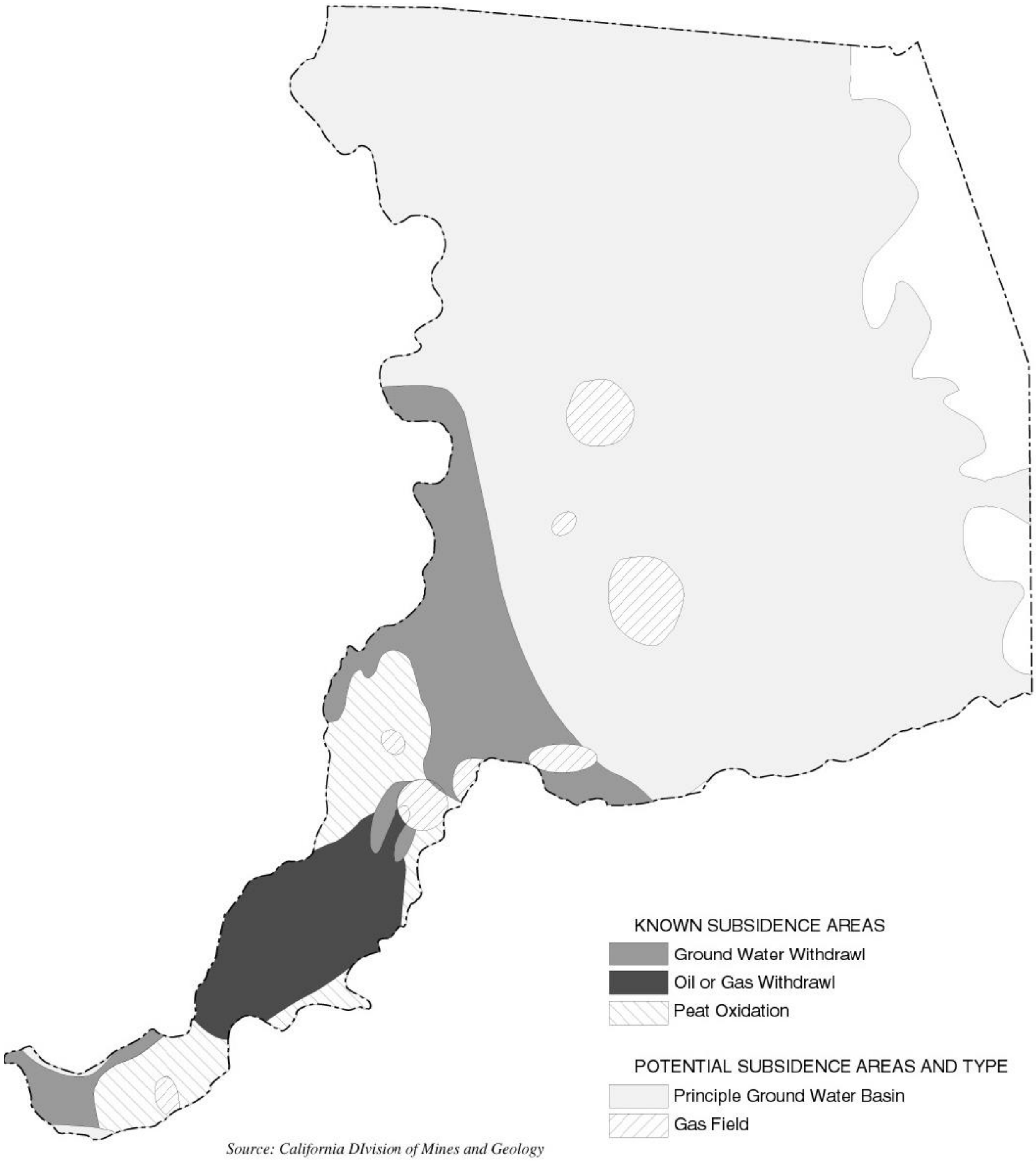
The Delta, located at the confluence of the Sacramento and San Joaquin Rivers, is blanketed by peat and peaty alluvium deposited where streams, originating in the Sierra Nevada, Coast Ranges, and southern Cascade Range, enter the San Francisco Bay system. In the late-1800s, large-scale agricultural development in the Delta required levee-building to prevent frequent flooding. The leveed marshland tracts then had to be drained, cleared of wetland vegetation, and tilled. Levees and drainage systems were largely complete by 1930 and the Delta had taken on its current appearance, with most of its 1,150-squaremile area reclaimed for agricultural use. Today the Delta includes about 57 islands or tracts that are imperfectly protected from flooding by more than 1,100 miles of levees.

Sacramento County is affected by five types of subsidence. They are:

- compaction of unconsolidated soils by earthquake shaking (liquefaction)
- compaction by heavy structures
- the erosion of peat soils
- peat oxidation
- fluid withdrawal

These areas are shown in Figure 4-53.

Figure 4-53 Known and Potential Subsidence Areas in Sacramento County



Source: Sacramento County General Plan Background Report, 2011

Compaction of Unconsolidated Soils by Earthquake Shaking (Liquefaction)

Compaction of unconsolidated soils by earthquake shaking is also known as liquefaction. Liquefaction is profiled as a separate hazard in Section 4.2.13. Refer to that section for more detail.

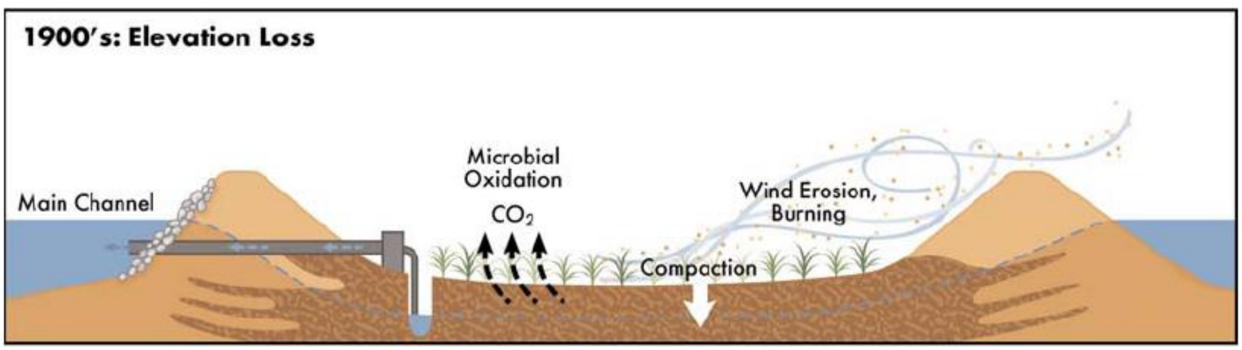
Compaction by Heavy Structures

Land development pressures are forcing the building of structures on top of fine grained water saturated sediments. Unfortunately, the weight of the structures presses the water out of the soils. To mitigate the problem, piles are installed from the footings of the heavy structures to a subsurface zone that will support the structural footing loads. The utilities, travel ways, and smaller building will be constructed to rest on the soil surface. As surface loading causes subsidence, the footings and pile support systems of the heavy structures will be exposed. In extreme situations, it may be necessary to build up the area to gain access into the pile supported structure as the area subsides. Structures that are not supported on piles will have a high probability of damage as the area subsides.

The Erosion of Peat Soils

Prior to 1950, poor land use practices, including burning of peat soils and wind erosion, exacerbated soil losses due to microbial oxidation (discussed in the next section and shown in Figure 4-54). Peat soils, being much less dense than mineral soils, are more easily eroded by wind. Peat soils are frequently wet either at, or close to, the surface thus limiting the amount of material which can be lost. Nevertheless, peat soils do blow causing spectacular dust clouds and degradation of this valuable resource.

Figure 4-54 Causes of Subsidence in the Delta during the 20th Century

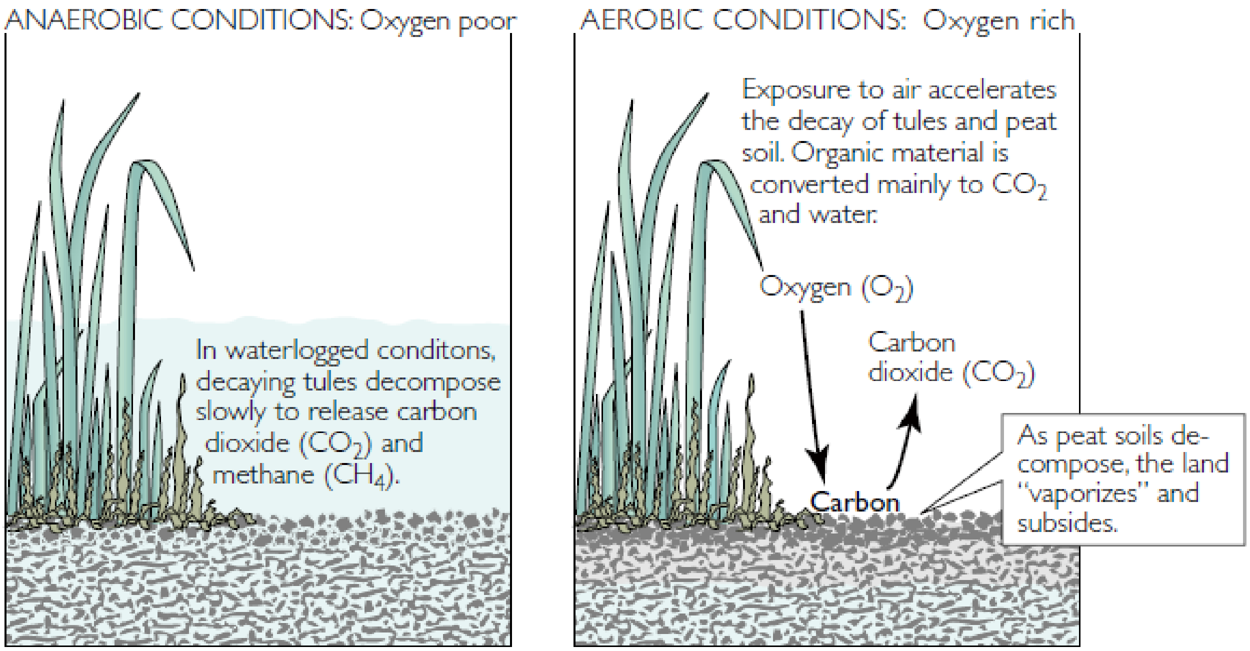


Source: Mount J, Twiss R. 2005. Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1 (March 2005), Article 5.

Peat Oxidation

The dominant cause of land subsidence in the Delta is decomposition of organic carbon in the peat soils. As shown in Figure 4-55, prior to agricultural development, the soil was waterlogged and anaerobic (oxygen-poor). Organic carbon accumulated faster than it could decompose. Drainage for agriculture led to aerobic (oxygen-rich) conditions that favor rapid microbial oxidation of the carbon in the peat soil. Most of the carbon loss is emitted as carbon dioxide gas to the atmosphere.

Figure 4-55 Peat Oxidation in Anaerobic and Aerobic Conditions



Source: USGS Publication "Sacramento-San Joaquin Delta: The Sinking Heart of the State." Report FS-005-00

Fluid Withdrawal

In the late-1800s, large-scale agricultural development in the Delta required levee-building to prevent frequent flooding. The leveed marshland tracts then had to be drained, cleared of wetland vegetation, and tilled. Levees and drainage systems were largely complete by 1930 and the Delta had taken on its current appearance, with most of its 1,150-square mile area reclaimed for agricultural use. As oxidation, erosion, and burning continued to cause subsidence of the land, more water needed to be withdrawn to maintain a constant water table to ensure agricultural plant growth. Water levels in the depressed islands are maintained 3 to 6 feet below the land surface by an extensive network of drainage ditches, and the accumulated agricultural drainage is pumped through or over the levees into stream channels. Without this drainage the islands would become waterlogged.

Groundwater Pumping

Central Sacramento County Groundwater Management Plan discussed groundwater pumping in the County.

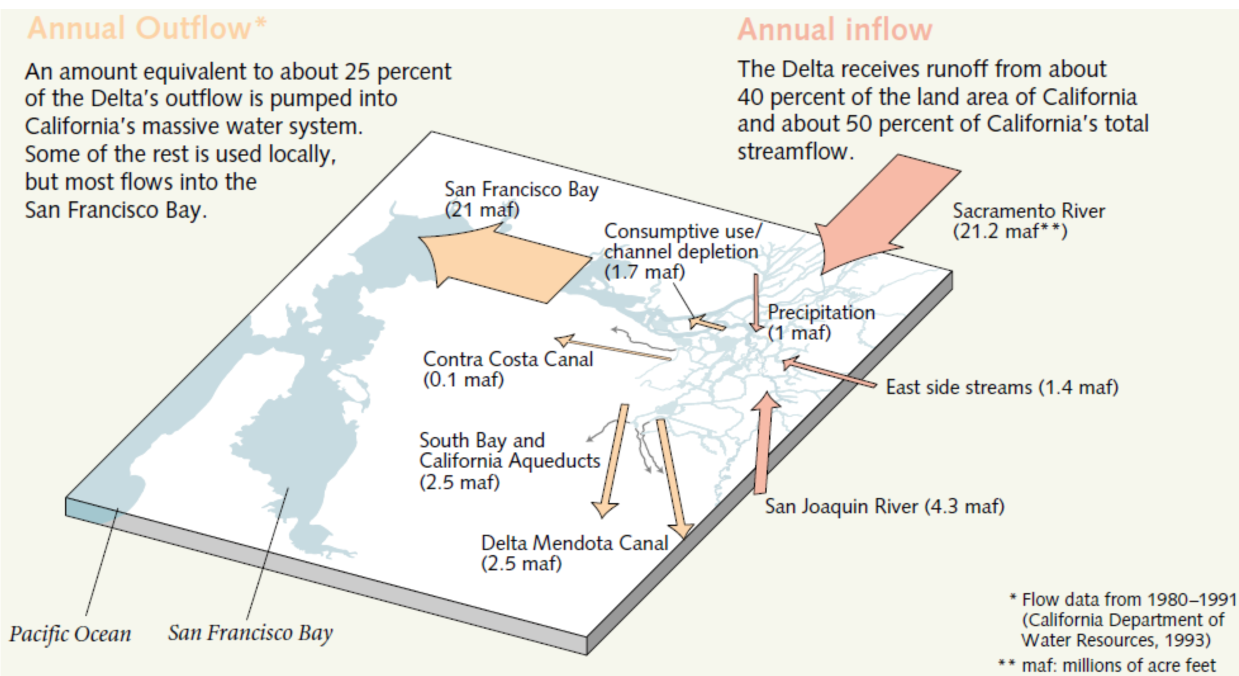
> *Historical benchmark elevation data for the period from 1912 through the late 1960s obtained from the National Geodetic Survey (NGS) were used to evaluate land subsidence in north Sacramento County. From 1947 to 1969, the magnitude of land subsidence measured at benchmarks north of the American River ranged from 0.13 feet to 0.32 feet, with a general decrease in subsidence in a northeastward direction. This decrease is consistent with the geology of the area: formations along the eastern side of the Sacramento Valley are older than those on the western side and are subject to a greater degree of pre-consolidation, making them less susceptible to subsidence. The maximum documented land subsidence of 0.32 feet was measured at both benchmark L846, located approximately two miles northeast of the former McClellan AFB, and benchmark*

G846, located approximately one mile northeast of the intersection of Greenback Lane and Elkhorn Boulevard. Another land subsidence evaluation was performed in the Arden-Arcade area of Sacramento County from 1981 to 1991. Elevations of nine wells in the Arden-Arcade area were surveyed in 1981, 1986, and 1991. The 1986 results were consistently higher than the 1981 results; this was attributed to extremely high rainfall totals in early 1986 that recharged the aquifer and caused a rise in actual land surface elevations. The 1991 results were consistently lower than the 1986 results; this was attributed to five years of drought immediately preceding the 1991 measurements which caused depletion of the aquifer and resulting land surface subsidence. Comparison of eight of the locations indicates that seven benchmarks had lower elevations in 1991 than in 1981 and one benchmark had a higher elevation in 1991. Of the seven benchmarks with lower elevations in 1991, the maximum difference is 0.073 feet (less than one inch). Whether this is inelastic subsidence is indeterminate from the data, but it is clear that the magnitude of the potential subsidence in the benchmarks between 1981 and 1991 was negligible.

Subsidence and Delta Water Supply

The Delta receives runoff from about 40 percent of the land area of California and about 50 percent of California's total streamflow, as shown in Figure 4-56. It is the heart of a massive north-to-south water-delivery system whose giant engineered arterials transport water southward. State and Federal contracts provide for export of up to 7.5 million acre-feet per year from two huge pumping stations in the southern Delta near the Clifton Court Forebay. About 83 percent of this water is used for agriculture and the remainder for various urban uses in central and southern California. Two-thirds of California's population (more than 20 million people) gets at least part of its drinking water from the Delta.

Figure 4-56 The Delta and California's Water System



Source: USGS Publication "Sacramento-San Joaquin Delta: The Sinking Heart of the State." Report FS-005-00

Land subsidence of Delta islands indirectly affects the north-to-south water transfer system, which is predicated on the available water supply (annual inflows to the Delta), the viability of aquatic species populations, and acceptable water quality in the southern Delta. The statewide water-transfer system in California is so interdependent that decreased water quality in the Delta, whether due to droughts or levee failures, might lead to accelerated subsidence in areas dependent on imported water from the Delta.

The waterways of the Delta are subject to tidal action. Ocean tides propagating into San Francisco Bay are observed 5–6 hours later along the Cosumnes River in the eastern Delta. The position of the interface between the saline waters of the Bay and the freshwaters of the Delta depends upon the tidal cycle and the flow of freshwater through the Delta. Before major dams were built on rivers in the Delta watershed, the salinity interface migrated as far upstream as Courtland along the Sacramento River. Today, releases of freshwater from dams far upstream help reduce the maximum landward migration of the salinity interface during the late summer. In the spring, however, reservoirs and Delta exports consistently act in concert to increase the landward migration of the salinity interface over that expected under conditions of unimpaired flows.

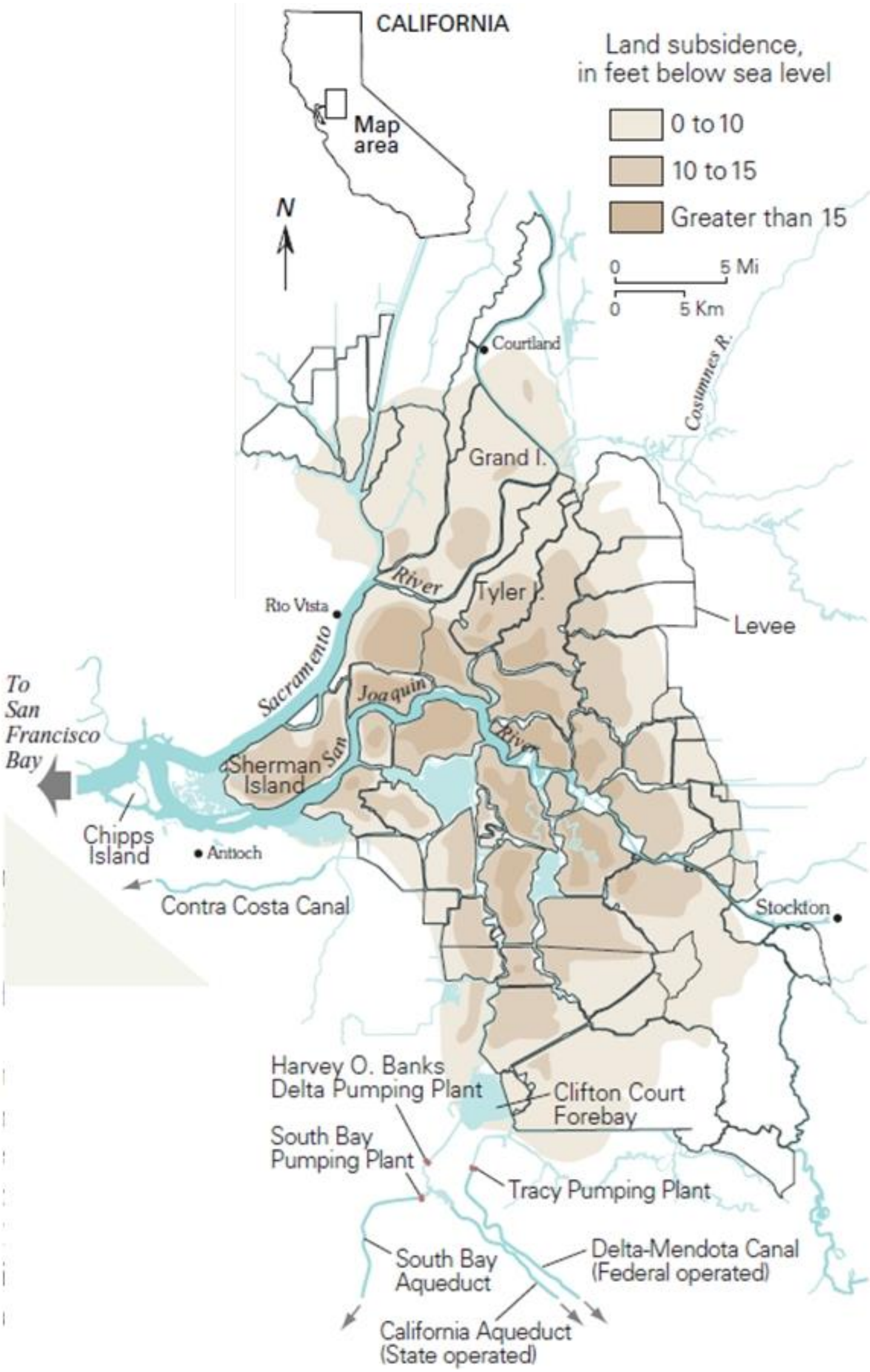
A less significant, terms of acreage effected, but no less severe problem arising from subsidence of bayward Delta islands is salt water intrusion of subsurface fresh water. River water runoff during years of comparatively normal precipitation has been sufficient to retard salt water from intruding into the fresh water table. However, the rate of salt water intrusion of west Delta islands increases during years of below normal precipitation, causing damage to crops irrigated with subsurface water contaminated with salt water. Efforts to develop salt tolerant crops and a reduction in the subsidence rate might enable farming to continue on west Delta islands for a limited time. However, continuing crop production accelerates peat oxidation and potentially lessens irrigation water quality from salt water intrusion of subsurface fresh water sources.

Subsidence and Levee Failure

Island subsidence has reduced the stability of Delta levees, increasing the risk of failure (see the discussion of Levee Failure in Section 4.2.17). Embankment and foundation materials for most Delta levees are substandard, adding the risk of failure during seismic events. Subsidence of levees and crop covered islands is occurring, though levees lower at a slower rate due primarily to a slow oxidation process from reduced tillage and irrigation.

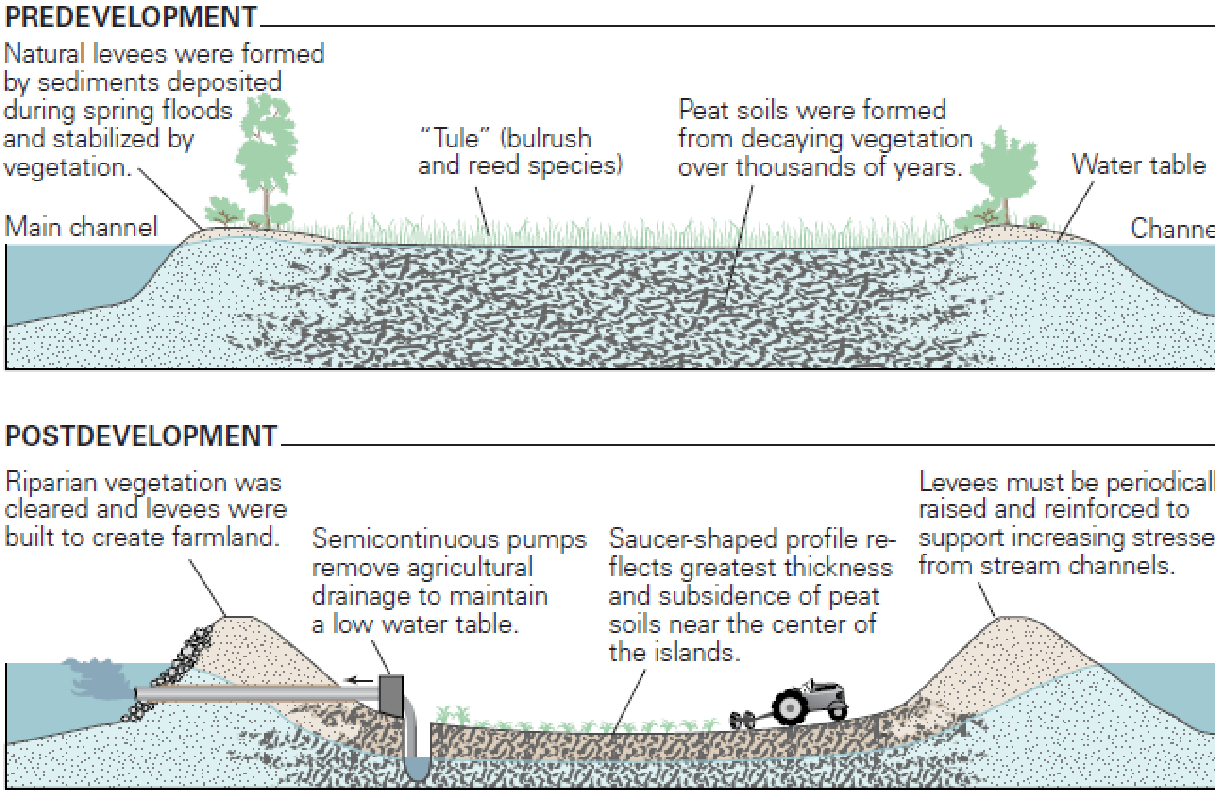
As shown in Figure 4-57, many of the islands in the central Delta are presently 10 to nearly 25 feet below sea level. The land surface profile of many islands is somewhat saucer-shaped, because subsidence is greater in the thick peat soils near their interior than in the more mineral-rich soils near their perimeter. As subsidence progresses, the levees themselves must be regularly maintained and periodically raised and strengthened to support the increasing stresses on their banks.

Figure 4-57 Land Subsidence in the Sacramento-San Joaquin Delta



Source: USGS Publication "Sacramento-San Joaquin Delta: The Sinking Heart of the State." Report FS-005-00

Figure 4-58 Subsidence in Peat Soils on the Delta Islands



Source: USGS Publication "Sacramento-San Joaquin Delta: The Sinking Heart of the State." Report FS-005-00

When levee breaches occur on deeply-subsided islands, rapid filling draws brackish water into the Delta, temporarily degrading water quality over a large region. Known colloquially as the "Big Gulp," the water quality impact of island filling is principally a function of the magnitude and location of anthropogenic accommodation space (vertical space once filled by peat but that has now subsided). Island flooding directly affects tidal prism dynamics within the Delta, with the potential for long-term degradation of water quality. The magnitude of the impact depends upon the location of flooded islands, the volume of water within the island, and the geometry of breach openings.

The costs of levee construction and maintenance are borne by the State of California and the Federal government, as well as by local reclamation districts. These costs increase as subsidence progresses, forcing levees to be built higher and stronger. Between 1981 and 1986, the total amount spent on emergency levee repairs related to flooding was about $97 million, and in 1981 to 1991 the amount spent on routine levee maintenance was about $63 million. Annual cost of repair and maintenance of Delta levees in the 1980s averaged about $20 million per year.

Subsidence and Natural Resources Protection

The Delta provides at least a portion of the water supply for about two-thirds of California's population, and provides a migratory pathway for four fish that are listed as endangered or threatened pursuant to the federal Endangered Species Act.

Past Occurrences

Disaster Declaration History

There have been no disaster declarations related to subsidence in Sacramento County.

NCDC Events

The NCDC database shows no past occurrences of subsidence.

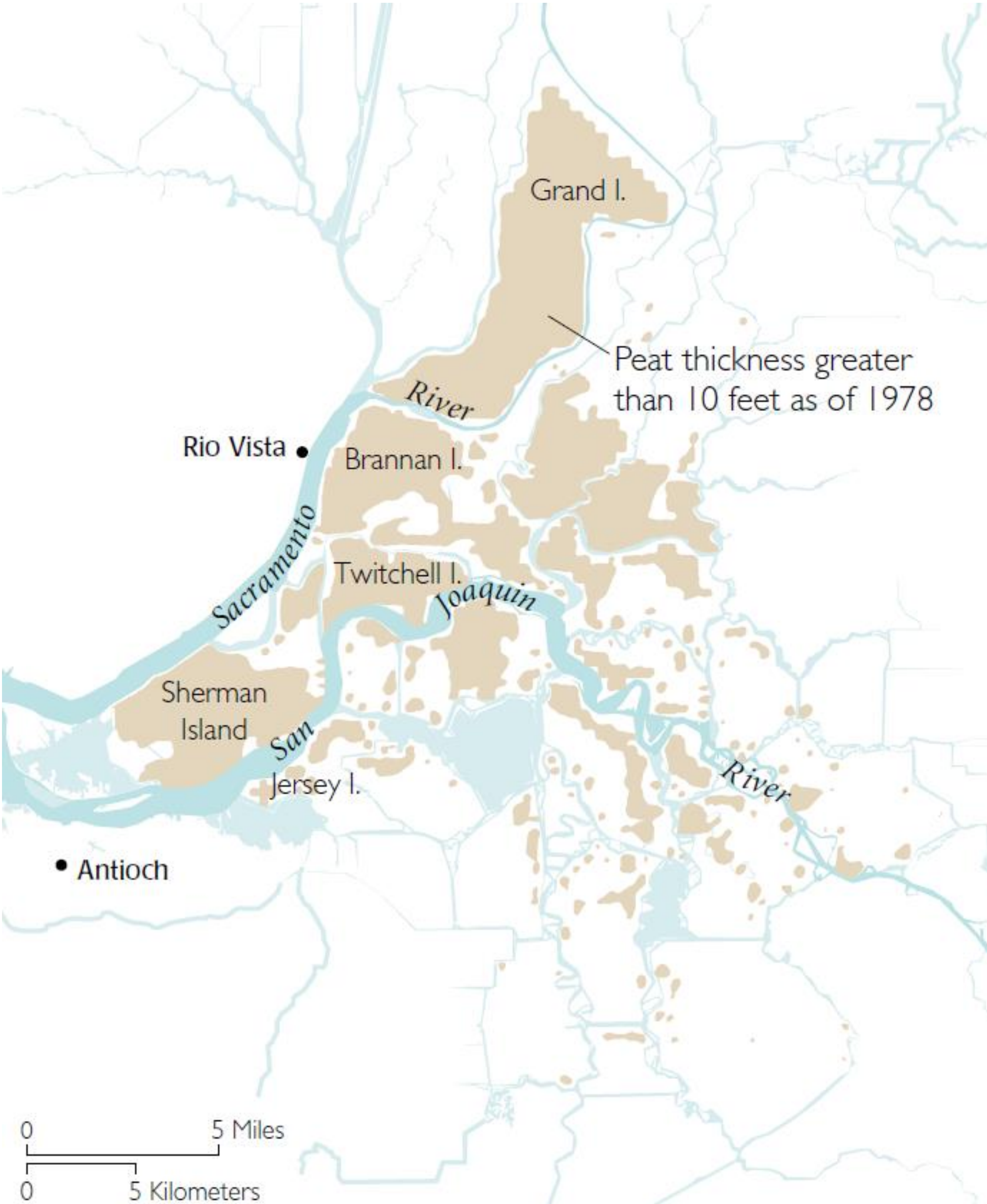
HMPC Events

Subsidence has been occurring since the late 1800s, when the land in the Delta region first was converted to farmland. Reclamation projects continued, and by the 1930s the levee system was complete. The best evidence for long-term rates of subsidence comes from two sources—measurements of the exposure of transmission-line foundations on Sherman and Jersey Islands in the western Delta and repeated leveling surveys on Mildred and Bacon Islands and Lower Jones Tract in the southern Delta. The transmission lines in the western Delta were installed in 1910 and 1952. They are founded on pylons driven down to a solid substrate, so that comparison of the original foundation exposure with the current exposure allows estimates of soil loss. The southern Delta transect was surveyed 21 times between 1922 and 1981; in 1983 further surveys were precluded when Mildred Island flooded. Both data sets indicate long-term average subsidence rates of 1 to 3 inches per year, but also suggest a decline in the rate of subsidence over time, probably due to a decreased proportion of readily oxidizable peat in the near surface. In fact, rates of elevation loss measured at three selected sites in 1990 to 1992 were less than 0.4 inches per year, consistent with the inferred slowing of subsidence. However, all of these sites were near island edges, and likely underestimate the average island-wide elevation loss.

Likelihood of Future Occurrences

Highly Likely—Subsidence in the Delta has been a historical problem, occurring on an annual basis. Although changes in farming techniques and improved land use practices have slowed levels of subsidence, subsidence continues to occur. This is unlikely to change in the near future. Areas with peat thickness over 10 feet have a great potential for continued subsidence. These areas are shown in Figure 4-59.

Figure 4-59 Peat Thickness Estimates



Source: California Department of Water Resources, 1998

Climate Change and Subsidence

Climate change may further contribute to subsidence in the County, by increasing evapotranspiration rates for agriculture and other vegetation and by increasing periods of drought, both of which can increase demand for water, accelerate groundwater pumping and the drilling of new groundwater wells and lead to further lowering of the groundwater table.

4.2.20. Volcano

Hazard/Problem Description

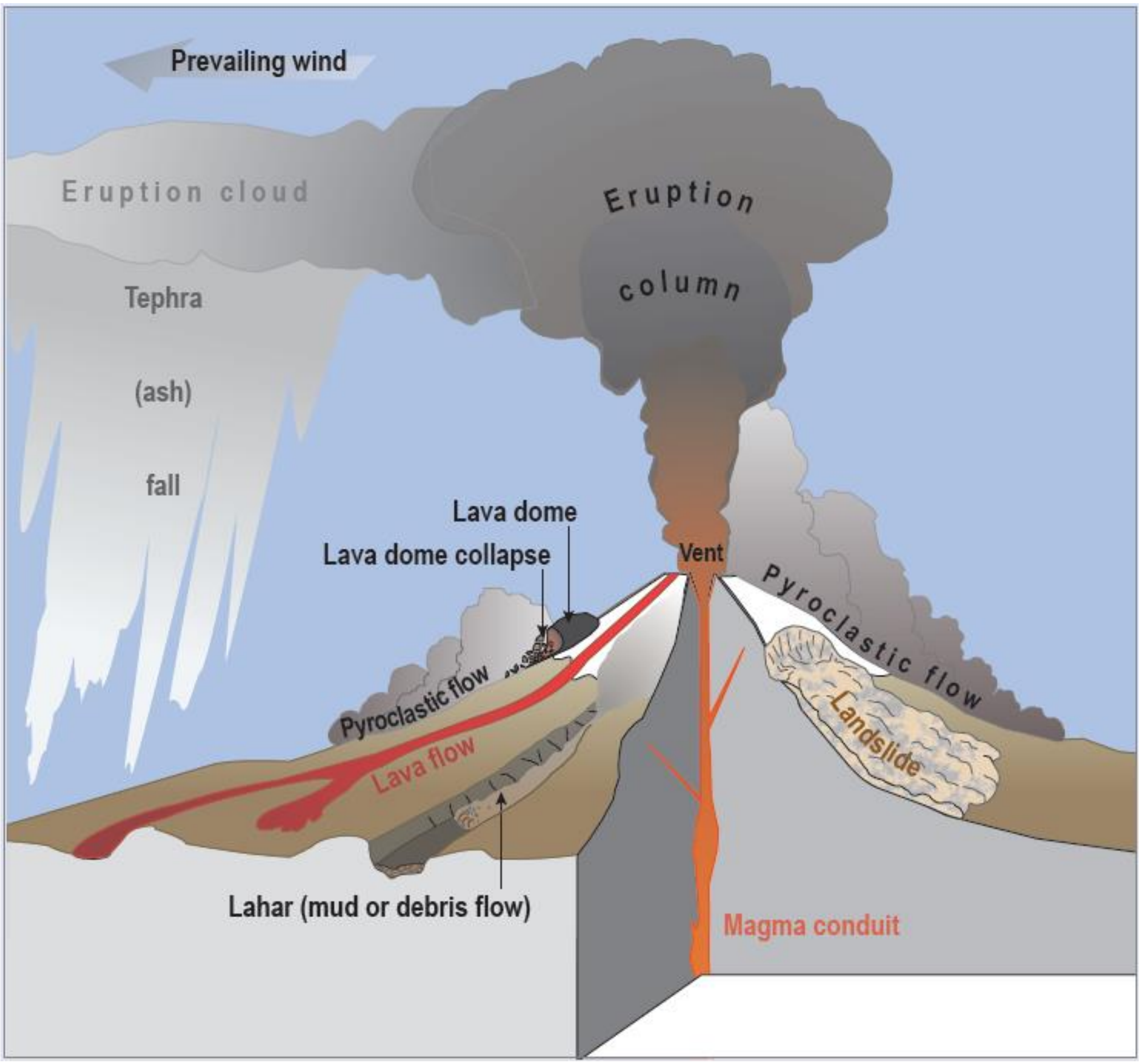
The California State Hazard Mitigation Plan identifies volcanoes as one of the hazards that can adversely impact the State. However, there have been few losses in California from volcanic eruptions. Of the approximately 20 volcanoes in the State, only a few are active and pose a threat. Of these, Long Valley Caldera and Lassen Peak are the closest to Sacramento County. The Long Valley area is considered to be an active volcanic region of California and includes features such as the Mono-Inyo Craters, Long Valley Caldera, and numerous active and potential faults. Figure 4-60 shows volcanoes in or near California and the location of the Lassen Peak and the Long Valley area relative to the Sacramento County Planning Area.

Figure 4-60 Active Volcanoes in California and in the Sacramento County Area

Source: 2013 State of California Hazard Mitigation Plan

As shown in Figure 4-61, active volcanoes pose a variety of natural hazards. Explosive eruptions blast lava fragments and gas into the air with tremendous force. The finest particles (ash) billow upward, forming an eruption column that can attain stratospheric heights in minutes. Simultaneously, searing volcanic gas laden with ash and coarse chunks of lava may sweep down the flanks of the volcano as a pyroclastic flow. Ash in the eruption cloud, carried by the prevailing winds, is an aviation hazard and may remain suspended for hundreds of miles before settling to the ground as ash fall. During less energetic effusive eruptions, hot, fluid lava may issue from the volcano as lava flows that can cover many miles in a single day. Alternatively, a sluggish plug of cooler, partially solidified lava may push up at the vent during an effusive eruption, creating a lava dome. A growing lava dome may become so steep that it collapses, violently releasing pyroclastic flows potentially as hazardous as those produced during explosive eruptions.

Figure 4-61 Volcanoes and Associated Hazards

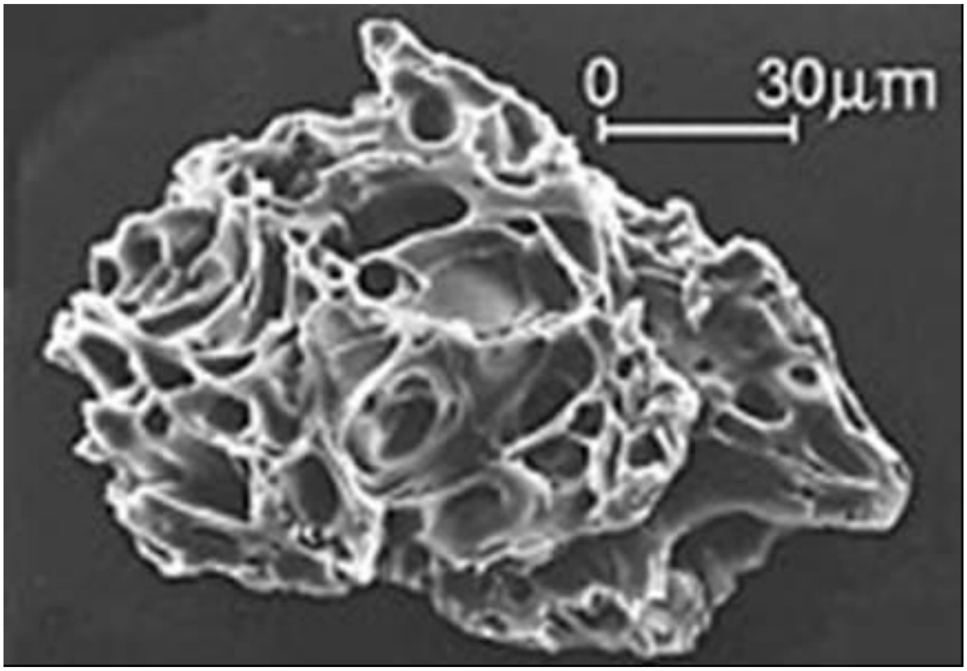


Source: USGS Publication 2014-3120

During and after an explosive or effusive eruption, loose volcanic debris on the flanks of the volcano can be mobilized by heavy rainfall or melting snow and ice, forming powerful floods of mud and rock (lahars) resembling rivers of wet concrete. These can rush down valleys and stream channels as one of the most destructive types of volcano hazards.

Populations living near volcanoes are most vulnerable to volcanic eruptions and lava flows, although volcanic ash can travel and affect populations many miles away and cause problems for aviation. The USGS notes specific characteristics of volcanic ash. Volcanic ash is composed of small jagged pieces of rocks, minerals, and volcanic glass the size of sand and silt, as shown in Figure 4-62. Very small ash particles can be less than 0.001 millimeters across. Volcanic ash is not the product of combustion, like the soft fluffy material created by burning wood, leaves, or paper. Volcanic ash is hard, does not dissolve in water, is extremely abrasive and mildly corrosive, and conducts electricity when wet.

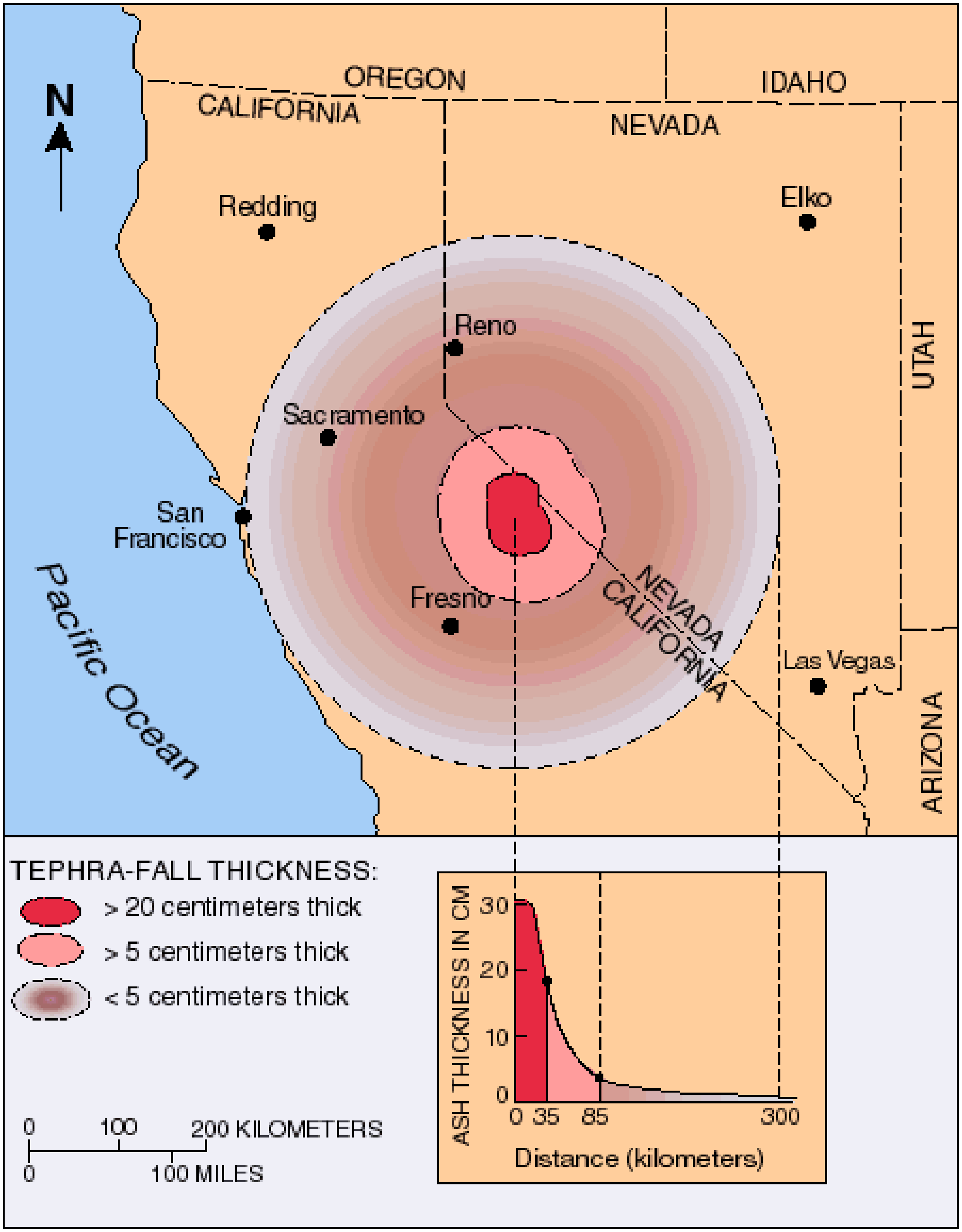
Figure 4-62 Ash Particle from 1980 Mt. St Helens Eruption Magnified 200 Times



Source: US Geological Survey: Volcanic Ash: Effect & Mitigation Strategies. http://volcanoes.usgs.gov/ash/properties.html.

Volcanic ash is formed during explosive volcanic eruptions. Explosive eruptions occur when gases dissolved in molten rock (magma) expand and escape violently into the air, and also when water is heated by magma and abruptly flashes into steam. The force of the escaping gas violently shatters solid rocks. Expanding gas also shreds magma and blasts it into the air, where it solidifies into fragments of volcanic rock and glass. Once in the air, wind can blow the tiny ash particles tens to thousands of miles away from the volcano. Figure 4-63 is a volcanic hazard's ash dispersion map for the Long Valley Caldera, which could possible affect Sacramento County.

Figure 4-63 Volcanic Hazards Ash Dispersion Map for the Long Valley Caldera



Source: US Geological Survey

The average grain-size of rock fragments and volcanic ash erupted from an exploding volcanic vent varies greatly among different eruptions and during a single explosive eruption that lasts hours to days. Heavier, large-sized rock fragments typically fall back to the ground on or close to the volcano and progressively smaller and lighter fragments are blown farther from the volcano by wind. Volcanic ash, the smallest particles (2 mm in diameter or smaller), can travel hundreds to thousands of kilometers downwind from a volcano depending on wind speed, volume of ash erupted, and height of the eruption column.

The size of ash particles that fall to the ground generally decreases exponentially with increasing distance from a volcano. Also, the range in grain size of volcanic ash typically diminishes downwind from a volcano (becoming progressively smaller). At specific locations, however, the distribution of ash particle sizes can vary widely. Based on Figure 4-63, the USGS estimated that ash of up to 2" could fall in areas of Sacramento County.

Past Occurrences

Disaster Declarations

There have been no disaster declarations related to volcano.

NCDC Events

The NCDC does not track volcanic activity.

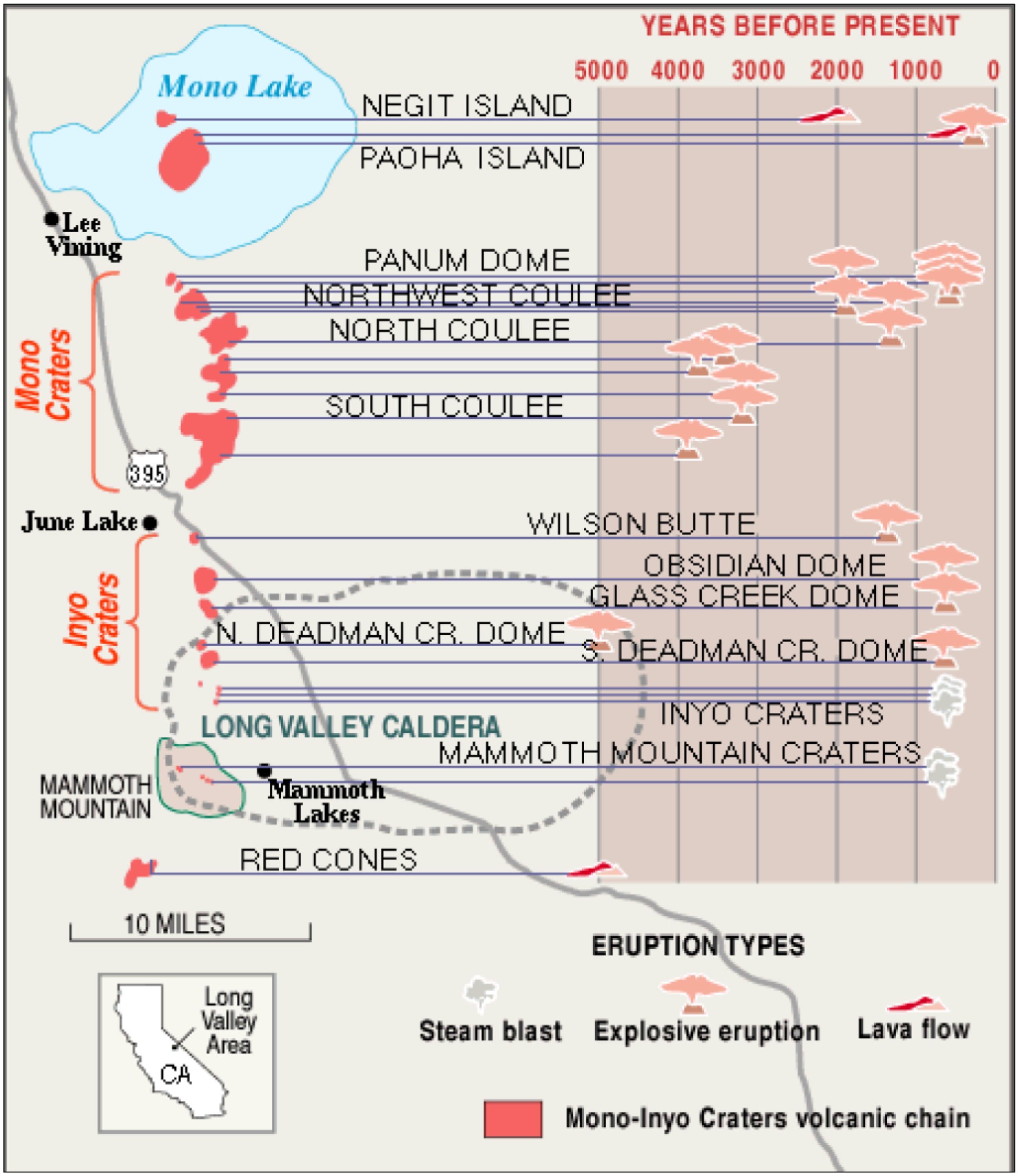
HMPC Events

The HMPC noted no volcanic events.

USGS Events

During the past 1,000 years there have been at least 12 volcanic eruptions in the Long Valley area. This activity is likely to continue long into the future. The Long Valley Caldera and Mono-Inyo Craters volcanic chain has a long history of geologic activity that includes both earthquakes and volcanic eruptions. Volcanoes in the Mono-Inyo Craters volcanic chain have erupted often over the past 40,000 years. As shown in Figure 4-64. over the past 5,000 years, small to moderate eruptions have occurred at various sites along the Mono-Inyo Craters volcanic chain at intervals ranging from 250 to 700 years.

Figure 4-64 Volcanic Activity in the Mono-Inyo Craters Volcano Chain in the Past 5,000 Years



Source: U.S. Geological Survey

As recently as 1980 four large earthquakes (greater than magnitude 6 on the Richter Scale) and numerous relatively shallow earthquakes occurred in the area. Since then, earthquakes and associated uplift and deformation in the Mammoth Lakes Caldera have continued. Because such activities are common precursors of volcanic eruptions, the U.S. Geological Survey closely monitors the unrest in the region. There are no records of past impacts from volcanic eruptions to the Sacramento County Planning Area.

Likelihood of Future Occurrences

Unlikely—According to the U.S. Geological Survey, the pattern of volcanic activity over the past 5,000 years suggests that the next eruption in the Long Valley area will most likely happen somewhere along the Mono-Inyo volcanic chain. However, the probability of such an eruption occurring in any given year is less than 1 percent. The next eruption will most likely be small and similar to previous eruptions along the Mono-Inyo volcanic chain during the past 5,000 years (see Figure 4-64 above). According to the State Multi-Hazard Mitigation Plan, only Medicine Lake, Mount Shasta, Lassen Peak, and the Long Valley Caldera are considered active and pose a threat of future activity. However, due to the location of the Planning Area relative to the active volcanoes, the State Plan does not consider Sacramento County to be vulnerable to eruption and/or ash from these volcanoes.

4.2.21. Wildfire (Burn Area/Smoke)

Hazard/Problem Description

Wildland fire is an ongoing concern for the Sacramento County Planning Area. Generally, the fire season extends from early spring through late fall of each year during the hotter, dryer months. Fire conditions arise from a combination of high temperatures, low moisture content in the air and fuel, accumulation of vegetation, and high winds.

Throughout California, communities are increasingly concerned about wildfire safety as increased development in the foothills and mountain areas and subsequent fire suppression practices have affected the natural cycle of the ecosystem. While wildfire risk is predominantly associated with wildland urban interface (WUI) areas, significant wildfires can also occur in heavily populated areas. The wildland urban interface is a general term that applies to development adjacent to landscapes that support wildland fire. Wildland fires affect grass, forest, and brushlands, as well as any structures located within them.

WUI fires are the most damaging. WUI fires occur where the natural and urban development intersect. Even relatively small acreage fires may result in disastrous damages. WUI fires occur where the natural forested landscape and urban-built environment meet or intermix. The damages are primarily reported as damage to infrastructure, built environment, loss of socio-economic values and injuries to people.

The pattern of increased damages is directly related to increased urban spread into historical forested areas that have wildfire as part of the natural ecosystem. Many WUI fire areas have long histories of wildland fires that burned only vegetation in the past. However, with new development, a wildland fire following a historical pattern now burns developed areas. WUI fires can occur where there is a distinct boundary between the built and natural areas or where development or infrastructure has encroached or is intermixed in the natural area. WUI fires may include fires that occur in remote areas that have critical infrastructure easements through them, including electrical transmission towers, railroads, water reservoirs, communications relay sites or other infrastructure assets.

Wildfire and urban wildfire are an ongoing concern for Sacramento County. Generally, the fire season extends from early spring to late fall. Fire conditions arise from a combination of hot weather, an accumulation of vegetation, and low moisture content in the air. These conditions when combined with high winds and years of drought increase the potential for a wildfire to occur. Urban wildfires often occur in those areas where development has expanded into the rural areas. A fire along this urban/rural interface can result in major losses of property and structures. Generally, there are three major factors that sustain wildfires and allow for predictions of a given area's potential to burn. These factors include fuel, topography, weather, and human actions.

- **Fuel**. Fuel is the material that feeds a fire and is a key factor in wildfire behavior. Fuel is generally classified by type and by volume. Fuel sources are diverse and include everything from dead tree needles and leaves, twigs, and branches to dead standing trees, live trees, brush, and cured grasses. Also to be considered as a fuel source, are man-made structures and other associated combustibles. The type of prevalent fuel directly influences the behavior of wildfire. Light fuels such as grasses burn quickly and serve as a catalyst for fire spread. The volume of available fuel is described in terms of Fuel Loading. Certain areas in and surrounding Sacramento County are extremely vulnerable to fires as a result of dense grassy vegetation combined with a growing number of structures being built near and within rural lands. In the northern portion of the County, such as Folsom, an increase in forested areas increase the risk and vulnerability of wildfire.
- **Topography**. An area's terrain and land slopes affect its susceptibility to wildfire spread. Fire intensities and rates of spread increase as slope increases due to the tendency of heat from a fire to rise via convection. The natural arrangement of vegetation throughout a hillside can also contribute to increased fire activity on slopes. Most of the Sacramento area is relatively flat, thus limiting the influence of this factor on wildfire behavior.
- **Weather**. Weather components such as temperature, relative humidity, wind, and lightning also affect the potential for wildfire. High temperatures and low relative humidity dry out the fuels that feed the wildfire creating a situation where fuel will more readily ignite and burn more intensely. Wind is the most treacherous weather factor. The greater a wind, the faster a fire will spread, and the more intense it will be. Winds can be significant at times in Sacramento County. However, it should be noted that the winds generally occur during the winter storm season, not during the summer, fire season. In addition to high winds, wind shifts can occur suddenly due to temperature changes or the interaction of wind with topographical features such as slopes or steep hillsides. Related to weather is the issue of recent drought conditions contributing to concerns about wildfire vulnerability. During periods of drought, the threat of wildfire increases.
- **Human Actions** – Most wildfires are ignited by human action, the result of direct acts of arson, carelessness, or accidents. Many fires originate in populated areas along roads and around homes, and are often the result of arson or careless acts such as the disposal of cigarettes, use of equipment or debris burning. Recreation areas that are located in high fire hazard areas also result in increased human activity that can increase the potential for wildfires to occur.

Potential losses from wildfire include human life, structures and other improvements, natural and cultural resources, quality and quantity of water supplies, cropland, timber, and recreational opportunities. Economic losses could also result. Smoke and air pollution from wildfires can be a severe health hazard. In addition, catastrophic wildfire can create favorable conditions for other hazards such as flooding, landslides, and erosion during the rainy season.

Consequently, wildland fires that burn in natural settings with little or no development are part of a natural ecological cycle and may actually be beneficial to the landscape. Century old policies of fire exclusion and aggressive suppression have given way to better understanding of the importance fire plays in the natural cycle of certain forest types.

Past Occurrences

Disaster Declaration History

There were no FEMA or Cal OES disaster declarations associated with wildfire in the Sacramento County Planning Area. There was one USDA Secretarial Disaster Declaration (S3626) for wildfire in 2014.

NCDC Events

The NCDC has tracked wildfire events in the County dating back to 1993. Events in Sacramento County are shown in Table 4-36.

Table 4-36 NCDC Wildfire Events in Sacramento County 1993 to 12/31/2015

Date	Event	Injuries (direct)	Deaths (direct)	Property Damage	Crop Damage	Injuries (direct)	Deaths (direct)
7/4/2014	Wildfire	0	0	$2,500,000	$0	0	0
7/22/2015	Wildfire	0	0	$0	$0	0	0
7/27/2015	Wildfire	0	0	$500,000	$0	0	0
Totals		**0**	**0**	**$3,000,000**	**$0**	**0**	**0**

Source: NCDC

*Deaths, injuries, and damages are for the entire event, and may not be exclusive to the County.

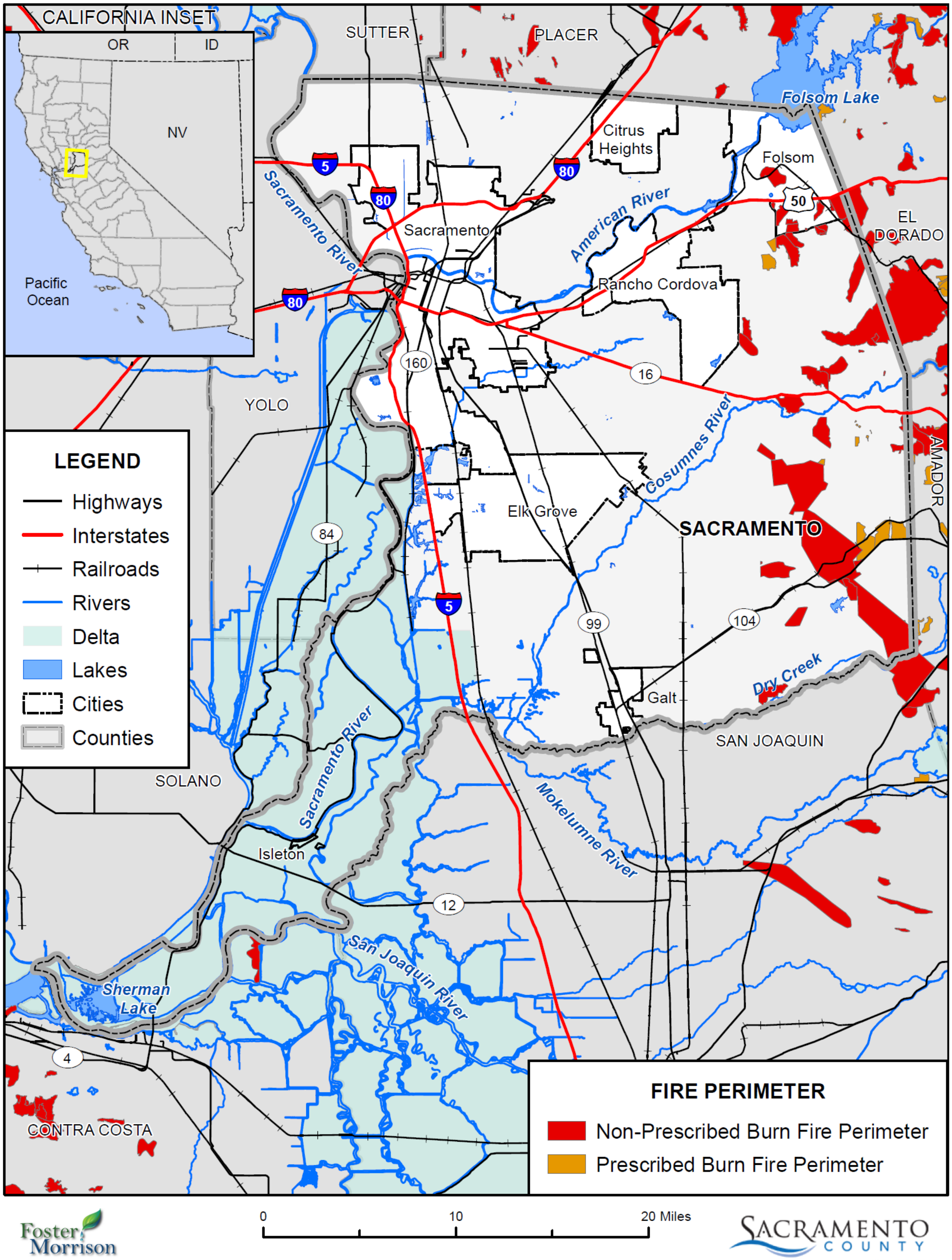
CAL FIRE Events

CAL FIRE, USDA Forest Service Region 5, Bureau of Land Management (BLM), the National Park Service (NPS), Contract Counties and other agencies jointly maintain a comprehensive fire perimeter GIS layer for public and private lands throughout the state. The data covers fires back to 1878 (though the first recorded incident for the County was in 1950). For the National Park Service, Bureau of Land Management, and US Forest Service, fires of 10 acres and greater are reported. For CAL FIRE, timber fires greater than 10 acres, brush fires greater than 50 acres, grass fires greater than 300 acres, and fires that destroy three or more residential dwellings or commercial structures are reported. CAL FIRE recognizes the various federal, state, and local agencies that have contributed to this dataset, including USDA Forest Service Region 5, BLM, National Park Service, and numerous local agencies.

Fires may be missing altogether or have missing or incorrect attribute data. Some fires may be missing because historical records were lost or damaged, fires were too small for the minimum cutoffs, documentation was inadequate, or fire perimeters have not yet been incorporated into the database. Also, agencies are at different stages of participation. For these reasons, the data should not be used for statistical or analytical purposes.

The data provides a reasonable view of the spatial distribution of past large fires in California. Using GIS, fire perimeters that intersect Sacramento County were extracted and are listed in Table 4-37. There are 50 fires recorded in this database for Sacramento County. 44 of these burned areas greater than 50 acres. Each of them was tracked by Cal Fire; Cal Fire last updated this database in June 2014. Table 4-37 lists each fire's date, cause, name, and acreage burned in Sacramento County. Figure 4-65 shows fire history for the County, colored by burn type. This map contains fires from 1950 to 2014.

Figure 4-65 Sacramento County Wildfire History



Data Source: Sacramento County GIS, Cal-Atlas, Cal-Fire 05/2015 Fire History Data; Map Date: 05/2016.

Table 4-37 Sacramento County Wildfire History 1950 to 2014

Alarm Date	Fire Name	Cause	Prescribed / Non-prescribed Burn	Acres
6/6/1950	Russi	Unknown / Unidentified	Non-prescribed Burn	534
6/19/1950	Questo Ranch	Unknown / Unidentified	Non-prescribed Burn	878
9/13/1950	Cavitt	Unknown / Unidentified	Non-prescribed Burn	339
10/4/1962	Roadside #31 Series	Unknown / Unidentified	Non-prescribed Burn	352
7/10/1964	Joerger	Unknown / Unidentified	Non-prescribed Burn	1514
6/22/1968	Van Vleck	Unknown / Unidentified	Non-prescribed Burn	2665
6/18/1973	Russell	Unknown / Unidentified	Non-prescribed Burn	408
6/7/1974	Cosumnes School	Unknown / Unidentified	Non-prescribed Burn	582
6/7/1974	Grantline	Unknown / Unidentified	Non-prescribed Burn	311
6/20/1976	Gill	Unknown / Unidentified	Non-prescribed Burn	715
7/29/1980	Michigan Bar	Unknown / Unidentified	Non-prescribed Burn	848
6/14/1981	Meiss	Miscellaneous	Non-prescribed Burn	14126
6/18/1981	Joerger Series	Equipment Use	Non-prescribed Burn	1676
6/20/1981	Silva	Arson	Non-prescribed Burn	248
9/21/1981	Prairie City	Arson	Non-prescribed Burn	593
7/6/1983	Clay	Equipment Use	Non-prescribed Burn	405
7/14/1983	White Rock	Miscellaneous	Non-prescribed Burn	169
8/28/1983	Meiss	Equipment Use	Non-prescribed Burn	603
3/1/1985	Arroyo Seco #3		Prescribed Burn	406
7/20/1986	White Rock Series	Arson	Non-prescribed Burn	7
7/20/1986	White Rock Series	Arson	Non-prescribed Burn	82
7/20/1986	White Rock Series	Arson	Non-prescribed Burn	162
7/20/1986	White Rock Series	Arson	Non-prescribed Burn	282
7/20/1986	White Rock Series	Arson	Non-prescribed Burn	33
6/17/1989	Trunk Handle (Unit1)		Prescribed Burn	56
6/17/1989	Trunk Handle (Unit2)		Prescribed Burn	178
6/21/1992	Smud #1	Powerline	Non-prescribed Burn	1179
6/26/1996	Prairie City		Prescribed Burn	316
8/2/1996	Scott	Arson	Non-prescribed Burn	8828
6/16/2001	Vanvleck		Prescribed Burn	23
6/23/2001	Bevan	Equipment Use	Non-prescribed Burn	687
7/4/2001	Dillard Wf2	Playing with Fire	Non-prescribed Burn	11
7/5/2001	Payen	Miscellaneous	Non-prescribed Burn	302
7/31/2001	Clay	Arson	Non-prescribed Burn	526
7/31/2001	Michigan #4	Arson	Non-prescribed Burn	55

Alarm Date	Fire Name	Cause	Prescribed / Non-prescribed Burn	Acres
6/8/2002	Twin	Arson	Non-prescribed Burn	322
6/12/2002	Pony	Powerline	Non-prescribed Burn	702
7/1/2002	White	Vehicle	Non-prescribed Burn	81
9/16/2002	Puerto	Arson	Non-prescribed Burn	17
10/10/2002	White #2	Unknown / Unidentified	Non-prescribed Burn	170
6/12/2003	Cosumnes River Preserve #2		Prescribed Burn	70
7/15/2003	Cosumnes River Preserve #1		Prescribed Burn	433
4/4/2004	Scott	Unknown / Unidentified	Non-prescribed Burn	609
9/26/2005	Twin	Vehicle	Non-prescribed Burn	104
6/9/2006	CHANCE Ranch VMP		Prescribed Burn	560
6/14/2006	Van Vleck Ranch VMP		Prescribed Burn	57
6/12/2007	Chance Ranch VMP		Prescribed Burn	479
7/7/2011	Chance Ranch		Prescribed Burn	263
3/25/2012	Van Vleck		Prescribed Burn	3
5/28/2013	Prairie City OHV - Prairie City		Prescribed Burn	176

Source: CAL FIRE

HMPC Events

The HMPC also provided the following information on historical fires in the County.

- **Late 1850**s: The worst fire in Sacramento history leveled nine-tenths of the City.
- **September/October 2014 – King Fire**. While the King Fire did not burn ground in Sacramento County, it did affect the County. Production from the Upper American River Hydroelectric Power Plant was disrupted for 2 weeks, requiring an additional unbudgeted $37 million for replacement power, by far the largest cost compared to the approximately $4M in immediate physical damage.
- **7/2015 NOAA** (fires regional to Sacramento County) – Rocky Fire burned 69,000 acres in Lake, Yolo & Colusa Counties. 43 homes and 53 outbuildings were destroyed.
- A 25-acre fire in Elk Grove occurred on **June 9, 2015**. A grass fire that started about 1:30 p.m. at Bond and Waterman roads was driven by high, shifting winds. It quickly spread toward homes that border the field to the east and south. The fire damaged one Elk Grove home and prompted evacuation of several other residences before it was contained.

Likelihood of Future Occurrence

Highly Likely — From May to October of each year, Sacramento County faces a wildfire threat. Fires will continue to occur on an annual basis in the Sacramento County Planning Area. The threat of wildfire and potential losses constantly increase as human development and population increase in the wildland urban interface area in the County. This results in a highly likely rating for future occurrence.

Climate Change and Wildfire

Preliminary Draft - Climate Change Vulnerability Assessment for the Sacramento County Climate Adaptation Plan (CAP), Ascent Environmental 2016 Analysis

According to the Sacramento County Phase 1 Vulnerability Assessment, contained within the 2016 Preliminary Draft CAP, which utilized Cal Adapt to model potential climate change impacts to Sacramento County, changes in precipitation patterns and increased temperatures associated with climate change will alter the distribution and character of natural vegetation and associated moisture content of plants and soils. Increased temperatures will increase the rate of evapotranspiration in plants, resulting in a greater presence of dry fuels in forests and grasslands and creating a higher potential for wildfire risks. Warmer temperatures will also create a more favorable habitat for bark beetles and other pests that will deteriorate tree health, increasing their vulnerability to wildfires. Thus, increasing heat coupled with declining precipitation can lead to a secondary impact of climate change – an increase in the frequency and intensity of wildfires. The Sacramento Metropolitan Fire District's CWPP also predicts an overall increase in the frequency and intensity of wildfires as a result of the changes associated with climate change.

Cal-Adapt's wildfire tool predicts the potential increase in the amount of burned areas for the year 2085, as compared to current (2010) conditions. Based on this model, Cal-Adapt predicts that wildfire risk in Sacramento County will increase slightly in the near term, and subside during mid-to late-century. However, wildfire models can vary depending on the parameters used. Cal-Adapt does not take landscape and fuel sources into account in their model. In all likelihood, in Sacramento County, precipitation patterns, high levels of heat, topography, and fuel load will determine the frequency and intensity of future wildfire.

Wildfires and Air Quality. In addition to a probable increase in wildfire risk, wildfires within the Sierra Nevada and areas outside the County affect air quality in Sacramento County and across the Sacramento Valley. Particulate matter from wildfire dissipates throughout the Central Valley degrading air quality conditions for short or extended periods of time. An increase in air pollutants can cause or exacerbate health conditions. The duration of wildfire-related particulate matter in the County's air is further linked to wind patterns (i.e., the Delta Breeze) originating from the Sacramento-San Joaquin Delta that disperse air pollutants north of the Sacramento Valley. However, during about half of the days from July to September (high fire season), a phenomenon called the "Schultz Eddy" prevents this from occurring. All of these factors will affect the severity of wildfire-related air pollution in Sacramento County. Climate change has already significantly lengthened California's fire season, as well as the intensity, frequency and size of individual wildfires around the state, and this trend is likely to continue without further mitigation. It is likely that Sacramento County will experience worsened air quality from increased wildfires throughout Northern California and even Oregon.

4.2.22. Natural Hazards Summary

Table 4-38 summarizes the results of the hazard identification and hazard profile for the Sacramento County Planning Area based on the updated hazard identification data and input from the HMPC. For each hazard profiled in Section 4.2, this table includes the likelihood of future occurrence and whether the hazard is considered a priority hazard for the Sacramento County Planning Area.

Table 4-38 Hazard Identification/Profile Summary and Determination of Priority Hazard: Sacramento County Planning Area

Hazard	Likelihood of Future Occurrence	Priority Hazard
Agricultural Hazards	Highly Likely	Y
Bird Strike	Highly Likely	Y
Climate Change	Highly Likely	Y
Dam Failure	Unlikely	Y
Drought and Water Shortage	Likely	Y
Earthquake	Occasional	Y
Earthquake: Liquefaction	Occasional	Y
Flood: 100/200/500-year	Occasional/Unlikely	Y
Flood: Localized Stormwater Flooding	Highly Likely	Y
Landslides	Unlikely	N
Levee Failure	Occasional	Y
River/Stream/Creek Bank Erosion	Highly Likely	Y
Severe Weather: Extreme Temperatures – Cold/Freeze	Likely	N
Severe Weather: Extreme Temperatures – Heat	Highly Likely	Y
Severe Weather: Fog	Highly Likely	N
Severe Weather: Heavy Rains and Storms (Thunderstorms/Hail, Lightning)	Highly Likely	Y
Severe Weather: Wind and Tornadoes	Highly Likely	N
Subsidence	Highly Likely	N
Volcano	Unlikely	N
Wildfire	Highly Likely	Y