# Chapter 3
# Historical and Existing Conditions

This chapter describes the historical and existing abiotic and biotic conditions of the *Salinas River Long-Term Management Plan* (LTMP) study area, including the physical characteristics, land uses, water uses, and biological resources. Additionally, the chapter summarizes the environmental pressures and stresses on the river hydrology and natural communities within the study area.

The physical characteristics of the LTMP study area include the location, topography, geology, soils, climate, watersheds, hydrology and geomorphology, historical flooding, groundwater, and water quality.  The LTMP study area includes 118 river miles of the Salinas River (69% of the total length of the Salinas River) and many of its primary tributaries: Arroyo Seco, Nacimiento River, San Antonio River, and San Lorenzo Creek. The topography of the study area is characterized by the high elevations of the Coast Ranges to the west and the Gabilan and Diablo Ranges to the east of the Salinas River down to the Salinas Valley, which comprises the lower elevations of the study area. Geologically recent tectonic activity, including movement on the Rinconada–Reliz Fault Zone (Rosenberg and Clark 2009) formed the Salinas Valley and Santa Lucia, Sierra de Salinas, Gabilan, and Diablo Mountain Ranges, which were uplifted to their present elevations in Quaternary time (2.6 million years ago [Ma] to present; Rosenberg 2001). The soils of the study area are derived from the underlying geologic formations. Productive agriculture of the Salinas Valley is supported by deep, dark, fertile soils, such as the Salinas clay loams. In addition, several classes of miscellaneous soils were mapped that included tidal marsh, peat, coastal beach and dune sands and the management area is dominated by the following four soil orders: mollisols, entisols, vertisols, and alfisols.

Climate in the study area is characterized by a Mediterranean climate with cool wet winters and warm dry summers. The Pacific Ocean influences the climate close to the coast, where the weather is often overcast or has coastal fog and cool temperatures. The inland areas are warmer in the summer and colder in winter. Precipitation in the study area varies from approximately 15 to 60 inches annually. The mountainous areas near the coast receive much more precipitation than the Salinas Valley, which has an annual average of approximately 15 inches of precipitation.

The bulk of the study area is located within the Salinas River watershed, with a small portion of the study area—near the mouth of the Salinas River—within the Monterey Bay watershed. Hydrology and geomorphology discussions in this chapter include historical and existing conditions of the upper watershed (River Mile [RM] 53 near Greenfield to RM 118 near San Miguel), Salinas River Valley (RM 53 to RM 7) and the Salinas River Lagoon (RM 7 to RM 0 from Blanco Road to Highway 1, downstream to the Salinas River Lagoon). Historical flooding in each watershed is also discussed.

The groundwater discussion of this chapter covers groundwater basins, groundwater recharge, and groundwater pumping. There are eight groundwater subbasins in the Salinas Valley Basin and these are described in geological terms. The ways groundwater recharge takes place in the groundwater basin is discussed. Groundwater is pumped to supply water for agricultural, residential, and municipal uses in the study area.

The water quality of the lower Salinas Valley is well documented by the Central Coast Regional Water Quality Control Board (Regional Water Board). Water quality issues range from groundwater contamination by nitrates and seawater intrusion to surface water contamination from agricultural chemicals and urban runoff. The following listed impairments known from the study area are further discussed in the chapter: fecal indicator bacteria, nutrients, pesticides, pH, salinity, sediment toxicity, turbidity, mercury, and water temperature.

Land use is discussed in three sections: historical land use, current land use, and protected lands. Historically, the Ohlone, Salinan and Esselen people used the lands in the Salinas Valley for hunting and gathering. Currently, land use is designated as agricultural and open space in the study area, except when the Salinas River approaches cities and unincorporated communities, where land uses are in most cases designated residential, industrial, resource conservation, and public/quasi-public. Protected lands within the management and study areas include lands owned and managed by federal, state, and local agencies and include local neighborhood parks; large regional parks, including state and national parks; golf courses; and reservoirs.

Biological resources in the study area include ecoregions, natural communities, special-status species, and habitat connectivity. Ecoregions include Monterey Bay Plains and Terraces, Salinas Valley, Gabilan Range, Diablo Range, Salinas-Cholame Hills, Northern Santa Lucia Range, Interior Santa Lucia Range, and Southern Santa Lucia Range as well as Paso Robles Hills and Valley. Communities in the study area include coastal strand and dune, grasslands, shrublands, forests and woodlands, riparian, wetlands, riverine, marine, estuarine, aquatic, agriculture, barren, and developed. Special-status species include nine target species, which have been consulted on for prior projects and may be impacted by future management activities. Habitat connectivity is essential for maintaining biological diversity and species populations in the study area. Maintaining movement corridors on land, in streams, and along riparian corridors is essential to helping special-status species thrive. Connectivity between aquatic habitats in the Salinas River and tributaries is imperative to maintain populations of fish and other aquatic animals in the watershed.

The environmental pressures and stresses relevant to the Salinas River LTMP study area are described. The primary section headings—*Changes in Natural Communities*, *Altered River Hydrology*, and *Changes in Climate*—are considered the primary pressures in the study area and the subsections cover the resulting stresses—e.g., habitat loss, altered flow, sea level rise, prolonged drought. The discussion in each section explains the history and status of the pressure within the study area and details the stresses to relevant special-status species. Changes in natural communities include habitat loss, fragmentation and degradation, shifting distribution of natural communities, invasive species, and changes to the natural fire regime. Altered river hydrology includes altered flow from diversions and dams, which could degrade water quality in both the Salinas River and the Salinas River Lagoon. Changes in climate include sea level rise, prolonged drought, changes in average rainfall, changes in storm intensity and frequency, and change in summer fog. Sea level rise, prolonged drought, and the factors that contribute to drought—decreased rainfall, changes in storm intensity and frequency, and decreases in fog—are discussed in this section; Section 3.5.1, *Changes in Natural Communities*, discusses how invasive species and changes to the duration and intensity of wildfires as stresses other than climate change, such as development and land management, also influence those pressures.

# 3.1 Physical Characteristics

The following sections describe the physical characteristics of the LTMP study area.

## 3.1.1 Location

The Salinas River runs through a valley in the Coast Ranges and is bounded to the west by the Sierra de Salinas and Santa Lucia Mountains and to the east by the Gabilan Range and Diablo Range. The Salinas Valley is approximately 10 miles wide and 155 miles long. The Salinas River watershed covers approximately 4,200 square miles of Monterey and San Luis Obispo Counties (Figure 1-1). The Salinas River flows in a northwest direction through the Salinas Valley and empties into Monterey Bay. As described in Chapter 1, *Introduction,* the LTMP study area is defined as the portion of the Salinas River watershed[1] where subwatersheds[2] have a confluence with the Salinas River at or downstream of the confluence of the Nacimiento River and lands surrounding Nacimiento Dam that are managed by the Monterey County Water Resources Agency (MCWRA). This study area includes 118 river miles of the Salinas River (69% of the total length of the Salinas River) and many of its primary tributaries: Arroyo Seco, Nacimiento River, San Antonio River, and San Lorenzo Creek (Figure 3-1).

## 3.1.2 Topography

The topography of the study area is characterized by the high elevations of the Coast Ranges to the west and the Gabilan and Diablo Ranges to the east of the Salinas River, respectively. The study area is located along the western margin of the Coast Ranges of California, which span 400 miles from Humboldt County south to Santa Barbara County. This central portion of the range is defined by the Sierra de Salinas and Santa Lucia Mountains (Figure 3-1). The highest peaks in this range are Junipero Serra Peak, Pinyon Peak, and Cone Peak in the Santa Lucia Mountains with an elevation of 5,853, 5,256, and 5,154 feet, respectively. The Gabilan Range and Diablo Range characterize the eastern portion of the study area with elevations over 5,000 feet. San Benito Mountain is the highest peak in the Diablo Range, at 5,240 feet (Figure 3-1). The Salinas Valley comprises the lower elevations of the study area. The lowest points include the city of Salinas, portions of the Salinas River such as the Salinas River Diversion Facility (SRDF) and the Salinas River Lagoon, and the coastal dunes (Figure 3-1).

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[1] As defined by the U.S. Geologic Survey (USGS) hydrologic unit code (HUC)-8 boundary (cataloging unit 18060005).

[2] As defined by the USGS HUC-10 boundaries.

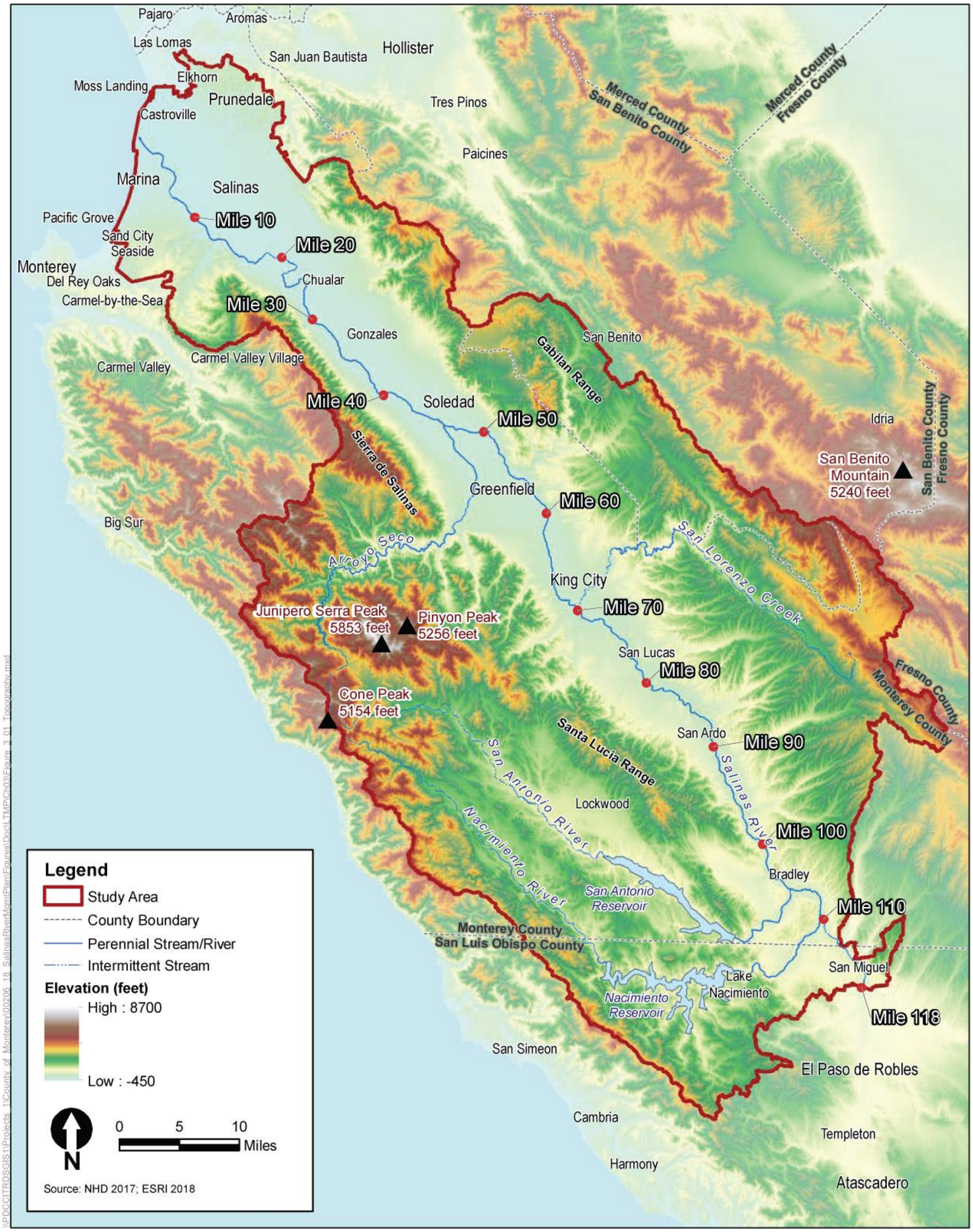



**Figure 3-1. Topography**

### 3.1.3 Geology

The Salinas Valley is underlain by the Salinian tectonic block, a geologic basement terrane consisting of metamorphic and granitic rock of Paleozoic to Mesozoic age. The Salinian Block is bordered on both east and west by tectonic blocks of the Franciscan Complex (Figure 3-2). The boundaries between these tectonic blocks are large-scale strike-slip faults: the San Andreas Fault Zone on the east, and the Sur-Nacimiento Fault Zone on the west (Figure 3-2). Millions of years of tectonic activity on these bounding fault systems transported the Salinan block hundreds of miles northward and inserted it between blocks of the Franciscan Complex.

Geologically recent tectonic activity, including movement on the Rinconada–Reliz Fault Zone (Figure 3-2) (Rosenberg and Clark 2009) formed the Salinas Valley and Santa Lucia, Sierra de Salinas, Gabilan, and Diablo Mountain Ranges, which were uplifted to their present elevations in Quaternary time (2.6 million years ago [Ma] to present; Rosenberg 2001).

Figure 3-3a presents a geologic map of the management and study areas, illustrating both the locations of faults and the geologic formations present at ground surface. The legend on Figure 3-3b presents the age sequence of the geologic materials from the youngest unconsolidated Quaternary sediments, labeled with “Q,” to the oldest pre-Cambrian basement rock.

The combination of tectonically driven land movement and sea level changes has influenced the depositional environment in the ancestral Salinas Valley from the Cretaceous through Quaternary time. Over millions of years, the Salinas Valley Basin has been filled with 10,000 to 15,000 feet of marine and continental sediments. A major marine transgression in middle to late Miocene time (approximately 16 to 6 Ma) resulted in thick, multi-layer accumulations of fine-grained sediment known as the Monterey Formation, which is as much as 12,000 feet thick in the Salinas Valley. More recent, minor marine transgressions that occurred between 80 and 125 thousand years ago, and between 15 and 25 thousand years ago, resulted in a single, thick layer of fine-grained sediment, which impedes inter-aquifer exchange and thus confines the shallower aquifers (Erskine and Fisher 2002). Uplift of the Santa Lucia Range began in early Pliocene time (approximately 5 Ma).

Material eroded from the uplifted ranges has been transported and deposited by the ancestral Salinas River and tributaries as gravel, sand, silt, and clay that make up the Quaternary alluvial deposits (<2.5 Ma) in the Salinas Valley. In addition to the fluvial material transported and deposited along the Salinas River corridor, the Quaternary deposits include alluvial fans along portions of the margins of the Valley that were eroded from the Gabilan and San Lucia Mountains and deposited by tributaries to the Salinas River. The alluvial fans coalesce with fluvial deposits associated with the ancestral river. Active geologic processes continue today, including erosion and deposition of fluvial sediment, wind-blown coastal dunes, landslides in the hills, and tectonic motion on faults. Table 3-1 summarizes the geologic history of the Salinas Valley.

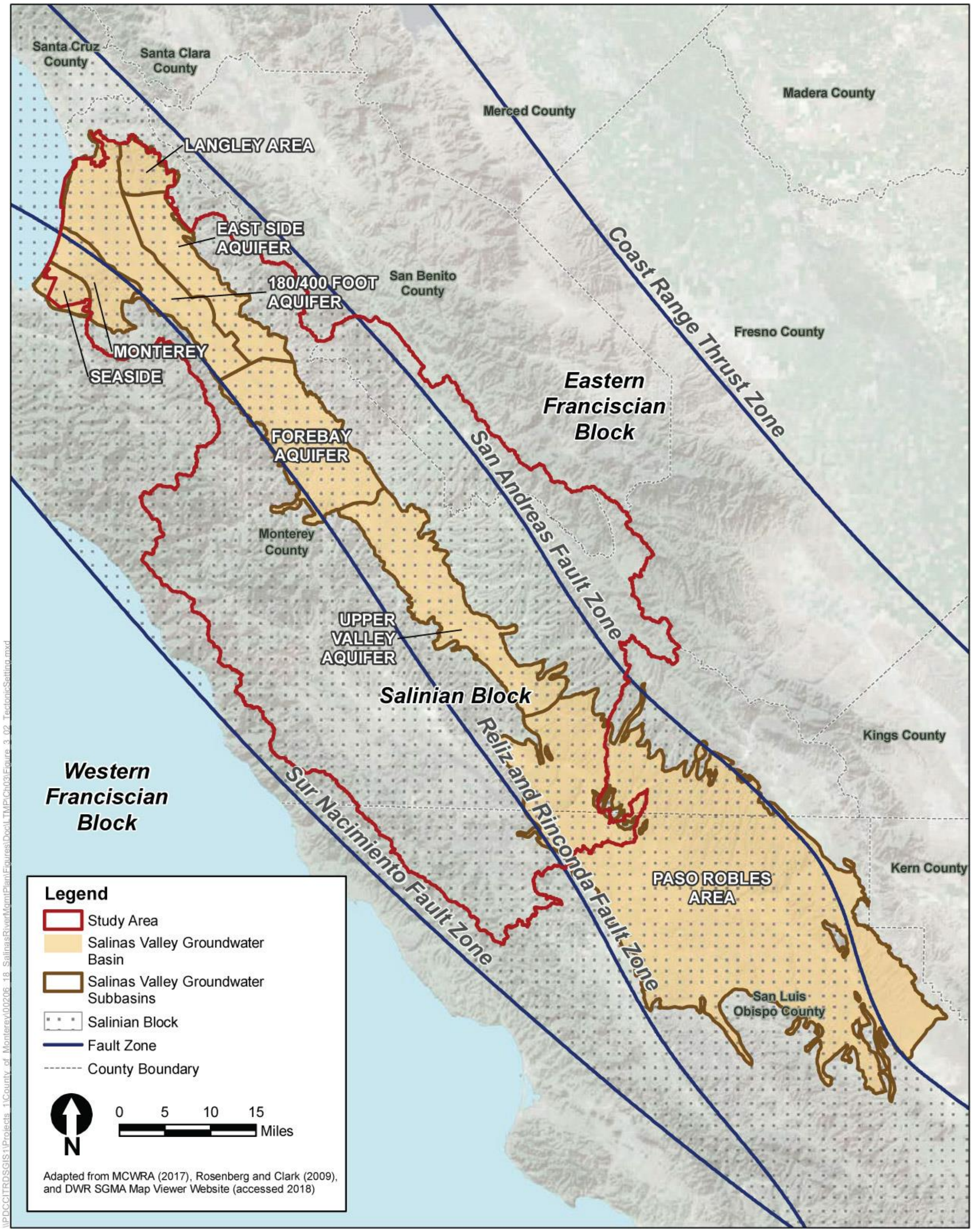



**Figure 3-2. Tectonic Setting of Salinas Valley**

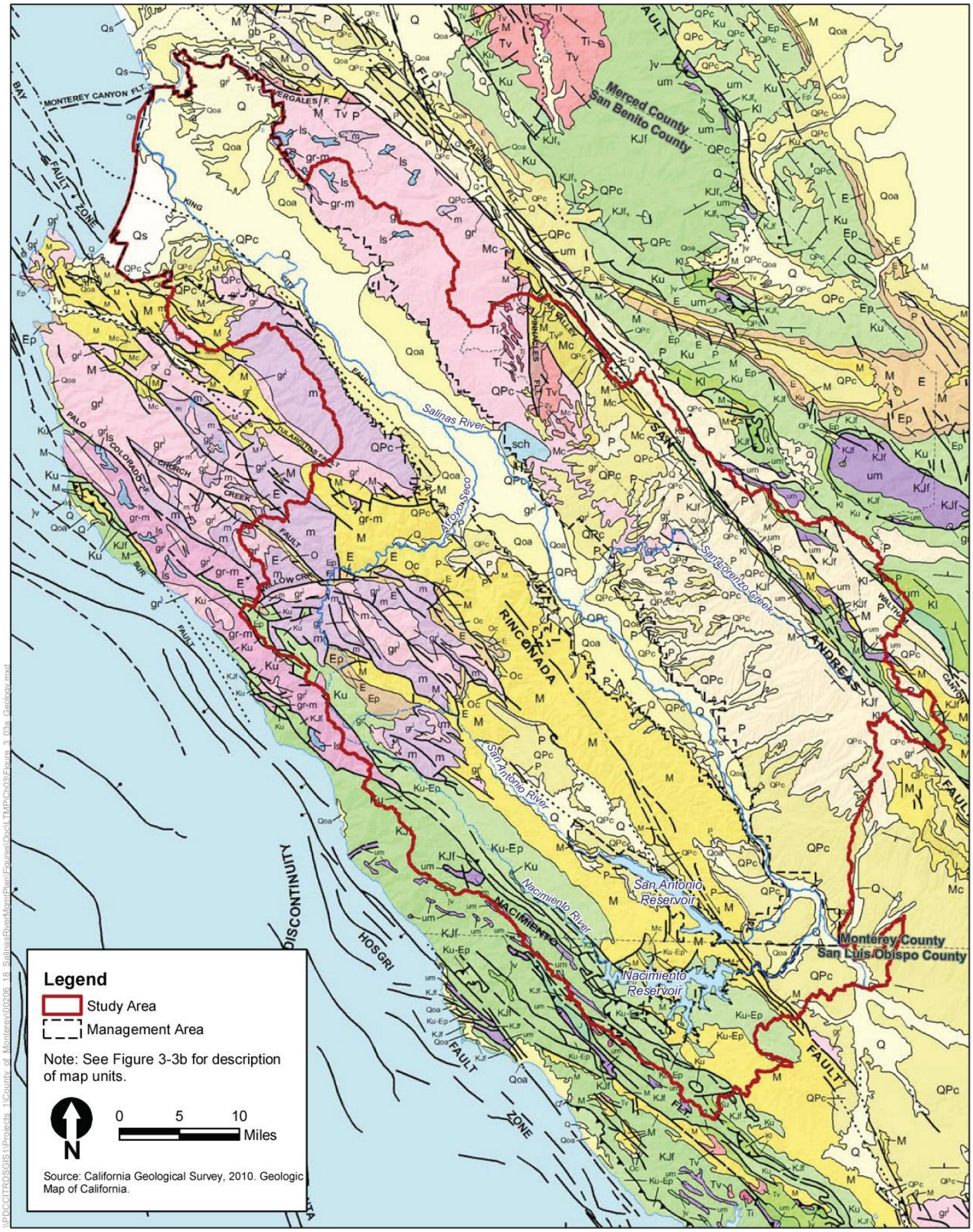



**Figure 3-3a. Geologic Map**

### QUATERNARY DEPOSITS

Qs - Extensive marine and nonmarine sand deposits, generally near the coast or desert playas.

Q - Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated. Mostly nonmarine, but includes marine deposits near the coast.

Qoa - Older alluvium, lake, playa, and terrace deposits.

QPc - Pliocene and/or Pleistocene sandstone, shale, and gravel deposits; mostly loosely consolidated.

### TERTIARY SEDIMENTARY ROCKS

P - Sandstone, siltstone, shale, and conglomerate; mostly moderately consolidated.

M - Sandstone, shale, siltstone, conglomerate, and breccia; moderately to well consolidated.

Mc - Sandstone, shale, conglomerate, and fanglomerate; moderately to well consolidated.

O - Sandstone, shale, conglomerate; mostly well consolidated.

Oc - Sandstone, shale, and conglomerate; mostly well consolidated.

E - Shale, sandstone, conglomerate, minor limestone; mostly well consolidated.

Ep - Sandstone, shale, and conglomerate; mostly well consolidated.

### TERTIARY VOLCANIC ROCKS

Tv - Tertiary volcanic flow rocks; minor pyroclastic deposits

Tvp - Tertiary pyroclastic and volcanic mudflow deposits.

Ti - Tertiary intrusive rocks; mostly shallow (hypabyssal) plugs and dikes.

### MESOZOIC SEDIMENTARY AND METASEDIMENTARY ROCKS

Ku - Upper Cretaceous sandstone, shale, and conglomerate.

Kl - Lower Cretaceous sandstone, shale, and conglomerate.

KJf - Franciscan Complex: Cretaceous and Jurassic sandstone with smaller amounts of shale, chert, limestone, and conglomerate. Includes Franciscan melange, except where separated - see KJfm.

J - Shale, sandstone, minor conglomerate, chert, slate, limestone; minor pyroclastic rocks.

sch - Schists of various types; mostly Paleozoic or Mesozoic age; some Precambrian.

ls - Limestone, dolomite, and marble whose age is uncertain but probably Paleozoic or Mesozoic.

### MESOZOIC MIXED ROCKS

gr-m - Granitic and metamorphic rocks, mostly gneiss and other metamorphic rocks injected by granitic rocks. Mesozoic to Precambrian.

### MESOZOIC METAVOLCANIC ROCKS

Mzv - Undivided Mesozoic volcanic and metavolcanic rocks. Andesite and rhyolite flow rocks, greenstone, volcanic breccia and other pyroclastic rocks; in part strongly metamorphosed. Includes volcanic rocks of Franciscan Complex: basaltic pillow lava, diabas

### MESOZOIC PLUTONIC ROCKS

grMz - Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite.

um - Ultramafic rocks, mostly serpentine. Minor peridotite, gabbro, and diabase; chiefly Mesozoic.

### PALEOZOIC MIXED ROCKS

m - Undivided pre-Cenozoic metasedimentary and metavolcanic rocks of great variety. Mostly slate, quartzite, hornfels, chert, phyllite, mylonite, schist, gneiss, and minor marble.

**Figure 3-3b. Description of Geologic Map Units**

**Table 3-1. Geologic History of Salinas Valley**

| Era | Period, System, Subsystem | Epoch | Age Estimates of Boundaries in Millions of Years | Salinas Valley Geologic Events, Features, and Deposits |
|---|---|---|---|---|
| Cenozoic (Age of Mammals) | Quaternary | Holocene | 0–0.010 | Flood-plain deposits, landslides, beach deposits |
| | | Pleistocene | 0.010–1.6 | Sea level fluctuates, sand dunes, marine terraces, Salinas Valley deposits |
| | Tertiary | Pliocene | 1.6–5 | Uplift of Santa Lucia Range |
| | | Miocene | 5–24 | Seas advanced and retreated |
| | | Oligocene | 24–38 | Seas retreated, lava flows |
| | | Eocene | 38–55 | Uplift, deep basins, and isolated islands |
| | | Paleocene | 55–66 | Seas advanced |
| Mesozoic (Age of Reptiles) | Cretaceous | | 66–138 | Salinian granitic rocks intruded |
| | Jurassic | | 138–205 | Franciscan rocks subducted and accreted |
| | Triassic | | 205–240 | |
| Paleozoic (Age of Fishes) | Permian | | 240–290 | Sur complex formed hundreds of miles south of Monterey County |
| | Carboniferous Systems: Pennsylvanian | | 240–290 | |
| | Carboniferous Systems: Mississippian | | 330–360 | |
| | Devonian | | 360–410 | |
| | Silurian | | 410–435 | |
| | Ordovician | | 435–500 | |
| | Cambrian | | 500–570 | |
| pre-Paleozoic | pre-Cambrian | | 570–4600 | -- |

Sources: Rosenberg 2001, Monterey County Water Resources Agency 2017a. Age estimates from Hansen 1991.

### 3.1.4 Soils

The soils of the study area are derived from the underlying geologic formations, influenced by the historical and current patterns of climate and hydrology. Productive agriculture of the Salinas Valley is supported by deep, dark, fertile soils, such as the Salinas clay loams. The arable soils of Salinas Valley historically were classified into four groups (Carpenter and Cosby 1925): residual soils, old valley-filling soils, young valley-filling soils, and recent-alluvial soils. In addition, several classes of miscellaneous soils were mapped that included tidal marsh, peat, coastal beach and dune sands.

More recent surveys classify the soils into many more categories based on detailed soil taxonomy (U.S. Department of Agriculture 2018). Figure 3-4 is a composite soils map of the LTMP study area from the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Gridded Soil Survey Geographic Database (2018) that is produced by the National Cooperative Soil Survey. The management area is dominated by the following four soil orders: mollisols, entisols, vertisols, and alfisols, each of which is summarized below.

#### 3.1.4.1 Mollisols

Mollisols are the most widespread soil order in the management area and study area. Mollisols are characterized by the presence of a dark colored surface horizon, indicative of high organic content. The organic content often originates from roots of surficial grasses or similar vegetation. Mollisols are highly fertile and often alkaline rich (calcium and magnesium). They can have any moisture regime, but enough available moisture to support perennial grasses is typical. Mollisols are often found in climates where there are seasonal dry and wet periods. Examples of mollisols include the farmlands adjacent to the Salinas River from King City to the coast, in addition to east-facing slopes on the Santa Lucia Range and west-facing slopes on the Gabilan Range. Mollisols comprise 53% of the study area and 48% of the management area.

#### 3.1.4.2 Entisols

Entisols are the predominant soil order along the active river corridor in addition to mountain slopes in the Santa Lucia and Gabilan Ranges. Entisols are mineral soils without distinct soil horizons because they have not been in place long enough for distinct horizons to develop. These soils are often found in areas of recent deposition such as active flood plains, river basins, and areas prone to landslides, and behind retreating glaciers where the rate of deposition is greater than the rate of soil development. Entisols comprise 28% of the study area and 26% of the management area.

#### 3.1.4.3 Vertisols

Large areas of vertisols are present on the valley lowlands in the central and northern Salinas Valley. Vertisols are predominantly clayey soils with high shrink-swell potential. Vertisols are present in climates that have distinct wet and dry seasons. During the dry season these soils commonly have deep, wide cracks. During the wet season these soils tend to have water pooling on the surface due to the high clay content. Because these soils are sticky in wet season but hard in dry season, they require special cultivation practices. Vertisols are found within the management area in the lowland areas northwest of Salinas and west of Gonzales. Vertisols comprise 5% of the study area and 7% of the management area.

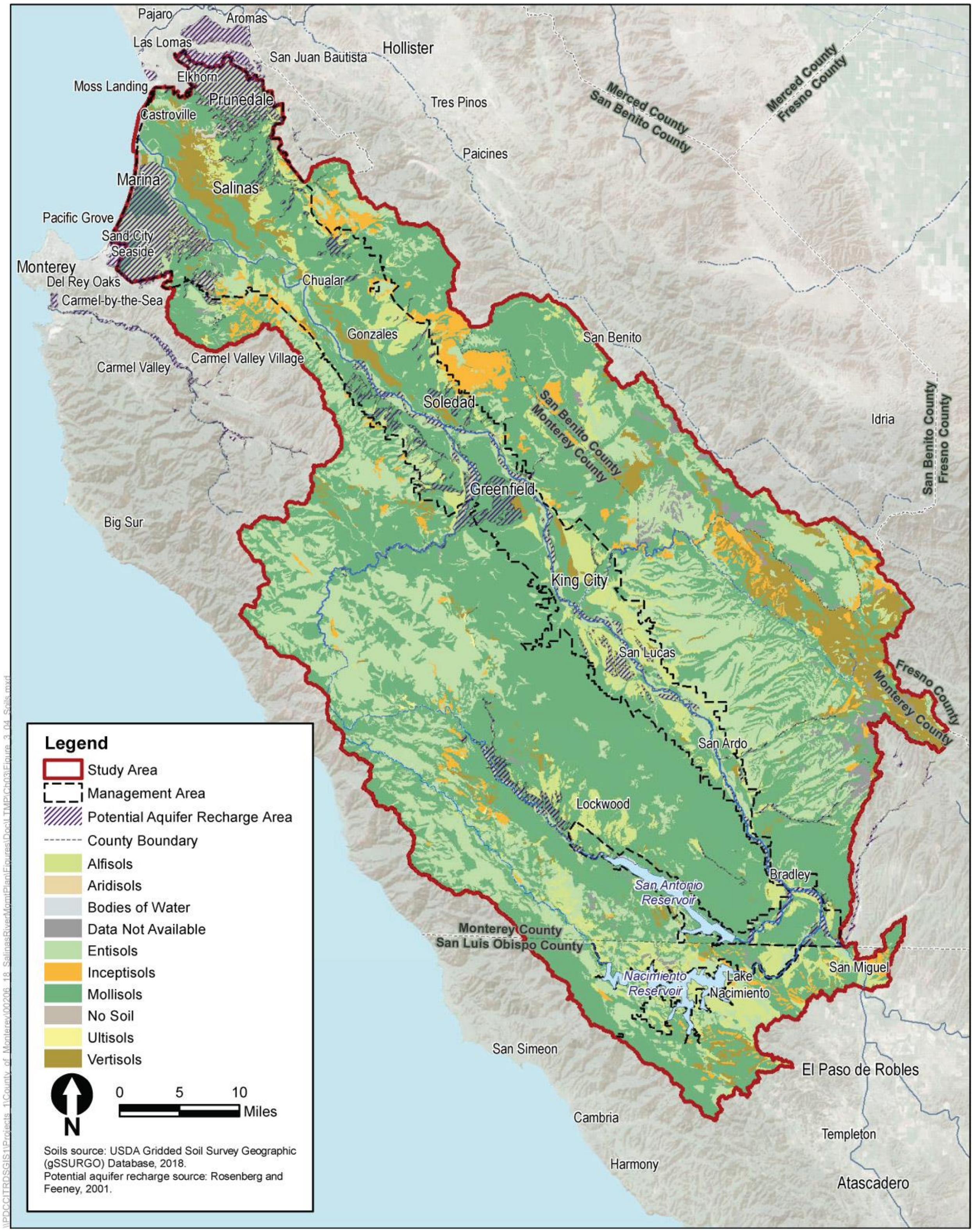



**Figure 3-4. Soils Map**

#### 3.1.4.4 Alfisols

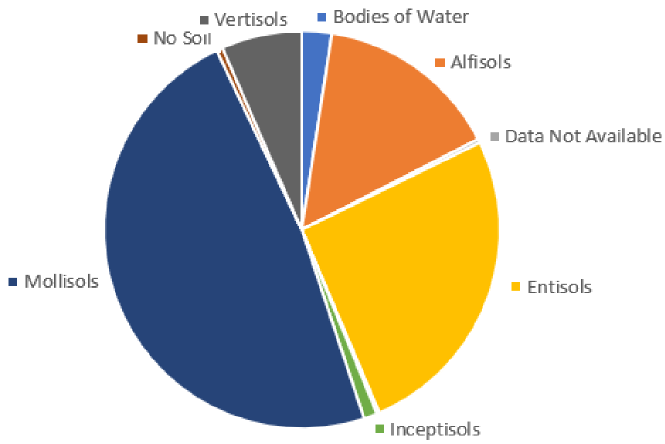
Alfisols are present along portions of the margin of the management area. Alfisols are known to have natural fertility both from clay accumulation in the subsurface horizons and from leaf litter when under forested conditions. This order of soils is commonly associated with high concentrations of base minerals such as calcium, magnesium, sodium, and potassium. Alfisols are commonly used for cultivation of crops, winter hayland (hardy), cattle pasture and ranging, and general forest use. Alfisols are found in the management area in large areas east of Gonzales, and north and southeast of King City. Alfisols comprise 8% of the study area and 15% of the management area.

The tables and pie charts below show the portions of different soil orders for both the management and study area (Tables 3-2 and 3-3; Figures 3-5 and 3-6). Other soil orders also present in the LTMP management area in small amounts, or present in the LTMP study area, that are not represented on the figures and tables below, include aridisols, inceptisols, and ultisols (Figure 3-4).

**Table 3-2. Relative Areas of Soil Groups in the Management Area**

| Soil Order | Acres | Percent |
|---|---|---|
| Bodies of Water | 16,858 | 2.4% |
| Alfisols | 103,756 | 15.0% |
| Data Not Available | 2,108 | 0.3% |
| Entisols | 178,231 | 25.8% |
| Histosols | 1,434 | 0.2% |
| Inceptisols | 7,572 | 1.1% |
| Mollisols | 331,333 | 48.0% |
| No Soil | 3,452 | 0.5% |
| Vertisols | 45,370 | 6.6% |
| **Total** | **690,113** | **100.0%** |

Source: U.S. Department of Agriculture 2018.



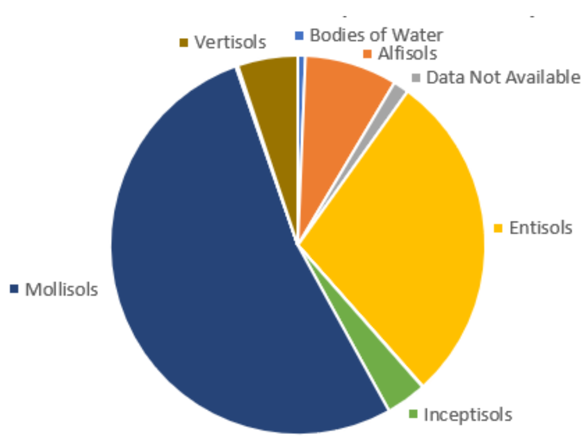

Source: U.S. Department of Agriculture 2018.

**Figure 3-5. Chart of Relative Areas of Soil Groups in the Management Area**

**Table 3-3. Relative Areas of Soil Groups in the Study Area**

| Soil Order | Acres | Percent |
|---|---|---|
| Bodies of Water | 17,437 | 0.7 |
| Alfisols | 212,893 | 8.0 |
| Data Not Available | 35,725 | 1.3 |
| Entisols | 760,185 | 28.4 |
| Histosols | 1,434 | 0.1 |
| Inceptisols | 93,117 | 3.5 |
| Mollisols | 1,409,517 | 52.7 |
| No Soil | 3,800 | 0.1 |
| Ultisols | 1,355 | 0.1 |
| Vertisols | 138,491 | 5.2 |
| **Total** | **2,673,955** | **100.0%** |

Source: U.S. Department of Agriculture 2018.




Source: U.S. Department of Agriculture 2018.

**Figure 3-6. Chart of Relative Areas of Soil Groups in the Management Area**

More detailed mapping and discussion of soils is available from the NRCS Gridded Soil Survey Geographic Database (2018) and from other specific studies of portions of the Salinas Valley (e.g., Harding Engineering and Environmental Sciences 2001).

## 3.1.5 Climate

The study area is characterized by a Mediterranean climate with cool wet winters, and warm dry summers. The Pacific Ocean influences the climate close to the coast, where the weather is often overcast or has coastal fog and cool temperatures. The maritime climatic influence dissipates with increasing distance from the ocean. As such, the inland areas are warmer in the summer and colder in winter. Below is summary of historical and current climatic conditions for the study area.

### 3.1.5.1 Temperature

Temperatures vary in the study area depending on location. Table 3-4 provides the average temperatures from 1981 to 2010 and from 1971 to 2000 at various locations within the study area. Areas near the coast, such as Monterey, generally have cooler summer temperatures. Areas within the Salinas Valley, such as near the cities of Salinas and King City have slightly higher temperatures because these areas have less fog cover and low clouds. Mountainous areas and areas that are located farther inland (and thus away from the fog layer), such as Paso Robles and Pinnacles National Monument, have hotter summer and colder winter temperatures. As shown in Table 3-4, winter day temperatures are generally the same throughout the study area.

Temperature in the study area is influenced by multiple factors, including the proximity to the coast and the amount of time an area is subject to fog and low clouds. The U.S. Geological Survey (USGS) completed detailed maps of fog and low cloud cover along the California Coast in 2016. This mapping shows the following.

1. Areas near the mouth of the Salinas River, including the cities of Monterey and Marina receive approximately 12 hours of fog and low clouds every 24 hours.
2. Areas in the Salinas Valley, including the cities of Salinas, Soledad, Greenfield, and King City receive approximately 5 hours of fog and low clouds every 24 hours.
3. Areas of higher elevations and areas inland, such as the mountainous regions of the Santa Lucia Mountains and Gabilan Range receive less than 2 hours of fog and low clouds every 24 hours. (Skibba 2016).

**Table 3-4. Average Temperatures from 1981 to 2010 and 1971 to 2000**

| | Average Temperature (°F) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1981–2010 | | | | | 1971–2000 | | | | |
| | | Summer | | Winter | | | Summer | | Winter | |
| **Location** | **Year-Round** | **Day** | **Night** | **Day** | **Night** | **Year-Round** | **Day** | **Night** | **Day** | **Night** |
| ***Coast*** | | | | | | | | | | |
| Monterey | 56 | 68 | 53 | 59 | 44 | 57 | 70 | 53 | 60 | 44 |
| ***Salinas Valley*** | | | | | | | | | | |
| Salinas | 58 | 71 | 54 | 62 | 42 | 58 | 73 | 55 | 62 | 42 |
| King City | 60 | 84 | 52 | 64 | 38 | 60 | 85 | 52 | 64 | 38 |
| ***Inland/Mountainous Regions*** | | | | | | | | | | |
| Paso Robles | 59 | 90 | 51 | 62 | 34 | 59 | 90 | 51 | 63 | 34 |
| Pinnacles National Monument | 56 | 93 | 44 | 62 | 28 | 59 | 93 | 50 | 64 | 34 |

Sources: National Climate Data Center 2000, 2010a, 2010b, 2010c, 2010d, 2010e.

Note: Based on long-term average data published by the National Weather Service (NWS). The NWS calculates long-term averages using climatic data over the most recent 30-year period ending in a decade. The current 30-year interval used by the NWS for this type of calculation goes from 1981 to 2010.

### 3.1.5.2 Precipitation

As shown on Figure 3-7, precipitation in the study area varies from approximately 15 to 60 inches annually. The mountainous areas near the coast receive much more precipitation than the Salinas Valley, which has an annual average of approximately 15 inches of precipitation. Table 3-5 identifies the annual precipitation from 1981 to 2010 and from 1971 to 2000 in various locations in the study area.

**Table 3-5. Average Annual Precipitation from 1981 to 2010 and 1971 to 2000**

| | Average Annual Precipitation (inches) | |
|---|---|---|
| **Location** | **1981–2010** | **1971–2000** |
| ***Coast*** | | |
| Monterey | 21.1 | 20.4 |
| ***Salinas Valley*** | | |
| Salinas | 12.8 | 12.9 |
| King City | 12.1 | 12.3 |
| ***Inland/Mountainous Regions*** | | |
| Paso Robles | 15.2 | 14.7 |
| Pinnacles National Monument | 17.2 | 17.3 |

Sources: National Climate Data Center 2000, 2010a, 2010b, 2010c, 2010d, 2010e.

Note: Based on long-term average data published by NWS. The NWS calculates long-term averages using climatic data over the most recent 30-year period ending in a decade.

## 3.1.6 Watersheds

The United States is divided and subdivided into successively smaller hydrologic units which are classified into four levels: regions, subregions, accounting units, and cataloging units. The hydrologic units are arranged or nested within each other, from large geographic area (regions) to small geographic areas (cataloging units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) (U.S. Geological Survey 2017). Regions are identified by 2-unit HUCs, whereas subregions have 4-unit HUCs. Accounting units are categorized using 6-unit HUCs, and the cataloguing units are further divided into 8-, 10-, and 12-unit HUCs. An example of the watershed coding system is as follows.

1. California Region (HUC 18)
2. Central California Subregion (HUC 1806)
3. Central California Coastal Accounting Unit (HUC 180600)
4. Salinas Cataloging Unit (HUC 18060005) and Monterey Bay Cataloging Unit (HUC 18060015)

Figure 3-8 shows the cataloging unit watersheds characterized by 8-unit HUCs (also referred to as HUC-8) located within and near the study area. The bulk of the study area is located within the Salinas Cataloging Unit watershed (also referred to as Salinas River watershed herein), with a small portion of the study area—near the mouth of the Salinas River—within the Monterey Bay Cataloging Unit watershed. The 10-unit HUCs are shown in Figure 2-7 and listed in Appendix C, *Watersheds in the Study Area*, along with the associated 12-unit HUCs.

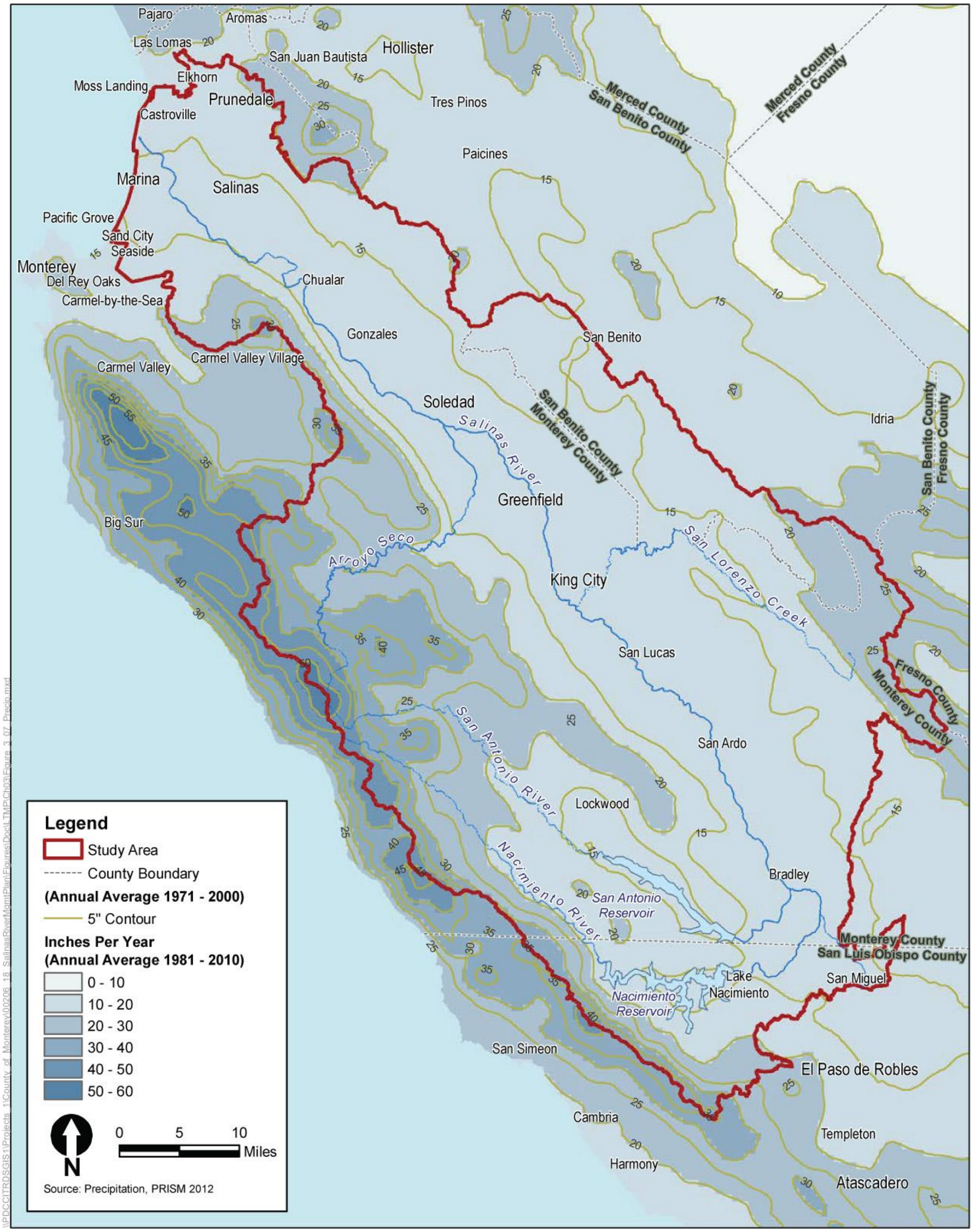



**Figure 3-7. Distribution of Precipitation across the Study Area**

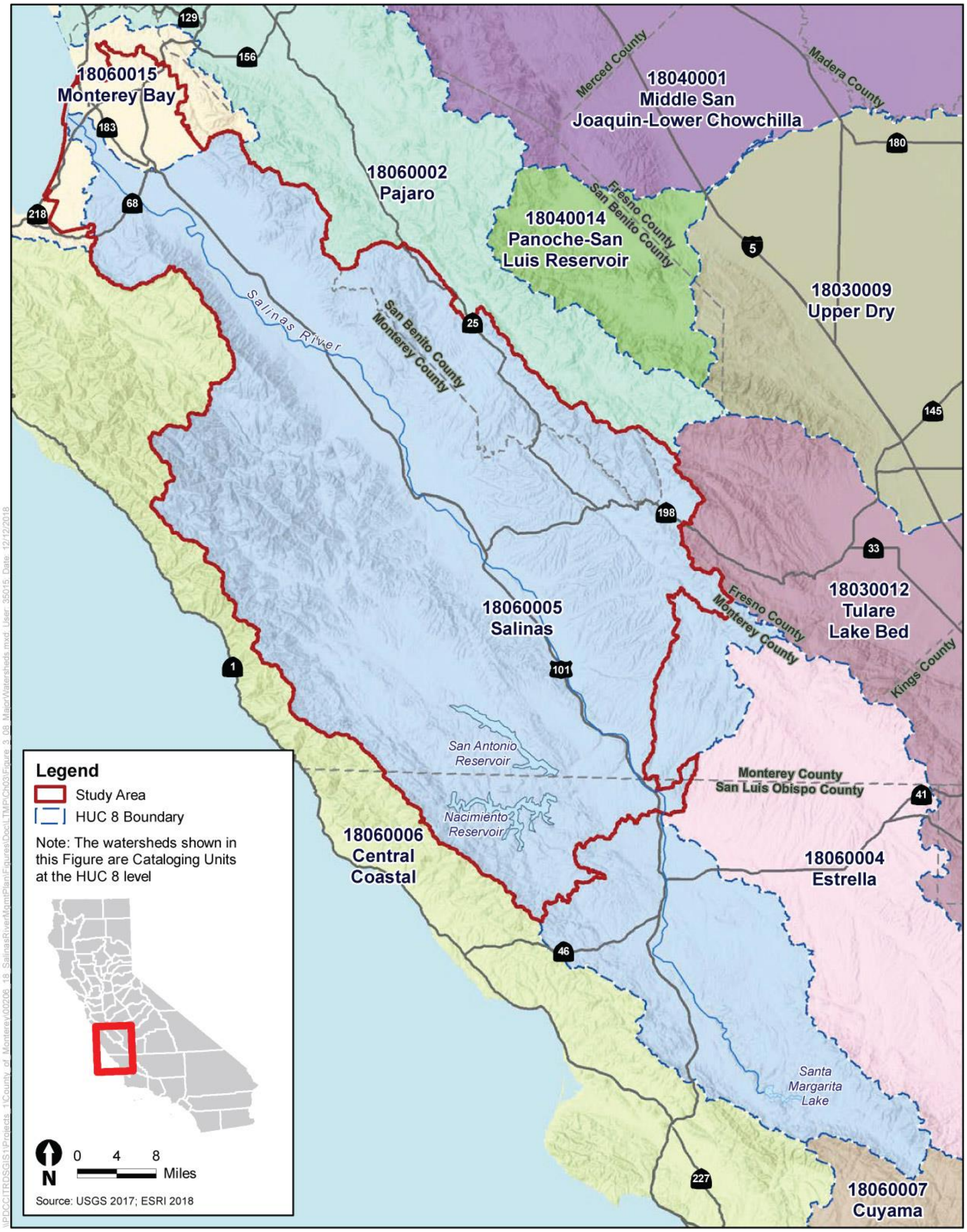



**Figure 3-8. Major Watersheds in the Study Area**

# 3.1.7 Hydrology and Geomorphology

The Salinas River watershed is the largest in the central coast of California draining approximately 4,240 square miles of land in Monterey and San Luis Obispo Counties (Monterey County Water Resources Agency 2014). Originating in the Los Padres National Forest, the headwaters of the Salinas River begin in the Santa Lucia and La Panza Mountain Ranges and flow approximately 184 river miles north-northwest through the Salinas Valley and into the Monterey Bay near Castroville (Monterey County Water Resources Agency 2014). The principal tributaries of the Salinas River floodplain within the study area are the Nacimiento River, the San Antonio River, San Lorenzo Creek, and the Arroyo Seco River (Figures 2-7 and 3-8).

Many of the tributaries to the Salinas River watershed are ungaged, meaning that streamflow generated within the watersheds is not monitored. Only a handful of stream gages exist in the watershed and are shown on Figures 2-1a and 2-1b. Streamflow temperature and water quality are not regularly monitored in the watersheds of the Salinas River, although flow at stream gage locations along the main stem of the river is frequently sampled for water quality.[3] For more details on water quality data, see Section 3.1.10, *Water Quality*. The Salinas Valley Integrated Hydrologic Model, currently under development by USGS and MCWRA, will be useful for simulating runoff generation in the watersheds' tributaries to the Salinas River.

In the study area, the Salinas River is approximately 118 miles long and can be roughly divided into three major reaches based on the dominant channel morphology: upper watershed, Salinas River Valley, and the Salinas River Lagoon. The upper watershed reach is located from River Mile (RM) 53 (near Greenfield) to RM 118 (near San Miguel) and characterized by Salinas River Stream Maintenance Program (SMP) river management units (RMUs) 1 and 2. The valley and river in the upper portions of this reach become increasingly narrow and confined. The second reach, from RM 53 to RM 7, is characterized by a channel width (as measured from top-of-bank to top-of-bank) ranging between 500 and 2,000 feet and contains the Salinas River SMP RMUs 3 through 6. This reach tends toward a weakly braided channel (i.e., a mainstem with side channels on either side that are separated by sandbars and riparian vegetation). The third reach includes RM 7 to RM 0 containing the perennial portion of the river from Blanco Road to Highway 1 (referred to as Salinas River SMP RMU 7) downstream to the Salinas River Lagoon. The lagoon is formed by a sandbar that separates the river from Monterey Bay (see Section 3.1.7.2, *Existing Conditions*, subheading *Salinas River Lagoon (RMU 7 to RM 0)* for additional information on the sandbar). The historical and existing conditions of these three reaches are discussed below in the context of these three major reaches.

## 3.1.7.1 Historical Conditions

### Upper Watershed (San Miguel to RMU 2)

The upper watershed reach of the Salinas River as defined for this LTMP spans from San Miguel (RM 118) in northern San Luis Obispo County to RM 53, upstream of and near Greenfield in central Monterey County. The Salinas River channel is relatively narrow and confined in the upper portion of this reach as it passes through the narrow canyons of the coastal mountain ranges. The primary tributaries of this reach, the Nacimiento River and San Antonio River, originate in the Santa Lucia Range along the coast and enter the Salinas River from the southwest, upstream of Bradley. The Nacimiento River is 65 miles long and drains 360 square miles in the study area (U.S. Geological

[3] See https://water.usgs.gov/lookup/getwatershed?18060005.

Survey 2018). The Nacimiento Dam was built in 1957. The San Antonio River is 59 miles long and drains 350 square miles in the study area (U.S. Geological Survey 2018). The San Antonio dam was built in 1965. The peaks of the Santa Lucia Range from the southwestern boundary of these adjacent watersheds were historically capable of producing a substantial proportion of flow to the Salinas River (as indicated by early flow records in Nacimiento River [USGS gage station 11149500] and in Salinas at Bradley [USGS gage station 11150500] in Table 3-6). Historically, the Nacimiento River's winter flow regime supported spawning runs of steelhead (CALFED 1976). During the dry season, the lower Nacimiento River was often intermittent, resulting in long stretches of dry river bed between a few isolated pools. Dry water years were characterized by no surface flow for long periods of time (CALFED 1976).[4] North of San Ardo, the valley and river begin to widen, and the main stem begins to morph into a more braided channel where it meets another large tributary known as the San Lorenzo Creek. The San Lorenzo Creek drains a 261-square-mile watershed (Appendix C) that originates in the Diablo Mountain Range and runs through Peachtree Valley in southern San Benito County before entering eastern Monterey County and merging with the Salinas River from the northeast in King City.

## Salinas River Valley (RMU 3 to RMU 6)

The Salinas River Valley reach as defined for this LTMP spans from upstream of Soledad (RM 53) downstream to Blanco Road (RM 7). The major tributary in this reach is the Arroyo Seco, which drains a 275-square-mile watershed that originates in the Santa Lucia Range and enters the Salinas from the west near the city of Soledad.

With the exception of the last 15 miles of the Salinas River Valley reach, the Salinas River bed was historically broad and sandy—spanning up to about a half mile wide. The active channel was bare or sparsely vegetated with willows and grasses, and punctuated with periodic low-flow channels (e.g., narrow and shallow channels characterized by decreased flows of the dry season) (San Francisco Estuary Institute 2009). It has long been characterized by lateral shifts in channel alignment, steep banks, and nested sets of broad benches and bluffs. The outermost bluffs defined the lateral migration limit and margin between the river corridor and the valley floor. The lowest elevation benches immediately adjacent to the riverbed, referred to as "bottomlands," were subject to periodic flooding and were generally well-vegetated with willows, cottonwoods, brush, grasses, and some oaks. Between the two were terraces, varying in number and extent (depending on the reach), which were drier than the bottomlands and represented previously abandoned river floodplains.

Historical records from eighteenth-century explorers and nineteenth-century surveyors often described the banks of the Salinas River as fairly steep or nearly vertical as it constantly scoured and rebuilt the channel bed and floodplain throughout much of the lower watershed (San Francisco Estuary Institute 2009). These geomorphic processes led to a diverse array of habitats, including meander cutoffs, oxbows, freshly scoured surfaces, riparian forest of varying ages, and wetlands occupying abandoned channel segments and along natural levees. Ponds and depressional wetlands were scattered throughout the Salinas Valley. Downstream of Spreckels, these features were widely distributed across the Salinas Valley due to frequent migrations of the river.

Prior to the construction of major reservoirs and diversion, Salinas River Valley reach experienced a considerable amount of variability in seasonal flows on both an average and inter-annual basis. During the wet season, the sediment-laden Salinas River would flood and overflow onto the adjacent

[4] Historical accounts of San Antonio River hydrology could not be found.

bottomlands, depositing sand as the river receded (San Francisco Estuary Institute 2009). During the dry season, the Salinas River was described as a discontinuous, shallow brook that regularly maintained baseflows and substantial summertime pools in many of the reaches (San Francisco Estuary Institute 2009). The presence of quicksand—mentioned in many early accounts of the river—indicates that near-surface flows were likely substantial, even during dry times.

## Salinas River Lagoon (RMU 7 to RM 0)

Historically, the Salinas River Lagoon filled, opened, and closed according to seasonal variations in river flow and coastal wave action. During the low-flow summer months, littoral processes would build a sandbar at the river mouth, closing the direct connection between the Salinas River and the Monterey Bay (Hagar Environmental Science 2015). In late fall or winter, storms would increase Salinas River flow, filling the closed lagoon (Hagar Environmental Science 2015). As water levels continued to rise, inundating adjacent low lands bordering the lagoon, winter waves would work to erode the dune from the ocean side. At some point, water levels in the lagoon would increase enough to overtop the sandbar at the mouth, naturally opening the lagoon (Hagar Environmental Science 2015). The location of this opening to the Monterey Bay and the configuration of the lagoon was dynamic in nature. Historical accounts put the mouth at locations spanning from south of its present location (mapped by the U.S. Coast Survey in 1854) to as far north as Moss Landing (prior to 1908), which appears to have been the most prevalent route (see Figure 3-9) (San Francisco Estuary Institute 2009).

In 1947, the U.S. Army Corps of Engineers constructed the Moss Landing Harbor and opened the mouth of the Elkhorn Slough. The influence of freshwater was already markedly decreased by reclamation ditching and well pumping. Now the wetland complex was exposed to daily tidal scour. Extensive mudflats were exposed in the sloughs for the first time in recorded history. The old mouth was less than 2 feet deep in a narrow channel (15 feet wide). The mouth is now 25–30 feet deep and the channel is a large, dominant feature (ABA Consultants 1989). The artificial mouth increased tidal amplitude and velocity in the estuary, leading to substantial tidal scour and contributing to loss of wetland habitats (Elkhorn Slough Tidal Wetland Project 2012).

Near the time of the harbor entrance’s completion, tide gates were put in place on several of the sloughs and wetland habitats to the south of Moss Landing, including the Moro Cojo Slough, Old Salinas River (OSR) and Tembladero Slough. This has limited the amount of erosion in these sloughs in addition to muting the tides and preventing salt water from intruding inland during high tides.

1854 Lagoon and River, with mouth located north near Moss Landing

Current Lagoon and River, with mouth located in its current location

Source: Central Coast Watershed Studies 2006.

**Figure 3-9. Historical and Existing Terminus Location of the Salinas River**

### 3.1.7.2 Existing Conditions

Over the past century and a half spanning from the first euro-American accounts to now, the Salinas River has gone through many changes that have impacted its hydrology and geomorphology. These changes began with the development of the Salinas Valley as a major agricultural region primarily dependent on groundwater for irrigation. As the amount of irrigated crops and pumping increased, the amount of fresh water removed from the groundwater basin exceeded the amount replenished through natural hydrologic processes. By the late 1930s, wells in the Salinas Valley Basin near

Monterey Bay had been abandoned due to excess salinity (California Department of Water Resources 1946). Accelerated encroachment of salinity into the groundwater basin was observed in 1943, which led to an investigation of the Salinas Valley Basin (California Department of Water Resources 1946) and ultimately to the construction of the Nacimiento Dam in 1957 followed by the San Antonio Dam in 1965. These reservoirs have been primarily operated to capture winter flows and release them at a low enough rate throughout the year to maximize groundwater recharge in the Salinas Valley aquifer (CALFED 1976) so that groundwater wells for irrigation continue to function.

## Upper Watershed (San Miguel to RMU 2)

The Nacimiento and San Antonio Rivers, historically capable of producing large flows, are now regulated by dams operated by MCWRA (Monterey County Water Resources Agency 2014). The operation of these dams has significantly altered the seasonal distribution and magnitude of streamflow in the Salinas River by reducing wet season flows and increasing dry season flows.

Stream gages at three locations in the upper watershed were analyzed within the study area—two in Nacimiento River downstream of the current reservoir and one in the Salinas River at Bradley (Figures 2-1a and 2-1b). After construction of the Nacimiento Dam, the Nacimiento River gage at San Miguel (USGS 11149500) was decommissioned and replaced by a gage at Bradley (USGS 11149400, approximately 5 miles upstream of the San Miguel gage). Peak flow frequency analyses for all three gages in the upper watershed are shown in Table 3-6. Analysis at the Nacimiento River gages before and after dam construction showed significant reductions in peak return interval flows from between 78% (for the 100-year event) to 95% (for the 2-year event). These values were not adjusted to account for the 6% smaller watershed area reported at the post-dam gage (USGS 11149500) because this difference was deemed insignificant relative to the large decreases observed following construction of the dam. Downstream of the Nacimiento River and San Antonio River, the Salinas River gage at Bradley was installed in 1949, only 8 years before the Nacimiento Dam was completed. According to USGS guidelines for determining flow frequency (Bulletin No. 17B), a minimum of 10 years of peak flow data are required. Therefore, the flow frequency analyses at Bradley are only shown for post-dam years.

### Table 3-6. Peak Flow Frequency Analyses for Gages in the Upper Watershed

| | | Peak Flow (cubic feet per second) | | | | | |
|---|---|---|---|---|---|---|---|
| **Gage** | **Years** | **2-Year** | **5-Year** | **10-Year** | **25-Year** | **50-Year** | **100-Year** |
| Nacimiento River near San Miguel[a] | 1938–1956 (pre-dam) | 20,000 | 37,000 | 51,000 | 69,000 | 83,000 | 98,000 |
| Nacimiento River below Nacimiento Dam near Bradley[b] | 1957–2018 (post-dam) | 1,000 (-95%) | 3,000 (-92%) | 6,000 (-88%) | 10,000 (-86%) | 15,000 (-82%) | 22,000 (-78%) |
| Salinas River near Bradley[c] | 1957–2018 | 4,000 | 16,000 | 32,000 | 67,000 | 107,000 | 162,000 |

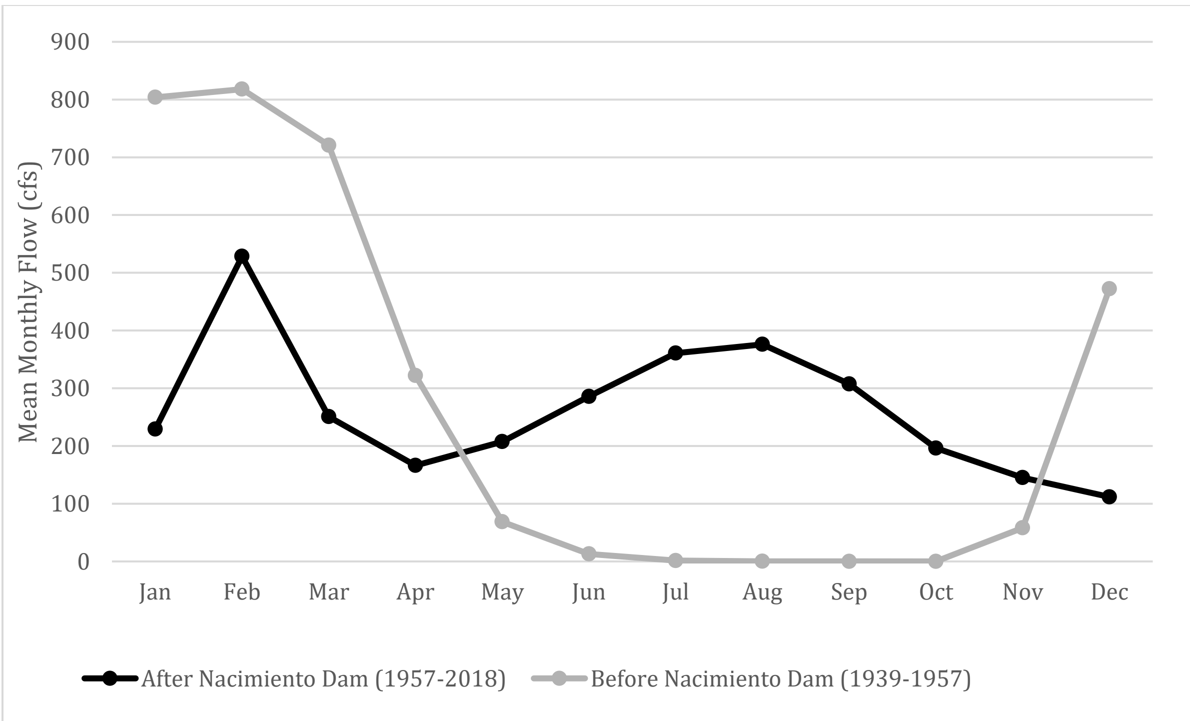
Source: U.S. Geological Survey 2018.

[a] USGS Gage 11149500 located near the San Luis Obispo/Monterey County border, approximately 7 river miles downstream of dam (Latitude 35°47'00", Longitude 120°47'24" NAD27).

[b] USGS Gage 11149400 located approximately 2 river miles downstream of dam (Latitude 35°45'41", Longitude 120°51'16" NAD27).

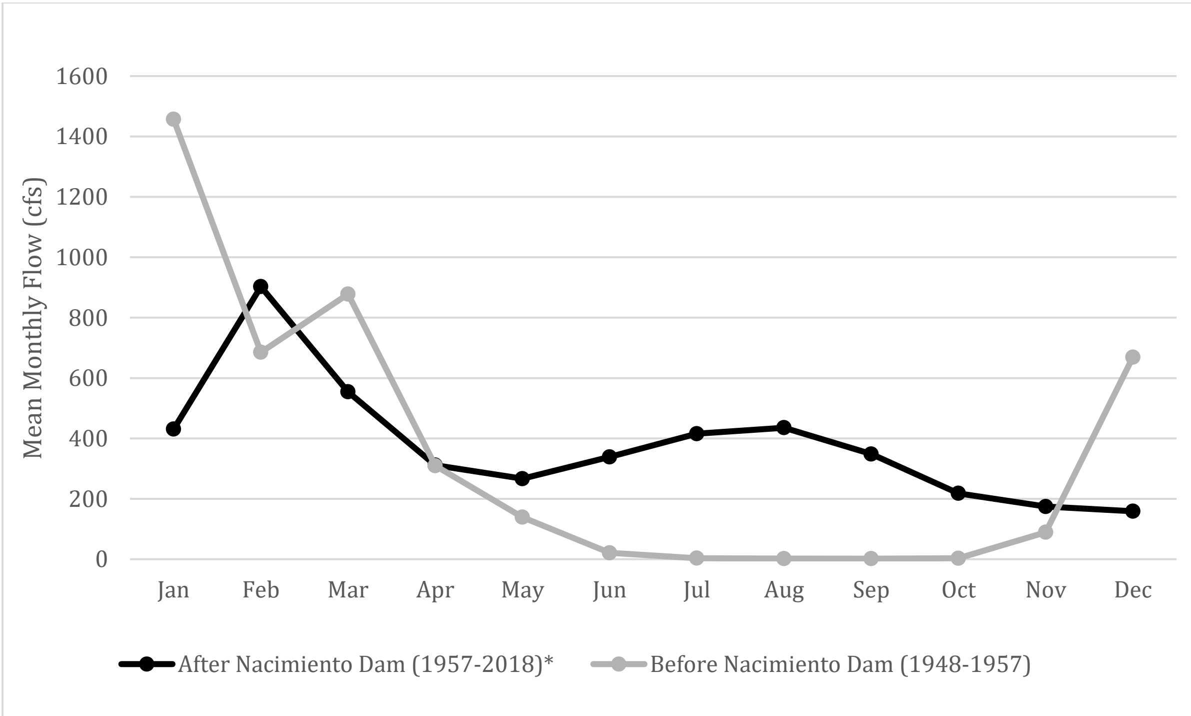
[c] USGS Gage 11150500 located approximately 6.5 river miles downstream of town of Bradley (Latitude 35°55'49", Longitude 120°52'04" NAD27).

Comparison of pre- and post-dam mean monthly flows can provide insights into shifts in average seasonal flow timing and magnitude. In the Nacimiento River, the natural flow prior to dam construction reflected the seasonal nature of rainfall in the watershed—with the majority of the stream flow occurring during the wet season from December to April (Figure 3-10). Following the completion of Nacimiento Dam, average stream flows during the winter and spring wet season were reduced in magnitude, and releases during the dry season increased substantially. Similar effects can be observed in the Salinas River at Bradley, which accounts for the combined effect of both upstream dams in addition to other upstream operations such as the Santa Margarita Dam (Figure 3-11). This gage shows a more pronounced delay in the timing of seasonal flows from January to February, greater reductions in average winter flows, and greater increases in average summer flows.




Source: U.S. Geological Survey 2018.

**Figure 3-10. Mean Monthly Flow in Nacimiento River, Before and After Dam Construction (USGS 11149400 and 11149500)**




Source: U.S. Geological Survey 2018.
*A portion of the analysis period also includes effects of San Antonio Dam (constructed in 1967).

**Figure 3-11. Mean Monthly Flow in Salinas River at Bradley, Before and After Dam Construction (USGS 11150500)**

## Salinas River Valley (RMU 3 to RMU 6)

Relative to historical conditions, the channel bed in this reach has narrowed significantly and become more highly vegetated, with varying amounts of vegetation growing on bars and the channel bottom (Monterey County Water Resources Agency 2014). In the past, seasonal high flows regularly scoured the bars and channel bottom, transporting sediment and leaving the Salinas River channel bed largely bare. The combination of reduced peak flow and increased summer flows caused by the operation of the Nacimiento Dam starting in 1957 and the San Antonio Dam starting in 1967 has today allowed vegetation growth to expand onto the bars and channel bottom and largely persist there. This vegetation growth has increased since the revised operation of Nacimiento Dam in April 2010 (Monterey County Water Resources Agency 2014).

Today, agriculture occurs in what was once the riparian corridor (i.e., the bottomlands) of the Salinas River. As a result, significant narrowing of the riparian corridor has occurred throughout this reach. Landowners along much of the Salinas River have historically constructed levees to protect agricultural lands from flooding (Monterey County Water Resources Agency 2014) and continue to do so today. Many of these informal levee sections are not engineered, and are often composed of sand, broken concrete, and other construction materials (Monterey County Water Resources Agency 2014). The bank slopes below the levees are generally well-vegetated.

Flow frequency analyses for the gages located in this reach are presented in Table 3-7. While the Salinas River hydrology has been altered by dam construction and diversions, both San Lorenzo Creek and Arroyo Seco are unregulated. Therefore, the hydrologic patterns of these watersheds are likely more similar to historical conditions than those in the mainstem of the Salinas River. These data show that San Lorenzo Creek contributes a much lower proportion of flow to the Salinas River than Arroyo Seco. Comparison of the return interval flows in the Salinas River at Bradley—before the inputs of San Lorenzo Creek, to the Salinas River at Soledad, after the inputs of San Lorenzo Creek but before Arroyo Seco (Table 3-7)—shows a drop in peak flows between the upper watershed and the Salinas Valley (i.e., upstream and downstream of San Lorenzo Creek). In other words, the small flows of San Lorenzo Creek are insufficient to offset the downstream water loss from groundwater infiltration and evaporation. In contrast, flows in the Salinas River downstream of Arroyo Seco (Salinas River at Chualar gage in Table 3-7) are considerably higher than flows upstream of the Arroyo Seco confluence (Salinas River at Soledad gage), despite losses likely to groundwater infiltration.

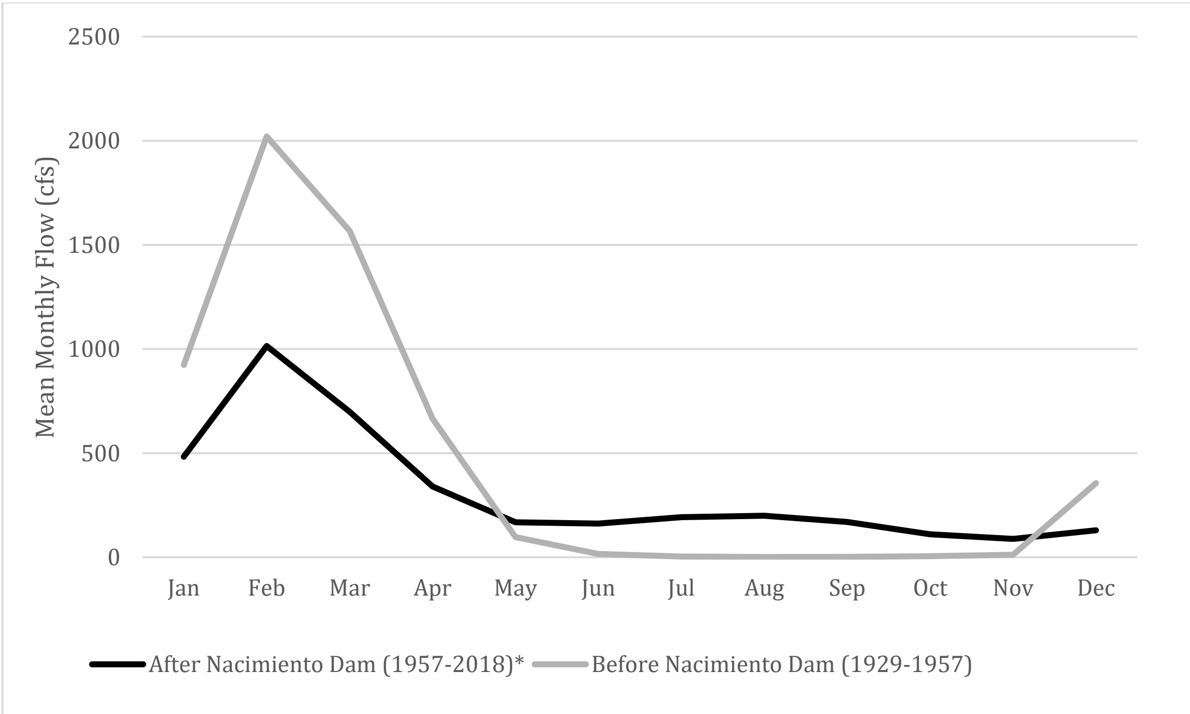
The farthest downstream gage near Spreckels contained a long enough period of record to compare flow frequencies before and after construction of the Nacimiento and San Antonio Dams (Table 3-7). These gages show reductions in peak flows between 3% (for the 50-year event) to 54% (for the 2-year event) and an increase in peak flows of 12% for the 100-year event for the period of record after dam construction. Although reductions in low to moderate peak flows would be expected as a result of upstream dam construction, some proportion of these changes may also be due to differences in the number of events and hydrologic characteristics represented by pre- and post-dams periods of record.

Comparisons of Salinas River mean monthly flows near Spreckels before and after dam construction show reductions by up to 50% from pre-dam conditions during the winter and spring wet season (December to April) and substantial increases during the dry season (Figure 3-12). However, the timing of peak wet season flows appears to have remained unchanged. This is likely related to the fact that the Arroyo Seco, a significant contributor to Salinas River flows, remains undammed.

**Table 3-7. Peak Flow Frequency Analyses for Gages in the Salinas River Watershed in the Management Area**

| | | Peak Flow (cubic feet per second) | | | | | |
|---|---|---|---|---|---|---|---|
| **Gage** | **Years** | **2-Year** | **5-Year** | **10-Year** | **25-Year** | **50-Year** | **100-Year** |
| Salinas River – Bradley (USGS 11150500) | 1957–2018 | 4,000 | 16,000 | 32,000 | 67,000 | 107,000 | 162,000 |
| San Lorenzo Creek – King City (USGS 11151300) | 1959–2017 | 1,000 | 3,000 | 6,000 | 10,000 | 13,000 | 17,000 |
| Salinas River – Soledad (USGS 11151700) | 1969–2018 | 2,000 | 12,000 | 26,000 | 58,000 | 94,000 | 142,000 |
| Arroyo Seco – Greenfield (USGS 11151870) | 1962–2018 | 7,000 | 12,000 | 15,000 | 19,000 | 22,000 | 26,000 |
| Arroyo Seco – Soledad (USGS 11152000) | 1906–2018 | 8,000 | 14,000 | 18,000 | 24,000 | 28,000 | 32,000 |
| Salinas River – Chualar (USGS 11152300) | 1976–2018 | 5,000 | 15,000 | 27,000 | 52,000 | 80,000 | 120,000 |
| Salinas River – Spreckels (USGS 11152500) | 1930–1956 (pre-dams) | 8,000 | 33,000 | 53,000 | 75,000 | 88,000 | 99,000 |
| | 1957–2018 (post-dams) | 3,700 (-54%) | 17,000 (-48%) | 33,000 (-38%) | 60,000 (-20%) | 85,000 (-3%) | 111,000 (+12%) |

Source: U.S. Geological Survey 2018.

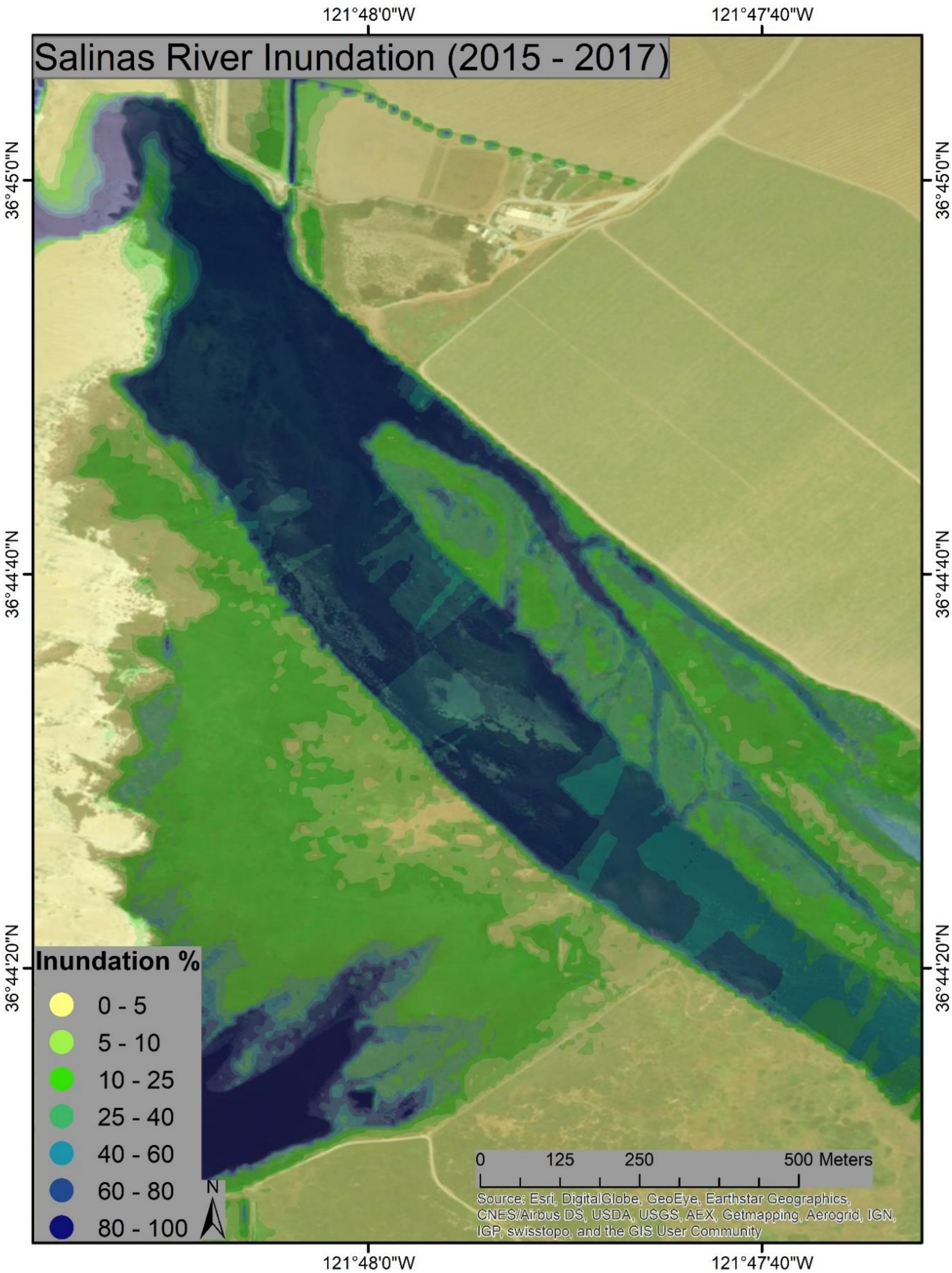



Source: U.S. Geological Survey 2018.
*A portion of the analysis period also includes effects of San Antonio Dam (constructed in 1967).

**Figure 3-12. Mean Monthly Flow in Salinas River near Spreckels, Before and After Dam Construction (USGS 11152500)**

## Salinas River Lagoon (RMU 7 to RM 0)

Today, water levels in the Salinas River Lagoon are managed by MCWRA to limit flooding of adjacent agricultural lands and homes (Hagar Environmental Science 2015). These management actions include releasing flows through a slide gate to the OSR and periodically lowering the sandbar elevation to allow direct outflow to the ocean (Figure 2-1a). Sandbar management involves grading or excavating a drainage channel across the sandbar to drain the lagoon at the critical elevation. At a stage of about 6 feet- National Geodetic Vertical Datum 1929 (NGVD 29) (8.7 feet North American Vertical Datum 1988 [NAVD 88]), the lagoon begins to crest the south bank and floods an extensive area of low marsh vegetation in the Salinas National Wildlife Refuge to the south of the lagoon (Hagar Environmental Science 2015). There are low-lying agricultural fields on the north side of the lagoon that also begin to be inundated under these conditions. The initial breach usually occurs in conjunction with winter storms in November through January, but can occur anytime between October and June (Hagar Environmental Science 2015). River flow may recede to low levels between storms and, depending on tide and wave conditions, the mouth may close again for periods of time with subsequent natural or artificial opening (Hagar Environmental Science 2015) (Figures 3-13).




Source: Central Coast Wetlands Group 2015.

**Figure 3-13. Percent of Time the Salinas River Lagoon Marsh Plain was Inundated by Water for 2015–2017**

In April 2010, MCWRA began operation of the Salinas River Diversion Facility (SRDF) located at about RM 4.8 near the upper part of the Salinas River Lagoon as part of the Salinas Valley Water Project (SVWP). Water released from Nacimiento and San Antonio Dams are impounded and diverted at the SRDF throughout the irrigation season (April 1 to October 31). When the SRDF is in operation, MCWRA is required to provide bypass flows to the lagoon based on water year type. Before implementation of the SVWP, there was no requirement for provision of flow to the lagoon, and there was generally no flow to the lagoon after storm flows ceased in the spring (a pattern more consistent with natural river flow patterns before development of the Salinas Valley for agriculture).

## 3.1.8 Historical Flooding

The Salinas River and its valley have a long history of flooding because of the broad valley topography and the flashy hydrology characteristic of the area. As agricultural and urban development in the floodplain has increased over time, the adverse effects of flooding have grown. Flooding along the Salinas River has caused significant damage and economic impacts to the region. Significant floods occurred in the following years.

- March 1911: Described by the *Salinas Daily Index* paper as a disastrous event that destroyed over 2,000 acres of farmland.
- January and February 1969: Two floods each caused Monterey County to be declared a disaster area.
- February 1978: A series of storms caused extensive beachfront and coastal damage.
- March 1983: “El Niño” storms brought an extremely unusual series of high tides, storm surges, and storm waves along the coast, and heavy rains causing extensive flooding and erosion in the valley.
- March 1995: A significant winter storm brought devastating flooding and extensive damage throughout the county, including loss of life.
- February 1998: A series of “El Niño” winter storms caused flooding that impacted agricultural lands and the city of Salinas. Several communities were evacuated, and Monterey County was declared a disaster area. Countywide losses from these storms were estimated at over $38 million, with agriculture-related losses totaling over $7 million and involving approximately 29,000 damaged acres.

More minor flood events occurred in recent years such as 2005, 2011, and 2017, causing minor flood damage. Flood propensity by reach is described in the sections below.

### Upper Watershed (San Miguel to RMU 2)

The upper watershed from San Miguel to RM 94 is characterized by a narrow channel form compared to the Salinas Valley. There is little development along the mainstem or Nacimiento and San Antonio Rivers in this reach, and therefore flooding and flood risk are not significant. As the river widens and the valley supports more development including King City and the San Lorenzo Creek from RM 94 to RM 53, flooding becomes a risk. Because of this development, and the fact that the channel is generally shallow with a broad floodplain, this portion of the reach is more prone to flood risk.

### Salinas River Valley (RMU 3 to RMU 6)

The Salinas Valley as characterized within RMU 3 to RMU 6 is highly developed, with agriculture throughout its length as well as the cities of Greenfield, Soledad, Gonzales, Chualar, and Salinas. Because of this development, and the fact that the channel is generally shallow with a broad floodplain, the Salinas Valley is an area of major flood risk. Flood risk and historical flood damage tends to be greatest at the northern end of the valley, with the communities of Gonzales, Chualar, and Salinas subject to the greatest flood risk.

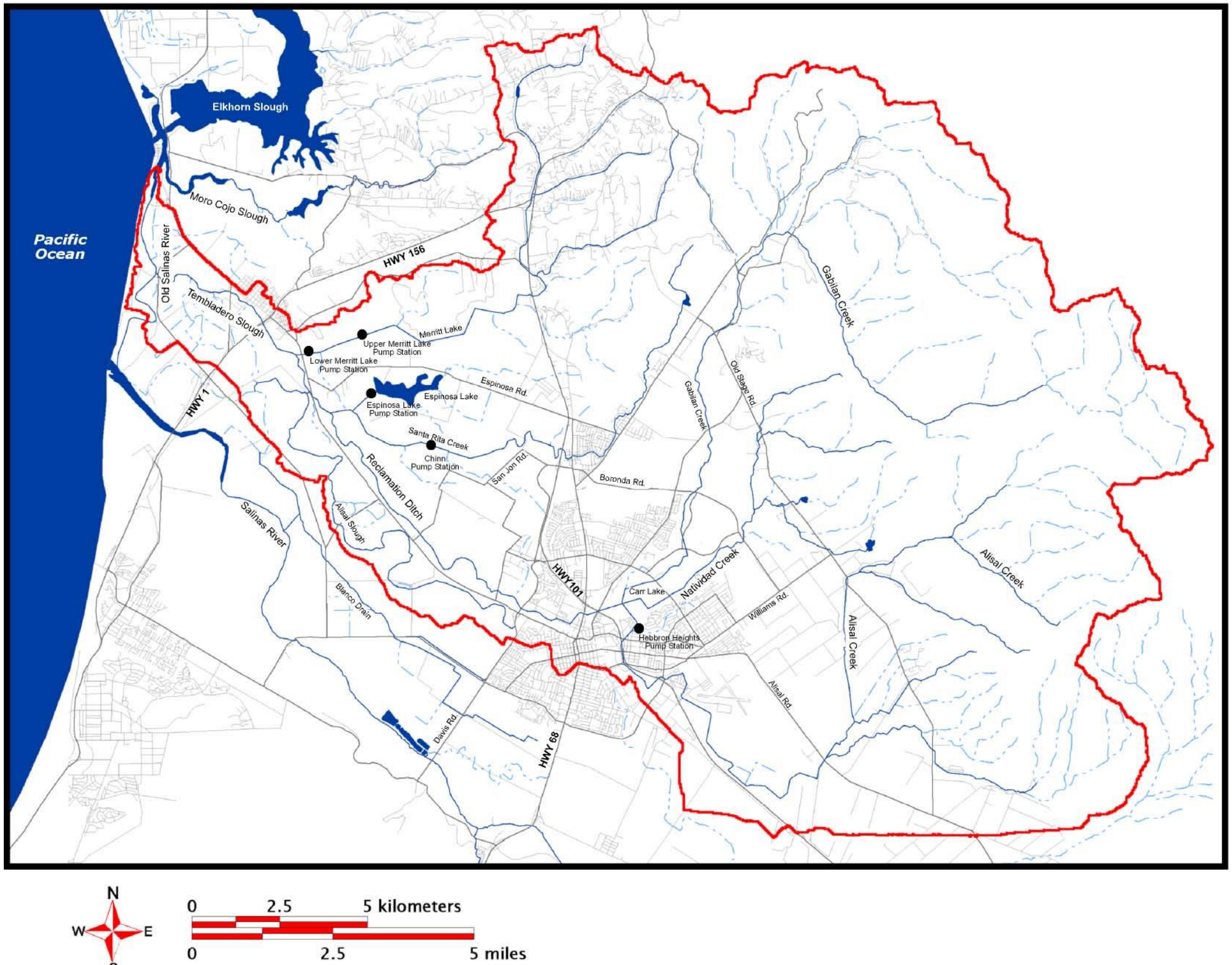
### Salinas River Lagoon (RMU 7 to RM 0)

This reach encompasses the mouth of the river and lagoon from Blanco Road downstream, and includes the communities of Marina, Moss Landing, and Castroville. Flood risk is extremely high in this area due to low land surface elevations, the potential for storm surges from the ocean, and the influence of the sand bar on flooding. When tidal conditions limit Salinas River outflows via the sand bar or the OSR, this reach can be subject to extreme flood risk.

## 3.1.8.2 Additional Flooding Sources

The Gabilan/Tembladero watershed is a 157-square-mile drainage (also known as the Reclamation Ditch System) located to the northeast of the Salinas River watershed and is known to cause localized flooding (Figures 2-7 and Figure 3-14). The watershed includes the following subwatersheds: Tembladero Slough, Merritt Lake, Santa Rita Creek, Espinosa Lake, Gabilan Creek, Natividad Creek, Alisal Slough, and Alisal Creek. The watershed drains the Gabilan mountain range west through the city of Salinas and the agriculture lands of the Lower Salinas Valley (northern end of the watershed) through multiple drainages before joining the OSR halfway between the lagoon and Moss Landing Harbor.

The hydrologic regime of the water bodies in the Gabilan/Tembladero watershed varies markedly. The streams are non-perennial in the uppermost sections, perennial or near-perennial in certain reaches mid-way down the range, and then again non-perennial in the lowest parts of the watershed as the streams begin to flow over old alluvium at the foot of the range. Upon entering the broad system of alluvial plains that is the Salinas Valley, most of the streams are non-perennial, sparsely vegetated, and relatively small. As they near the cities of Salinas and Castroville, the drainages become wider, with perennial standing water (urban runoff, agricultural tailwater, and permitted discharges) in the dry season and storm runoff in the wet season. Finally, within a few miles of the coast, the streams flow into an extended brackish, sub-tidal slough. The lowest reaches are joined by overflow (slide gate–controlled) from the Salinas River Lagoon to become a back-beach swale that runs behind the dunes toward Moss Landing Harbor (Figure 3-14). The whole system is highly episodic; flooding of managed lands adjacent to streams and channels is not uncommon.




Source: Central Coast Watershed Studies 2006.

**Figure 3-14. Locations of Major Surface Water Pump Stations in the Gabilan/Tembladero Watershed**

Since pre-European times, the hydrology of the study area has been dramatically altered. An extensive system of interconnected sub-tidal lakes and swamps existed where the drainages exist today. Most of the lakes are now farmed but still flood regularly during winter storm events, providing valuable detention storage. The impervious area has increased significantly with the expansion of the cities of Salinas and Castroville. The final result in the middle to lower sections of the watershed is that there is less standing water in the dry season and more runoff in the wet season.

Following the dewatering of the original lakebeds, land subsidence (Bechtel Corp 1959) of up to several feet was observed, resulting in poor natural drainage of surface waters. To prevent flooding of both agricultural and urban lands, surface water pump stations have been installed throughout the system. Today, MCWRA operates and maintains several pump stations in the Gabilan/Tembladero watershed as shown in Figure 3-14 and described in Chapter 2, Section 2.3.3.3, *Other Facilities*.

During high discharge events (especially before the river mouth sand berm is breached), the combined discharge of the OSR and the Gabilan/Tembladero watershed can cause localized flooding. Recent flooding events resembled projections by the Federal Emergency Management Agency (FEMA) Flood Hazard maps (Figures 3-15a and 3-15b). On December 12, 2014, localized rainfall within the Gabilan hills caused discharges of almost 700 cfs within the Gabilan/Tembladero watershed (specifically from Gabilan Creek) while, during that same period, the Salinas River flow at Spreckels did not surpass 10 cfs. River flows increased during winter king tides, reducing discharge capacity through the Potrero Road and Moss Landing tide gates, causing significant flooding of agriculture lands within the lower Salinas Valley (Figure 3-15a). Crop losses were estimated at more than $2 million (Central Coast Wetlands Group 2017).

100-year inundation December 2014


Source: Central Coast Wetlands Group 2017.
*Red arrows indicate water flow direction.

**Figure 3-15a. FEMA 100-Year Inundation Areas Compared to the December 2014 Flooding in the Gabilan/Tembladero Watershed**

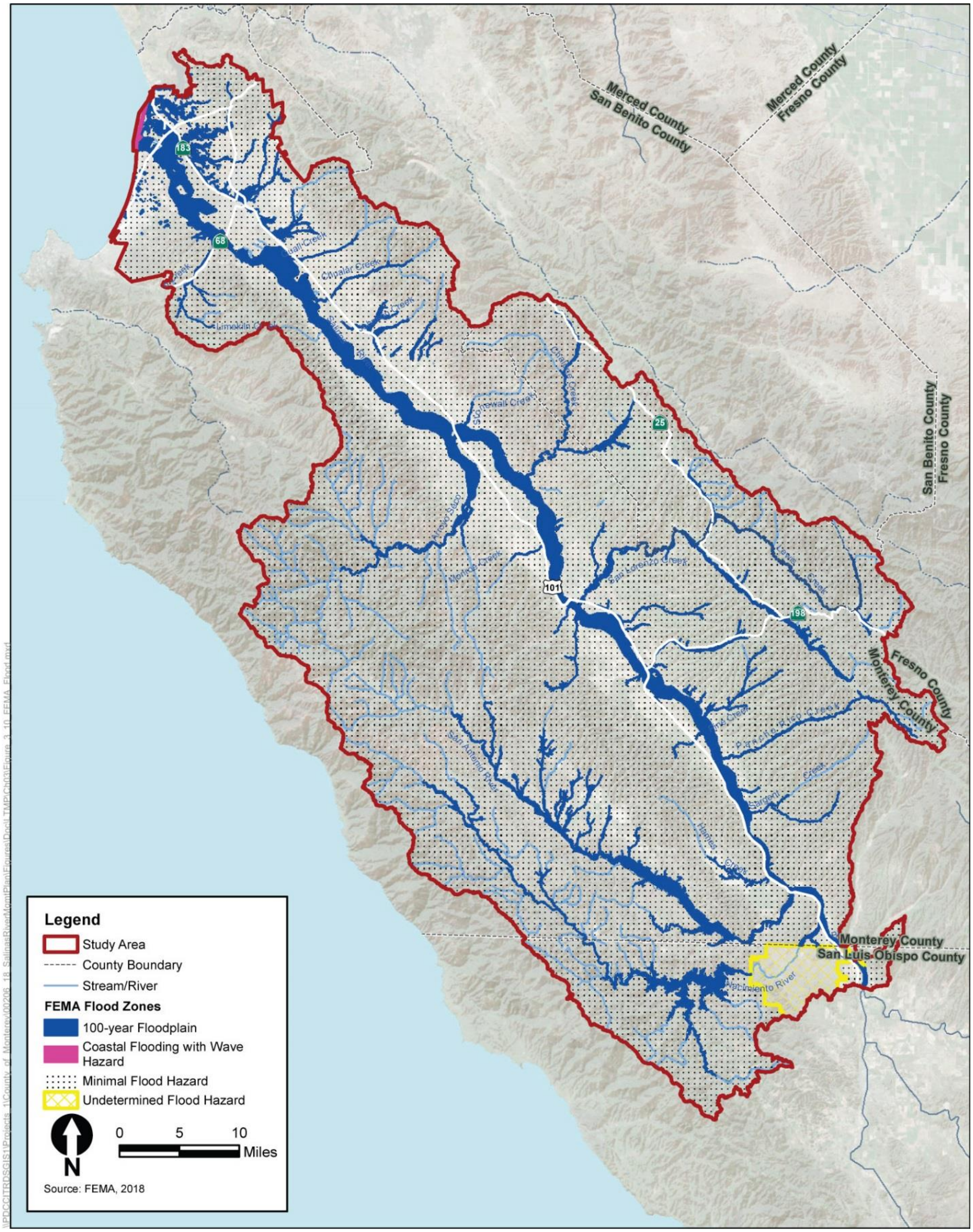



**Figure 3-15b. FEMA Flood Zones in the Study Area**

A significant area that includes agriculture, residences, and businesses around Moss Landing is currently vulnerable to flooding from the Gabilan/Tembladero watershed and OSR. Many of the farm fields vulnerable to flooding within the Moro Cojo Slough have been purchased for wetland restoration or conservation. Other historical wetland areas within the Gabilan/Tembladero watershed between Castroville and Salinas remain in agriculture production through the aid of water lift stations that pump water from drainage systems in the low-lying areas. Water elevation within these basins can be more than 8 feet below sea level. Obviously, these areas are vulnerable to flooding in the winter and have provided flood attenuation service to downstream resources during flood events.

Projected impacts from coastal flooding (wave overtopping dunes and levees causing inland flooding) demonstrate the dire vulnerabilities that agricultural lands, Moss Landing's coastline, and the surrounding area face in the future. By 2100 several portions of the protective dunes complex are projected to no longer restrict ocean waves, leading to significant flooding within the lower Salinas Valley. The long-term preservation of the Salinas State Beach dunes complex and the effective restriction of storm surge inland of Potrero Road are critical to the future viability of the southern Moss Landing region. The potential for inward migration of these dunes is likely but will come in conflict with present land use of those properties.

## 3.1.9 Groundwater

The Salinas Valley Basin is the largest coastal groundwater basin in Central California, and groundwater is a valuable resource for the valley's agriculture-based economy. Although the Salinas River is ultimately the primary water supply for the valley, most of the water used first infiltrates from the Salinas River into the underlying sediments before being extracted for use through groundwater pumping. Therefore, the Salinas Valley Basin serves as a critical reservoir for seasonal water storage, filled by wet season flows and depleted during the dry season when the agricultural water supply demand is greatest. The groundwater reservoir also provides critical storage during multi-year droughts, providing water supply when surface water resources are depleted. Nevertheless, conveyance of groundwater is a slow process. Typical time for groundwater to flow a mile down the valley within the alluvial aquifers is in the range of 10 to 20 years. The local rate of groundwater recharge and the aquifer thickness influence the quantity of available groundwater locally.

The following sections provide an overview of the groundwater basins present in the study area, the sources of groundwater, and groundwater pumping in the Salinas Valley.

### Groundwater Basins

For groundwater management purposes, the California Department of Water Resources (DWR) (2003) divided the Salinas Valley Basin into groundwater subbasins.

- 180/400-Foot Aquifer (also referred to as Pressure).
- East Side Aquifer.
- Forebay Aquifer.
- Upper Valley Aquifer.
- Paso Robles Area.

- Seaside Area.
- Langley Area.
- Corral de Tierra Area (also referred to as Monterey subbasin).

Groundwater within the Salinas Valley is present in a sequence of water-bearing alluvial deposits that range in age from Pliocene through Quaternary, each of which can be up to 2,000 feet thick (California Department of Water Resources 2003, Monterey County Water Resources Agency 2017a). The stratigraphic (rock layer stratification) and hydrostratigraphic (hydrologic characteristics relating to groundwater flow) nomenclature of the Salinas Valley Aquifer System is summarized below (from oldest to youngest) and illustrated on Figure 3-4.

- Deep Aquifers, which are present in the northern Salinas Valley, include portions of the Santa Margarita, Purisima or Pancho Rico, and Paso Robles Formations, and range in age from late Miocene to early Pliocene (approximately 12 to 4 million years). The deep aquifer system sometimes is called the 900-foot aquifer.
- The Paso Robles Formation consists of alluvium deposited in Pliocene and Pleistocene time and is an important aquifer for the entire valley. In the northern portion of the valley this aquifer is known as the 400-Foot Aquifer (also called the Pressure 400-Foot Aquifer). In many locations between the city of Salinas and the coast, fine-grained, low permeability zones within the Paso Robles Formation collectively function as an aquitard[5] called the 400-Foot/Deep Aquitard that limits the hydraulic connection between the 400-Foot Aquifer and the underlying Deep Aquifers.
- Near the coast, upper portions of the 400-Foot Aquifer consist of the Aromas Sands, which are Pleistocene wind-blown dune sand deposits that overlie the Paso Robles Formation. Farther south in the Salinas Valley, the Aromas Sands transition to the Paso Robles Formation.
- Pleistocene Valley Fill deposits and upper portions of the Aromas Sands near the coast comprise the 180-Foot Aquifer. Fine-grained intervals within the Aromas Sands near the coast comprise the 180/400-Foot Aquitard that limits the hydraulic connection between the 180-Foot and 400-Foot Aquifers.
- Discrete aquitard intervals are not present within the aquifer systems in the East Side Subarea. Consequently, the upper portions of the aquifer system are unconfined; however, the cumulative influence of local fine-grained intervals within the coalescing alluvial fans results in semi-confined to confined conditions at depth.
- The Salinas Valley Aquitard (SVA) consists of fine-grained, low permeability clayey sediments that were deposited in an estuary environment during high sea-level conditions in late Pleistocene time. The extent of the SVA is limited to the 180/400-Foot Aquifer subarea. It is over 100 feet thick near the Monterey Bay Coast but thins to 25 feet near the city of Salinas and pinches out farther south near the cities of Chualar and Gonzales. The SVA is an important limitation to hydraulic connection between surface water or shallow groundwater and the underlying aquifer system.
- In the Forebay Aquifer and Upper Valley Aquifer subbasins, the Plio-Pleistocene stratigraphy is similar to and correlates with the northern portion of the valley; however, the extensive aquitard intervals are not present. The result is an unconfined aquifer system and greater

[5] An aquitard is a bed of low permeability that slows but does not prevent vertical groundwater flow.

hydraulic connection between the aquifer system and the Salinas River and higher recharge rates. The thickness of the aquifer system also decreases in the Upper Valley Aquifer subbasins.

- Recent deposits (<10,000 years) include fluvial deposits along portions of the Salinas River Corridor and sand dunes near the coast (Table 3-8).

**Table 3-8. Stratigraphy and Hydrostratigraphy for the Salinas River**

| Period/Epoch | | Formation | Hydrostratigraphy |
|---|---|---|---|
| Quaternary 2.5 MYA to present | Holocene | Recent Alluvium | Shallow Aquifer |
| | Pleistocene | Valley Fill | Salinas Valley Aquitard |
| | | | Pressure 180-Foot Aquifer |
| | | Aromas Sands (near coast) | Pressure 180/400-Ft Aquitard |
| | | | Pressure 400-Foot Aquifer |
| | | Paso Robles | Pressure 400-Foot/Deep Aquitard |
| Tertiary 23 to 2.5 MYA | Pliocene | Purisima/ Pancho Rico | Deep Aquifers |
| | Miocene | Santa Margarita | |
| | | Monterey | Minimally water-bearing |
| Mesozoic | | Granitic basement | Non water-bearing |

Not to scale.

MYA = Million Years Ago

Source: Kennedy and Jenks 2004.

## Groundwater Recharge

Precipitation in the Salinas River watershed (HUC-8 Cataloging Unit) results in runoff and streamflow, which subsequently enters the Salinas Valley Basin through percolation, primarily in streambeds where flow is concentrated. Streamflow from the surrounding subwatersheds represents a major source of recharge to the aquifers of the Salinas Valley Basin (California Department of Water Resources 1946, California State Water Resources Board 1956, Brown and Caldwell 2015a). The amount of runoff generated by individual subwatersheds depends on the amount of precipitation, topography, vegetative cover, and ability of soils to absorb water. The Santa Lucia Mountains, on the west side of the Salinas Valley Basin, contribute approximately 70% of the total runoff to the Salinas Valley Basin (California State Water Resources Board 1956).

The soil type and timing of precipitation and river flows are critical factors for recharge. In areas with soil of low permeability (e.g., clayey soils), infiltration of water is slow and the majority of rainfall or river flow runs off over land. In areas with soil of high permeability (e.g., gravel) water can infiltrate rapidly into the ground. Recharge is also influenced by the water-holding capacity (specific retention) of soil. Generally, fine-grained soils (e.g., clay) retain larger amounts of water than coarse-grained soil (e.g., sand). Water retained by the soil matrix is utilized by root systems to meet evapotranspiration demands of plants and is critical to support native vegetation and "dry-farming" crops during the dry summer months.

Recharge to groundwater (deep percolation) only occurs when the retention capacity of the root-zone is exceeded and water infiltrates below the depth of roots. Like much of the western states with semi-arid climate, deep percolation of rainfall in the Salinas Valley only occurs episodically. Under natural conditions, the Salinas Valley Basin aquifer system is recharged by infiltration from the Salinas River and tributaries and by direct infiltration of rainfall. Based on modeling for MCWRA, infiltration of rainfall accounts for approximately 24% of natural recharge, and the infiltration from the Salinas River system accounts for the balance, approximately 76% (Rosenberg 2001).

In agricultural areas, some additional recharge occurs as infiltration of irrigation (return flows). However, the source of most of the irrigation is pumping of groundwater. Although the irrigation return flows could be considered an additional groundwater recharge source, it is generally more useful to treat it as a decrease in the net pumping (i.e., the net agricultural water use is equal to groundwater pumping minus return flow infiltration).

Areas identified by Rosenberg (2001) as being favorable for recharge are shown on Figure 3-4 and are based on the following criteria.

- Area must overlie a demonstrated aquifer system.
- Surficial soils must have moderate to high infiltration capacity and low to moderate retention capacity (e.g., sandy soils).
- The land is undeveloped (as noted above, agricultural return flow infiltration is not treated as recharge).

Many of the alluvial deposits along the Salinas River corridor are favorable recharge areas. However, much of the valley fill in the Salinas Valley is not favorable due to finer-grained texture, which results in relatively low permeability and high retention. The alluvial fans of the Arroyo Seco area and on the east side of the valley have high recharge potential, as does the alluvial fill in the San Antonio Valley area and soils of the Fort Ord and Seaside areas.

Recharge is also sensitive to the total and temporal distribution of rainfall over the year. For semi-arid climates similar to Salinas Valley, Blaney (1933) estimated threshold rainfall totals of 17 inches per year on native soils, and 11 inches per year on irrigated fields for significant amounts of recharge to occur. The threshold is lower for irrigated land because the soils are wetter at the beginning of winter so less rainfall is required to exceed the retention capacity of the soils. Rosenberg (2001) concludes that because most of Salinas Valley has average annual rainfall of less than 17 inches, even for favorable soil conditions, recharge of groundwater from rainfall is likely a rare occurrence.

Relative to natural conditions, irrigation increases the amount of deep percolation from rainfall, but the typical increase in recharge is more than offset by the evapotranspiration during the growing season. The groundwater pumping to meet irrigation needs typically exceeds the deep percolation enhancement by 20 to 30 times (Rosenberg 2001).

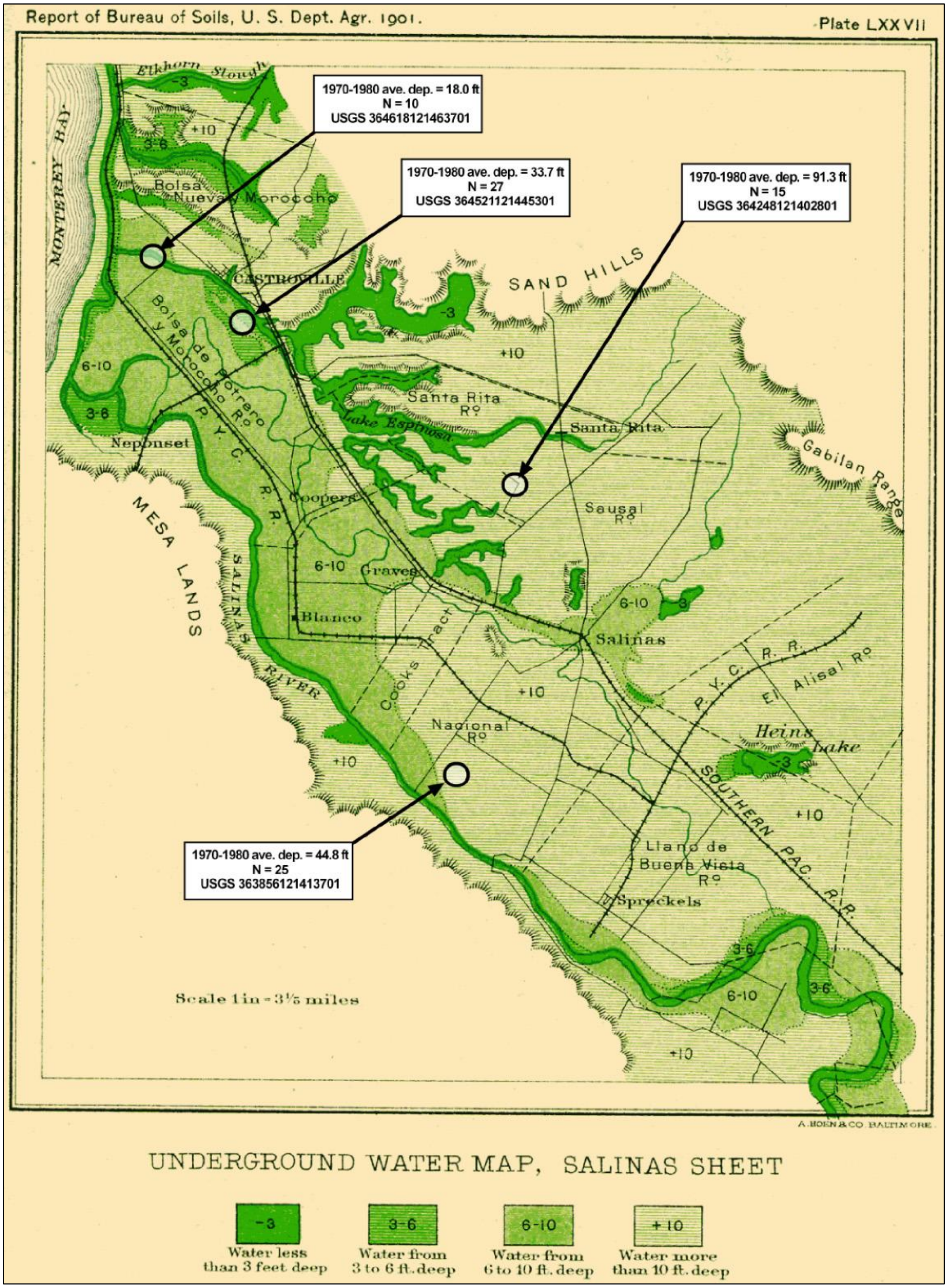
## Groundwater Pumping

Water was diverted from the Salinas River for irrigation as early as 1797. As agriculture expanded, the Salinas River could no longer meet water demands and growers began pumping groundwater in the late 1800s. In the early 1900s USGS reported 270 wells in the alluvial basin from the coast up to about King City (Hamlin 1904). The USGS study also noted several pumping plants along the Salinas River that each extracted as much as 10,000 gallons per minute, which equates to 16,000 AFY,[6] from the river and wells along the river. According to records during census investigations, the number of reported active wells in the Salinas Valley increased from 102 in 1909 to 606 in 1919 and 1,176 in 1929 (Brown and Caldwell 2015b).

By 1944, groundwater pumping in the entire valley was estimated to be 350,000 AFY (Brown and Caldwell 2015b). Since the late 1940s, irrigated acreage within the valley has increased substantially, with steady increases in the 1940s and 1950s and rapid increases in the 1960s and 1970s (Figure 3-16). Groundwater use in the Salinas Valley peaked in the early 1970s, then started declining due primarily to changes in crop patterns, continued improvements in irrigation efficiency, and some conversion of agricultural lands to urban land uses. Total irrigated acreage has remained relatively constant since the 1980s (Monterey County Water Resources Agency 2006). Urban development, however, is experiencing continued growth, predominantly in the Castroville, Gonzales, Greenfield, King City, Marina, Salinas, and Soledad areas. The increases in urban water use, particularly on non-irrigated lands in the northern portion of the Salinas Valley, place additional pressure on groundwater pumping. The reported total irrigated acreage in the Salinas Valley in 2016 was 181,610 acres (Monterey County Water Resources Agency 2017b).

According to the analysis of historical storage changes in the Salinas Valley Basin (Brown and Caldwell 2015b), the overdraft of groundwater that occurred in the mid-1940s and 1950s was mitigated in part by the management of the flows in the Salinas River by the reservoirs. In particular, early groundwater storage losses in the Forebay Aquifer and Upper Valley Aquifer subbasins were entirely recovered once both reservoirs were in operation (starting water year 1967). However, operation of the reservoirs provided little mitigation of storage losses in the 180/400-Foot Aquifer and East Side Aquifer subbasins because aquifers in these areas are largely disconnected from the Salinas River.

[6] One acre-foot is equal to 325,851 gallons. One acre-foot/year is equal to 0.62 gallon per minute.



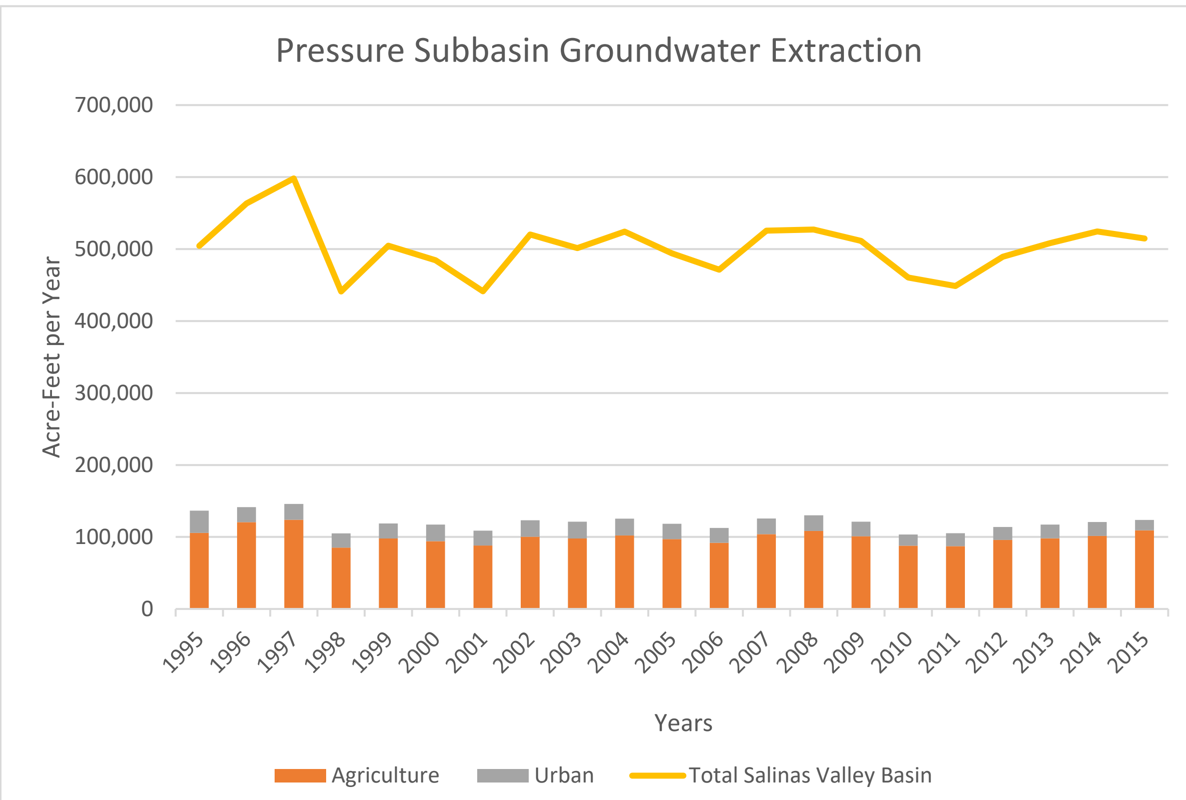

Source: Watson et al. 2003.

**Figure 3-16. Groundwater Elevation in the Northern Salinas Valley Based on USGS Groundwater Well Data (1970–1980) with Wells Containing at Least 10 or More Measurements (=N) during that Time**

Today, groundwater meets almost all agricultural and municipal water demands in the Salinas Valley, with agriculture constituting approximately 90% of the demand. In 2015 MCWRA reported an estimated total pumping of 509,000 AFY in the Monterey County portion of the Salinas Valley, with the following distribution by subareas[7] (Brown and Caldwell 2015b).

- 23% in the Pressure Subarea (180/400-Foot).
- 19% in the East Side Subarea.
- 29% in the Forebay Subarea (including the Arroyo Seco cone).
- 28% in the Upper Valley Subarea.

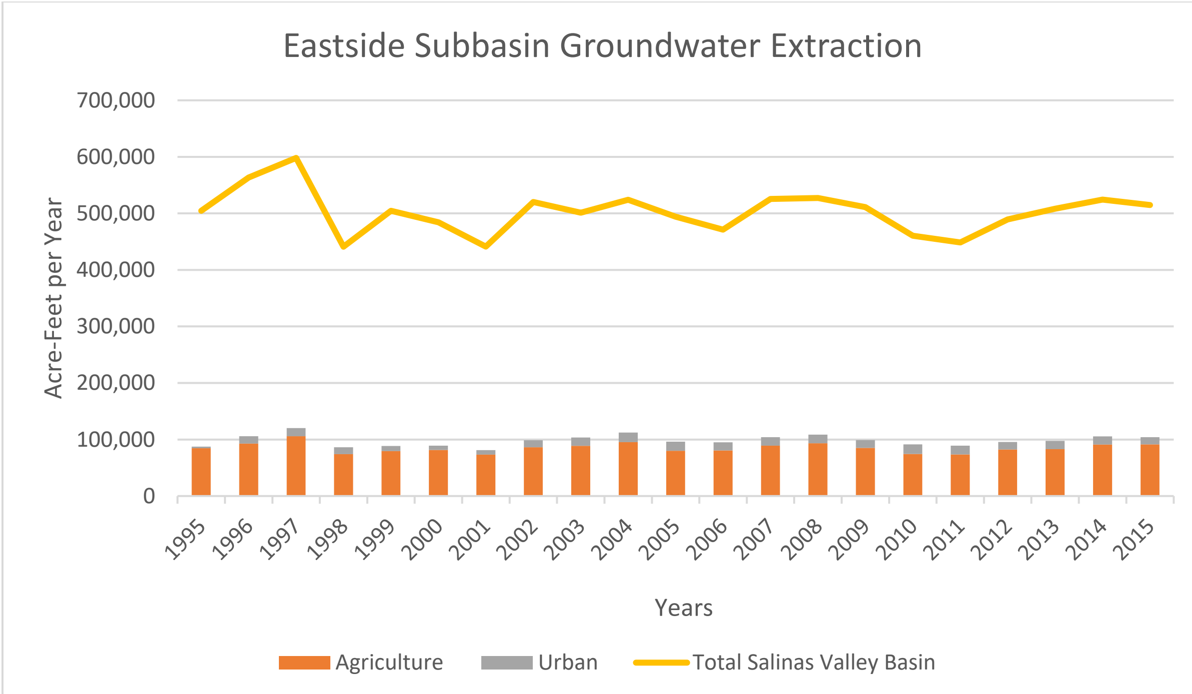
Since 1993, to help manage groundwater resources in the management area, owners of wells with a discharge pipe of 3 inches in diameter or greater have been required to report annual pumped quantities to MCWRA. The annual agricultural pumping totals are reported from November through October, and the urban pumping data is reported for each calendar year. MCWRA compiles the pumping data and provides a report each year (Monterey County Water Resources Agency 2018a). The groundwater pumping data reported by MCWRA by the four major subbasins are presented on Figures 3-17 through 3-20.




Source: Monterey County Water Resources Agency 2018a.

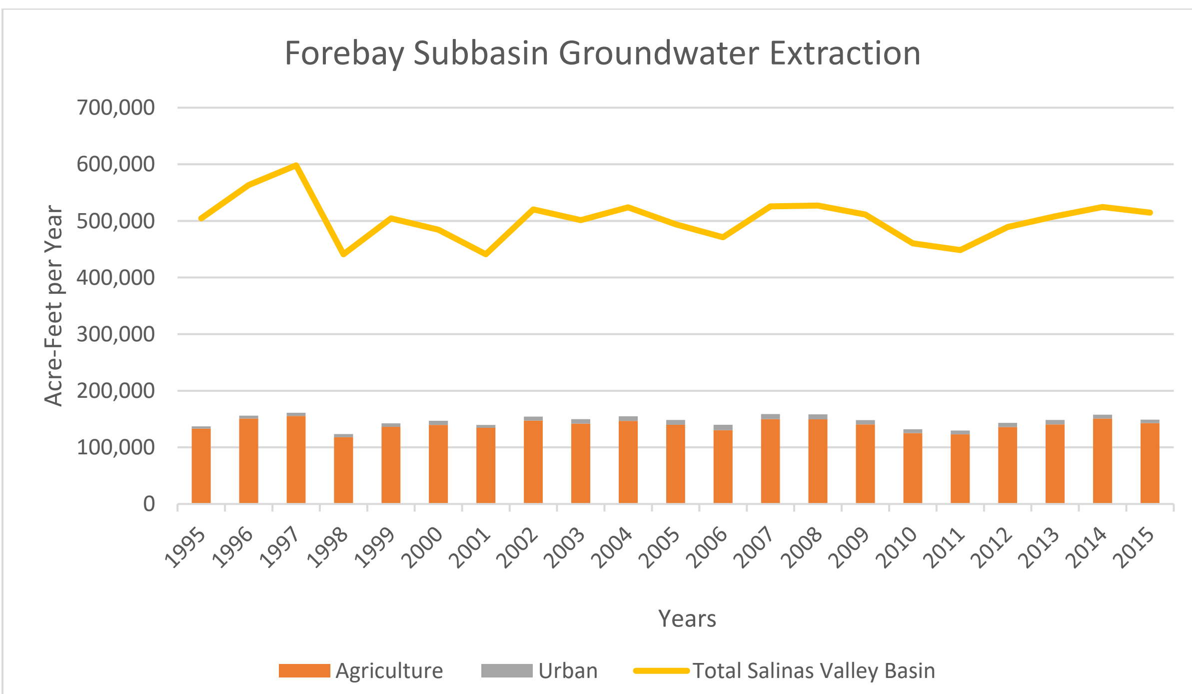
**Figure 3-17. Total Reported Groundwater Extraction in the Pressure Subbasin**

[7] MCWRA compiles and reports groundwater pumping data by subareas. The MCWRA subareas and DWR subbasins are similar but not identical in extent.



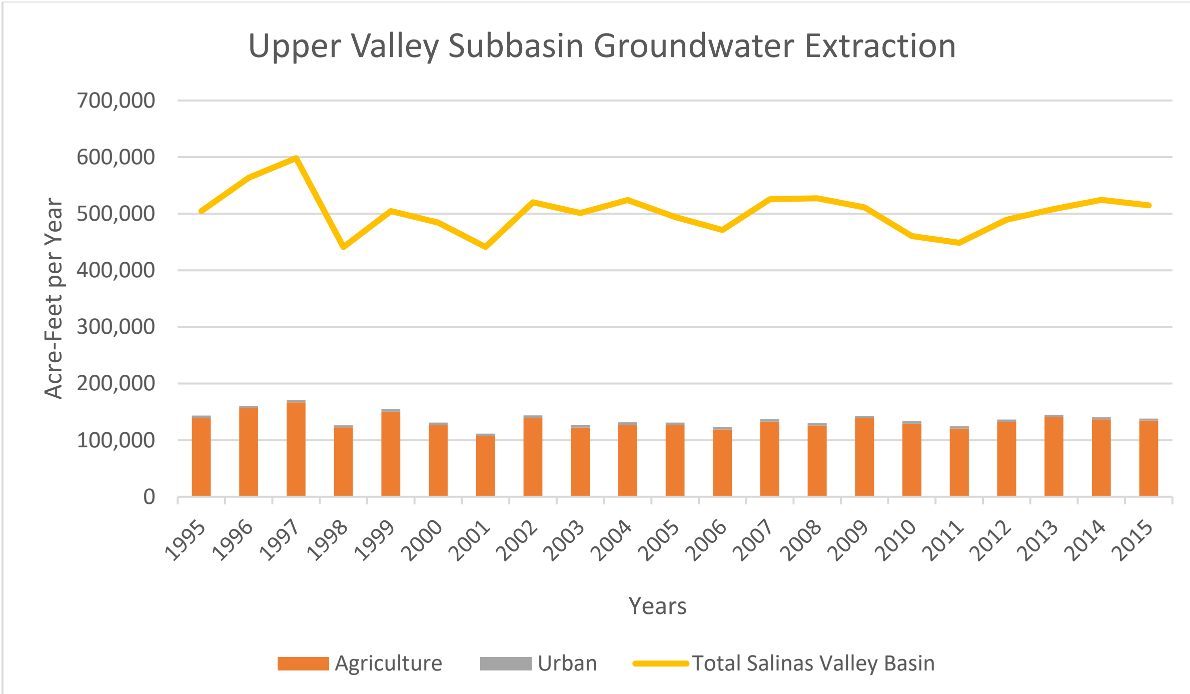

Source: Monterey County Water Resources Agency 2018a.

**Figure 3-18. Total Reported Groundwater Extraction in the Eastside Subbasin**




Source: Monterey County Water Resources Agency 2018a.

**Figure 3-19. Total Reported Groundwater Extraction in the Forebay Subbasin**




Source: Monterey County Water Resources Agency 2018a.

**Figure 3-20. Total Reported Groundwater Extraction in the Upper Valley Subbasin**

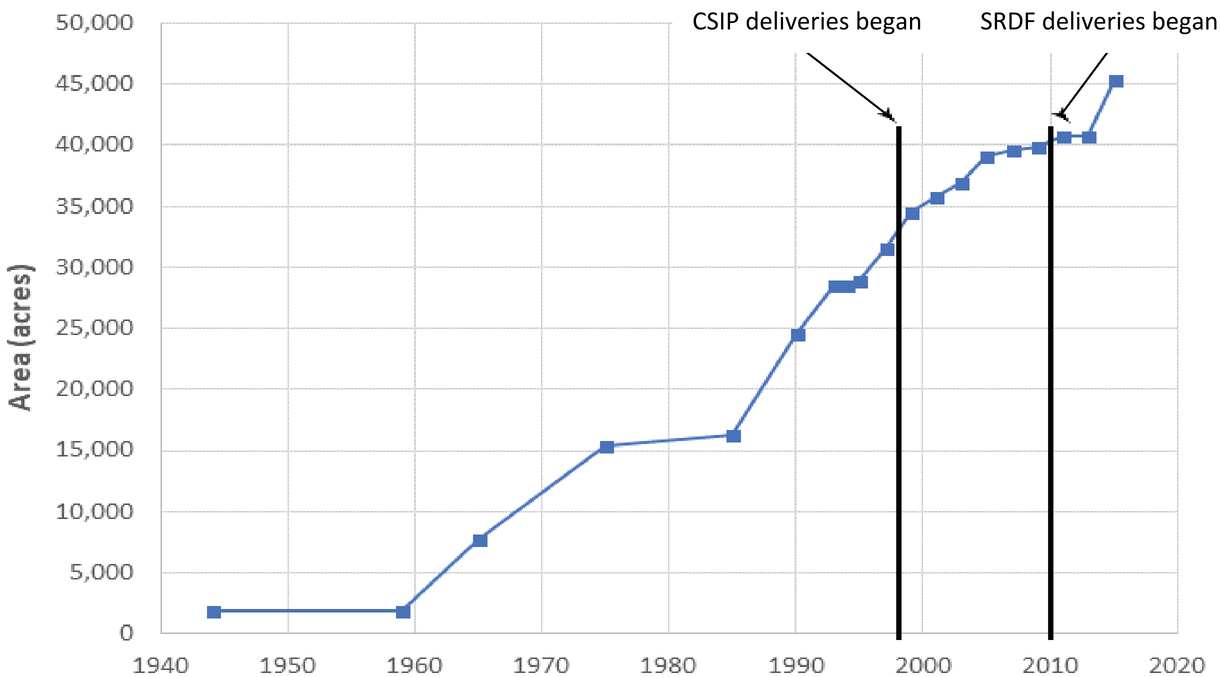
In the Upper Valley Subarea, groundwater wells are relatively shallow, and the aquifers system is unconfined. The wells are mostly close to the Salinas River. Compared to the deeper wells in the northern subareas, the production rates from wells in the Upper Valley Subarea are more influenced by short-term fluctuations in recharge, which influences depths to groundwater.

Shallow groundwater in the Forebay and East Side Subareas also is unconfined, but semi-confined at depth. Because of the greater thickness of the aquifer system and deeper wells, groundwater pumping rates in the Forebay and East Side Subareas are relatively stable. However, continued overdraft of groundwater in the East Side Subarea has contributed to the lowering of groundwater levels well below sea level north of Salinas.

Groundwater production in the Pressure (180/400-Foot) Subarea is mainly from the 180-Foot and 400-Foot Aquifers, which are generally under confined conditions. Because of groundwater levels below sea level, seawater has been intruding the 180-Foot and 400-Foot Aquifers for many decades. Seawater intrusion of the coastal margin aquifers of Salinas Valley was first documented in 1946 (Monterey County Water Resources Agency 2017a). MCWRA has monitored groundwater levels since the 1940s. Water levels are measured monthly at approximately 94 wells and annually at approximately 400 wells in the Salinas Valley. MCWRA monitors the extent of seawater intrusion by measuring the chloride content[8] in a network of wells in the northwestern portion of Salinas Valley. Today, seawater intrusion extends approximately 7 miles inland within the 180-Foot Aquifer and 4

[8] MCWRA defines the seawater intrusion front as the inland extent at which the concentration of chloride in groundwater is at least 500 mg/L. A chloride concentration of 500 mg/L is twice the National Secondary Drinking Water Regulation (250 mg/L) and exceeds the chloride concentration of 350 mg/L, which is considered by the U.S. Department of Agriculture to be of “Class III - injurious or unsatisfactory” quality for agricultural irrigation (Monterey County Water Resources Agency 2018a).

miles inland in the 400-Foot Aquifer (e.g., Monterey County Water Resources Agency 2012, 2017a). Figure 3-21 shows a time series of the cumulative area of the 180-Foot and 400-Foot Aquifers with chloride concentrations exceeding 500 milligrams per liter (mg/L).



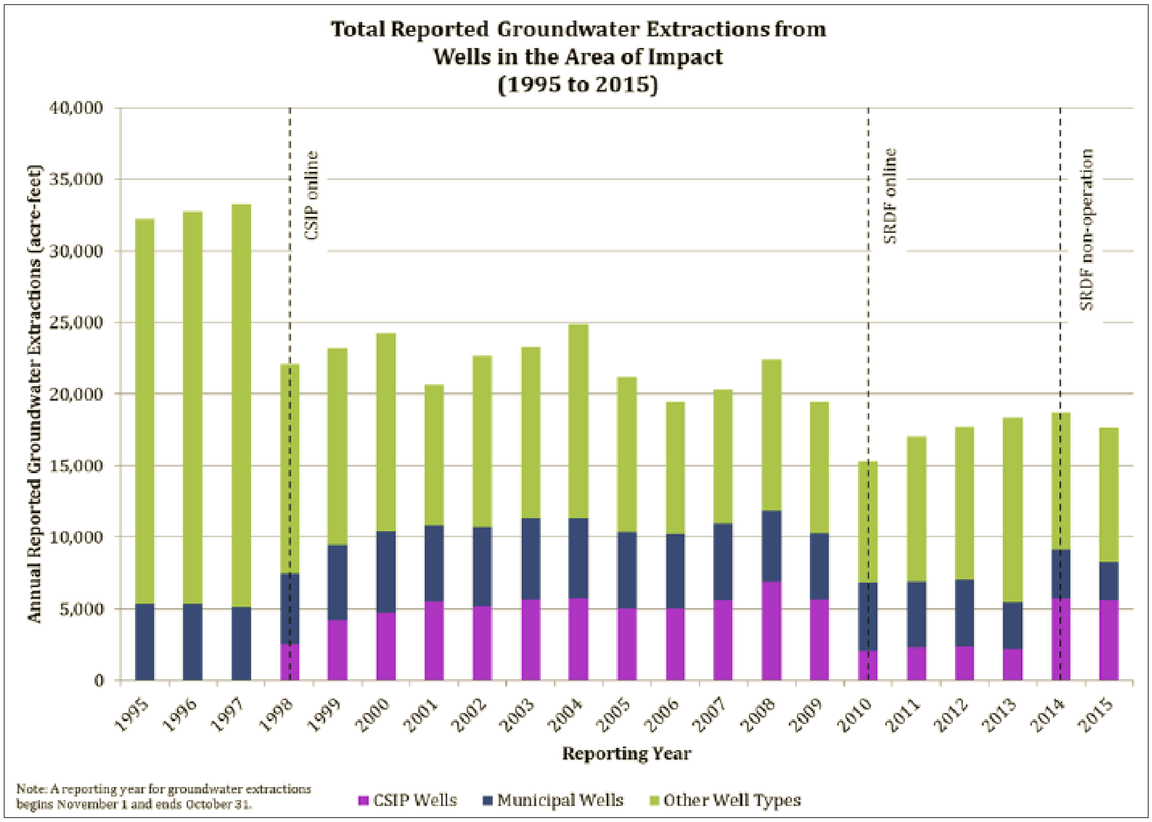

Source: Monterey County Water Resources Agency 2017b.

**Figure 3-21. Cumulative Area with Time of Seawater Intrusion in 180- and 400-Foot Aquifers (areas with chloride exceeding 500 mg/L)**

To help decrease the rate of seawater intrusion, since 1998 the Castroville Seawater Intrusion Project (CSIP) has delivered recycled water and groundwater pumped from supplemental wells to the Castroville area for irrigation to facilitate a decrease in pumping rates near the coast. Since 2010the CSIP has been supplemented with treated surface Salinas River water released from the reservoirs, which is a component of the SVWP. Average annual pumping in the Pressure (180/400-Foot) Subarea was 134,068 AFY from 1970 to 1997 (Montgomery Watson 1997), and 117,330 AFY from 1998 to 2015 ( Monterey County Water Resources Agency 2017a; data provided by MCWRA). These data reflect a 12% decrease in average pumping in the Pressure Subarea after CSIP deliveries began.

For management recommendations, MCWRA also has defined an area impacted by incipient seawater intrusion based on a threshold chloride concentration in either the 180-Foot or 400-Foot Aquifer of 250 mg/L, which is the National Secondary Drinking Water Regulation for chloride (Monterey County Water Resources Agency 2017b). As illustrated by Figure 3-22 (Monterey County Water Resources Agency 2017b), the decrease in pumping within the "area of impact" since the CSIP and SRDF deliveries began is substantial: approximately a 32% decrease in the annual rate of pumping since CSIP deliveries began in 1998, and 46% since the additional deliveries from the SRDF, relative to pumping the 3 years (1995–1997) before CSIP came online.

A decrease in the rate of advancement of seawater intrusion because of replacement of some pumping by CSIP and the SRDF water deliveries can be seen on Figure 3-21. However, groundwater levels are still below sea level in aquifers near the coast and therefore seawater intrusion continues.




Source: Monterey County Water Resources Agency 2017b.

**Figure 3-22. Annual Reported Groundwater Extractions in the Pressure Subbasin "Area of Impact" from 1995 to 2015**

## 3.1.10 Water Quality

Water quality is a measure of the physical, chemical, and biological characteristics of water. The water quality of a stream is controlled by multiple factors, including the chemical and physical nature of streambed material (e.g., erodibility, grain size, rock type) and influences from outside the stream corridor, such as quality of groundwater and upstream runoff that may be recharging the stream system (Monterey County Water Resources Agency 2014). The California Porter-Cologne Water Quality Control Act of 1969, which became Division Seven of the State Water Code, establishes the responsibilities and authorities of the nine Regional Water Boards and the State Water Resources Control Board to coordinate and control water quality. Each Regional Water Board is directed to "...formulate and adopt water quality control plans for all areas within the region." For each water body in the regional jurisdiction, these plans are required to designate beneficial uses that are to be protected, water quality objectives that protect those uses, and an implementation plan that accomplishes those objectives (Central Coast Regional Water Quality Control Board 2017a).

The Salinas River is in the jurisdiction of the Central Coast Regional Water Board. Table 3-9 summarizes designated beneficial uses for a selected subset of waterbodies in the study area from the Basin Plan for the Central Coastal Region (Central Coast Regional Water Quality Control Board 2017a), and Table 3-10 outlines the U.S. Environmental Protection Agency 303(d) listings that are impairing the beneficial uses for each water segment (U.S. Environmental Protection Agency 2018). Figure 3-23 portrays the impaired waterbodies in the Gabilan/Tembladero watershed.

**Table 3-9. Designated Beneficial Uses by Waterbody**

| Waterbody | MUN | AGR | PROC | IND | GWR | REC1 | REC2 | WILD | COLD | WARM | MIGR | SPWN | BIOL | RARE | EST | FRSH | COMM | SHELL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nacimiento River (downstream of reservoir) | X | X | | | X | X | X | X | X | X | | X | | X | | X | X | |
| San Antonio River (downstream of reservoir) | X | X | | X | X | X | X | X | | X | X | X | | X | | | X | |
| Salinas River (Nacimiento to Chualar) | X | X | X | X | X | X | X | X | X | X | X | X | | X | | | X | |
| San Lorenzo Creek | X | X | | | X | X | X | X | | X | | X | | | | | X | |
| Salinas River (Chualar to Spreckels) | X | X | X | X | X | X | X | X | X | X | X | | | | | | X | |
| Arroyo Seco | X | X | | X | X | X | X | X | X | X | X | X | | X | | | X | |
| Salinas River (Spreckels to Lagoon) | X | X | | | | X | X | X | X | X | X | | | | | X | X | |
| Salinas River Lagoon (North) | | | | | | X | X | X | X | X | X | X | X | X | X | | X | X |
| Salinas River Refuge Lagoon (South) | | | | | | X | X | X | X | X | X | X | X | X | | | X | X |

Source: Central Coast Regional Water Quality Control Board 2017a.

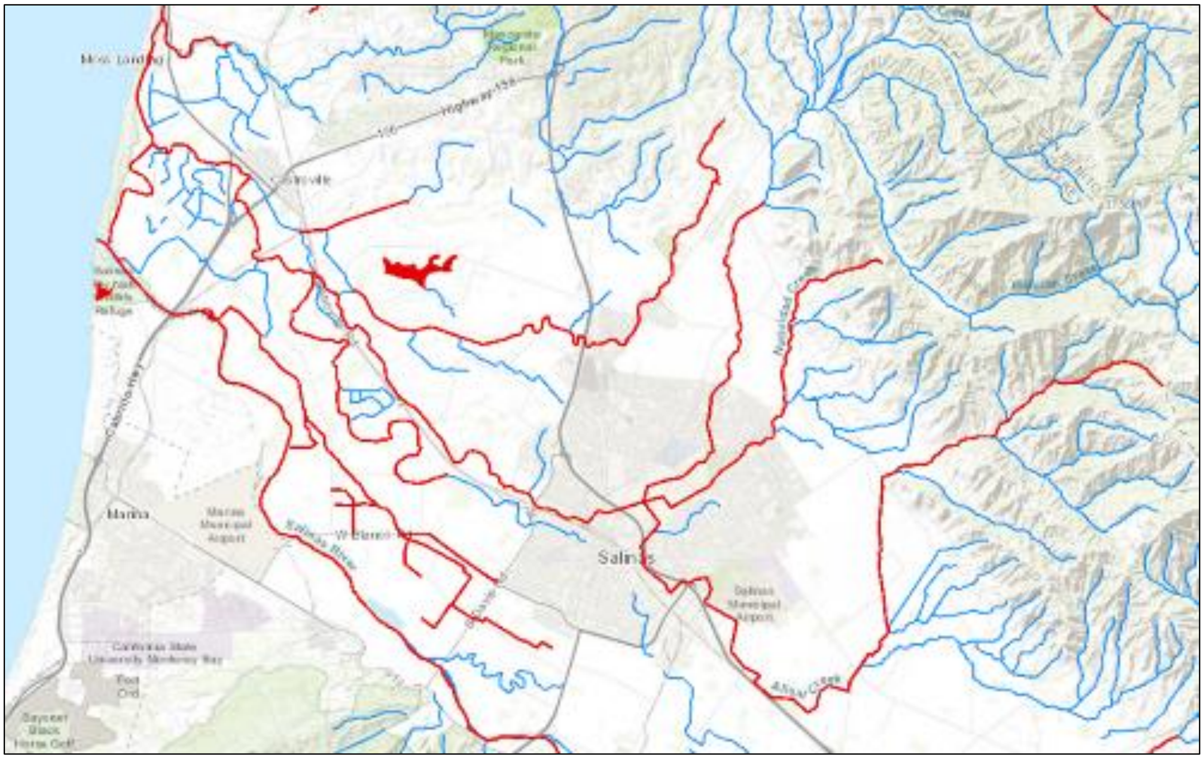
Key to beneficial uses:

AGR – Agricultural Supply
BOIL – Preservation of Biological Habitats of Special Significance
COLD – Cold Fresh Water Habitat
COMM – Commercial and Sport Fishing
EST – Estuarine Habitat
FRSH – Fresh Water Replenishment
GWR – Groundwater Recharge
IND – Industrial Service Supply
IGR – Migration of Aquatic Organisms
MUN - Municipal and Domestic Supply
PROC – Industrial Process Supply
RARE – Rare, Threatened, or Endangered Species
REC1 – Water Contract Recreation
REC2 – Non-Contact Water Recreation
SHELL – Shellfish Harvesting
SPWN – Spawning, Reproduction, and/or Early Development
WARM – Warm Fresh Water Habitat
WILD – Wildlife Habitat

**Table 3-10. Listed Impairments by Waterbody**

| Waterbody | 303(d) List Constituents |
|---|---|
| Nacimiento Reservoir | Mercury |
| San Antonio Reservoir | Mercury |
| San Antonio River (downstream of reservoir) | Fecal Indicator Bacteria, Escherichia coli |
| Salinas River (Nacimiento to Chualar) | Fecal Indicator Bacteria, pH, Toxicity, Turbidity, Water Temperature |
| San Lorenzo Creek | Boron, Chloride, Escherichia coli, Fecal Indicator Bacteria, pH, Sodium, Specific Conductivity |
| Salinas River (Chualar to Spreckels) | Benthic Community Effects, Chlordane, Chloride, Chlorpyrifos, Enterococcus, Escherichia coli., Fecal Indicator Bacteria, Nitrate, PCBs, pH, Salinity, Toxicity, Turbidity |
| Arroyo Seco | Fecal indicator bacteria and Water Temperature from the confluence with Tassajara Creek downstream to the confluence with the Salinas River. |
| Salinas River (Spreckels to Lagoon) | Benthic Community Effects, Chlordane, Chloride, Chlorpyrifos, DDE, DDT, Diazinon, Dieldrin, Escherichia coli, Fecal Indicator Bacteria, Nitrate, PCBs, pH, Sodium, Total Dissolved Solids, Toxaphene, Toxicity, Turbidity |
| Salinas River Lagoon (North) | Chlorpyrifos, DDE, Nutrients, pH, Toxicity, and Water Temperature |
| Salinas River Refuge Lagoon (South) | pH and Turbidity |
| Old Salinas River | Chlorophyll-a, Chlorpyrifos, Diazinon, Escherichia coli, Fecal Indicator Bacteria, Nitrate, Oxygen, dissolved, pH, Toxicity, Turbidity |
| Reclamation Ditch System | Ammonia, Chlorpyrifos, Copper, Diazinon, Escherichia coli, Fecal Indicator Bacteria, Malathion, Nitrate, Oxygen, Dissolved, Permethrin, pH, Priority Organics, Toxicity, Turbidity |

Sources: State Water Resources Control Board 2018, U.S. Environmental Protection Agency 2018. https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2014_2016.shtml




Source: Central Coast Watershed Studies 2006.

**Figure 3-23. Impaired Waterbodies in the Gabilan/Tembladero Watershed**

All of the pollutants listed in Table 3-10 require the development of a Total Maximum Daily Load (TMDL) to bring the associated water segments into compliance at levels that protect designated beneficial uses. The following TMDLs are in development or have been approved by the Central Coast Regional Water Board for the Salinas River watershed.

- Fecal coliform TMDL—approved September 2, 2010.
- Chlorpyrifos and diazinon TMDL—approved May 5, 2011.
- Nutrient TMDL—approved March 14, 2013.
- Sediment toxicity TMDL—approved July 14, 2017.
- Turbidity TMDL—in development.
- Salts TMDL—in development.
- Mercury TMDL in reservoirs—in development.

### 3.1.10.1 Fecal Indicator Bacteria

Many waterbodies in the Salinas River watershed from Chualar into the Salinas River Lagoon are impaired due to exceedances of Basin Plan (Central Coast Regional Water Quality Control Board 2017b) water quality criteria for fecal indicator bacteria concentrations affecting the beneficial uses of water contact recreation (REC-1) and shellfish harvesting (SHELL) (State Water Resources Control Board 2018, U.S. Environmental Protection Agency 2018). The fecal coliform TMDL (Central Coast Regional Water Quality Control Board 2010) attributes exceedances to specific sources by water segment and establishes numeric targets for reducing discharges to the affected watersheds in order to restore beneficial uses by 2023. Generally, the primary sources include domestic animals/livestock discharges in areas that do not drain to municipal separate storm sewer systems, discharges from municipal separate storm sewer systems, illegal dumping, and sanitary sewer collection system leaks (Central Coast Regional Water Quality Control Board 2010).

### 3.1.10.2 Nutrients

Many waterbodies in the Salinas River watershed from Chualar into the Salinas River Lagoon are impaired due to exceedances of Basin Plan (Central Coast Regional Water Quality Control Board 2017b) water quality criteria for nitrate, unionized ammonia, and associated nutrient-related problems such as excessive orthophosphate, dissolved oxygen imbalances, microcystin toxicity, and excess algal biomass (Central Coast Regional Water Quality Control Board 2013). These exceedances have affected designated beneficial uses including municipal and domestic supply (MUN), agricultural supply (AGR), groundwater recharge (GWR), water contact recreation (REC-1), cold fresh water habitat (COLD), and warm fresh water habitat (WARM). The Nutrient TMDL, established in 2013, identifies sources of these water quality impairments and describes a plan to achieve water quality objectives and ultimately restore the designated beneficial uses of surface waters by 2043. The primary source of nutrients to the watershed is fertilizer application on irrigated cropland (Central Coast Regional Water Quality Control Board 2013). Other sources include urban stormwater sewer system discharge (minor source at basin-scale but locally significant), and livestock and domestic animal manure (minor source, currently meeting load allocations). Proposed actions include minimization of nutrient loading to receiving waters from irrigated lands through using restored or created wetland and riparian habitat as water quality management areas (which involve low-cost, highly effective ecological engineered watershed restoration techniques) in the lower Salinas Valley, implementation of the Central Coast Water Board Agricultural Order, incorporation of waste load allocations into municipal separate storm sewer systems National Pollutants Discharge Elimination System permits, and maintenance of existing water quality by supporting self-monitoring activities for owners of livestock and domestic animals with technical guidance from existing rangeland water quality management plans (Central Coast Regional Water Quality Control Board 2014).

### 3.1.10.3 Pesticides

Many waterbodies in the Salinas River watershed are also impaired due to exceedances of Basin Plan (Central Coast Regional Water Quality Control Board 2017b) water quality criteria for pesticide concentrations from Chualar into the Salinas River Lagoon affecting the beneficial uses of wildlife habitat (WILD), cold fresh water habitat (COLD), warm fresh water habitat (WARM), migration of aquatic organisms (MIGR), spawning, reproduction and/or early development uses (SPWN), rare, threatened, or endangered species (RARE), and estuarine habitat (EST) (Central Coast Regional Water Quality Control Board 2011). Discharges from irrigated agriculture were identified as the primary source of pesticides within the watershed. The Lower Salinas River watershed Chlorpyrifos and Diazinon TMDL (Central Coast Regional Water Quality Control Board 2011) established numeric targets for the application of the two targeted organophosphate pesticides, chlorpyrifos and diazinon. The TMDL implementation schedule calls for achieving TMDL numeric targets for chlorpyrifos and diazinon by 2025. Since the establishment of the TMDL and restrictions of these pesticide uses by the California Department of Pesticide Regulation, significant reductions in chlorpyrifos and diazinon application and water column concentrations have been observed according to the 2016 TMDL report card. However, the report also indicates some of these reductions could be offset by a possible switch in types of organophosphate pesticides (e.g., malathion).

### 3.1.10.4 pH

Surface waters in the Salinas River watershed from the confluence with Nacimiento River into the Salinas River Lagoon are impaired for high pH. These surface waters do not meet the Basin Plan (Central Coast Regional Water Quality Control Board 2017a) objectives for pH affecting municipal and domestic supply (MUN), water contact recreation (REC-1), non-contact recreation (REC-2), cold freshwater habitat (COLD), and warm freshwater habitat (WARM) beneficial uses (U.S. Environmental Protection Agency 2018). A pH TMDL is required, but has not yet been started.

### 3.1.10.5 Salinity

Surface waters in the Salinas River watershed from the Spreckels to the Salinas River Lagoon are impaired for salinity as measured by sodium, chloride, and total dissolved solids concentrations. These surface waters do not meet the Basin Plan (Central Coast Regional Water Quality Control Board 2017a) objectives for salinity affecting agricultural supply (AGR) and wildlife habitat (WILD) beneficial uses (U.S. Environmental Protection Agency 2018). Development of a Salinity TMDL is currently underway.

### 3.1.10.6 Sediment Toxicity

Surface waters in the Salinas River watershed from the City of Gonzales into the Salinas River Lagoon are impaired for sediment toxicity to the aquatic invertebrate (*Hyalella azteca*) and for pyrethroid pesticides in sediment. These surface waters do not meet the Basin Plan (Central Coast Regional Water Quality Control Board 2017b) general narrative objectives for toxicity and pesticides affecting aquatic life beneficial uses cold freshwater habitat (COLD) and warm freshwater habitat (WARM). The Sediment Toxicity and Pyrethroid Pesticides in Sediment TMDL, established in 2017, identifies sources of toxicity and describes a plan to achieve water quality objectives that will ultimately restore the designated beneficial uses of surface waters by 2032. Source analysis presented in the TMDL indicates the most likely source of sediment toxicity is pyrethroid pesticides that are commonly used in urban and agricultural areas to control insect pests, and both land uses are sources of pyrethroids in sediments and associated sediment toxicity impairments in the Salinas River watershed (Central Coast Regional Water Quality Control Board 2017b). Implementation actions include requiring operators of municipal separate storm sewer systems to develop a Waste Load Allocation Attainment Plan and enforcement of existing implementation actions enacted by the Central Coast Regional Water Board (i.e., Agricultural Order No. R3-2012-011) and the U.S. Environmental Protection Agency regarding pesticide use and surface water monitoring.

### 3.1.10.7 Turbidity

Surface waters in the Salinas River watershed from the confluence with Nacimiento River into the Salinas River Lagoon are impaired for turbidity. These surface waters do not meet the Basin Plan (Central Coast Regional Water Quality Control Board 2017a) general narrative objectives for turbidity affecting aquatic life beneficial uses cold freshwater habitat (COLD) and warm freshwater habitat (WARM). Development of a Turbidity TMDL is currently underway.

#### 3.1.10.8 Water Temperature

Surface waters in the Salinas River watershed from the confluence with Nacimiento River into the Salinas River Lagoon are impaired for water temperature. These surface waters do not meet the Basin Plan (Central Coast Regional Water Quality Control Board 2017a) objectives for water temperature affecting cold freshwater habitat (COLD) beneficial uses (U.S. Environmental Protection Agency 2018). A water temperature TMDL is required but has not yet been started.

#### 3.1.10.9 Mercury

Mercury is negatively impacting the beneficial uses of many waters of the state by making fish unsafe for human and wildlife consumption. Although mercury occurs naturally in the environment, concentrations exceed background levels because of human activities. Gold and mercury mines and atmospheric deposition are the predominant sources of mercury, with minor contributions from industrial and municipal wastewater discharges and urban run-off. The State and Regional Water Board staff are developing a statewide water quality control program for mercury in reservoirs. The Statewide Mercury Control Program for Reservoirs will address 131 reservoirs identified as mercury-impaired in the state as of January 2018. Nacimiento and San Antonio Reservoirs are being monitored, and development of a Mercury TMDL is currently underway. As of December 2018, both reservoirs are under a fish consumption advisory by the State Office of Environmental Health Hazard Assessment.

## 3.2 Land Use

The study area is in Monterey County and a portion of San Luis Obispo County, and consists of land within the Salinas Valley near the Salinas River (Figure 3-24). There are incorporated cities and unincorporated communities within the study area and near the Salinas River. Incorporated cities within the study area include King City, Greenfield, Soledad, Gonzales, Salinas, and Marina. Unincorporated communities within the study area include San Miguel, Bradley, San Ardo, San Lucas, Chualar, Boronda, Spreckels, Castroville, and Moss Landing. The Salinas River flows through or near the following Monterey County planning areas: South County, Central Salinas Valley, Toro, Greater Salinas, Greater Monterey Peninsula, and North County.

### 3.2.1 Historical Land Use

A historical ecology reconnaissance of the lower Salinas River indicates that prior to human alteration, the historical river was a dynamic and complex system with a broad array of habitat types, including riparian forests around the Salinas River (San Francisco Estuary Institute 2009). Before the Spanish arrived in Monterey County, the Ohlone, Salinan, and Esselen people used the lands in the Salinas Valley for hunting and gathering. The Spanish established a mission in Monterey County in the 1770s and began awarding land grants to ranchers and farmers to use the land for agricultural purposes. Subsequent to the Spanish settlement in Monterey County, agriculture developed with greater intensity in the Mexican period (1822–1848) and after California became a part of the United States (1850) (Monterey County Parks Department 2011).

The land in Monterey County, particularly surrounding the Salinas River, has historically been used for agricultural purposes. Table 3-11 shows the number of farms in Monterey County, as well as the area in Monterey County that was used for farming operations. Table 3-11 and Figure 3-25 show that overall the number of farms has decreased since 1900, while the area farmed has increased; however, it should be noted that total area farmed today is less than what it is was at its peak in the 1950s. Between 1900 and 2012 the area of farms has ranged between 1.1 and 1.6 million acres.

**Table 3-11. History of Agricultural Use in Monterey County**

| | Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1900** | **1910** | **1920** | **1930** | **1940** | **1950** | **1959** | **1969** | **1978** | **1992** | **2002** | **2012** |
| Number of Farms | 1,850 | 1,658 | 1,712 | 1,891 | 1,999 | 1,893 | 1,438 | 1,344 | 1,253 | 1,245 | 1,216 | 1,179 |
| Land Used in Farming (million acres) | 1.1 | 1.1 | 1.1 | 1.3 | 1.3 | 1.6 | 1.6 | 1.5 | 1.4 | 1.4 | 1.3 | 1.3 |

Sources: U.S. Department of Agriculture 1910, 1930, 1940, 1950, 1959, 1969, 1978, 1992, 2012a, 2012b.

The history of urban development in the Salinas Valley is linked to the history of agricultural development and the development of roads, railroads, and other infrastructure that facilitated both agricultural and urban development. Rail (Southern Pacific Railroad) came to Monterey County in 1871. The Southern Pacific rail line reached Salinas in 1871 and Soledad in 1872, and, after 1886, the rail line extended south through King City, San Lucas, San Ardo, and Bradley (Monterey County Parks Department 2011). In Monterey County, the railroad facilitated the expansion of agriculture; fostered land speculation; transported agricultural laborers throughout the region; and helped spur community development, including communities like Aromas, Pajaro, Las Lomas, Castroville, Salinas, Spreckels, Chualar, Gonzales, Soledad, Greenfield, King City, San Lucas, San Ardo and Bradley (Monterey County Parks Department 2011).

In addition to rail, roadways were historically built near the Salinas River. Early during the Spanish occupation of Monterey County, transportation routes were built to follow natural low lands and waterways (Monterey County Parks Department 2011). This is evident today by the multiple bridge locations for vehicles and rail that cross the Salinas River. Many of these bridges are near cities and unincorporated communities, including Castroville, Marina, Blanco, Salinas, Chualar, Gonzalez, Soledad, Greenfield, King City, San Lucas, San Ardo, Bradley, and San Miguel.

Furthermore, the Salinas Valley has also been affected by the implementation of water infrastructure. Ranchers and farmers in the Salinas Valley relied on water from the Salinas River for their agricultural operations. By 1901, farmers had filed 70 water claims for the Salinas River and its tributaries; they also claimed water from the Arroyo Seco, San Lorenzo, and San Antonio Rivers (Monterey County Parks Department 2011). Monterey County farmers have used many canals and dams to deliver water to their crops. For example, the 9-mile Salinas Canal drew water from the Salinas River. Dams held water impounded from smaller streams, and ditches carried the water to the fields. The Salinas Dam was built in 1941 in the upper Salinas Valley to supply the water needs of Camp San Luis Obispo and the city of San Luis Obispo. More dams followed in the 1950s and 1960s (Monterey County Parks Department 2011).

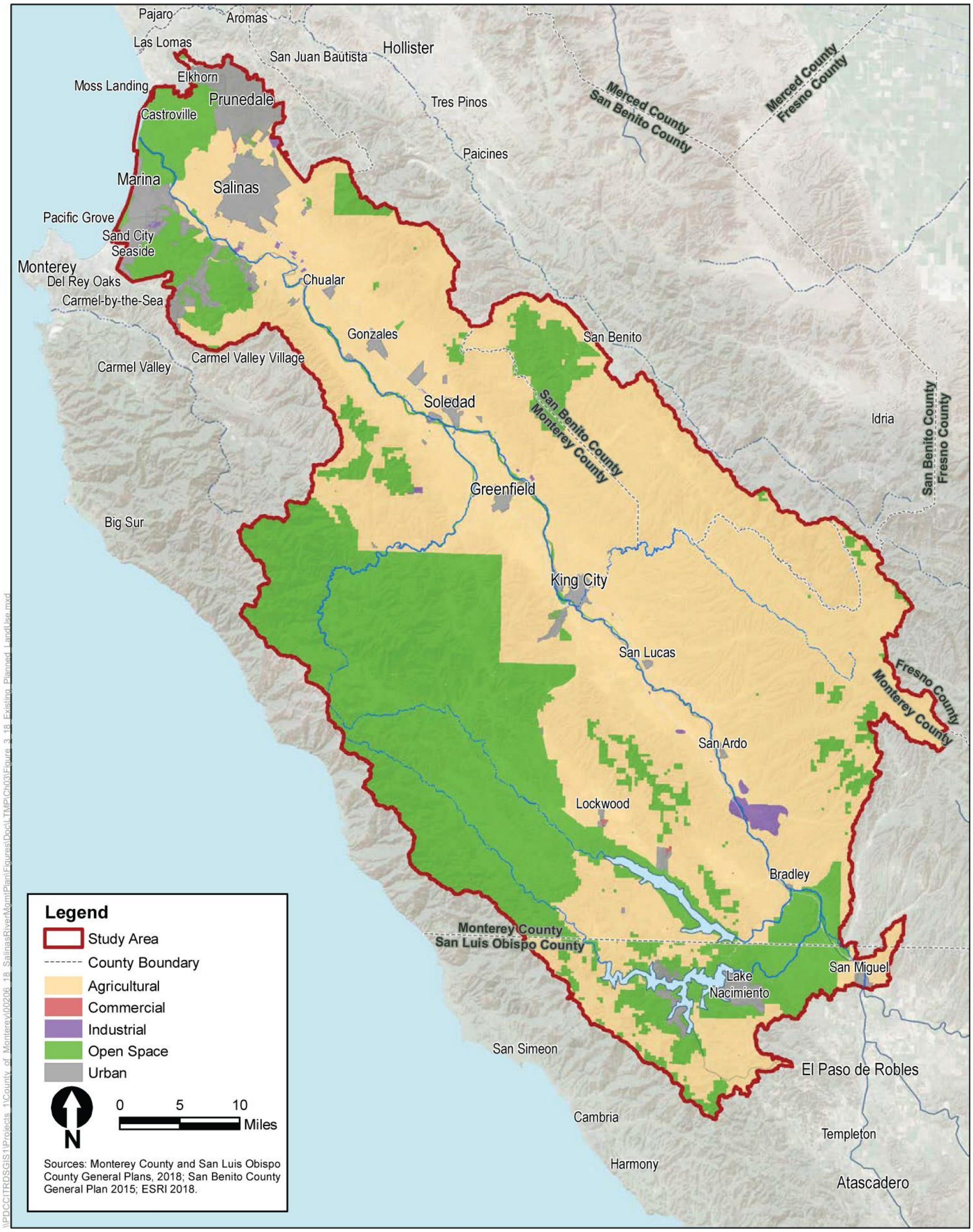
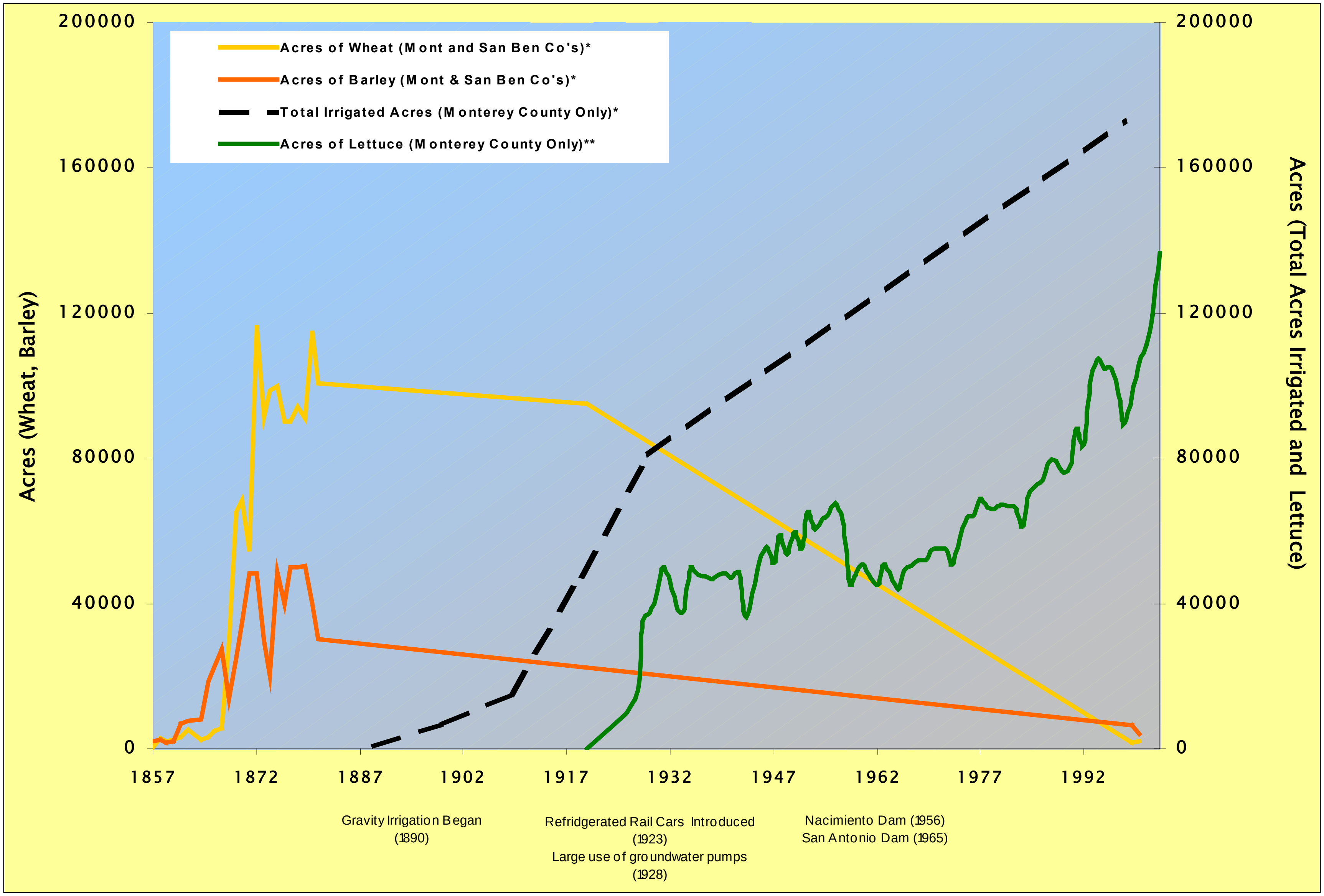



**Figure 3-24. Land Use Designations**




Original data source: *Breschini et al. 2000, **Monterey County Agricultural Commissioner Crop Reports (1929 data).

**Figure 3-25. History of Agricultural Use in Monterey County**

## 3.2.2 Current Land Use Designations and Land Uses

### 3.2.2.1 Introduction

Land use designations indicate both current and potential future land uses as defined by local land use plans. The current land use designations in the study area were identified by reviewing mapping in the general plans for the Counties of Monterey, San Luis Obispo, and Sen Benito (County of Monterey 2018, County of San Luis Obispo 2018, County of San Benito 2015). Agricultural and open space are the primary land use designations in the study area, as shown on Figure 3-24. When the Salinas River approaches cities and unincorporated communities, the land use changes from agricultural to urban uses more typical of cities and communities, including residential, industrial, resource conservation, and public/quasi-public land uses. Figure 3-24 maps these land uses as *urban*. Furthermore, there is one area south of Bradley classified as mineral extraction, which is shown on Figure 3-24 under the industrial land use designation. Table 3-12 summarizes the percentage of land cover that is classified for agricultural, open space, urban, industrial, and commercial uses.

**Table 3-12. Area of Land Use Designations in the Study Area**

| Land Use Designation | Area (acres) | Percent Land Cover |
|---|---:|---:|
| Agricultural | 1,046,954 | 60.6% |
| Open Space | 590,476 | 34.3% |
| Urban | 77,925 | 4.5% |
| Industrial | 7,743 | 0.5% |
| Commercial | 657 | 0.1% |
| **Total** | **1,720,755** | **100%** |

Sources: County of Monterey 2018, County of San Luis Obispo 2018, County of San Benito 2015, GreenInfo Network 2016.
Note: The area does not sum to the total study area due to overlaps and gaps in the available source data.

### 3.2.2.2 Agricultural Land Use

The land use adjacent to the Salinas River is primarily classified as farmlands. The Monterey County General Plan identifies that farmlands are typically 40-acre minimum sites and allow a range of uses to conserve and enhance the use of the important farmlands while also providing opportunity to establish necessary support and ancillary facilities for those agricultural uses (County of Monterey 2018). Permanent grazing land use is located east and west of the farmland land uses. The Monterey County General Plan identifies that permanent grazing lands are typically 40- to 160-acre minimums and allow a range of land uses to conserve and enhance the productive grazing lands in the county (County of Monterey 2018).

> Agriculture consisting of crop farming and livestock grazing is the largest industry in the County and contributes a significant amount of money to Monterey County's economy. Out of approximately 1.3 million acres of County land dedicated to agriculture, most of this area (approximately 80%) is used for grazing. The most productive and lucrative farmlands in the County are located in the North County, Greater Salinas, and Central Salinas Valley Planning Areas. The main type of crop production

in the County consists of cool season vegetables, strawberries, wine grapes and nursery crops. (County of Monterey 2018, Agriculture Element).

Crop types are more difficult to quantify and map because of their dynamic nature and differences in classification schemes between regional and statewide datasets. Based on recent data available from 2017, the extent of each crop type within the LTMP management area in 2014 is shown in Table 3-13. The mix of crops in the Salinas Valley changes annually, but this snapshot in 2014 provides an indication of the dominant crops currently being produced.

**Table 3-13. Area of Crops within the Management Area in 2014**

| Crop Classification | Crop | Area (acres) | Percent Cover |
|---|---|---|---|
| Citrus and Subtropical Fruits | Avocados | 89 | 1.3% |
| | Citrus | 855 | |
| | Miscellaneous Subtropical Fruits | 1,499 | |
| | Olives | 19 | |
| Deciduous Fruits and Nuts | Apples | 4 | 0.2% |
| | Kiwis | 2 | |
| | Miscellaneous Deciduous | 25 | |
| | Walnuts | 321 | |
| Grain and Hay | Miscellaneous Grain and Hay | 229 | 0.1% |
| Idle | Idle | 6,054 | 3.2% |
| Pasture | Alfalfa and Alfalfa Mixtures | 95 | 0.1% |
| | Miscellaneous Grasses | 9 | |
| | Mixed Pasture | 81 | |
| Truck Nursery and Berry Crops | Bush Berries | 1,316 | 72.3% |
| | Carrots | 99 | |
| | Cole Crops | 14,817 | |
| | Flowers, Nursery and Christmas Tree Farms | 151 | |
| | Greenhouse | 549 | |
| | Lettuce/Leafy Greens | 19,013 | |
| | Melons, Squash and Cucumbers | 44 | |
| | Miscellaneous Truck Crops | 91,898 | |
| | Onions and Garlic | 38 | |
| | Peppers | 45 | |
| | Potatoes and Sweet Potatoes | 579 | |
| | Strawberries | 9,818 | |
| Vineyard | Grapes | 43,666 | 22.8% |
| Young Perennial | Young Perennial | 25 | 0.01% |
| | **Total** | **191,341** | **100%** |

Source: Land IQ LLC 2017.

## Important Farmlands

The Farmland Mapping and Monitoring Program (FMMP) was established in 1982 under the California Department of Conservation, Division of Land Resource Protection. FMMP is a non-regulatory program, whose purpose is to assess the location, quality, and quantity of the state's agricultural lands and to identify changes in use on those lands. The program classifies farmland throughout the state based on soil ratings and current land use. The latest FMMP mapping (Figure 3-26) shows that most of the agricultural lands in the Salinas Valley are concentrated around the Salinas River, including agricultural lands classified as prime farmland, farmland of statewide importance, and unique farmland (California Department of Conservation 2014, 2016a, 2016b, 2016c). Furthermore, grazing lands are mapped east and west of the Salinas River (California Department of Conservation 2014, 2016a, 2016b, 2016c). Table 3-14 provides a summary of the agricultural lands mapped in the FMMP within the management area and the study area.

**Table 3-14. FMMP in Study Area and Management Area**

| Land Use Category | Management Area (acres) | Study Area (acres) |
|---|---:|---:|
| Prime Farmland | 152,576 | 157,467 |
| Farmland of Statewide Importance | 37,792 | 42,040 |
| Unique Farmland | 21,803 | 26,854 |
| Farmland of Local Importance | 0 | 3,394 |
| Farmland of Local Potential | 417 | 8,726 |
| Grazing Land | 123,070 | 952,211 |

Sources: California Department of Conservation 2014, 2016a, 2016b, 2016c.

## Williamson Act Lands and Farmland Security Zones

Agricultural lands in California may also be protected under the California Land Conservation Act, commonly called the Williamson Act. Local governments can enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open-space use. Landowners receive substantially reduced property tax assessments in return for enrollment under Williamson Act contracts. Landowners can also enter into Farmland Security Zones, whose contracts are of longer duration than Williamson Act lands. Similar to the FMMP mapping, the latest mapping of Williamson Act lands in Monterey County shows protected areas concentrated around the Salinas River. The Williamson Act lands around the river are primarily classified as Prime Williamson Act lands and Farmland Security Zone lands. Non-Prime Williamson Act lands are mapped east and west of the Salinas River (California Department of Conservation 2016d).

### 3.2.3 Protected Lands

The California Protected Areas Database and the California Conservation Easement Database were reviewed to identify protected lands in the study area (California Protected Areas 2018). A total of 32 different conservation and agricultural easements are located within the management area and study area. Table 3-15 identifies the 12 largest easements located within the management area and/or study area. Table 3-15 also identifies the rivers and creeks that are crossed by these easements. Other easements within the management area and study area are shown on Figure 3-27.

There are 162 different protected areas within the management and study areas, with 207,789 acres of protected lands in the study area and 48,571 acres of protected lands in the management area. This totals approximately 256,360 acres of protected lands, or approximately 15% percent of the study area. Approximately 3% of the management area includes protected lands. These protected areas are a combination of lands that are owned and managed by federal, state, and local agencies and include local neighborhood parks; large regional parks, including state and national parks; golf courses; and reservoirs. Many of the large protected areas are in the mountainous areas surrounding the Salinas River, including the Los Padres National Forest, Pinnacles National Park, and Fort Ord National Monument. Some large protected areas are near the Salinas River and other waterbodies, including Bureau of Land Management land, the Lake San Antonio Recreation Area, Nacimiento County Recreation Area, and Toro Regional Park. Table 3-16 identifies the 12 largest protected areas located within the management area and study area, listed from largest to smallest. Table 3-16 also identifies the rivers and creeks that are crossed by these protected areas. Other protected areas within the management and study area are shown on Figure 3-27.

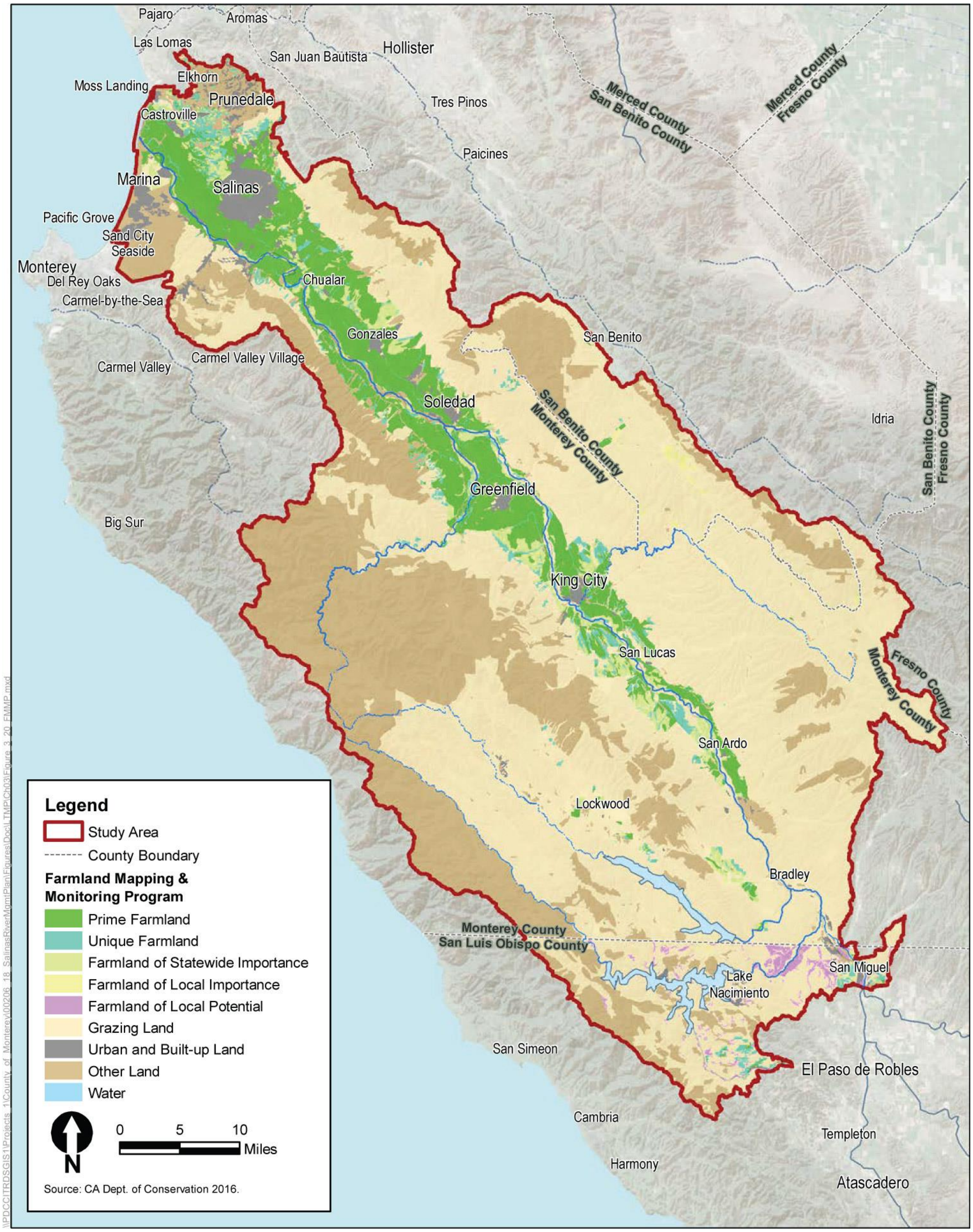



**Figure 3-26. Farmland Mapping and Monitoring Program**

**Table 3-15. Conservation and Agricultural Easements within the Management Area and Study Area**

| No. | Easement | Agency | Easement Type | Area in Management Area (acres) | Area in Study Area Outside Management Area (acres) | Rivers/Creeks that Intersect Easements |
|---|---|---|---|---|---|---|
| 1 | Hearst Ranch Conservation Area | California Rangeland Trust | Agricultural/ Conservation | 17 | 14,923 | Caballada, Gould, Little Burnett, Tobacco, and Waterdog Creeks |
| 2 | Conservation Easement | Land Conservancy of San Luis Obispo County | Agricultural/ Conservation | 1 | 6,784 | N/A |
| 3 | Arroyo Seco Easement | The Nature Conservancy | Conservation | 0 | 2,876 | Arroyo Seco, Sweetwater Creek, Vaqueros Creek |
| 4 | Monterey County Agricultural Land Trust Conservation Easement | Monterey County Agricultural Land Trust | Agricultural | 2,263 | 0 | N/A |
| 5 | Tularcitos Oaks | The Nature Conservancy | Conservation | 0 | 2,805 | N/A |
| 6 | Arroyo Seco River Conservation Easement | California Department of Fish and Wildlife | Conservation | 0 | 1,596 | Arroyo Seco, Horse Creek, Piney Creek |
| 7 | Grasslands Reserve Program (GRP) 83910405013DM | United States Natural Resource Conservation Service | Conservation | 0 | 1,478 | Las Tablas Creek |
| 8 | Phillip S. Berry – Morellini Creek | Rocky Mountain Elk Foundation | Conservation | 0 | 1,442 | Morellini Creek |
| 9 | Johnson Ranch | Monterey County Agricultural Land Trust | Agricultural | 921 | 0 | Salinas River |
| 10 | Monterey County Agricultural Land Trust | Monterey County Agricultural Land Trust | Agricultural | 813 | 0 | Salinas River |
| 11 | Oreggia Conservation Easement | Monterey County Agricultural Land Trust | Agricultural | 617 | 0 | Salinas River |
| 12 | Tan Oak Canyon Ranch | Monterey County Agricultural Land Trust | Agricultural | 544 | 0 | N/A |
| **Total** | | | | **5,176** | **31,904** | |

Source: GreenInfo Network 2017, U.S. Geological Survey 2016.


**Figure 3-27. Protected Lands**

**Table 3-16. Protected Areas within the Management Area and Study Area**

| No. | Protected Area | Agency | Area in Management Area (acres) | Area in Study Area outside of Management Area (acres) | Rivers/ Creeks that Intersect Protected Area |
|---|---|---|---|---|---|
| 1 | Los Padres National Forest | U. S. Forest Service | 0 | 148,650 | Arroyo Seco, Calaboose Creek, Camp Creek, Carrizo Creek, Carrizo Creek, Church Creek, Forest Creek, Higgins Creek, Horse Run, Lost Valley Creek, Nacimiento River, Negro Fork, Negro Fork Nacimiento River, North Fork San Antonio River, Paloma Creek, Pinal Creek, Pinalito Creek, Piney Creek, Rattlesnake Creek, Reliz Creek, Rocky Creek, Roosevelt Creek, Salsipuedes Creek, San Antonio River, Santa Lucia Creek, Shovel Handle Creek, Slickrock Creek, South Fork Santa Lucia Creek, Sweetwater Creek, Tan Oak Creek, Tassajara Creek, Vaqueros Creek, Willow Creek, Zigzag Creek |
| 2 | BLM | U.S. Bureau of Land Management | 56 | 27,448 | Basin Creek, Hames Creek, Hepsedam Creek, Horse Creek, Lewis Creek, Sand Creek, Sargent Creek, Sweetwater Creek, Vaqueros Creek |
| 3 | Pinnacles National Park | U.S. National Park Service | 0 | 26,524 | Chalone Creek, North Fork Chalone Creek, West Fork Chalone Creek |
| 4 | Fort Ord National Monument | U.S. Bureau of Land Management, U.S. Dept. of Defense, County of Monterey, City of Marina | 15,524 | 2 | El Toro Creek, Salinas River |
| 5 | Lake San Antonio Recreation Area | Monterey County Water Resource Agency | 7,426 | 336 | Copperhead Creek, Harris Creek, San Antonio River |
| 6 | Monterey County Recreation Area | County of San Luis Obispo | 6,181 | 378 | Nacimiento River, Town Creek |

| No. | Protected Area | Agency | Area in Management Area (acres) | Area in Study Area outside of Management Area (acres) | Rivers/ Creeks that Intersect Protected Area |
|---|---|---|---|---|---|
| 7 | Toro Regional Park | County of Monterey | 5,526 | 3 | Harper Creek |
| 8 | Lake San Antonio | Monterey County Water Resource Agency | 4,700 | 0 | Copperhead Creek, Harris Creek, San Antonio River |
| 9 | Big Sur Land Trust | Mueller | 0 | 1,712 | Arroyo Seco, Horse Creek, Piney Creek |
| 10 | California State Lands Commission | California State Lands Commission | 0 | 1,126 | Chalone Creek |
| 11 | Fort Ord Dunes State Park | California Department of Parks and Recreation | 1,034 | 0 | N/A |
| 12 | Fort Ord Natural Reserve | University of California | 762 | 0 | N/A |
| **Total** | | | **41,209** | **206,179** | |

Source: GreenInfo Network 2017, U.S. Geological Survey 2016.

# 3.3 Water Budget

A water budget is an accounting of the total groundwater and surface water entering and leaving a groundwater basin, including the changes in the amount of water stored. MCWRA and USGS are currently developing the Salinas Valley Integrated Hydrologic Model that, once completed, will be used to develop a current and detailed accounting of the water budget in the Salinas River basin.

# 3.4 Biological Resources

This section summarizes the biological resources of the LTMP study area and management area, including ecoregions, communities, special-status species, and habitat connectivity.

## 3.4.1 Ecoregions

Ecoregions are areas that exhibit general similarity in their ecosystems and in the composition of their biotic and abiotic phenomena, including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. Ecoregions have been designated in California to help structure and implement management strategies for federal and state agencies and other organizations responsible for resource management. The state of California is home to 13 level III ecoregions and 177 level IV ecoregions (hierarchical levels are indicated by Roman numerals such that levels I and II are broad and may span multiple state boundaries; Griffith et al. 2016). The Salinas Valley encompasses several diverse ecoregions, all of which are included in the Central California Foothills and Coastal Mountains Level III Ecoregion. This ecoregion is defined by its Mediterranean climate (hot dry summers and cool moist winters) and associated vegetation comprised primarily of chaparral and oak woodlands, grasslands in lower elevations, and patches of pine at high elevations. Surrounding the Salinas Valley, the region consists of open low mountains or foothills, with some areas of irregular plains and narrow valleys. Natural vegetation includes coast live oak woodlands, Coulter pine, and unique native stands of Monterey pine. The LTMP study area overlaps with seven ecoregion subregions (level IV) in the Salinas Valley, each of which is described in more detail below and shown on Figure 3-28.

### 3.4.1.1 Monterey Bay Plains and Terraces

The Monterey Bay Plains and Terraces subregion (6w) occurs near the mouth of the Salinas River along the coast and consists of alluvial plains and terraces that wrap around Monterey Bay. The climate is cooler and wetter than adjacent subregions farther upstream in the watershed due to the marine-influenced climate, which receives more precipitation and consistent summer fog. Its geology is shaped by quaternary marine and non-marine deposits, and elevations range from about 0–400 feet above sea level. Extensive sand dunes are present along the coast and support some herbaceous plant communities with coastal scrub and sage common on stabilized dunes in the southeast of Monterey Bay. The surrounding plains are home to species such as coast live oak and California oatgrass. Soil moisture regimes are mostly xeric with some aquic regimes on floodplains. Soluble salts have accumulated in some soils near the ocean. In estuaries, including the Salinas River Lagoon, pickleweed is common.

### 3.4.1.2 Salinas Valley

The Salinas Valley subregion (6af) is inland and farther upstream along the Salinas River from the Monterey Bay Plains and Terraces subregion (6w), and includes gently sloping alluvial plains, stream terraces, and lowland floodplains. Pleistocene and some Plio-Pleistocene non-marine deposits and recent alluvium predominate the geologic strata. Soils are mostly well drained, although some poorly drained soils are present on floodplains. Soil temperature regimes are thermic and soil moisture regimes are xeric, with some aquic soils on floodplains. The climate in the northwestern portion of the ecoregion has more coastal influence, leading to cooler summer temperatures and milder winter temperatures compared to the greater climate extremes in the upper valley to the southeast. Cropland is the dominant land cover in the subregion, with some valley oak and cottonwood-willow riparian forest in undeveloped areas.

### 3.4.1.3 Gabilan Range

The Gabilan Range subregion (6y) consists of steep mountains sandwiched between the San Andreas Fault to the northeast and the Salinas Valley to the southwest. These mountains are made of granitic, metamorphic, and volcanic rocks and are steeper and have more coastal oaks than the sedimentary-dominated Salinas-Cholame hills subregion (6al) to the southeast. Although Mesozoic granitic rocks are found in most of the region, Miocene rhyolite and pyroclastic rocks are exposed in the hills of Pinnacles National Park. Coast live oak is common on north-facing slopes in the northwestern portion of the ecoregion, with more blue oak to the south and east. Some black oak and mixed conifers occur on north-facing slopes at high elevations. Chamise is common on shallow soils.

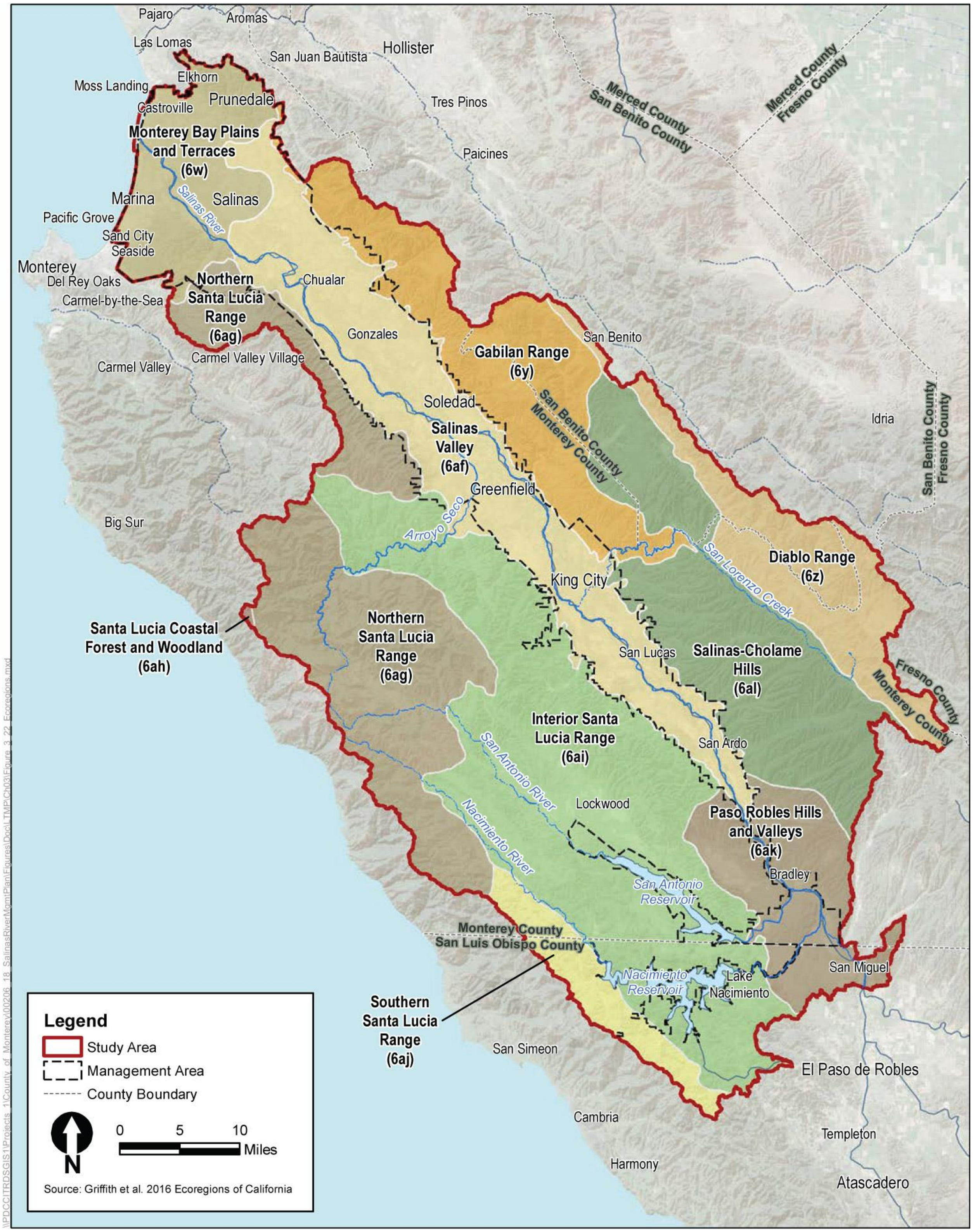



**Figure 3-28. Central California Foothills and Coastal Mountains Level III Ecoregions**

### 3.4.1.4 Diablo Range

The Diablo Range subregion (6z) consists of mountains with rounded ridges and steep sides, as well as narrow canyons and valleys. This ecoregion has different geology and vegetation compared to the Gabilan Range and the Salinas-Cholame Hills to the west. The Diablo Range is dominated by Cretaceous-Jurassic Franciscan sedimentary, minor volcanic, and metamorphic rocks that are intensely folded and faulted. Ultramafic rocks are also widely scattered throughout the region. Elevations range from about 600 feet near San Luis Reservoir up to about 5,000 feet in the mountains, with a peak of 5,248 feet on San Benito Mountain. The natural plant communities include blue oak woodlands and savannas. Leather oak occurs on serpentine soils and mixed chaparral shrublands, and Jeffrey pine occurs on serpentine soils on San Benito Mountain. Some black oak and mixed conifers are on north-facing slopes at high elevations. Soil temperature regimes are mostly thermic, and soil moisture regimes are xeric. All but the larger streams are dry through most of the summer.

### 3.4.1.5 Salinas-Cholame Hills

The Salinas-Cholame Hills subregion (6al) occurs on Pliocene and Miocene marine and nonmarine sediments, as well as Plio-Pleistocene unconsolidated sedimentary materials. This sedimentary geology separates it from the igneous and metamorphic rocks of the Gabilan Range subregion (6y) to the northwest. In addition, the Salinas-Cholame Hills are less steep than the Gabilan Range subregion (6y), and the soils tend to be more calcareous. Vegetation is predominantly grassland and blue oak woodland, with relatively fewer coast live oaks. The soil temperature regime is thermic and soil moisture regime is xeric. Elevations range from about 600 to 2,600 feet above sea level.

### 3.4.1.6 Northern Santa Lucia Range

The Northern Santa Lucia Range subregion (6ag) is located along the northern and western side of the Santa Lucia Range and consists of mountains with rounded ridges, steep sides, and narrow canyons. It is made up predominantly of Mesozoic granitic and pre-Cretaceous metamorphic rocks, as well as some Miocene marine sedimentary rocks. Coast live oak is common, especially on north-facing slopes, and California sagebrush-black sage is common on south-facing slopes near the northwestern end of the Santa Lucia Range and inland. Canyon live oak can be found on steep canyon slopes, and chamise and live oak shrublands are found on shallow soils inland and at higher elevations. Soil temperature regimes are thermic and mesic at high elevations, and soil moisture regimes are xeric and ustic. There are fewer Douglas-fir, tanoak, and redwood compared to more coastal subregions.

### 3.4.1.7 Interior Santa Lucia Range

The Interior Santa Lucia Range and subregion (6ai) is a steep, mountainous part of the Santa Lucia Range that is more inland that other ecoregions of the Santa Lucia, and as a result, has relatively little marine influence on its climate. It stretches southeast from near Greenfield in the Salinas Valley subregion (6af), to near the Sisquoc River, east of the Santa Maria Valley subregion (6aq). Cretaceous sedimentary rocks and Miocene marine sediments (calcareous shales, sandstone, and mudstone) define the geology. Vegetation is predominantly blue oak and coast live oak woodlands, chamise or mixed chaparral shrublands, and annual grasslands.

#### 3.4.1.8 Southern Santa Lucia Range

The Southern Santa Lucia Range subregion (6aj) is located along the southern and western side of the Santa Lucia Range and consists of mountains with rounded ridges, steep sides, and narrow canyons. Along the coast are narrow benches on marine terraces. It is made up predominantly of Mesozoic-age metamorphic rocks of the Franciscan Complex and Miocene sandstone. Elevations range from sea level to 3,408 feet on Pine Mountain. Coast live oak woodlands and chaparral shrublands are the dominant vegetation types. Open patches and lower elevation terraces are often dominated by annual grasslands. Soil temperature regimes are thermic and mesic at high elevations, and soil moisture regimes are xeric.

#### 3.4.1.9 Paso Robles Hills and Valleys

The Paso Robles Hills and Valleys subregion (6ak) is a dissected plain with low, rolling to moderately steep hills. It is lower, drier, and has less relief than the adjacent Interior Santa Lucia (6ai) and Salinas-Cholame Hills (6al) subregions. The geology is predominantly Plio-Pleistocene nonmarine sediments, with areas of Quaternary alluvium on the flatter plains. Some small areas of Miocene and Pliocene marine sediments occur. The soil temperature regime is thermic and soil moisture regime is xeric. Common vegetation includes blue oak savannas and annual grasslands, with some valley oak occurring on deep soils and a few small areas of chamise chaparral on shallow or dry soils. Ranching and livestock grazing is a dominant land use, with some pasture, hay, and cropland in the valleys.

### 3.4.2 Communities

The LTMP uses the terms *community* and *land cover type* to classify and describe the biological setting of the study area. The term *community* means land cover types that are grouped together because of similarity in vegetation type, vegetation structure, ecological function, and current land use. The LTMP recognizes three types of communities: natural communities, semi-natural communities, and non-natural communities. Communities are composed of land cover types. Natural communities are an assemblage of species (plant and animal) that co-occur in the same habitat or area and interact through trophic and spatial relationships. Communities are typically characterized by reference to one or more dominant species (Lincoln et al. 1998). The wide range of climatic, topographic, and soil conditions in the study area contribute to the variety and uniqueness of the natural communities present. Ten broad categories of natural communities in the study area are coastal strand and dune, grasslands, shrublands, forests and woodlands, riparian, wetlands, riverine, marine, estuarine, and aquatic (ponds, lakes). Three other semi-natural or human-made habitats described herein are agriculture, barren, and developed. Following are descriptions of the components of these communities. The approximate location and extent of each community is depicted on Figure 3-29.


**Figure 3-29. Natural, Semi-Natural, and Developed Communities**

Natural community and land cover types were mapped for the study area using six GIS datasets.

- Salinas River Generalized Land Use/Land Cover Mapping (The Nature Conservancy et al. 2014).
- Salinas River Vegetation (The Nature Conservancy 2008).
- Salinas River Arundo–mapping of extent along river corridor[9] (California Invasive Plant Council 2011).
- CALVEG (U.S. Forest Service 2017).
- Fire Resource and Assessment Program (FRAP) Vegetation (Cal Fire 2015).
- National Wetlands Inventory (U.S. Fish and Wildlife Service 2018a).

The majority of the study area was mapped using a combination of CALVEG and FRAP vegetation data; where CALVEG data were not available, FRAP data were used. Because of the better resolution and more recent data, the Salinas River corridor was mapped using vegetation mapping conducted by The Nature Conservancy in 2008 and 2014, supplemented by more recent detailed mapping of patches of invasive Arundo. Besides the two Nature Conservancy data sets, detailed wetland mapping was used from the National Wetlands Inventory. Appendix D, *Community and Land Cover Mapping Methods,* provides more detail about these land cover types, including the photography type and resolution, as well as the rationale for choosing the final land cover datasets. This appendix also describes the specific decision rules used to combine these data sets into a single composite vegetation layer for this project, when GIS data sets overlapped.

Terrestrial and wetland vegetated mapping types for each dataset were compared in a crosswalk to the National Vegetation Classification System (NVCS) macrogroups consistent with the State Wildlife Action Plan (California Department of Fish and Wildlife 2015). Agricultural mapping types were compared in a crosswalk to naming convention at the NVCS cultural formation level. Aquatic types were compared to the National Wetlands Inventory naming convention at “system” level. In addition, a number of unique naming conventions were created for a number of developed land cover types. The methods and assumptions employed to perform the crosswalk are further described in Appendix D. Table 3-17 presents the amounts of natural communities and land cover types in the management and study areas.

[9] The Monterey Resource Conservation District also maintains datasets of Arundo stands that have been treated or mowed (2017 data). These data were not incorporated into the land cover layer for the LTMP.

**Table 3-17. Extent of Communities[a] and NVCS Land Cover Types in the Management and Study Areas**

| Salinas River Communities and Land Cover Type | Amount in Management Area (acres) | Amount in Study Area (acres)[a] |
|---|---|---|
| **Coastal Strand and Dune Communities** | **2,285** | **2,311** |
| Pacific coastal beach and dune | 1,638 | 1,664 |
| North Pacific coastal ruderal grassland and shrubland | 647 | 647 |
| **Grasslands** | **81,975** | **545,962** |
| California annual and perennial grassland | 81,975 | 545,962 |
| **Shrublands** | **30,334** | **495,133** |
| Californian chaparral | 23,089 | 417,521 |
| Californian coastal scrub | 5,341 | 74,391 |
| Cool interior chaparral | 0 | 2 |
| Warm and cool desert alkaline-saline marsh, playa and shrubland | 154 | 777 |
| Western North American ruderal grassland and shrubland | 1,750 | 2,442 |
| **Forests and Woodlands** | **44,816** | **375,160** |
| Californian forest and woodland | 43,485 | 371,671 |
| Californian ruderal forest | 1,310 | 1,349 |
| Intermountain singleleaf pinyon – juniper woodland | 0 | 185 |
| Southern Vancouverian montane-foothill forest | 21 | 1,955 |
| **Riparian** | **5,639** | **9,180** |
| Interior warm and cool desert riparian forest | 3,870 | 4,852 |
| Interior west ruderal flooded swamp forest and woodland | 0 | 35 |
| North American warm-desert xeric-riparian scrub | 7 | 97 |
| Vancouverian flooded and swamp forest | 307 | 2,741 |
| *Arundo donax* | 1,455 | 1,455 |
| **Wetlands** | **11,783** | **12,674** |
| North American Pacific coastal salt marsh | 917 | 931 |
| Vancouverian lowland marsh, wet meadow and shrubland | 33 | 47 |
| Warm desert lowland freshwater marsh, wet meadow and shrubland | 9,596 | 10,219 |
| Western North American montane-subalpine-boreal marsh, wet meadow and shrubland | 1,237 | 1,477 |
| **Riverine** | **2,522** | **3,097** |
| Riverine | 2,522 | 3,097 |
| **Marine** | **127** | **933** |
| Marine | 127 | 933 |
| **Estuarine** | **141** | **147** |
| Estuarine | 141 | 147 |
| **Aquatic (Ponds, Lakes, Reservoirs)** | **10,362** | **10,881** |
| Artificial lake or pond | 1,932 | 2,013 |
| Lacustrine | 8,006 | 8,359 |
| Water feature | 424 | 509 |

| Salinas River Communities and Land Cover Type | Amount in Management Area (acres) | Amount in Study Area (acres)[a] |
|---|---|---|
| **Agriculture[b]** | **210,949** | **230,708** |
| Dairy and other bovine confined feeding operations | 171 | 171 |
| Fallow field and weed vegetation | 157,888 | 158,316 |
| Forest plantation and agroforestry | 14 | 14 |
| Pasture and hay field crop | 1,165 | 1,887 |
| Row and close grain crop | 4,427 | 11,793 |
| Woody horticultural crop | 47,284 | 58,527 |
| **Barren[b]** | **5,498** | **8,661** |
| Barren | 5,496 | 8,635 |
| Western North American cliff, scree and rock vegetation | 2 | 26 |
| **Developed[c]** | **40,040** | **43,700** |
| Urban/developed | 40,040 | 43,700 |
| **Total** | **446,471** | **1,738,547** |

[a] Inclusive of the LTMP management area.

[b] Agriculture and Barren are considered semi-natural communities.

[c] Developed is considered a non-natural community.

### 3.4.2.1 Coastal Strand and Dune Communities

Coastal strand and dune scrub habitats of the coastal dunes are dynamic plant communities that respond to a moving sand substrate, wind and wave patterns, and changing dune and beach configurations. Blowing sand undermines and buries plants, but most dune plants are adapted to shallow burial and blasting by sand. Large areas of destabilized sand, called "blowouts," result in large-scale removal of vegetation and change in dune structure. As plants reinvade the bare sand they stabilize the dune. Dune structure creates a variety of habitats. The foredune is more exposed to wind and salt spray than the rear dune. Dune crests are subject to high winds and substrate removal, while interdune valleys are protected from wind, have higher soil moisture, and experience sand deposition. North-facing dune slopes are usually moister and cooler than south-facing dune slopes. Native plants likely to be found in healthy coastal strand and foredune habitats on Monterey Bay include coastal sand verbena (*Abronia latifolia*), pink sand verbena (*Abronia umbellata* var. *umbellata*), beach sagewort (*Artemisia pycnocephala*), beach bur (*Ambrosia chamissonis*), beach evening primrose (*Camissonia cheiranthifolia* ssp. *cheiranthifolia*), beach morning-glory (*Calystegia soldanella*), live-forever (*Dudleya* ssp.), woolly paintbrush (*Castilleja lanata*), coastal paintbrush (*Castilleja affinis*), Douglas' bluegrass (*Poa douglasii*), mock heather (*Ericameria ericoides*), sea thrift (*Armeria maritima* ssp. *californica*), coast buckwheat (*Eriogonum latifolium*), seacliff buckwheat (*Eriogonum parvifolium*) and cudweed aster (*Corethrogyne filaginifolia*).

There are an estimated 2,311 acres (<1%) of coastal strand and dune communities, all in the northwestern portion of the study area, north and south of the Salinas River Lagoon. Of this total, approximately 99% (2,285 acres) occurs within the management area (Table 3-17, Figure 3-29). Historically, this coastal community likely occurred farther inland to the north and south of the current river mouth location. Due to several accounts of frequent changes in the river mouth configuration, dune communities were noted in these exposed coastal areas (San Francisco Estuary Institute 2009).

The majority of this habitat today occurs on protected lands such as Salinas River State Beach, Salinas River National Wildlife Refuge, Marina State Beach, and Fort Ord Dunes State Park. Much of the habitat is composed of beaches, bluffs, blowouts, and disturbed dunes that are generally devoid of vegetation because of frequently moving substrates. The vegetation that does establish in these areas consists of species tolerant of frequent ground disturbance such as sea rocket (*Cakile maritima; C. edentula*), beach primrose (*Camissonia cheiranthifolia* ssp. *cheiranthifolia*), soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus diandrus*), annual fescue (*Festuca* ssp.) and kikuyu grass (*Pennisetum clandestinum*). Some areas support a stabilized dune community dominated by the nonnative, aggressive ice plant, which forms extensive mats. While it provides cover for some wildlife, it crowds out native plant species and provides very little forage material for wildlife.

Common wading birds, such as sanderlings (*Calidris alba*), plovers (*Charadrius* ssp.), and godwits (*Limosa* ssp.), occur along the beaches; California ground squirrels (*Spermophilus beecheyi*), deer mice (*Peromyscus maniculatus*), gray fox (*Urocyon cinereoargenteus*), red-tailed hawk (*Buteo jamaicensis*), red-shouldered hawk (*Buteo lineatus*), American kestrel (*Falco sparverius*), loggerhead shrike (*Lanius ludovicianus*) and red foxes (*Vulpes vulpes*) occur in the disturbed dune habitats. Healthy coastal strand and dune scrub communities in the study area contain native perennial herbs, shrubs and subshrubs including wild buckwheat, seaside painted cup (*Castilleja latifolia*), Douglas' bluegrass, bush lupine (*Lupinus albifrons*), Chamisso bush lupine (*Lupinus chamissonis*), mock heather, poison oak (*Toxicodendron diversilobum*), coyote bush (*Baccharis pilularis*), bracken fern (*Pteridium aquilinum*), and deer weed (*Acmispon glaber*). Wildlife diversity increases in the central dune scrub relative to other dune communities because soils are more stable and vegetation is more abundant.

Special-status species most strongly associated with coastal strand and dune scrub in the study area are Smith's blue butterfly (*Euphilotes enoptes smithi*), western snowy plover (*Charadrius nivosus* ssp. *nivosus*), black legless lizard (*Anniella pulchra nigra*), sand gilia (*Gilia tenuiflora* ssp. *arenaria*), Monterey spineflower (*Chorizanthe pungens* var. *pungens*), seaside bird's beak (*Cordylanthus rigidus* var. *littoralis*), and coast wallflower (*Erysimum ammophilum*).

## 3.4.2.2 Grasslands

Approximately 545,962 acres (31%) of the study area is dominated by grasslands (Table 3-17, Figure 3-29). The majority of these areas support grassland comprised of non-native annual grasses, although there are some areas in the western section of the study area supporting a good component of native perennial bunchgrasses. Annual grasslands in the study area are dominated by mostly non-native annual grasses such as foxtail chess (*Bromus madritensis*), Harding grass (*Phalaris aquatica*), hare barley (*Hordeum murinum* ssp. *leporinum*), nit grass (*Gastridium phleoides*), oats (*Avena barbata* and *A. fatua*), rattail sixweeks grass (*Festuca myuros*), ripgut grass, rye grass (*Festuca perennis*), silver hair grass (*Aira caryophyllea*), small fescus (*Festuca microstachys*), soft chess, barbed goat grass (*Aegilops triuncialis*) and water beard grass (*Polypogon viridis*). The associated herbaceous cover includes native and nonnative forbs. Common herbaceous species in the study area include black mustard (*Brassica nigra*), California poppy (*Eschscholzia californica*), clover species (*Trifolium* spp.), common fiddleneck (*Amsinckia menziesii*), common yarrow (*Achillea millefolium*), filaree species (*Erodium* spp.), four-spot (*Clarkia purpurea* ssp. *quadrivulnera*), Ithuriel's spear (*Triteleia laxa*), knapweed species (*Centaurea* spp.), lupine species (*Lupinus* spp.), purple owl's-clover (*Castilleja exserta*), and soap plant (*Chlorogalum pomeridianum*). Of this total, approximately 15% (81,975 acres) occurs in the management area (Figure 3-29).

Perennial grasslands are of two types in the study area: valley needlegrass (*Stipa pulchra*) and blue wildrye (*Elymus glaucus*). Perennial grasslands support native perennial grass species as dominant or important components of the vegetative cover and intergrade with annual grassland, oak savanna, and oak woodland on hills along the western portion of the study area. Small occurrences of perennial grassland are also in grassland areas characterized by mima mound topography associated with wetland areas in the central lands of the Fort Ord National Monument.

Historically, much of the valley above the active river channel was characterized by grasslands. Prior to European settlement, perennial grasslands dominated the upper terraces of the river valley as well as openings in shrublands, woodlands, and forests in the study area (San Francisco Estuary Institute 2009). Today, much of this habitat has been converted to agricultural fields or overran by nonnative annual grasses. The remnant patches of perennial grasslands dominated by valley needlegrass and blue wildrye in the study area are considered sensitive by the California Department of Fish and Wildlife (CDFW) (California Department of Fish and Wildlife 2018a).

Grasslands provide nesting and foraging habitat and movement areas for a variety of wildlife species including reptiles, amphibians, small and large mammals, and raptors. Common wildlife species include California ground squirrel, Heerman's kangaroo rat (*Dipodomys heermanni*), narrow-faced kangaroo rat (*Dipodomys venustus*), western meadowlark (*Sturnella neglecta*), and American kestrel. In addition, grasslands provide one of the primary upland habitats for special-status species like the California tiger salamander (*Ambystoma californiense*) and the California red-legged frog (*Rana draytonii*). Grasslands also protect the soil from erosion and provide the primary source of forage for grazing domestic livestock.

### 3.4.2.3 Shrublands

The shrublands natural community is composed of chaparral and scrub land cover types. Chaparral occurs on rocky, porous, nutrient-deficient soils on steep slopes up to 6,562 feet in elevation (Keeley 2002). Chaparral communities are dominated by densely packed and nearly impenetrable drought-adapted evergreen woody shrubs with small, thick, leathery sclerophyllous (hard-leaved) leaves (Hanes 1988, Keeley 2002). In comparison, the scrubland cover types generally consist of low "soft" shrubs in open to dense shrublands, interspersed with grassy openings or little to no herbaceous layer usually found at elevations below approximately 1,640 feet (Holland and Keil 1995).

Chaparral habitats include a variety of shrubs with thick, stiff, sclerophyll leaves where no one species is clearly dominant. At maturity, this community can be dense and nearly impenetrable. Stand structure is dependent on age since last burn, precipitation, aspect, and soil type. Dominant species include chamise (*Adenostoma fasciculatum*), birchleaf mountain mahongany (*Cercocarpus betuloides*), silktassle (*Garrya* spp.), coyote bush, hollyleaf cherry (*Prunus ilicifolia*) and several species of ceanothus (*Ceanothus cuneatus C. leucodermis,*), manzanita (*Arctocstaphylos glandulosa, A. glauca*), redberry (*Rhamnus ilicifolia*, *R. crocea*) and oak (*Quercus chrysolepis, Q. dumosa, Q. berberidifolia, Q. wizlizenii*) (U.S. National Vegetation Classification System 2017, Mayer and Laudenslayer 1988, Holland 1986). Chamise chaparral supports pure or nearly pure stands of chamise. Due to the density of the vegetation, there is usually little or no understory. This community generally occurs below 3,000 feet elevation along the Sierra de Salinas, Santa Lucia, and the Gabilan Ranges accounting for 95% (417,521 acres) of the study area. Of this total, approximately 7% (30,334 acres) is located in the management area (Table 3-17, Figure 3-29).

Maritime chaparral is another coastal form of chaparral associated with specific soil conditions. Two forms are recognized in the northwestern portion of the study area based on the substrate that supports them: sand hill maritime chaparral occurs on relict dunes of the late Pleistocene Epoch, and Aromas formation maritime chaparral occurs on weakly consolidated red sandstone that is a relic of mid-Pleistocene dunes located along the Central Coast Ranges. The occurrence of maritime chaparral may be limited to the summer fog zone. It is characterized by a wide variety of evergreen, sclerophyllus shrubs occurring in moderate to high density on sandy, well-drained substrates. This community is primarily dominated by woollyleaf manzanita (*Arctostaphylos tomentosa* subsp. *tomentosa*). Other species found in the shrub layer include chamise, Toro manzanita (*Arctostaphylos montereyensis*), sandmat manzanita (*Arctostaphylos pumila*), toyon (*Heteromeles arbutifolia*), blue blossom ceanothus (*Ceanothus thyrsiflorus*), and Monterey ceanothus (*Ceanothus rigidus*).

Coastal scrublands are typically dominated by California sagebrush (*Artemisia californica*) and black sage (*Salvia mellifera*), with associated species including coyote brush, California buckwheat (*Eriogonum fasciculatum*), poison oak, and sticky monkeyflower (*Mimulus aurantiacus*) (Holland 1986). The dominant woody plants in this land cover type are nearly the same among different soil types. Northern coastal scrub occupies approximately 74,391 acres (17%) of the study area and is located in small, scattered patches dispersed throughout the mixed chaparral land cover types in the coastal and interior ranges on sandy or shallow soils.

The greatest diversity of wildlife species in the study area occur in the chaparral. Birds such as orange-crowned warbler (*Vermivora celata*), spotted towhee (*Pipilo maculatus*), and California quail (*Callipepla californica*) nest in the chaparral. Small mammals such as the California mouse (*Peromyscus californicus*) and brush rabbit (*Sylvilagus bachmani*) forage in this habitat and serve as prey for gray fox, bobcat (*Lynx rufus*), spotted skunk (*Spilogale gracilis*), and western rattlesnake (*Crotalus viridus helleri*). In addition, special-status species like the California tiger salamander, California red-legged frog, and San Joaquin kit fox (*Vulpes macrotis mutica*) may use shrubland areas for movement and upland habitat, especially in relative proximity to breeding habitats.

#### 3.4.2.4 Forests and Woodlands

The forest and woodland natural community is an upland vegetation community dominated by hardwood tree species. This broad community consists of savannas, woodlands, and forests dominated by warm-temperate and Mediterranean climate–endemic oak and conifer species within California below approximately 8,200 feet in elevation. In the region, this community includes characteristic taxa such as various oak species (*Quercus* spp.), various pines (*Pinus* spp.), California bay (*Umbellularia californica)*, and tanoak (*Lithocarpus densiflorus)* (U.S. National Vegetation Classification 2018). Understory species found in this community include sticky monkeyflower, California coffeeberry (*Frangula californica*), California sagebrush, and spiny redberry (*Rhamnus crocea*) (Allen-Diaz et al. 1999). In addition, bugle hedge nettle (*Stachys ajugoides*), California blackberry (*Rubus ursinus*), California wood fern (*Dryopteris arguta*), and poison oak are often present. Across the Central Coast Ranges, stands of this community occur at lower elevations (200 to 3,250 feet) on north and northeast aspects. Slopes are generally steep, and parent material is primarily sedimentary sandstone and shale, with loam soils. Forest and woodlands account for 84% (375,160 acres) of the study area. Of this total, approximately 12% (44,816 acres) occurs in the management area (Table 3-17, Figure 3-29).

Throughout the study area, oak woodlands and forests are characterized by either coast live oak (*Quercus agrifolia*), blue oak (*Q. douglasii*), black oak (*Q. kelloggii*), or valley oak (*Q. lobata*) from the eastern slopes of the Santa Lucia Mountains to the Gabilan Range. In the management area, coast live oak is the dominant oak type found from King City downstream to Salinas (Monterey County Water Resources Agency 2014). Black oak is also present along the upland transition zones between the riparian corridor and inland areas. Valley and blue oaks are present in the driest areas of the four oak woodlands observed, often lining seasonal drainages on north- and west-facing slopes in inland portions of the study area. In most oak-dominated areas, an understory of California blackberry, poison oak, and invasive annual grasses are common (Monterey County Water Resources Agency 2014). Blue oak woodland is considered a sensitive natural community by the CDFW (2018) when blue oak and valley oak are present.

The study area also includes low- to mid-montane elevation forests dominated by conifer trees, either with one dominant species or as mixed-conifer forests. Montane hardwood forests occur on a wide range of slopes with soils that are rocky, alluvial, coarse textured, poorly developed, and well drained. Characteristic species in the region include Coulter pine (*Pinus coulteri*), gray pine (*P. sabiniana*), Ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and coast redwood (*Sequoia sempervirens*) (U.S. National Vegetation Classification 2018). The scattered understory vegetation can consist of manzanita (*Arctostaphylos* spp.), mountain mahogany (*Cercocarpus betuloides*), and poison oak, as well as patches of forbs and grasses.

The western portion of the study area, north of Nacimiento and San Antonio, consists of dense mixed coniferous forest found along the western slopes of the Santa Lucia Range. Conifers that characterize this forest type include Ponderosa pine, Douglas fir, coast redwood, Coulter pine, gray pine, and a local endemic, Santa Lucia fir (*Abies bracteata*). Other associates include coast live oak, tanoak, white alder (*Alnus rhombifolia*), California bay, Pacific madrone (*Arbutus menziesii*), black oak, and knobcone pine (*Pinus attenuata*). In the management area, a native stand of Monterey pine (*Pinus radiata*) is known to occur near Salinas (Monterey County Water Resources Agency 2014).

Ruderal forests are also present near coastal cities and inland valley towns of the study area. Ruderal forests are those areas where ruderal and other introduced species of trees, including *Eucalyptus* species, have been planted or naturalized and dominate, forming a dense forest-like canopy. Ruderal forest can be an important feature of this community as some stands could provide suitable nesting habitat for raptors in the region.

The forest and woodland community is considered an important natural community because it provides a variety of ecological, aesthetic, and economic values. Forests and woodlands support a variety of plant and wildlife species, including multiple special-status species. They provide nesting sites, cover, forage, habitat connectivity, and other ecological values important to regional wildlife. Common wildlife species in coast live oak woodlands include black-tailed deer (*Odocoileus hemionus columbianus*), California mouse, raccoon (*Procyon lotor*), California quail, scrub jay (*Aphelocoma californica*), and Nuttall's woodpecker (*Picoides nuttallii*). Red-tailed hawks and great-horned owls (*Bubo virginianus*) nest and roost in this community as well. Some special-status species associated with forests and woodlands in the study area include California tiger salamander, California red-legged frog, and arroyo toad.

### 3.4.2.5 Riparian

The riparian natural community consists of a multilayered woody plant community dominated by a hydrophytic tree overstory and diverse shrub layer associated with riverine water sources. In mature riparian forests, canopy heights reach up to 100 feet and canopy cover ranges from 20 to 80%. The riparian habitats of the Central Coast are found in and along the margins of the active channel of intermittent and perennial streams including the Salinas River. Many vegetation alliances dominated by riparian species are considered sensitive by CDFW (2018a).

Generally, no single species dominates the canopy, and composition varies with elevation, aspect, hydrology, and channel type. Canopy species include Fremont cottonwood (*Populus fremontii* ssp. *fremontii*), arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), box elder (*Acer negundo*), white alder, and coast live oak (U.S. National Vegetation Classification 2018). Associated trees and shrubs include western sycamore (*Platanus racemosa*), northern California black walnut (*Juglans hindsii*), California bay, bigleaf maple (*Acer macrophyllum*), and Goodding's black willow (*Salix gooddingii*). California grape (*Vitis californica*) creates a dense network of vines in the canopy. In areas that are disturbed by frequent flooding, fire, or human activity, this natural community often consists of smaller trees, more shrubs, and more invasive nonnative species such as giant reed (*Arundo donax*), salt cedar (*Tamarix ramosissima*), and Himalayan blackberry (*Rubus armeniacus*). The understory is disturbed by winter flows, and herbaceous vegetation is typically sparse or patchy. Typically, plants such as mule fat (*Baccharis salicifolia*), California buckeye (*Aesculus californica*), poison oak, California mugwort (*Artemisia douglasiana*), California blackberry, common chickweed (*Stellaria media*), coyote brush, goose grass (*Galium aparine*), and Italian thistle (*Carduus pycnocephalus* ssp. *pycnocephalus*) populate the stream banks (Monterey County Water Resources Agency 2014). The riparian natural community accounts for 2% (9,180 acres) of the study area. Of this total, 61% (5,639 acres) occurs in the management area (Table 3-17, Figure 3-29).

Historically, riparian communities were vast and dense throughout the valley floor often immediately adjacent to the river extending over 0.5 mile on one or both sides of the main channel (e.g., referred to as "bottomlands" by early explorers). Willows dominated the tree canopy; however, several species of cottonwoods (e.g., Fremont and black) were also reported by many of the early explorers in the region. A diverse list of trees was noted in scattered patches such as sycamore, maple, and buckeye, while native shrubs (e.g., California rose, gooseberry, and poison oak) and grasses (described as tufts of grass 6 to 8 inches tall creating a dense mat over the valley floor in some areas) characterized the understory of these forests (San Francisco Estuary Institute 2009). Aerial photography dating back to 1937 shows a channel of varying widths, from 100 to 2,600 feet wide with little riparian vegetation growing on large bars and the channel bottom (San Francisco Estuary Institute 2009). This shift was likely caused by major flood events that scoured the bars and channel bottom, removing vegetation and transporting sediments downstream (San Francisco Estuary Institute 2009).

Since operation of the Nacimiento Dam beginning in 1957 and the San Antonio Dam in 1967, reduced flood peaks along with summer flow releases have allowed for both native and nonnative vegetation growth to expand onto the bars and channel bottom. Growth has further increased since the reoperation of the Dams in April 2010, the intention of which was to provide sufficient flows to the SRDF at RM 5 to meet agricultural demands and fish bypass flow requirements during the dry season. With more water present year-round, riparian vegetation persists throughout the valley and downstream to the lagoon.

As mapped currently, the riparian natural community is composed of four vegetation types (Table 3-17), reflecting the diversity of riparian conditions. These types represent recognizably different abundances of the main constituent tree and shrub species (i.e., willow, cottonwood, sycamore, and alder) and several shrub types, including those dominated by the highly invasive nonnative giant reed and salt cedar. The riparian community occurs most extensively along the Salinas River floodplain as well as its tributaries including its many tributaries such as San Antonio River, Nacimiento River, Sargent Creek, Chalone Creek, Arroyo Seco, San Lorenzo Creek, and El Toro Creek.

A mix of willow-dominated riparian scrub also occurs in the management area and is characterized by various species of native willows (*Salix* sp.), primarily sandbar willow (*Salix exigua*) and arroyo willow. Scattered deciduous trees, such as Fremont cottonwood, white alder, box elder, and oaks are also present. The mixed willow riparian forests are commonly observed along sandbars, mid-channel islands, and upland areas with sandy soils that receive some seasonal flooding. Poison oak and California sagebrush (*Artemisia californica*) formed a dense understory in upland areas where this community was present. Bush lupines, especially Chamisso bush lupine, were observed in some sandy areas in the downstream reaches of the management area. Giant reed is also common in riparian scrub throughout the management area (Monterey County Water Resources Agency 2014). The giant reed and salt cedar currently found along the Salinas River are extensive, and efforts are under way to eliminate these nonnative invasive species throughout the watershed (Monterey County Water Resources Agency 2014).

Riparian forests also occur in the upper elevations of the Santa Lucia and Gabilan Ranges in the study area along major stream courses (i.e., Arroyo Seco, Nacimiento River, San Lorenzo Creek) and include broadleaf dominant species such as California sycamore, big-leaf maple, red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), shining willow (*Salix lucida* ssp. *lasiandra*), and/or Oregon ash (*Fraxinus latifolia*) (U.S. National Vegetation Classification 2018).

Riparian communities are important wildlife habitat because they typically support the highest diversity of wildlife and provide movement corridors between different communities. Riparian habitat provides important forage, cover, and water to resident black-tailed deer, and serves as travel corridors for predators such as mountain lions (*Puma concolor*) and coyotes (*Canis latrans*). Other wildlife species associated with this community include Pacific tree frog (*Pseudacris regilla*), California slender salamander (*Batrachoseps attenuatus*), Wilson's warbler (*Wilsonia pusilla*), dark-eyed junco (*Junco hyemalis*), striped skunk (*Mephitis mephitis*), and coyote. Special-status species that utilize this community include the South-Central California Coast steelhead (*Oncorhynchus mykiss*), arroyo toad (*Anaxyrus californicus*), California red-legged frog, least bell's vireo (*Vireo bellii pusilus*), bank swallow (*Riparia ripiaria*), Abbott's bush-mallow (*Malacothamnus abbottii*), and Davidson's bush-mallow (*Malacothamnus davidsonii*). Species known to occur in the Salinas River riparian zone include gray fox, coyote, American badger (*Taxidea taxus*), coast horned lizard (*Phrynosoma coronatum*), western pond turtle (*Actinemys marmorata*), Monterey dusky-footed woodrat (*Neotoma fuscipes luciana*), bobcat, mountain lion, and numerous avian species, including some species of special concern.

## Arundo donax

*Arundo donax* (giant reed; referred to herein as Arundo) is known as one of the worst plant invaders of California's riparian and wetland communities. It is a fast-growing, tall grass species that spreads easily, consumes large amounts of water, forms dense monotypic stands, crowds out native vegetation, degrades wildlife habitat, increases fire frequencies, and causes flooding into adjacent upland areas during high flow events. As of 2011, approximately 8,907 acres of Arundo were mapped in coastal California watersheds from Monterey to San Diego (California Invasive Plant Council 2011). Of this total, the Salinas River supported 2,006 acres (23% of known Arundo stands mapped in all of coastal California) in 2011. After extensive and continuing eradication efforts by the Resource Conservation District of Monterey County (RCDMC) and the implementation of MCWRA's Salinas River SMP projects in the management area, approximately 1,455 acres of Arundo is currently present (Table 3-17, Figure 3-29).

Similar to bamboo, Arundo is a clonal grass species native to eastern Asia. It can reproduce sexually (i.e., cross pollination) and asexually (i.e., vegetative propagation) originating from a large fleshy rhizome that forms dense mats underground. With its high reproductive fitness, the species is very successful in colonizing habitats where water is easily accessible and establishing thick stands over short timeframes. It was introduced to California by Spanish colonists in the 1700s and used as erosion control in drainage canals in the early 1800s. By the late 1990s Arundo was abundant in the watersheds of California, distributed mainly through disturbance events such as flooding, fire, and grading/clearing activities where stem and rhizome fragments were transported to new favorable locations in the watersheds where they quickly formed into new colonies.

These dispersal events—along with the plant's average daily growth rate of 1.65 feet/week, average height of 21 feet, and lateral growth up to 10 inches/year—allowed for rapid expansion of the species throughout much of the coastal watersheds in California. As a result, Arundo has developed into a major threat to California's riparian communities and the endemic species that rely on them. Recent data compiled by the California Invasive Plant Council (2011) shows how Arundo negatively impacts natural communities in several ways.

- Decreases native species richness and diversity.
- Decreases native forest canopy and understory plant cover.
- Decreases habitat for native fauna through a reduction in food resources.
- Decreases native wildlife opportunities for nesting or denning.
- Acts as physical migration barriers for native wildlife.

Moreover, Arundo is known to utilize up to 1.6 inches of water per day, negatively impacting groundwater supply and exacerbating coastal rates of seawater intrusion (California Invasive Plant Council 2011).

Once a system is occupied by dense stands of Arundo, it typically will have higher fire frequencies and intensity, as well as altered flooding patterns. Native riparian vegetation displacement by Arundo exacerbated by flood and fire events results in alterations in natural riparian successional patterns, and generally leads to more dominance of Arundo. These abiotic and biotic impacts have been documented in the Salinas River watershed and are the main driving force that propelled local groups like the RCDMC and MCWRA's efforts to try to eradicate Arundo from the management area.

### 3.4.2.6 Wetlands

The wetland natural community includes habitats subject to seasonal or perennial flooding or ponding and may have hydrophytic herbaceous vegetation. Salt marsh and freshwater wetlands generally differ in their surface area to volume ratio, water level fluctuations, and vegetation cover. Salt marsh wetlands typically support halophytic (i.e., plants that grow in high salinity water) vegetation, while freshwater wetlands do not. Historically, much of the wetland communities in the study area dominated the coastal sloughs and lagoons in the form of salt or brackish marshlands (as they do today) as well as in abandoned channels of the Salinas River adjacent to the active floodplain. In addition, freshwater wetlands were also reported throughout the valley behind natural levees of the river, especially along the northeast margin of the valley (San Francisco Estuary Institute 2009). Unable to access the active channel directly, runoff from some of the local tributaries created a chain of wetland habitats along the landward margins of the river's natural levees. Today, wetlands occur predominantly along the coastline, including portions of the Salinas River Lagoon, Moro Cojo Slough, and Elkhorn Slough totaling approximately 3% (12,674 acres) of the study area. Of this total, approximately 93% (11,783 acres) of wetland habitat is located within the management area (Table 3-17, Figure 3-29).

Coastal salt marsh contains halophytic wetland vegetation below the high tide line, subject to the ebb and flow of daily tides. Coastal salt marsh vegetation colonizes microhabitats within tidal areas dependent upon tidal elevations and drainage patterns. Salt marsh vegetation in the lowest, wettest portion of the marsh, where inundation/saturation is nearly permanent, typically includes California cordgrass (*Spartina foliosa*), pickleweed (*Salicornia* spp.), saltmarsh bulrush, and tules (*Schoenoplectus* spp.). Coastal salt marsh vegetation is typically most expansive in the middle marsh. In these broad, nearly flat areas, dense woody pickleweed vegetation dominates the landscape mixed with scattered patches of salt marsh dodder (*Cuscuta salina*), jaumea (*Jaumea carnosa*) alkali-heath (*Frankenia salina*), and saltgrass (*Distichlis spicata*). Many of the coastal salt marsh alliances are considered sensitive by CDFW (2018a).

Often referred to as tidal plains, the middle marsh typically floods during higher tides but is not continually inundated/saturated. Higher marsh occurs in drier areas of the marsh above the mean high water level along elevated or better-drained sediment deposits. These areas can be dominated by marsh gumplant, nonnative grasses, marsh baccharis, and coyote brush, and can integrate with the coastal freshwater community (U.S. Fish and Wildlife Service 2013).

The perennial freshwater marsh land cover type is dominated by emergent herbaceous plants (e.g., reeds, sedges, grasses) with either intermittently flooded or perennially saturated soils. Perennial freshwater marshes are found throughout the coastal drainages of California wherever flowing water slows down and accumulates, even on a temporary or seasonal basis. A perennial freshwater marsh usually features shallow water that is often clogged with dense masses of vegetation, resulting in deep peaty soils. Plant species common to perennial freshwater marsh predominantly consist of cattails (*Typha* spp.), bulrushes (*Schoenoplectus* and *Bolboschoenus* spp.), sedges (*Carex* spp.), and rushes (*Juncus* spp.). Dominant species in perennial freshwater marsh in the study area include beard grass (*Polypogon* sp.), tall cyperus (*Cyperus eragrostis*), willow weed (*Persicaria lapathifolia*), yellow cress (*Rorippa* spp.), and false loosestrife (*Ludwigia* spp.). Dominant species in nontidal perennial freshwater marsh are narrow-leaved cattail (*Typha angustifolia*), broadfruit bur-reed (*Sparganium eurycarpum*), and perennial pepperweed (*Lepidium latifolium*). Many of the freshwater wetland alliances are considered sensitive by CDFW (2018a).

Perennial brackish marsh is characterized by having both freshwater and salt marsh species dominate the landscape. These types of wetlands usually occur at the upper tidal reaches of stream channels and are dominated by bulrushes, sedges, rushes, saltgrass, alkali-heath, and marsh baccharis.

Seasonal wetlands are freshwater wetland habitats that support ponded or saturated soil conditions during winter and spring, but dry through the summer and fall until the first substantial rainfall. Seasonal wetlands consist of relatively low-growing vegetation similar to perennial freshwater marsh, such as rushes, sedges, and grasses. The vegetation may also consist of wetland generalists, such as hyssop loosestrife (*Lythrum hyssopifolia*), cocklebur (*Xanthium* spp.), and Italian ryegrass (*Festuca perennis*) that typically occur in frequently disturbed sites, such as along streams.

Fresh emergent wetlands support a number of common wildlife species, including the great blue heron (*Ardea herodias*), American bittern (*Botaurus lentiginosus*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), black-crowned night heron (*Nycticorax nycticorax*), sora (*Porzana carolina*), American coot (*Fulica americana*), song sparrow (*Melospiza melodia*), mallard (*Anas platyrhynchos*), red-winged blackbird (*Agelaius phoeniceus*), marsh wren (*Cistothorus palustris*), and many species of wintering waterfowl in large numbers.

### 3.4.2.7 Riverine

Riverine communities in the study area (Figure 2-7) include perennial, intermittent, and ephemeral watercourses characterized by a defined bed and bank, commonly referred to as streams. Perennial streams support flowing water year-round in normal rainfall years. These streams are often marked on USGS quadrangle maps with a blue line, and are known as blue-line streams. Intermittent (seasonal) streams carry water through some of the dry season (May–October) in a normal rainfall year. More specifically, in the wet season, intermittent streamflow occurs when the water table is raised, or rejuvenated, following early season rains that fill shallow subsurface aquifers. Ephemeral streams carry water only during or immediately following a rainfall event.

The study area is characterized by the Salinas River, the third largest riverine system in California, and accounts for approximately 3,097 acres (<1%) of the study area. Of this total, approximately 81% (2,522 acres) of riverine habitat is within the management area (Table 3-17, Figures 3-8 and 3-29). Historically, the river was characterized by a dynamic, vegetated floodplain about a half a mile wide surrounded by a complex set of lower and higher terraces that ranged from 75 to 150 feet above the river bed (San Francisco Estuary Institute 2009). Channel migration was common, but dramatic lateral shifts in channel alignment occurred in the river's lowest 15 miles. Many old channels in this downstream section are identified as lowland sloughs today, such as Tembladero and Alisal Sloughs. Early explorers also reported sustained perennial baseflows throughout the dry season (San Francisco Estuary Institute 2009).

Today, the Salinas River, as well as some of its major tributaries (i.e., Arroyo Seco and Nacimiento River) have some perennial reaches due to a combination of high groundwater levels, agriculture runoff, and releases from dams in the valley floor reaches. For instance, the portion of the Salinas River where the SRDF is located (RM 5) is perennial. However much of the floodplain is dry throughout the dry season, with baseflows in the low-flow channel artificially sustained by upstream reservoir releases during parts of the year. The upper reaches of the Arroyo Seco are also perennial due to high groundwater levels and provide accessible spawning habitat for native fish, including steelhead, in the study area (Figure 2-7).

Streams in the study area are associated with riparian plants described in Section 3.4.2.5, *Riparian*. The riparian plant composition and the width of the riparian corridor varies depending on channel slope, magnitude and frequency of channel and overbank flows, and the frequency and duration of flooding flows that inundate the broader floodplain. Similarly, wildlife supported by riverine communities are similar to those species described in Section 3.4.2.5. Additional wildlife include South-Central California Coast steelhead, arroyo toad, Pacific tree frog (*Pseudacris regilla*), California slender salamander (*Batrachoseps attenuatus*), belted kingfisher (*Megaceryle alcyon*), and Cooper's hawk (*Accipiter cooperii*).

### 3.4.2.8 Marine

The marine environment of Monterey Bay is widely recognized as important habitat for an array of marine wildlife and has been approved for federal protection as part of the Monterey Bay National Marine Sanctuary. Most species of marine mammals and seabirds that occur in the Monterey Bay occur as non-breeding residents or spring and fall migrants. Special-status birds may fly over the marine range area or float in the open water, and southern sea otters (*Enhydra lutris nereis*) may occasionally feed in the marine range area, but there are no important marine mammal haul-out or breeding areas (EMC Planning Group and EDAW 1997). In addition to the aforementioned special-status species associated with the coastal strand and dune communities, other species in the marine environment known to occur in the study area include harbor seals (*Phoca vitulina*), sea lions (*Zalophus californianus*), and aquatic species such as the South-Central California Coast steelhead and tidewater goby (*Eucyclogobius newberryi*). Approximately 933 acres of the Monterey Bay occur along the coastline of the study area (<1%). Approximately 14% (127 acres) of marine habitat is designated in the management area (Table 3-17, Figure 3-29).

### 3.4.2.9 Estuarine

The estuarine natural community consists of tidally influenced aquatic areas below the topographical contour that corresponds to the maximum possible extent of the tides. This natural community is subject to tidal fluctuations in water height that may be natural or muted by human-made structures such as tidal gates or culverts. An estuary is a semi-enclosed body of water where two other waterbodies, usually saltwater and freshwater, meet and mix. Examples of estuaries include bays, lagoons, sounds, and sloughs.

There are three estuarine natural communities immediately adjacent to the Monterey Bay in the northwestern portion of the study area: Elkhorn Slough, Moro Cojo Slough, and the Salinas River Lagoon. Approximately 147 acres of estuarine habitat (<1%) occur in the study area. Of this total, approximately 97% (142 acres) of this habitat is within the management area (Table 3-17, Figure 3-29). Historically, these main estuaries were noted by explorers in addition to smaller estuarine-like features near Spence, Salinas, and Castroville (San Francisco Estuary Institute 2009).

The Salinas River Lagoon is a bar-built estuary, which is the dominant estuary type in California. Many of these small estuaries are subject to closure with a sand barrier separating a lagoon estuary from the ocean for days, months, or even years. In the lagoon impounded behind the sand barrier, water levels may rise or fall depending on net water budget, and water quality extremes may develop. The frequency and duration of inlet closure varies naturally across bar-built estuary s and across years, and can be altered by mouth management (i.e., breaching). The mouth state is not binary (fully open or fully closed) as these systems transition among multiple mouth states, including non-tidal phases (closed mouth), perched overflow, tidal choking (muted tides relative to ocean), and fully tidal (fully open mouth). The salinity regime of a bar-built estuary can be highly variable, exhibiting tidal fluctuations when open; also, different bar-built estuary s can be entirely fresh, vertically stratified, or entirely hypersaline when closed, dependent on the hydrological balance and the condition of the sand barrier at the mouth of the system.

Elkhorn Slough, Moro Cojo Slough, and the Salinas River Lagoon are currently the coastal nurseries of the study area, as they support a vast array of marine and estuarine fauna that depend on them for food and spend a portion of their life cycle there. In the region, species such as tidewater goby, southern sea otter, western snowy plover, California tiger salamander, California brackish water snail (*Tryonia imitator*), and brown pelican (*Pelecanus occidentalis*) can be found in this community. Estuarine habitats are also a major stopover point for a multitude of migratory waterfowl like western sandpiper (*Calidris mauri*), American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), marbled godwit (*Limosa fedoa*), long-billed curlew (*Numenius americanus*), and Caspian tern (*Hydroprogne caspia*).

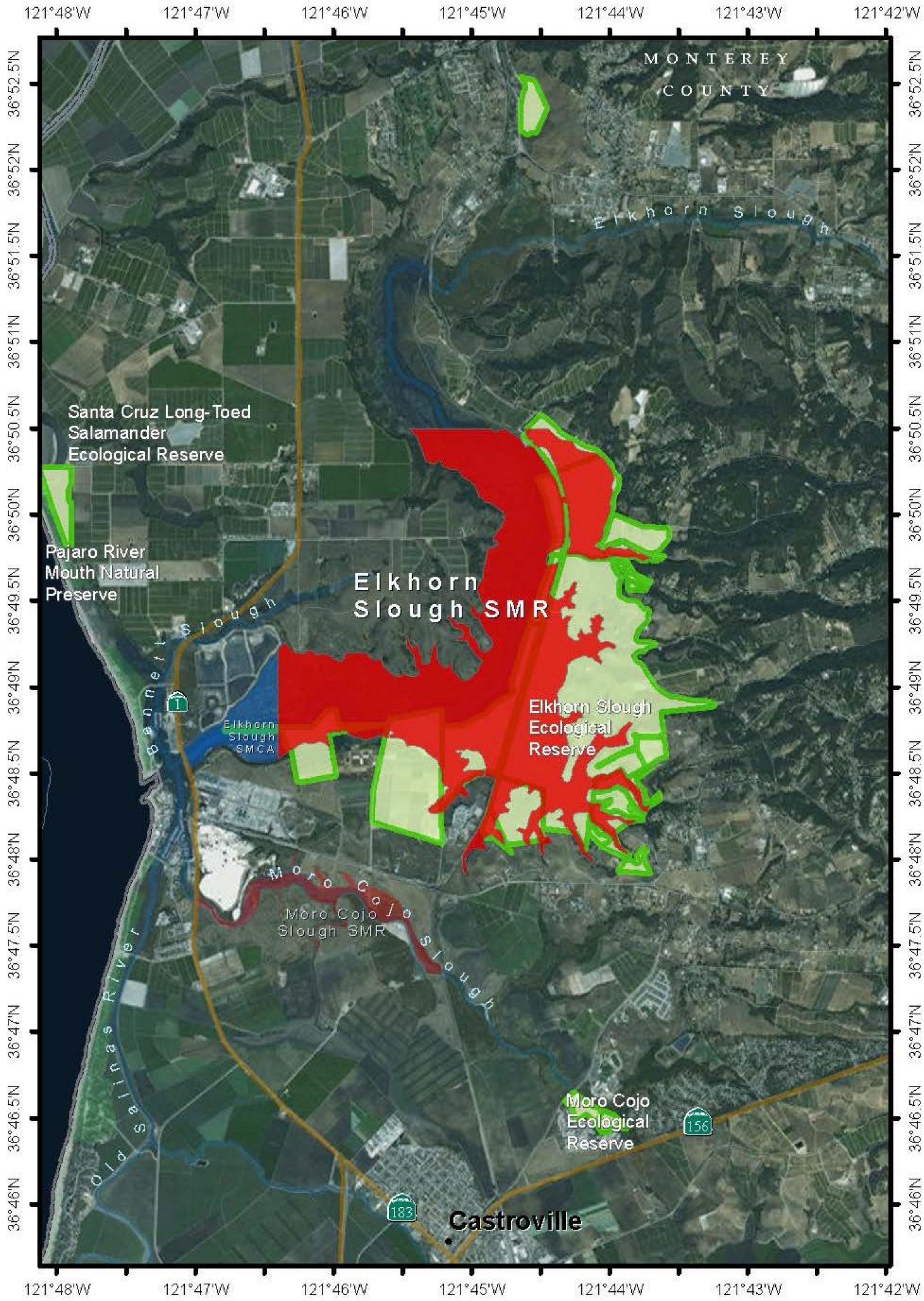
All three estuaries have some level of management and protection. The Moro Cojo and Elkhorn Sloughs both have State Marine Reserves, while the Elkhorn Slough also has a State Marine Conservation Area (Figure 3-30). The Salinas River Lagoon is within the Salinas River National Wildlife Refuge as well as Salinas River State Beach (Figure 3-31).

Estuarine communities are associated with coastal saltmarsh and brackish marsh plants described in Section 3.4.2.6, *Wetlands*. The wetland plant composition and the width of the estuarine corridor vary depending on slope, magnitude, and frequency of estuarine flows, and the frequency and duration of flooding flows that inundate the estuary. Common plants found in study area estuaries include pickleweed (*Salicornia pacifica*), cordgrass (*Spartina foliosa*), alkali heath, jaumea, saltgrass, alkali bulrush (*Bolboschoenus maritimus*), creeping ryegrass (*Leymus tritichoides*), fat hen (*Atriplex patula*), and rabbitsfoot grass (*Polypogon monspeliensis*).

### 3.4.2.10 Aquatic (Ponds, Lakes, Reservoirs)

Historically, the study area supported natural aquatic features such as seasonal ponds, swales, and lakes, both in the valley and the surrounding terraces and hillsides (San Francisco Estuary Institute 2009). These features were likely associated with topographic lows that may have been former segments of the Salinas River along the valley floor or intermittent waterways of the Santa Lucia and Gabilan Ranges. These features were likely subject to seasonal or perennial flooding or ponding that supported hydrophytic herbaceous vegetation.

The aquatic community in the study area today includes artificial lakes, ponds, and reservoirs that are typically devoid of vegetation and primarily used for flood control and water resource management. Features generally differ in their surface area to volume ratio, vegetation cover (if any), and water level fluctuations. Approximately 10,881 acres (2%) of the aquatic community occur in the study area. Of this total, approximately 95% (10,362 acres) occurs in the management area (Table 3-17, Figure 3-29).




Source: California Department of Fish and Wildlife 2019.

**Figure 3-30. Moro Cojo and Elkorn Slough Protected Areas**


Source: Google Earth Pro 2018.

**Figure 3-31. Salinas River Lagoon Protected Lands. Salinas River State Beach (solid green), Salinas River National Wildlife Reserve (open green)**

Artificial lakes (i.e., reservoirs) are large, open water bodies that are highly managed for water storage, water supply, flood protection, or recreational uses. Depending on lake temperature, water level, and other environmental conditions, algal blooms may occur, resulting in thick algal mats on the surface of the lake. Where lake edges are shallow, plant species similar to those found in ponds may be present (see below). If a lake has steeper edges, water depth and fluctuations in height may prevent the establishment of vegetation. Upland and riparian trees that were not removed during the construction of the artificial lake, or that were planted afterwards, may be present around the perimeter. In the management area, two major artificial lakes were built in the mid-twentieth century: Nacimiento and San Antonio (Figure 3-29).

The pond land cover type is characterized by small perennial or seasonal water bodies with little or no vegetation. If vegetation is present, it is typically submerged, floating, or growing along the margins. Ponds may occur naturally or may be created or expanded for livestock use (stock ponds). Pond vegetation is influenced by surrounding land use, livestock and wildlife activity, and site soil and hydrology. Plants often associated with ponds include floating plants such as duckweed (*Lemna* spp.) or rooted plants such as cattails, bulrushes, sedges, rushes, watercress, and water-primrose. Stock ponds are often surrounded by grazing land with grazing livestock. Immediately adjacent to a stock pond, soil may be exposed due to the continued presence of livestock or wildlife (e.g., feral pigs). Other open water features including retention basins are also known from the study area.

The aquatic natural community in the study area supports a number of common wildlife species including migratory birds. When ponds and reservoirs are full, mallards, cinnamon teal (*Anas cyanoptera*), canvasback (*Aythya valisineria*), northern pintail (*Anas acuta*), bufflehead (*Bucephala albeola*), ruddy duck (*Oxyura jamaicensis*), American coot, osprey (*Pandion haliaetus*), and California gull (*Larus californicus*) can easily be seen out on the water. Ponds and other smaller open water features can support northern rough-winged swallow (*Stelgidopteryx serripennis*) and red-winged blackbird, as well as garter snake (*Thamnophis sirtalis*), California red-legged frog, and California tiger salamander.

## 3.4.2.11 Agriculture

Agriculture was introduced to the study area in the 1770s by the Spanish settlers. Over the next century, agriculture developed with greater intensity, first during the Mexican period (1822–1848) and even more so after the state of California was established (1850) (Monterey County Parks Department 2011). Cattle ranching and small-scale croplands were historically common in the Monterey County region.

Over the last 150 years, the agricultural community of the region diversified into an array of cultivated row crops, horticultural crops, vineyards, orchards, dairies, and pastures that require either soil tillage or other land maintenance activities. In the study area, agriculture is located throughout the valley floor surrounding the Salinas River corridor from San Miguel to Moss Landing. Approximately 230,708 acres of agricultural lands occur in the study area (52%). Of this total, approximately 210,949 acres (91%) occur in the management area (Table 3-17, Figure 3-29).

This land cover type is predominantly characterized by tilled land supporting various fruits, vegetables, and hay crops. Row crops are those areas tilled and cultivated for common agricultural crops such as strawberries, lettuce, artichoke, and cauliflower. Irrigated or dry, these crops are usually harvested in rows as edible or useful herbaceous products for stock or human use. Agricultural crop fields are also occasionally planted for both animal forage and to improve nitrogen levels, as with legumes such as alfalfa (*Medicago sativa*) or sweet clovers (*Melilotus* spp.). This land cover type includes ruderal areas and areas that have been left fallow for several growing seasons. Ruderal sites may be dominated by weeds such as black mustard or thistles.

Hay is also produced in Salinas Valley for grain. Common vegetation includes fast-growing forage grasses, such as oats (*Avena* spp.) and Italian rye grass, as well as irrigated legumes such as alfalfa, sweet clover, and clover (*Trifolium* spp.). In some areas, nonnative weedy vegetation, such as thistles, mustards, and a variety of other weedy forbs are also common.

About 10% of this land cover type consists of other agricultural uses such as vineyards, orchards, dairies, and pastures. Vineyard is characterized by row production pattern and open canopy, where vines or shrubs dominate the land use and include grapes, kiwi, blueberries, and raspberries. Orchards are those areas planted for fruit-bearing trees. Orchards are generally characterized by evergreen or deciduous small trees producing fruit or nut crops, such as apples, walnuts, and olives, usually planted in rows with or without irrigation channels. Orchard is distinguished on the basis of its tree cover, canopy characteristics, and distinctive production rows. Dairies and pastures are lands used to support bovine species for milk and meat production.

Most agricultural lands are accompanied by the presence of large buildings or other developed lands such as greenhouses, shadehouses, or nurseries. Equipment storage and farm worker housing is usually preset but accounts for only a small percentage of the area. Dairies and pastures typically have corrals, barns, and equipment storage structures. These uses occur within agricultural areas, rather than urban settings.

Herons, egrets, and hawks often congregate in large numbers to forage on insects, voles, and other prey found in these areas. Other common wildlife species found in agricultural lands include the American kestrel, western meadowlark, red-winged blackbird, house finch (*Carpodacus mexicanus*), California vole (*Microtus californicus*), house mouse (*Mus musculus*), brown rat (*Rattus norvegicus*), and cottontail rabbit (*Sylvilagus floridanus*). Special-status species, such as western burrowing owl, may utilize agricultural lands to breed and forage, whereas others such as American badger and San Joaquin kit fox could migrate through it.

## 3.4.2.12 Barren

The barren land cover type includes nonagricultural areas that are devoid of vegetation. Barren areas are historically and recently disturbed land in urban or rural areas. Land uses in barren areas can include aggregate facilities and mine tailings. Rock areas are nonserpentine rock outcrops, which are exposures of bedrock that typically lack soil and have sparse vegetation. Within the study area, several types of rock outcrops are present and are derived from sedimentary, volcanic, and metamorphic sources. These rock outcrops can support native species and provide important habitat for wildlife.

The barren land cover type occupies approximately 2% (8,661 acres) of the study area. Approximately 64% (5,498 acres) of this total is located within the management area (Table 3-17, Figure 3-29). It is primarily found as barren or rocky patches within grassland, although this land cover type can also be present in shrublands, forests, and woodlands. Like agricultural lands, special-status species, such as the western burrowing owl, American badger, and San Joaquin kit fox may move through these areas.

## 3.4.2.13 Developed

Since the early twentieth century, when small rural communities were scattered across the study area, the Salinas Valley has hosted the slow advance into urban communities with densely populated town centers connected by major transportation highways. Today, the urban communities within the valley consist of areas where native vegetation has been replaced with residential, commercial, industrial, and transportation uses; or with structures, paved and impermeable surfaces, horticultural plantings, turf, and lawn; or other developed land use elements such as highways, city parks, and cemeteries. Vegetation found in the urban land cover type is typically cultivated vegetation associated with landscaped residences, nonnative planted street trees (i.e., elm, ash, liquidambar, pine, palm), and parklands. Approximately 43,700 acres of urban lands occur in the study area (10%). Of this total, approximately 92% (40,040 acres) occurs in the management area (Table 3-17, Figure 3-29).

Ornamental woodlands are also present in this community and are those areas where ornamental and other introduced species of trees, including *Eucalyptus* (usually species *globulus*) and Monterey pine (*Pinus radiata*) species, have been planted or naturalized and dominate, forming an open-to-dense canopy. Ornamental woodland is an important feature of the urban community as some stands could provide suitable nesting habitat for raptors in the region. Ornamental woodlands occur in small patches mainly in and around the cities and towns of the Salinas Valley.

Depending on their specific conditions, urban areas can support a number of common wildlife species, including the acorn woodpecker (*Melanerpes formicivorus*), barn swallow (*Hirundo rustica*), western scrub-jay (*Aphelocoma californica*), ruby-crowned kinglet (*Regulus calendula*), northern mockingbird (*Mimus polyglottos*), American robin (*Turdus migratorius*), cedar waxwing (*Bombycilla cedrorum*), yellow-rumped warbler (*Dendroica coronata*), white-crowned sparrow (*Zonotrichia leucophrys*), dark-eyed junco, house finch, raccoon (*Procyon lotor*), and numerous nonnative species, including the European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), North American opossum (*Didelphis virginiana*), eastern fox squirrel (*Sciurus niger*), house mouse, and black rat.

## 3.4.3 Special-Status Species

The CDFW (2018b) California Natural Diversity Database and U.S. Fish and Wildlife Service (USFWS) Information, Planning, and Conservation (IPaC) System (2018b) were queried for plants and animals in California that have special regulatory or management status and could occur in the study area. A complete list of the plant and animal species that were reviewed is provided in Appendix E, *Special-Status Species Potential to Occur Tables*, including scientific nomenclature, regulatory status, and habitat requirements.

The special-status species list was reviewed with the following considerations to develop a list of target species for the LTMP: (1) species known to occur in the proposed management area, (2) species that are federally or state-listed or have potential to become listed in the foreseeable future, (3) species that have potential to be impacted by management actions, (4) species with sufficient data to adequately evaluate potential impacts in the study area, and (5) species with the potential for beneficial effects through improved management.

Based on this analysis, the species listed in Table 3-18 are recommended for inclusion as target species in the LTMP. Table 3-18 summarizes the status, range, habitat requirements, and distribution in the study area for each of the target species. Detailed species accounts for nine target species, which have been consulted on for prior projects and may be impacted by future management activities, are included in Appendix F, *Species Accounts*. Each account includes details on species life history, distribution, abundance, population trends, conservation and recovery status. The LTMP target species are also those most likely to be considered for or included in a habitat conservation plan.

**Table 3-18. Target Species with the Potential to Occur in the Management Area and Study Area**

| **Common Name** ***Scientific Name*** | **Status Federal/ State/Other**[a] | **General Habitat Description** | **Potential in the Management Area** | **Potential in the Study Area** |
|---|---|---|---|---|
| South-Central California Coast steelhead *Oncorhynchus mykiss* | FT/–/– | Cool, clear, fast-flowing rivers and streams containing numerous riffles and cover. While these waterways are generally forested, snow-fed streams, steelhead are also found in rain-fed, intermittent streams. | **Present.** Known to occur in the Salinas River, Arroyo Seco, Nacimiento River, and San Antonio River. | **Present.** Known from the upper reaches of Arroyo Seco, which contains the majority of spawning habitat and half of the rearing habitat in the study area (National Marine Fisheries Service 2007). |
| Tidewater goby *Eucyclogobius newberryi* | FE/SSC/– | Found primarily in waters of coastal lagoons, estuaries, and marshes. | **Present.** Known to occur in the Salinas River Lagoon and in the OSR (Hellmair et al. 2018). | **Present.** Known from Bennett Slough located in the northern end of Elkhorn Slough (Hagar Environmental Science 2014). |
| Vernal pool fairy shrimp *Branchinecta lynchi* | FT/–/– | Primarily found in vernal pools or seasonal wetlands that fill with water during fall and winter rains and dry up in spring and summer. | **Present.** Known to occur on Fort Hunter Liggett. Critical habitat is designated near Nacimiento Creek on Fort Hunter Liggett (U.S. Fish and Wildlife Service 2007). | **Present.** Known from Fort Hunter Liggett and Camp Roberts (California Department of Fish and Wildlife 2018b). |
| Arroyo toad *Anaxyrus californicus* | FE/–/SSC | Low gradient, medium-to-large streams and rivers with intermittent and perennial flow. Inhabits semi-arid regions near washes or intermittent streams, including valley foothill and desert riparian, desert wash, rivers with sandy banks, willows, cottonwoods, and sycamores, as well as loose, gravelly areas of streams in drier parts of the range. | **Present.** Several occurrences known from the San Antonio River on Fort Hunter Liggett (California Department of Fish and Wildlife 2018b). | **Present.** Known from Fort Hunter Liggett along the San Antonio River (California Department of Fish and Wildlife 2018b). |

| **Common Name** *Scientific Name* | **Status Federal/ State/Other**[a] | **General Habitat Description** | **Potential in the Management Area** | **Potential in the Study Area** |
|---|---|---|---|---|
| California red-legged frog *Rana draytonii* | FT/–/SSC | Permanent and semi-permanent aquatic habitats, such as creeks and cold water ponds, with emergent and submergent vegetation; may aestivate in rodent burrows or cracks during dry periods. | **Present.** Known to occur in the Salinas River, Arroyo Seco, Fort Ord, and Elkhorn Slough (California Department of Fish and Wildlife 2018b). | **Present.** Known throughout from stock ponds and waterways in Salinas, Oakdale, and Prunedale. Also found in Elkhorn Slough, Natividad Creek, Los Vaqueros Creek, upper Gabilan Creek, Chalone Creek, and Dorrance Ranch in the foothills east of Spence and Chualar (California Department of Fish and Wildlife 2018b, McGraw 2008). |
| California tiger salamander *Ambystoma californiense* | FT/ST/– | Small ponds, lakes, or vernal pools in grasslands and oak woodlands for breeding; rodent burrows, rock crevices, or fallen logs for upland cover during dry season. | **Present.** Known to occur in Fort Ord and Elkhorn Slough. Also known from Chualar, Gonzales, and Soledad (California Department of Fish and Wildlife 2018b). | **Present.** Known throughout from stock ponds and waterways in Castroville, Salinas, Prunedale, and San Juan Bautista. Also found in Elkhorn Slough, and Fort Hunter Liggett (California Department of Fish and Wildlife 2018b). |
| Bank swallow *Riparia ripiaria* | –/ST/– | Nests in bluffs or banks, usually adjacent to water, where the soil consists of sand or sandy loam. | **Present.** Known from the Salinas River near Moss Landing, Greenfield, and King City. Also known from Seaside (California Department of Fish and Wildlife 2018b). | **Present.** Known from north of Castroville (California Department of Fish and Wildlife 2018b). |
| California least tern *Sterna antillarum browni* | FE/SE/ FP | Nests along the coast; colonial breeder on bare or sparsely vegetated flat substrates, such as sand beaches, alkali flats, landfills, or paved areas. | **Present.** Known as an occasional spring migrant in the Salinas River Lagoon (U.S. Fish and Wildlife Service 2002a). | **Potential.** Last nesting pair observed in study area in the 1930s (U.S. Fish and Wildlife Service 2002a). |
| Least Bell's vireo *Vireo bellii pusillus* | FE/SE/– | Riparian thickets either near water or in dry portions of river bottoms; nests along margins of bushes and forages low to the ground; may also be found using mesquite and arrow weed in desert canyons. | **Present.** Known as a rare summer resident in the Salinas River watershed. Recent sightings have been recorded near San Ardo, San Lucas, San Juan Bautista, and Bradley (Roberson 2002). | **Present.** Recent sightings in the Salinas Valley and Santa Clara Valley indicate this species may be expanding back into its historical range to the north of current populations (U.S. Fish and Wildlife Service 2006). |

| Common Name *Scientific Name* | Status Federal/ State/Other[a] | General Habitat Description | Potential in the Management Area | Potential in the Study Area |
|---|---|---|---|---|
| Western snowy plover *Charadrius alexandrinus nivosus* | FT/–/SSC | Coastal beaches above the normal high tide limit in flat, open areas with sandy or saline substrates; vegetation and driftwood are usually sparse or absent. | **Present.** Known from mouth of the Salinas River and along sand bars of the Salinas River Lagoon in addition to surrounding coastal dune and beach areas managed on state and federal park lands (California Department of Fish and Wildlife 2018b). | **Present.** Known from Moss Landing State Beach, Elkhorn Slough salt ponds, Salinas River State Beach, Salinas River National Wildlife Refuge, Monterey Dunes, Fort Ord, and Marina State Beach (California Department of Fish and Wildlife 2018b). |
| Southern sea otter *Enhydra lutris nereis* | FT/FP/– | Nearshore marine environments. Needs canopies of giant kelp and bull kelp for rafting and feeding. Prefers rocky substrates with abundant invertebrates. | **Present.** Known from coastal waters of Monterey Bay including Elkhorn Slough, Moro Cojo Slough, and Moss Landing Harbor (U.S. Fish and Wildlife Service 2015). | **Present.** Known from coastal waters along Moss Landing State Beach, Elkhorn Slough, Salinas River State Beach, Salinas River National Wildlife Refuge, Monterey Dunes, Fort Ord, and Marina State Beach (U.S. Fish and Wildlife Service 2015). |
| San Joaquin kit fox *Vulpies macrotis mutica* | FE/ST/– | Saltbush scrub, grassland, oak, savanna, and freshwater scrub. | **Present.** Known from the Salinas River Valley from Soledad to Bradley (California Department of Fish and Wildlife 2018b). | **Present.** Known from Camp Roberts and Fort Hunter Liggett (California Department of Fish and Wildlife 2018b). |
| Monterey spineflower *Chorizanthe pungens* var. *pungens* | FT/–/1B.2 | Coastal dunes, chaparral, cismontane woodland, and coastal scrub; sandy soils in coastal dunes or more inland within chaparral or other habitats; 10–1,500 feet. Blooms: April–August. | **Present.** Known from 28 occurrences along the coastal habitats of the management area including Salinas River State Beach, Salinas River National Wildlife Refuge, Fort Ord, and Marina State Beach. Two are known from the coastal plain of the Salinas River Valley (California Department of Fish and Wildlife 2018b). | **Present.** Known from 28 occurrences along the coastal habitats of the study area including Salinas River State Beach, Salinas River National Wildlife Refuge, Fort Ord, and Marina State Beach, and the Salinas River Valley (California Department of Fish and Wildlife 2018b). |

| Common Name *Scientific Name* | Status Federal/ State/Other[a] | General Habitat Description | Potential in the Management Area | Potential in the Study Area |
|---|---|---|---|---|
| Sand gilia *Gilia tenuiflora* ssp. *arenaria* | FE/ST/ 1B.2 | Coastal dunes, coastal scrub, chaparral (maritime), cismontane woodland; bare, wind-sheltered areas often near dune summit or in the hind dunes; two records from Pleistocene inland dunes; 0–800 feet. | **Present.** Known from 19 occurrences along the coastal habitats of the management area including Salinas River State Beach, Salinas River National Wildlife Refuge, Fort Ord, and Marina State Beach (California Department of Fish and Wildlife 2018b). | **Present.** Known from 19 occurrences along the coastal habitats of the study area including Salinas River State Beach, Salinas River National Wildlife Refuge, Fort Ord, and Marina State Beach (California Department of Fish and Wildlife 2018b). |
| Abbott's bush-mallow *Malacothamnus abbottii* | –/–/1B.1 | Riparian scrub; among willows near rivers and along roadsides; 400–1,600 feet; blooms: May–October. | **Present.** Known from the Salinas River, Sargent Creek, Nacimiento, and San Antonio (California Department of Fish and Wildlife 2018b). | **Present.** All 13 occurrences for this species are located in the study area along the Salinas River, Sargent Creek, Nacimiento, and San Antonio, and along unnamed creeks in the Santa Lucia Mountains (California Department of Fish and Wildlife 2018b). |
| Davidson's bush-mallow *Malacothamnus davidsonii* | –/–/1B.2 | Chaparral, cismontane woodland, coastal scrub and riparian woodland, sandy washes; 600–2,800 feet; blooms June–January. | **Present.** Known from the Nacimiento and San Antonio Reservoirs (California Department of Fish and Wildlife 2018b). | **Present.** Known from 16 occurrences in the study area including within Camp Roberts, Fort Hunter Liggett, Pine Canyon, and along unnamed creeks in the Santa Lucia Mountains (California Department of Fish and Wildlife 2018b). |
| Santa Lucia purple amole *Chlorogalum purpureum var. purpureum* | FT/–/1B.1 | Chaparral, cismontane woodland, valley and foothill grassland often in grassy areas with blue oaks in foothill woodland on gravelly clay soils; 700–. 1,300 feet; blooms: April-June. | **Present.** Known from Fort Hunter Liggett (California Department of Fish and Wildlife 2018b). Critical habitat is designated on Fort Hunter Liggett (U.S. Fish and Wildlife Service 2002b). | **Present.** Known from Fort Hunter Liggett and Camp Roberts (California Department of Fish and Wildlife 2018b). |

[a] FE = Federally Endangered; FT = Federally Threatened; SE = State Endangered; ST = State Threatened; FP = State Fully Protected; SSC = State Species of Special Concern; 1B = California Native Plant Society Ranked rare or endangered in California and elsewhere; .1 = seriously endangered in California; .2 = fairly endangered in California.

### 3.4.4 Habitat Connectivity

Modification of natural habitats, including habitat fragmentation, is considered the most severe threat to the persistence of global biodiversity and affects all taxonomic groups (Fischer and Lindenmayer 2007). Habitat connectivity is essential for maintaining biological diversity and species populations in the study area. Maintaining connectivity between different habitats can improve population fitness and promote genetic diversity that is critical for adapting to environmental disturbances. In addition, connectivity among subpopulations can bolster resiliency and prevent inbreeding. For species with limited dispersal abilities, such as arroyo toad or tidewater goby, any habitat disturbances or habitat loss can affect the survival of a local population unless individuals are able to migrate to refugia habitat. Connectivity is also necessary for the recolonization of habitats following disturbances. For larger, more mobile species, habitat connectivity is critical to access resources that are heterogeneously distributed over the landscape. Many of the special-status species in the study area are limited in their range or only occupy specific habitats and, therefore, rely upon connectivity between suitable habitats to maintain their populations.

Several regional and local connectivity planning efforts have studied habitat connectivity, particularly where urbanization and agriculture have resulted in fragmented habitats. Connectivity has two components: structural and functional. Structural connectivity includes the physical landscape attributes along a dispersal corridor and is fairly easy to measure and observe. Functional connectivity includes an organism's response to those landscape attributes and is much more difficult to measure (Kindlmann and Burel 2008, Hughes et al. 2013). Maintaining and enhancing functional connectivity between fragmented habitats in the Central Coast Ecoregion is critical for protecting biodiversity in the Salinas River watershed. Spencer et al. (2010) used a focal species approach to determine Essential Connectivity Areas between landscape blocks across California, including the Salinas River watershed. Penrod et al. (2013) refined this effort for the San Francisco Bay Area and surrounding counties, including Monterey, and identified critical linkages for wildlife in the Salinas River watershed.

The California Essential Habitat Connectivity Project (Spencer et al. 2010) proposed 24 Essential Connectivity Areas for the Central Coast Ecoregion, which encompasses the Salinas River watershed, to connect 129 highly fragmented Natural Landscape Blocks. The Natural Landscape Blocks are large areas of undeveloped land mostly in rugged areas, with some smaller, more fragmented blocks on the region's gentler slopes, terraces, and valleys. The proposed Essential Connectivity Areas are diverse in land cover composition but tend to cover more urban and agricultural land uses and are crossed by numerous major and secondary roads.

Priorities for Salinas Valley Essential Connectivity Areas include maintaining potential movement corridors for endangered San Joaquin kit fox from Camp Roberts Military Reservation to the Carrizo Plain and the San Joaquin Valley and northeast toward the Cholame Hills area. The project also identified an important corridor for wide-ranging species along the Pajaro River and adjacent lands from the Santa Cruz Mountains to the Santa Lucia Mountains (Figure 3-32; Bunn et al. 2007 as cited by Spencer et al. 2010).


**Figure 3-32. Essential Connectivity Areas**

The Critical Linkages Project (Penrod et al. 2013) built upon the Essential Habitat Connectivity Project and was designed to provide live-in and move-through habitat for multiple species, support metapopulations of smaller species, ensure availability of key resources, buffer against edge effects, reduce contaminants in streams, allow natural processes to operate, and allow species and natural communities to respond to climatic changes. Based on these desired processes, a series of three linkages were proposed in and through the study area to connect the Santa Lucia Range and the Inner Coast Range for four target species: American badger, Tule elk, black-tailed deer, and California quail (Figure 3-32). The linkages encompass 286,688 acres, with over half (155,744 acres) consisting of rangeland or agriculture lands enrolled in the Williamson Act program, and an additional 11,899 acres protected in fee or conservation easements.

Conservation actions in this linkage may benefit several threatened, endangered, or sensitive species. Roughly 10% of the land in the linkage (29,170 acres) is designated as critical habitat for California red-legged frog, California tiger salamander, vernal pool fairy shrimp, or purple amole. The linkage design for the Santa Lucia Range-Inner Coast Range also incorporates the Salinas River Key Riparian Corridor, which provides 50 miles of streams and rivers designated as critical habitat for steelhead. Additional streams (not designated as critical habitat for steelhead) also serve as critical linkages for focal species and provide habitat connections between landscape blocks.

In total, about 80% of all animals use riparian resources and habitats during some life stage, and many animals have shown preferences for moving along riparian corridors (Beier 1995, Dickson et al. 2004), particularly when moving through rugged landscapes. Critically, riparian corridors provide connectivity between habitats and across elevational zones, which will allow species to respond and adapt to climate change in the future (Seavy et al. 2009). Maintaining and enhancing wildlife movement in several key areas across the Salinas River and surrounding valley will be key to ensuring habitat connectivity in the study area as many farmers have erected fences along the river to keep wildlife out of their fields.

Connectivity between aquatic habitats in the Salinas River and tributaries is imperative to maintain populations of fish and other aquatic animals in the watershed. Several riparian impediments exist in the watershed (see Figure 3-33), the majority of which are from anthropogenic sources: natural barriers, dams, culverts, vegetation clearing, invasion of nonnative species, accumulation of pollutants in streambeds, farming in channels, gravel mining, and high intensity livestock grazing.

Connectivity between the ocean and upstream spawning habitat is necessary for steelhead to complete its life history. While steelhead have a varied life history that is adapted to annual fluctuations in flow and connectivity between habitat types, connectivity between ocean rearing and upstream spawning habitat in most years is necessary for the species to persist in the watershed. One of the main impediments to migration in the Salinas River watershed is the disruption of flow (dry riverbed) over the long distances between the lagoon to suitable spawning and rearing habitat in the upper Salinas and its tributaries.

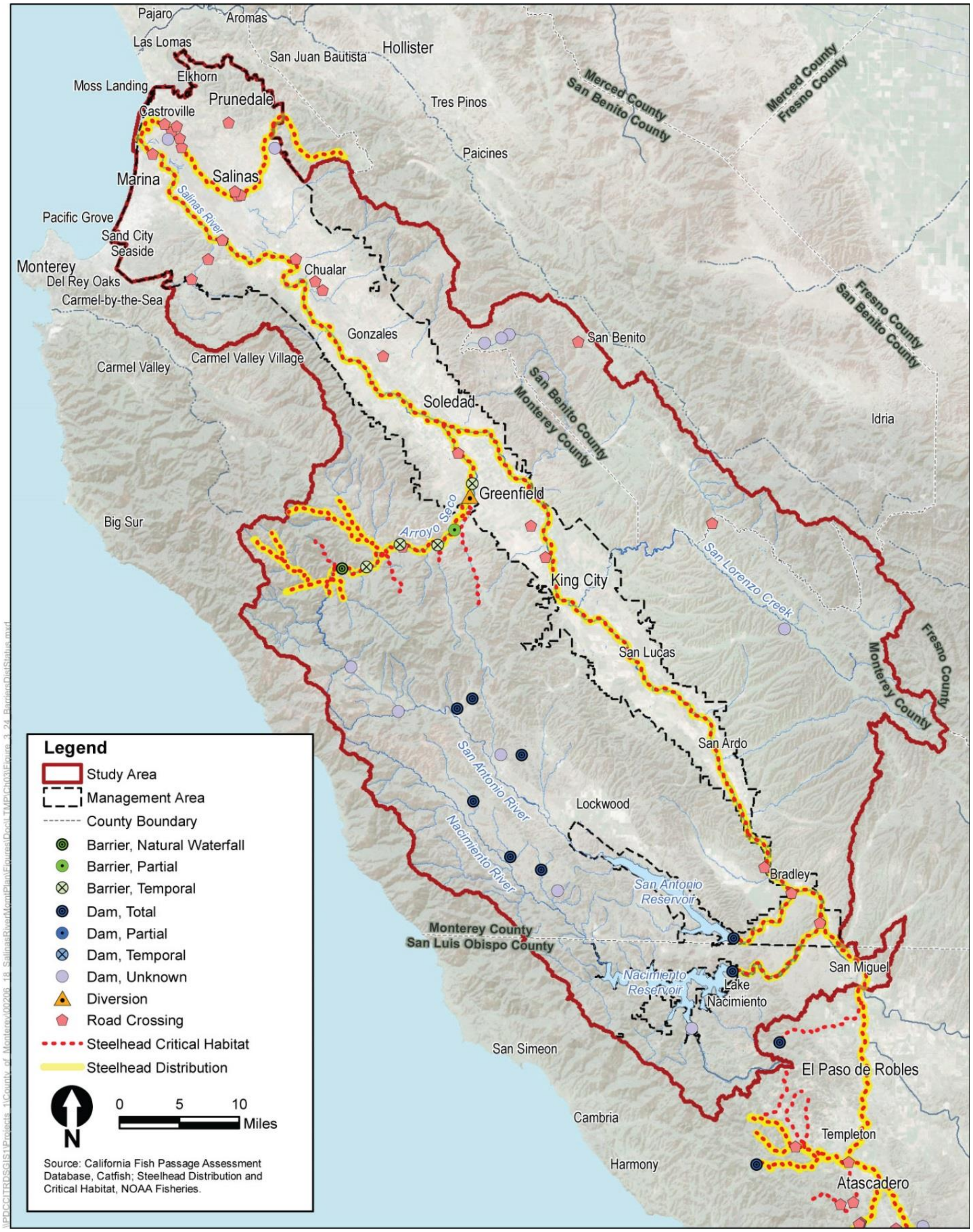



**Figure 3-33. Stream Classifications, Barriers, and Native Fish Habitat in the Salinas River Watershed**

The Salinas River, along with its major tributaries the Arroyo Seco, San Antonio River, and Nacimiento River, are all designated as critical habitat for steelhead (Figure 3-33; Appendix F, Figure F1-1). However, of these tributaries, only Arroyo Seco is not blocked by a major dam. The other two rivers are intensely regulated by the Nacimiento Dam (located along the Nacimiento River at RM 10; created in 1957) and San Antonio Dam (located along the San Antonio River at RM 8; completed in 1967). Arroyo Seco, the farthest downstream of the three tributaries that supports steelhead habitat, has at least 31 miles of suitable spawning and rearing habitat for the species. Arroyo Seco has a natural waterfall barrier to migration at approximately RM 31, although steelhead may be able to pass this waterfall at high flows. There are other temporal and partial barriers to migration along the waterway upstream of the confluence with the Salinas River, including culverts and old irrigation dams (Figure 3-33). In addition, the lower reaches are intermittent and typically dry up in the summer and fall months adding another barrier to migration to perennial habitat upstream. Nacimiento Dam blocks an estimated 38 miles of the river upstream of the reservoir (Becker and Reining 2008), much of which is likely suitable steelhead habitat. Similarly, San Antonio Dam blocks an estimated 32 miles of the river upstream of the reservoir (Becker and Reining 2008). Historically, these three tributaries were the "principal [steelhead] spawning areas and comprised some of the best spawning and rearing habitats in the watershed" (Snyder 1913; Titus et al. 2002; Good et al. 2005, as cited in National Marine Fisheries Service 2007). Currently, the majority of suitable habitat in the watershed, above the Nacimiento and San Antonio Dams, is not connected to the lower Salinas River and the ocean, limiting accessible spawning and rearing habitat for anadromous species in the watershed.

# 3.5 Environmental Pressures and Stresses

The California State Wildlife Action Plan (California SWAP) provides a framework for an ecosystem approach to the conservation and management of the state's native species and their habitats (California Department of Fish and Wildlife 2015). This framework identifies and describes ecosystem *pressures* and *stresses* and then proposes a wildlife management strategy that focuses on creating an ecological condition capable of withstanding those pressures and stresses. The California SWAP definitions for pressures and stresses are provided below and adopted for the LTMP.

- **Pressure:** an anthropogenic or natural driver that could result in changing the ecological conditions of the target. Pressures can be positive or negative, depending on the intensity, timing, and duration. Negative or positive, the influence of the pressure to the target may be significant.
- **Stress:** a degraded ecological condition of a target that resulted directly or indirectly from negative impacts of pressures defined above (e.g., habitat fragmentation).

This section identifies and discusses the pressures and stresses relevant to the Salinas River LTMP study area. The primary section headings—*Changes in Natural Communities*, *Altered River Hydrology*, and *Changes in Climate*—are considered the primary pressures in the study area. Section subheadings—e.g., habitat loss, altered flow, sea level rise, prolonged drought—are the resulting stresses. The discussion in each section explains the history and status of the pressure within the study area and details the stresses to relevant special-status species.

## 3.5.1 Changes in Natural Communities

Changes in the extent, distribution, and quality of natural communities occur as a result of climate change, land conversion, invasive species, and changes to the natural fire regime. Climate change allows certain natural communities to colonize new regions but if isolated by inhospitable habitat or development, climate change can lead to the loss or degradation of the community. Conversion of natural communities to agricultural, rural, or urban development results in a loss of community function and a degradation to remaining, adjacent patches. Invasive species can alter community structure and function and make the community more susceptible to wildfire. Changes to the natural fire regime caused by invasive species and land management practices interrupt or prolong typical fire cycles, which affects plant succession rates, reproductive cycles, and overall community diversity (California Department of Fish and Wildlife 2015). The sections below discuss each of these mechanisms of natural community shift in more detail.

### 3.5.1.1 Habitat Loss, Fragmentation, and Degradation

Habitat loss and fragmentation is by far the greatest stressor to biological resources in California and the study area. Indeed, the State Wildlife Action Plan calls habitat loss and fragmentation a "founding reason" for historical and current impacts on habitat and functioning ecosystems (California Department of Fish and Wildlife 2015). Habitat loss and fragmentation result in the degradation of remaining habitat by increasing the length of "edge" (boundaries between habitat and non-habitat), decreasing the overall size of natural habitats, and isolating patches of habitat. An increase in the total length of edge increases the potential for invasive or domestic predatory species (e.g., cats, dogs) to enter and colonize native communities. Habitat patches, because of their reduced size, typically support smaller populations of species, and as populations decrease in size, they become more vulnerable to disease, stochastic events, predation, and inbreeding. Fragmentation of habitat has a similar effect; the greater distance between patches of habitat, the greater potential there is for resource competition, genetic isolation, and inbreeding. Fragmentation of habitat can also separate populations from important, seasonal foraging and breeding habitat.

In the Salinas Valley, habitat loss and fragmentation have primarily occurred as a result of agricultural development, including ranchlands, and urban development, including cities, highways, railroads, and military bases. Prior to development of the river valley, the lands surrounding the Salinas River were primarily composed of riparian forests, but also included wetlands, floodplain, grasslands, and scrublands (San Francisco Estuary Institute 2009). The riparian forest is now concentrated along the river as a thin, linear strip. The reduction in the extent of the riparian forest is likely the primary cause of local extirpations of species such as the least Bell's vireo and the yellow-billed cuckoo that require larger patches of riparian forest with mixed canopy structure. Similarly, the loss and degradation of wetland and grassland habitats within the Salinas Valley is likely the primary cause of the reduction in occurrence of wetland-dependent species such as California red-legged frog and California tiger salamander.

Development and human-induced pressures from recreation and pollution can further degrade remaining, fragmented habitats, especially where patch sizes are relatively small. Within the Salinas Valley, natural communities persist primarily as dune, coastal strand, and wetland communities near the coast and as riparian and scrubland communities farther inland. Recreational visitors trample vegetation, disturb local wildlife (with noise primarily), and leave behind trash and garbage. Pollution, especially in the form of agricultural and urban runoff, also degrades the quality and composition of communities as some vegetation types, particularly invasive types, may be more tolerant of degraded conditions than native species.

How the combined effects of habitat loss, fragmentation, and degradation affect species is well illustrated by the western snowy plover. Dune habitat, where western snowy plovers nest, has been lost and fragmented over time as a result of development, road infrastructure, and sea level rise. The remaining habitat is greatly affected by predation, much of which is from nuisance species associated with human development (e.g., cats, crows, raccoons, fox), and disturbance from human recreation (including domestic dogs). The decrease in habitat, coupled with predation and recreational stresses, has led to the decline in the western snowy plover population.

### 3.5.1.2 Shifting Distribution of Natural Communities

Shifts in natural community distribution and extent are primarily related to climate change, altered hydrology, invasive species, and changes to the natural fire regime. Changes related to the fire regime are discussed in Section 3.5.1.4, *Changes to the Natural Fire Regime*, below. Climate-related shifts in natural communities are not expected to be the primary driver of habitat degradation for Salinas Valley species; however, they are expected to exacerbate existing degraded conditions.

Climate change is expected to affect natural communities in California through the following mechanisms, as described in Section 3.5.3, *Changes in Climate:* sea level rise, prolonged drought, more intense rain events, and a decrease in coastal fog. Warmer temperatures are also expected to affect the distribution of natural communities.

Sea level rise will change the average salinities and hydrologic regime in nearshore and coastal environments, particularly for dune, coastal strand, wetland, and riparian communities. Increased erosion will also affect these communities. This will likely result in the inland shift of salt-tolerant vegetation and a reduction in riparian forest canopy in the coastal areas. The reduction in the frequency of coastal fog is also expected to reduce the extent of scrub and forest communities that persist near the coast and rely upon fog-related precipitation.

Prolonged drought is expected to cause shifts in natural community distribution and extent, particularly in the riparian community. With lower average rainfall, reduced river flows, and shortened hydroperiods, natural community composition will shift to communities with greater drought tolerance. Natural communities may also shift upward in elevation, where there are cooler temperatures. Grassland and scrubland communities may be able to adapt with an increase in elevation, but woodland and forest communities that exist in the upper elevations may see an overall decline in extent, at least in the southern portions of their distribution. The stress to natural communities as a result of drought can also create vulnerabilities to disease, wildfire, and invasion by nonnative, drought-tolerant species.

More intense rain events may cause increased erosion, especially when coupled with prolonged drought that dries soils and weakens root structures that hold vegetation in place. Vegetation communities in the higher elevations, especially in areas that are moderately or steeply sloped, will be most vulnerable to rain-related erosion and landslide events.

#### 3.5.1.3 Invasive Species

Human introduction of nonnative species to the environment is a critical environmental stressor in the Salinas Valley, and one that is expected to be exacerbated by climate change. Invasive nonnative species are loosely defined as any kind of living organism that causes economic and/or ecological harm, specifically species that grow and reproduce quickly and have a propensity to outcompete native flora and fauna. Invasive species were introduced in California as early as the first European settlement, with some introductions occurring intentionally and others occurring unintentionally as a result of people and goods moving throughout the state. Often, invasive species lack any natural predators or controls because native wildlife cannot evolve defenses against the invader. Direct threats from invasive species include preying on native species, outcompeting native species for food or other resources (i.e., habitat, water), causing or carrying diseases, and preventing a native species from reproducing. Indirect threats from invasive species include reducing habitat areas, altering the food web by replacing or destroying a native food source, and altering the abundance or diversity of species that are important for natural ecological processes.

##### Invasive Plant Species

*Photo courtesy of the Resource Conservation District of Monterey County*

Anthropogenic disturbances (e.g., modified flow regime, agriculture, urbanization) have created conditions that favor invasions globally (Lockwood et al. 2013). Prior to dam construction in the watershed, seasonal high flows and natural floods caused flushing and scouring of the Salinas River channel, and the lack of dry season flow prevented excess growth of vegetation in the channel (ENTRIX and EDAW 2002). Following a reduction in naturally occurring flood disturbances, hundreds of exotic species have been able to find a niche in riparian corridors, with a few becoming significant problems, like Arundo and salt cedar (*Tamarisk* spp.). Removing stressors and reestablishing natural flow regimes can help bring riparian communities back into balance; however, some exotics are persistent and physical eradication is necessary to restore degraded systems (Shafroth et al. 2008, Stromberg et al. 2007).

Among the most problematic invasive plant species is Arundo, which covers approximately 1,455 acres in the Salinas River watershed, the second-largest infestation in California (Figure 3-29). Arundo is a nonnative perennial grass, similar to bamboo, which forms dense stands along riverbanks and can grow over 30 feet tall. It crowds out native vegetation, degrades wildlife habitat, consumes large amounts of water, increases flood risk to surrounding areas, and poses a fire hazard (Resource Conservation District of Monterey County 2018). Arundo is known to draw over three times as much water as native vegetation, and provides no riparian stream cover, leading to increased water temperatures and reduced habitat quality for aquatic wildlife.

Although the cumulative impact of Arundo in the Salinas River watershed is moderate, many of the target species in this LTMP—such as steelhead, tidewater goby, arroyo toad, California red-legged frog, California tiger salamander, and others—are expected to be negatively impacted by Arundo in some part of their range (California Invasive Plant Council 2011). Arundo changes the structure of a native community's habitat matrix by outcompeting and replacing native vegetation. This is the primary mode in which it affects terrestrial species. For example, Arundo infestation can degrade the quality of woody vegetation and food resources in riparian woodland habitats used by southwestern willow flycatcher (California Invasive Plant Council 2011). The primary impact on aquatic species relates to high water usage, high water temperatures, bank stabilization, and accumulation of dead Arundo biomass. The ability of Arundo to stabilize banks causes stream channels to become incised and disconnected from floodplains, which can affect arroyo toad's food resources and breeding habitat. Arundo crowds out native riparian vegetation, resulting in a lack of shady stream cover and increased water demands, both of which may decrease freshwater inputs into the Salinas River Lagoon and affect the habitat quality for steelhead and tidewater goby. Degrading accumulated Arundo litter can also increase biological oxygen demand in the water, further decreasing water quality for steelhead and tidewater goby. Also, Arundo litter can form dense mats and potentially cover spawning habitat for goby and other fish species if washed downstream (California Invasive Plant Council 2011). Therefore, it is possible for a species to be impacted by Arundo, even if there is not an infestation in its distribution. Cumulative impact scores for species to be affected within the Salinas River watershed are provided in Table 3-19 (Monterey County Water Resources Agency 2014).

The infestation of Arundo has prompted two removal programs in the watershed: the Salinas River Watershed Invasive Non-Native Plant Control Program and the Salinas River SMP. More information on these programs can be found in Section 2.4.2, *MCWRA Partnership Projects and Programs*.

The rich soils and moderate climate of Monterey County have facilitated the colonization and spread of invasive weedy species. Grasslands occur throughout the Salinas River watershed in open areas of valleys and foothills, and these grasslands are often dominated by nonnative annual grasses and forbs. Common nonnative annual grasses include ripgut brome, soft chess, rattail fescue, slender oat, barnyard foxtail, and perennial ryegrass. Although nonnative grasses can outcompete native species, these grasslands also provide habitat for a number of wildlife species, including rodents, reptiles, and birds. Wildlife species that have the potential to occur within the nonnative grasslands include American badger, Monterey ornate shrew, western burrowing owl, California horned lark, California legless lizard, coast horned lizard, white-tailed kite, and pallid bat.

**Table 3-19. Arundo Impacts on Threatened and Endangered Species in the Salinas River Watershed**

| Category | Federal Listing | Scientific Name | Common Name | Impact |
|---|---|---|---|---|
| Mammal | FE | *Vulpes macrotis mutica* | San Joaquin kit fox | Very low impact expected because Arundo is not abundant on the upper Salinas River where San Joaquin kit fox is most likely to occur. |
| Amphibian | FE | *Ambystoma californiense* | California tiger salamander | Very low impact expected as there is little overlap between California tiger salamander and Arundo distributions. |
| Amphibian | FE | *Bufo californicus* | Arroyo toad | High impact expected on arroyo toad habitat, breeding, and diet. |

| Category | Federal Listing | Scientific Name | Common Name | Impact |
|---|---|---|---|---|
| Amphibian | FT | *Rana aurora draytonii* | California red-legged frog | Low impact expected due to moderate overlap in distributions. |
| Fish | FE | *Eucyclogobius newberryi* | Tidewater goby | High impact expected on tidewater goby habitat, breeding, and movement. |
| Fish | FT | *Oncorhynchus mykiss* | Steelhead | High impact expected on ecological needs due to its impacts on water use, channel form, and sediment transport. |

Source: California Invasive Plant Council 2011.
FE = federally listed as endangered; FT = federally listed as threatened

## Invasive Animal Species

Direct and indirect effects of invasive species pose several threats to special-status species in the study area. Barred tiger salamanders (*Ambystoma tigrinum mavortium*) were introduced to California in the Salinas Valley over 50 years ago and now threaten native California tiger salamanders (*Ambystoma californiense*) through hybridization between the two species. Since their introduction, the number and range of hybrid progeny has expanded and may have negatively impacted the populations of native California tiger salamanders (Ryan et al. 2009; see Appendix F for more detail). Another example of the impacts of invasive species is parasitism by invasive brown-headed cowbirds on least Bell's vireo, a federally endangered species. Brown-headed cowbirds lay their eggs into the nests of least Bell's vireo (as well as numerous other species) and often remove and destroy the eggs of the host bird, greatly reducing the reproductive success of the vireo (Sharp and Kus 2006; see Appendix F for more detail).

The expansion of the range and population sizes of urban predators has also impacted special-status species in the study area. Red fox (*Vulpes vulpes*), an introduced species, has become a significant threat to many endangered species as well as other vulnerable native animals. Red foxes are known to present problems for birds that nest in the dunes along the coast as they will feed on the eggs of nesting birds, and they have been identified as a major limiting factor for reproductive success of western snowy plover (Neuman et al. 2004) and California least tern (Jurek 1992). Red foxes are also known to prey upon the smaller San Joaquin kit fox (Ralls and White 1995), as well as compete with them for the limited available prey.

Nonnative species can indirectly impact native species by spreading diseases and parasites. For example, the endangered San Joaquin kit fox has been especially vulnerable to sarcoptic mange, a highly contagious skin disease caused by parasitic mites that is potentially fatal. The outbreak of mange in San Joaquin kit foxes is thought to have first occurred among an urban population of the species living in Bakersfield, California. It is not clear if infected individuals have been observed in the study area, but there is potential for this disease to spread to the area through a number of canid hosts. In addition, parasites and bacteria (e.g., *Toxoplasma gondii*) that are commonly found in cat feces have been linked to sea otter deaths in Central California (Kreuder et al. 2003), with these protozoans often found near locations that discharge urban runoff into the ocean. Sea otters can also be infected by another brain parasite, the protozoan *Sarcocystis neurona,* which is commonly found in the feces of opossums.

## Invasive Aquatic Plant and Animal Species

The presence of nonnative aquatic species, some of which can be highly invasive and difficult to control, are increasingly common in coastal habitats worldwide. Aquatic nuisance species are common throughout the Salinas River Lagoon, especially farther downstream in the watershed where flows are maintained year-round. Invasive aquatic species in the lagoon and other perennial water bodies include water hyacinth (*Eichhornia crassipes*), Brazilian Elodea (*Egeria densa*), Eurasian watermilfoil (*Myriophyllum spicatum*), and hydrilla (*Hydrilla verticillata*), as well as several species of algae. These species, although they vary morphologically, tend to form dense mats at the water's surface that can inhabit movements of other aquatic species. In addition, these species can overtake habitats and outcompete native aquatic plants. Invasive aquatic plants may also be unsuitable for providing shelter, food, and nesting/rearing habitat for native species, including steelhead and tidewater goby. In addition, approximately 40 nonnative species are known to exist in Elkhorn Slough (Denise Duffy and Associates 2016). Elkhorn Slough, which occurs in a small portion of the study area, is indirectly connected to the Salinas River through the Moss Landing Harbor and OSR. Introduced species include terrestrial plants and algae (European dune grass, sea rocket, brown alga), invertebrates (sponges, anemone, snails, mussel, clams), and several species of fish.

Several invasive fish species inhabit the Salinas River and its tributaries. Fisheries monitoring conducted since 2010 in the mainstem Salinas River, Nacimiento River, Arroyo Seco, and Salinas River Lagoon has revealed populations of nonnative common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), golden shiner (*Notemigonus crysoleucas*), bluegill sunfish (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), black crappie (*Pomoxis nigromaculatus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), white bass (*Morone chrysops*), striped bass (*Morone saxatilis*), channel catfish (*Ictalurus punctatus*), white catfish (*Ictalurus catus*), and western mosquitofish (*Gambusia affinis*) (FISHBIO 2014a, 2014b; Hagar Environmental Science 2014). The vast majority of these species are known to either prey upon native species, including juvenile steelhead, or compete with native species for food resources. In general, the most impactful nonnative species, with respect to steelhead and tidewater goby, are large-bodied piscivorous fish including striped bass, largemouth and smallmouth bass, and channel and white catfish. Of these species, striped bass are the most commonly observed and likely present the biggest threat to steelhead given their prevalence in the Salinas River watershed and their propensity to prey upon salmonids (National Marine Fisheries Service 2013). Although predation and nonnative species were identified in the South-Central California Coast Steelhead Recovery Plan (National Marine Fisheries Service 2013) as a high threat in the Salinas, Nacimiento, and San Antonio Rivers and Arroyo Seco, the impacts of nonnative species on naturally reproducing *O. mykiss* are not well known, and the removal of nonnative fish species was not included as a critical recovery action for any of the rivers (National Marine Fisheries Service 2013) (Table 3-20).

Extensive Growth of Floating Aquatic Plants and Algae in the Salinas River Lagoon during October

**Table 3-20. Nonnative Fish Species Observed in the Salinas River Watershed and Its Associated Tributaries**

| Common Name | Scientific Name | Reclamation Ditch System [a] | Old Salinas River[b] | Salinas Lagoon[c] | Salinas River[d] | Nacimiento River[d] | Arroyo Seco[d] |
|---|---|---|---|---|---|---|---|
| American shad | *Alosa sapidissima* | | | | | x | |
| Threadfin shad | *Dorosoma patenense* | | | x | | x | |
| Goldfish | *Carassius auratus* | x | | | x | x | |
| Common carp | *Cyprinus carpio* | x | x | x | x | x | |
| Golden shiner | *Notemigonus chrysoleucas* | x | | | x | x | x |
| Fathead minnow | *Pimephales promelas* | x | | | | | |
| Bullhead | *Ameiurus* sp. | x | | | | | |
| Western mosquitofish | *Gambusia affinis* | x | x | x | x | | |
| Green sunfish | *Lepomis cyanellus* | x | | | x | | x |
| Bluegill sunfish | *Lepomis macrochirus* | x | | | x | x | x |
| Largemouth bass | *Micropterus salmoides* | x | | | x | | |
| Smallmouth bass | *Micropterus dolomieu* | | | | | x | x |
| Striped bass | *Morone saxatilis* | | | x | x | | |
| White bass | *Morone chrysops* | | | | | x | |
| Black crappie | *Pomoxis nigromaculatus* | x | x | | x | x | |
| White catfish | *Ameiurus catus* | | | | | x | |
| Channel catfish | *Ictalurus punctatus* | | | | | x | |
| Inland silverside | *Menidia beryllina* | | | | | x | |
| Yellowfin goby | *Acanthogobius flavimanus* | | | x | | | |

[a] Central Coast Watershed Studies 2006.
[b] Hagar Environmental Science 2001.
[c] Hagar Environmental Science 2014.
[d] Hellmair et al. 2018.

The frequency and intensity of nonnative species invasions and the distribution of nonnative species in the study area will likely be affected by climate change. Changes in species growth, reproduction, and mortality are all expected as a result of climate change. In general, many species are moving towards the poles and up in elevation where temperatures are lower (Parmesan and Yohe 2003); however, shifts in species distribution may be constrained by interactions with other species and surrounding forest cover (Van der Putten et al. 2010, Guo et al. 2018). The effects of climate change on the abundance and distribution of invasive species in the Salinas River watershed are difficult to predict given the uncertainty in climate change scenarios and our understanding of how species will respond to those changes. In general, for plant and vertebrate species, climate change is expected to more frequently contribute to a decrease in species range rather than an increase in overall area occupied. Alternatively, the range of invertebrates and pathogens is expected to increase (Bellard et al. 2018). Invasive species often have short generation times, strong dispersal abilities, and broad environmental tolerances, which allow them to cope with rapid environmental changes. Climate change will lead to range shifts for native species, which may allow invasive species to succeed in environments with abundant resources and relatively few competitors.

#### 3.5.1.4 Changes to the Natural Fire Regime

The duration, frequency, intensity, and timing of wildfires describe a landscape's fire regime, which is a major factor that determines the natural vegetative community composition (Pausas and Keeley 2009). For example, grassland and shrubland communities have historically experienced frequent, small, lightning-induced wildfires, and as a result many plants in these communities have evolved to germinate after fires. Vegetation types that depend on fire, meaning they are fire-prone and fire-adapted, cover over half the surface area of California and more than half of Monterey County. According to the Monterey County Community Wildfire Protection Plan (Monterey Fire Safe Council 2010), fuels such as grass, light brush, grass/woodland, and hardwood litter account for 80.5% of land cover in the county. Within the study area, grassland, shrubland, and forest/woodland make up 81% of the natural communities (Table 3-17). Therefore, changes to natural fire regimes in these land cover types could influence large sections of the study area.

Monterey County has had an active fire history, owing to the topography, vegetation, climatic conditions, and expansion of the wildland-urban interface (Figure 3-34). Some areas of the county are more fire prone than others. Specifically, the western side of the county along the Los Padres National Forest has exhibited the most frequent fires over recorded history (Monterey Fire Safe Council 2010). Based on fire perimeter data from CAL FIRE and U.S. Forest Service, there have been 28 fires greater than 10 acres in size between 1950 and 2000 in the county. These fires ranged in size from the 160-acre Morse-Pebble Beach Fire (1987) to the 173,000-acre Marble-Cone Fire (1977). Notably, the damage from the smaller Morse-Pebble Beach Fire was approximately $18,000,000 because it burned within the wildland-urban interface, destroying 31 homes.

Throughout the study area, there have been numerous fires since 2000 that have together burned approximately 235,951 acres (Table 3-21). Two years (2008 and 2016) experienced particularly large burns, at 141,995 and 59,375 acres, respectively. Although the management area along the Salinas River riparian corridor has experienced fewer fires and less area burned during this time, the management area is composed mostly of the wildland-urban interface.

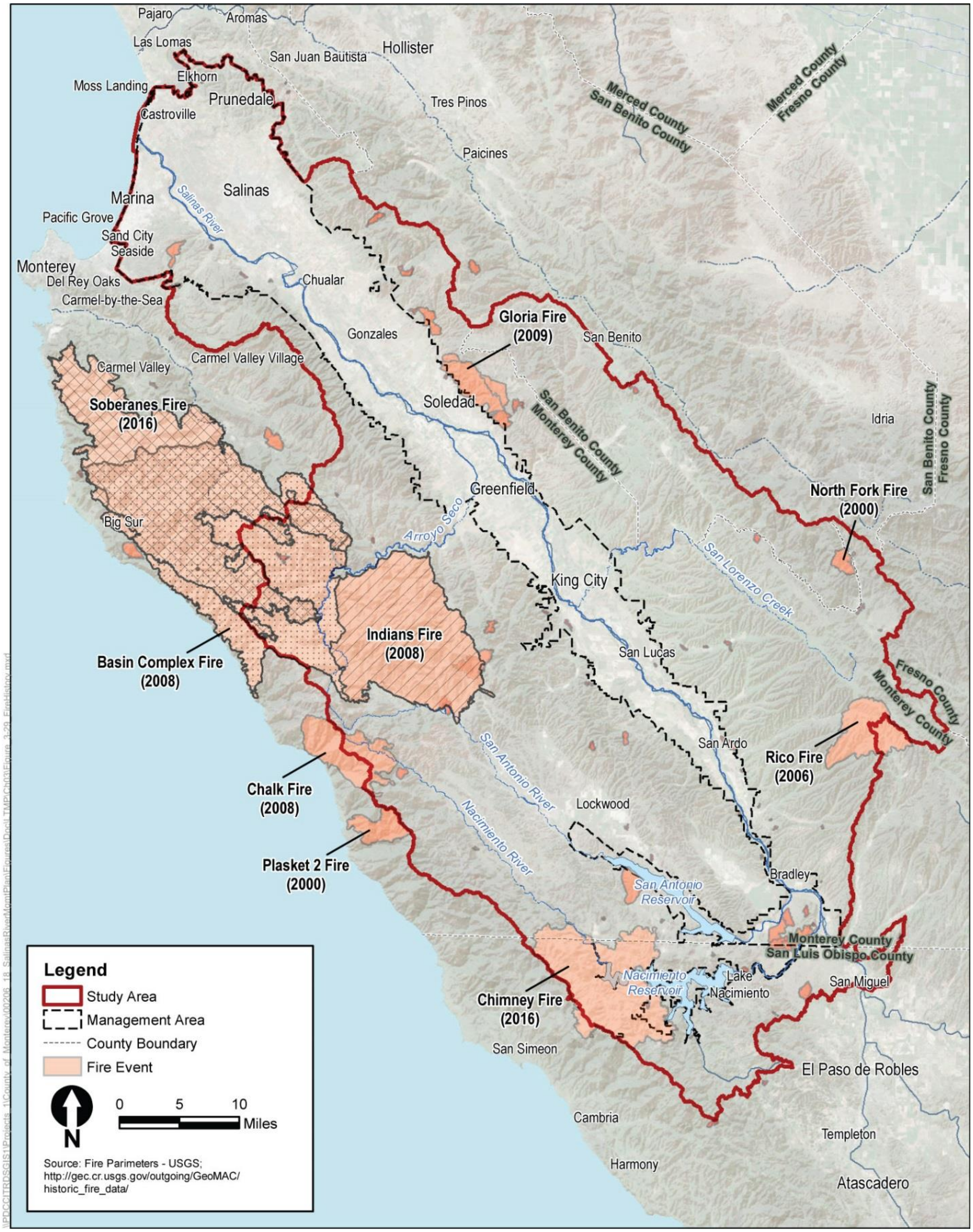



**Figure 3-34. Past Fire Events**

**Table 3-21. Annual Wildfire Burned Area in the LTMP Study and Management Areas from 2000 through 2016**

| Year | Management Area Only (acres) | Study Area Only (acres) | Total |
|---|---|---|---|
| 2000 | 2,747 | 2,811 | 5,558 |
| 2001 | 581 | -- | 581 |
| 2003 | 951 | 744 | 1,695 |
| 2004 | 18 | 1,250 | 1,268 |
| 2005 | 175 | 1,633 | 1,808 |
| 2006 | 17 | 10,998 | 11,015 |
| 2007 | 38 | 87 | 124 |
| 2008 | 102 | 141,995 | 142,096 |
| 2009 | 808 | 14,246 | 15,054 |
| 2010 | 2 | 345 | 348 |
| 2011 | 475 | 1,426 | 1,901 |
| 2012 | -- | 104 | 104 |
| 2013 | -- | 411 | 411 |
| 2014 | -- | 476 | 476 |
| 2015 | 135 | 50 | 185 |
| 2016 | 4,045 | 59,375 | 63,420 |
| **Total** | **10,094** | **235,951** | **246,045** |

A number of factors can lead to an altered fire regime, including climate-induced changes in weather patterns, direct suppression by forestry management practices, or invasive species and pathogens creating increased fuel loads (Hurteau et al. 2014). As discussed in Section 3.5.3, *Changes in Climate*, the projected changes to the Mediterranean climate will be an increase in prolonged droughts, decreased fog, warmer temperatures, and changes to the predominant wind patterns, which together will exacerbate the dry conditions currently experienced during the fire season. Primary changes in fuels come from forestry management practices (particularly fire suppression without active fuel management), invasive plants such as Arundo creating new fuel sources, or tree die-offs either from drought or disease spreading pests. Coupled with an expanding wildland-urban interface, the frequency of large, intense wildfires causing economic damage is likely to increase (Moritz et al. 2012).

The alteration of natural fire regimes is an important ecological stress, particularly in forest and shrub-dominated habitats (California Department of Fish and Wildlife 2015). During the latter part of the twentieth century, policy-driven suppression of fire frequency was implemented for the purposes of protecting natural resources (trees used for lumber, paper, and recreation) and human development in the wildland-urban interface. This has led to many forest types experiencing changes in vegetation structure, in addition to fuel accumulation (Marlon et al. 2012). Fire suppression has led to dense, even-aged forests that lack the complexity that helps reduce fire potential and intensity. In these biological communities the changes to the frequency of fires alter natural successional dynamics.

Invasive species have also altered the natural fire regime. Invasive species are more likely to occur in higher densities, as a result of low competition from native species, and can then become an unnatural fuel source. The lack of habitat complexity associated with invasive-dominated vegetation communities makes these communities more vulnerable to fire. In the Salinas River, Arundo is an invasive species that has increased the potential for wildfire in the riparian community. This is primarily related to two factors: Arundo is highly productive as a fuel source, and stands of Arundo retain significantly higher amounts of dry, dead biomass compared to native woody and herbaceous vegetation types (California Invasive Plant Council 2011). Arundo contains a significant amount of energy and aboveground plant biomass in the form of dry primary and secondary leaves both on the plant and the ground.

After a fire, Arundo begins to immediately (within 2 weeks) grow from its rhizomes whereas native species can remain dormant for months. High mortality of native trees and shrubs is frequent in comparison to Arundo, and, in addition, Arundo grows more quickly (up to 3 or 4 times faster) than native riparian plants. This fire-adapted phenology, in combination with high growth rates and increased nutrient levels after fires, creates an "invasive plant-fire regime cycle" that can hasten the conversion of a mixed-Arundo/native vegetation stand to an Arundo-dominated stand (California Invasive Plant Council 2011).

Increased frequency and severity of droughts are predicted over the next 30 to 90 years (Dai 2013) and will pose multiple challenges to terrestrial and aquatic biota. Increased frequency and intensity of wildfires have been documented during past Holocene warming periods (Pierce et al. 2004). Wildfires can have short- and long-term effects on aquatic species. Short-term negative effects of wildfires include intense temperatures while burning through the riparian corridor, toxicity from flame retardants, and ash and debris sediment flows that reduce dissolved oxygen and cause acute ammonia toxicity. Long-term negative consequences from wildfires can include increased water temperatures from decreased stream shading, increased run-off and flash floods, and reduced woody debris inputs. Although the negative effects of wildfires on stream biota vary due to proximity to wildfires and post-fire precipitation events, many western salmonid populations evolved physiology and behavioral mechanisms to tolerate wildfires. Habitat fragmentation appears to be a principle component in how salmonids respond demographically and genetically to intense wildfires (Neville et al. 2009); the loss of mature, native streamside vegetation as a result of development (i.e., habitat fragmentation) can increase the intensity of fire and thus increase the loss of vegetation and the potential for erosion, both of which can negatively affect the quality of salmonid habitat. In Mediterranean climates, global warming is expected to increase the numbers of fires, but their impacts on the landscape may be mitigated through fire and landscape management (Turco et al. 2014).

### 3.5.2 Altered River Hydrology

Altered river hydrology can lead to changes in flow, water quality, and the sediment deposition and erosion regime (California Department of Fish and Wildlife 2015). These changes can affect the presence and persistence of wildlife in a watershed. For example, reduced flows can affect connectivity between spawning and rearing habitat for steelhead. Reduced groundwater levels can shorten the hydroperiod in rivers that support freshwater fish assemblages such as steelhead and breeding ponds for wetland species such California red-legged frog and California tiger salamander. An altered sediment deposition and erosion regime can reduce the quality of spawning and rearing habitat for steelhead and alter the quality of riparian habitats. This discussion of altered river hydrology as a pressure is separated into two major stressors, altered flow and degraded water quality, each of which is described in detail below.

### 3.5.2.1 Altered Flow

Flows in the Salinas River have been altered substantially by two primary mechanisms, upstream reservoir management and in-stream diversions. Groundwater pumping meets almost all agricultural and municipal water demands in the Salinas Valley with agriculture constituting approximately 90% of the demand. One of the methods for offsetting the decrease in groundwater table elevation due to pumping is to increase the efficiency for groundwater table "recharge" by storing winter flows for release during the dry season. To achieve this goal, MCWRA manages two large dams within the study area—Nacimiento Dam and San Antonio Dam, which create Nacimiento and San Antonio, respectively.

Another method for offsetting groundwater extraction is to divert water off channel for irrigation, alleviating some pressure on the groundwater table. There are two major diversions within the Salinas River basin: one on the Arroyo Seco and one on the Salinas River mainstem (known as the SRDF). The Arroyo Seco diversion takes water during the growing season to supply small-scale agriculture at Clark Colony. Diversions from the Arroyo Seco reduce the extent and duration of wetted stream habitat in the Arroyo Seco as well as limit the number of days the Arroyo Seco is connected to the Salinas, and thus the number of days steelhead migration is possible. The SRDF supplies treated Salinas River water to agricultural users to reduce groundwater pumping and decrease seawater intrusion. The SRDF diverts water released from the reservoirs during the dry season.

The management of reservoir releases and diversions alter historical hydrology in two primary ways: decreasing flows during the wet season and increasing flows during the dry season. These stresses are discussed in the following sections.

#### Decreased Flow during the Wet Season

Winter and spring storms, and associated peak flood velocities, created complex habitat (backwaters, deep holes, undercut banks, log jams), moved sediment downstream, and eroded the river mouth. These flows created connectivity between oceanic, estuarine, and riverine habitats for steelhead in the winter and spring when adult and juvenile migration takes place. The unique life history of steelhead was developed to take advantage of this flow regime. Changes to the flow regime may have altered the timing of sandbar formation and opening, disconnected habitat types, and degraded water quality and quantity in the river and the lagoon. Each of these factors has had negative effects on the steelhead population as well as on other native fish populations.

Minimizing peak flood flows reduces the erosive power of rivers and streams; it is the erosive power of peak flood flows that creates complex habitat (i.e., deep pools, undercut banks, piles of large woody debris) for aquatic species such as steelhead. With fewer and weaker peak flood flows, large boulders and woody debris are moved less frequently, minimizing the amount of new, complex habitat that is created.

Minimizing peak flood flows also reduces the sediment carrying capacity of a river system, a reduction in channel forming processes that provides for habitat features. Reduced flows minimize the amount of fine- and medium-sized sediment particles (clay, silt, and sand) that can be carried downstream, where they can be deposited onto a floodplain. Fine- and medium-sized sediment that remains in the upper watershed can fill in important deep pool habitat and may degrade the quality of run and riffle habitat. Run and riffle habitat is typically composed of large gravel and small- and medium-sized cobbles. These habitat types provide important habitat niches for spawning and primary habitat for aquatic macroinvertebrates, the primary food source for rearing steelhead. Clay, silt, and sand fill the spaces between rocks, prohibiting water flow and oxygen from reaching steelhead eggs, and macroinvertebrate eggs and larvae, which primarily live in these small spaces.

Minimizing peak flood flows also affects sandbar dynamics at the river mouth. Large storm events are needed to move large quantities of sand away from the river mouth where it is stored offshore until wave events bring the sand back ashore. Without the large flow events, less sand is moved offshore, likely resulting in the sandbar forming sooner and persisting longer. The modification of sandbar dynamics can affect connectivity between oceanic and riverine steelhead habitat; if the sandbar is in place for long durations, migrating adults and juveniles have fewer and shorter opportunities to enter or leave the system.

## Increased Flow during the Dry Season

Dams not only affect peak winter flows but also affect flows during the dry season. Historically, flows in the Salinas River and its tributaries in the dry season (summer and fall) have been very low to non-existent. Since the building of the dams, flows that are released during the dry season to maximize groundwater percolation and recharge adversely affect the riparian community, river hydrology, and species habitat. Groundwater pumping and reservoir releases managed to recharge groundwater tables have changed natural flow and dynamics.

Releasing stored water in the summer has the effect of artificially extending the wet season. This results in a prolonged growing season for streamside vegetation and allows for nonnative species like Arundo to become invasive. The prolonged growing season results in not only a loss of water (to plants) that would otherwise be available for downstream use but also to a loss in the stream's ability to convey flood flows through increased constriction. In addition, when reservoir flows are reduced during drought conditions, this vegetation dies back and is transported downstream where it further reduces the flood flow carrying capacity by increasing the stream's "roughness" or resistance to flowing water (i.e., increased constriction). Dry season flows are also subject to greater evapotranspiration rates; smaller amounts of water that move more slowly during warm weather conditions evaporate more quickly, further decreasing available water rates for downstream uses.

Prolonged low flows during the dry season can extend the duration and extent of wetted habitat for aquatic species such as steelhead. However, low reservoir flows are typically warm and hold fine suspended sediments. Small sediment particles, primarily clay and silt, remain suspended for long periods of time within reservoirs. When water is released from reservoirs, these fine sediments settle out of the water column and deposit onto gravels and cobbles, an important habitat niche that supports spawning and the food web for rearing juvenile steelhead. Warmer temperatures also increase the metabolic rates of resident fish. Higher metabolic rates require a greater abundance of food; without additional food to compensate for the metabolic increase, the fish will starve. If water temperatures get high enough to exceed certain physical tolerances, fish will die.

The reduction in habitat complexity and degradation of habitat quality caused by a reduction in peak flows and prolonged low flows may also reduce the number of ecological niches or habitat types within the river. Deep pools and gravel and cobble beds fill with sediment, becoming shallow, sandy habitat types. Complex habitat types such as backwater channels, undercut banks, and large piles of wood debris are formed less frequently. This affects habitat suitability for native freshwater fish species such as the Sacramento sucker, Sacramento perch, and Sacramento blackfish communities. While the suitability for native fish decreases, warmer temperatures improve the suitability for predatory species such as bass and bluegill (which escape from reservoirs where they are often planted for recreational purposes) that prefer or tolerate warmer water. These warm water fish assemblages, once established, can prey upon native species and outcompete them for resources.

### 3.5.2.2 Degraded Water Quality

Decreased river flows and reduced groundwater levels, coupled with the effects of climate change, may result in degraded water quantity and quality (California Department of Fish and Wildlife 2015). River habitat is, on average, shallower, narrower, less complex, and warmer compared to historical conditions. Lagoon habitat has also declined in extent and quality with a decrease in overall surface water elevation, an increase in average salinity, and a decrease in average dissolved oxygen concentrations (Hagar Environmental Science 2015). In addition, inflows from agricultural and urban sources contribute pollutants and nutrients to the river and lagoon systems, causing further degradation.

#### River

Altered river hydrology has the potential to affect water temperature, chemistry, and pollutant/nutrient concentrations and dynamics (California Department of Fish and Wildlife 2015). As discussed above, prolonged low flows created as part of a reservoir release strategy to maximize groundwater recharge results in shallow, warm water that puts additional metabolic pressure on the native cold water fish assemblages and favors predatory, warm water fish assemblages. In the lower parts of the Salinas Valley, runoff and return flows from agricultural and urban sources can deliver chemical fertilizers, pesticides, and other chemicals that can further degrade water quality.

Chemical fertilizers include nitrogen, phosphorus, and other chemical constituents meant to aid in plant production. When these fertilizers enter the river system, they stimulate growth of algae and rooted aquatic plants. Both warmer temperatures and increased nutrient concentrations can increase primary productivity. While plants contribute oxygen to the water column during the daytime, oxygen levels can become depleted at night as animal respiration continues but primary productivity does not. This effect is most severe in low flow or isolated pools that are not receiving enough new, oxygenated water. In these instances, aquatic organisms such as fish are at increased risk for predation, starvation, or suffocation.

Pesticides can be toxic to aquatic species, especially in low flow situations where organisms may experience prolonged exposure times and increased concentrations. Pesticides can cause neurological or physiological complications that impair an organism's overall fitness and make it more vulnerable to predation or disease. In high enough concentrations, pesticides can be lethal to riverine organisms such as macroinvertebrates and fish. Prolonged exposure to pesticides can also alter the aquatic community as some species have higher tolerances for toxicity than others.

#### Lagoon

The Salinas River, like most central California coastal river systems, terminates in a seasonal lagoon. The lagoon forms when the estuary is separated from the ocean by the formation of a sandbar, which forms as a result of seasonal sand deposition onto the beach combined with reduced river outflows. For a typical or average water year, sandbars form across central California coast estuaries in late spring or summer and remain intact until high river flows due to winter rain and wave events breach it. In wet water years, the sandbar may form later in the summer or in the fall, while in dry years the bar may form in the late winter or early spring (Smith pers. comm.). Modification of the river mouth, diking of adjacent wetlands, management of surface water elevation, and the diversion of river inflows also have potential to affect the timing of sandbar formation. The timing of sandbar formation and the quantity and quality of freshwater inflows determine the quality of water in the lagoon (Hagar Environmental Science 2015, Smith pers. comm.).

Historically, the Salinas River Lagoon was a complex of natural dune, scrub, riparian, wetland, and riverine communities (San Francisco Estuary Institute 2009). The river mouth was likely "meandering," with the river mouth moving north and south along the beach in response to oceanic and river processes. In the late nineteenth and early twentieth centuries the Salinas River flowed north, along the dune community, until it joined Elkhorn Slough and opened to the ocean near Moss Landing (San Francisco Estuary Institute 2009). With the construction of Moss Landing Harbor, in addition to agricultural and residential development beginning in the 1950s, the northward connection to the ocean was severed and the river mouth now opens to the ocean in its current position just southwest of the small, unincorporated town of Castroville.

The OSR is now a tidal channel with a 48-inch culvert and slide gate located at the northeast corner of the lagoon. The slide gate allows lagoon water to discharge into the OSR when water surface elevations reach 3 feet (NGVD 29 [4.3 feet NAVD 88]) (Hagar Environmental Science 2005). The slide gate is closed when the river mouth is open and open when the river mouth is closed (H. T. Harvey & Associates 2009). However, the volume of water that can flow through the slide gate is limited by the capacity of the outlet structure and the channel. Capacity in the channel is also limited by tidal influence (from Moss Landing) and flows from other sources, primarily Tembladero Slough (Hagar Environmental Science 2015). These limitations can cause localized flooding and root zone saturation.

When the water surface elevation in the lagoon rises quickly in response to a rain event, the discharge capacity through the slide gate is typically exceeded and water surface elevations can quickly rise to flood levels (6 feet NGVD 29 [8.7 feet NAVD 88] above sea level or greater). To relieve this flooding pressure, MCWRA lowers the sandbar in a small section to alleviate flooding pressure. Typically, once the channel is created and surface water begins to drain, the sandbar erodes and a more natural connection to the ocean is established. However, there are times when outflows are not strong enough to erode the mouth and keep wave-deposited sand from reestablishing the sandbar; in these instances, the mouth closes soon again after artificial opening. Artificial opening can occur anytime between October and June (Hagar Environmental Science 2010a and 2015).

Managing the sandbar and lagoon elevation is made complicated by the presence of rare and special-status species and degraded water quality. The sandbar and beach provide nesting habitat for western snowy plovers and roosting habitat for brown pelicans. The dune and scrub communities provide habitat for northern California legless lizard and Smith's blue butterfly (H. T. Harvey & Associates 2009). The lagoon provides rearing and migratory habitat for steelhead and year-round habitat for the tidewater goby (Hagar Environmental Science 2015). The

Old Salinas River Slide Gate Looking Southwest Toward the Salinas River Lagoon

lagoon is not known to provide suitable breeding habitat for California red-legged frogs due to high flow rates during the winter breeding season and increased salinity levels. However, there is suitable upland habitat adjacent to the southern boundary of the lagoon in the Salinas River National Wildlife Refuge, which is within the Salinas River-Pajaro River Recovery Core Area designated for the species (U.S. Fish and Wildlife Service 2007). In addition, there are occurrences to the north of the lagoon near Prunedale and Elkhorn Slough Reserve. Historically the California red-legged frog occurred in fresh, backwater wetlands surrounding the lagoon and it likely still persists in small patches of habitat upstream of the lagoon.

Another complication is managing water quality in the Salinas River Lagoon. When the sandbar is in place, the quality of water in the lagoon decreases (Central Coast Wetlands Group 2015, Hagar Environmental Science 2015). A halocline forms, with higher salinity and heavier seawater sinking to the bottom layer of the lagoon and a lighter freshwater layer on top. The force of the salinity stratification is strong and can remain in place for some time after artificial sandbar breaching events (Central Coast Watershed Studies 2001). This is likely a result of low energy scouring at the mouth and thus reduced tidal volume; that is, the breach event may not have enough energy to reduce elevations at the mouth such that the typical volume of seawater can enter and exit the lagoon. Because the saltwater layer is not mixing with surface waters it will typically become hypoxic (<5 mg/L dissolved oxygen) or anoxic (< 1 mg/L dissolved oxygen) (Hagar Environmental Science 2015, Central Coast Wetlands Group 2015, Central Coast Watershed Studies 2001) as a result of respiration of benthic organisms.

In addition to hypoxia and anoxia, non-point source agricultural runoff also contributes to poor water quality in the lagoon. Nutrients such as phosphorus and nitrogen are applied to crops to help improve yields, but these nutrients also promote the growth of plankton, filamentous algae, and rooted aquatic vegetation when they enter the watershed as runoff. This excess in nutrients and the subsequent “bloom” in primary productivity is known as *eutrophication*.

In a stratified lagoon system with limited mixing, very little to no tidal interaction, and low freshwater inflows, increased primary productivity can further exacerbate low dissolved oxygen conditions caused by salinity stratification. On sunny days, aquatic plant respiration can saturate the top, fresh layer of water with dissolved oxygen concentrations greater than 15 mg/L (150% saturation) (Hagar Environmental Science 2015, Central Coast Wetlands Group 2015). However, at night, or on foggy or cloudy days when plant respiration is low and animal respiration continues, dissolved oxygen levels can quickly decline, even in the fresh, surface waters. This diurnal fluctuation in surface dissolved oxygen occurs primarily in the late summer and early fall when plant biomass, temperatures, and solar radiation are high (Sloan 2006).

In addition to contributing to swings in surface dissolved oxygen concentrations, the abundant mass of dead plant matter, or dead organic matter, delivered to the benthos also further exacerbates hypoxia and anoxia in the isolated bottom layer. Sulfur-reducing microbes in the sediment consume plant matter and create hydrogen sulfide as a byproduct of anaerobic respiration—a process that garners energy by reducing sulfate, $SO_4^{-2}$, to hydrogen sulfide, $H_2S$. Hydrogen sulfide concentrations in the saline layer increase over time and can reach toxic levels (> 5 mg/L). When the bottom layer is finally mixed with the surface layer, the $H_2S$ quickly oxidizes, further depleting oxygen from the water column (Sloan 2006).

Monitoring of the Salinas River Lagoon illustrates a wide variation in the timing and duration of sandbar formation and of water quality (Monterey County Water Resources Agency unpublished data; Central Coast Wetlands Group 2015; Hagar Environmental Science 2010a, 2010b, 2012, 2013, 2014, 2015). The timing and duration of sandbar closure has been recorded since 1964; dates and duration of closures and openings since 2004 are presented in Table 3-22. Water quality, flow, and fisheries data has been collected in the lagoon for the years between 2009 and 2016; the most recent years reported are summarized in the paragraphs below.

**Table 3-22. Opening and Closing Dates of Sandbar at the Mouth of the Salinas River**

| Water Year | Date Sandbar Open | Date Sandbar Closed | Duration of Lagoon Open to Ocean (days) |
|---|---:|---:|---:|
| 2017/2018 | 3/25/18 | 4/22/18 | 29 |
| 2016/2017 | 1/13/17 | 10/2/17 | 264 |
| 2015/2016 | Lagoon did not open | Lagoon did not open | 0 |
| 2014/2015 | Lagoon did not open | Lagoon did not open | 0 |
| 2013/2014 | Lagoon did not open | Lagoon did not open | 0 |
| 2012/2013 | 12/26/12 | 1/28/13 | 33 |
| 2012/2013 | 12/4/12 | 12/21/12 | 17 |
| 2011/2012 | 4/13/12 | 5/5/12 | 22 |
| 2010/2011 | 4/26/11 | 10/22/11 | 179 |
| 2009/2010 | 6/11/10 | 7/18/10 | 37 |
| 2009/2010 | 5/23/10 | 6/4/10 | 12 |
| 2009/2010 | 1/21/10 | 5/21/10 | 120 |
| 2008/2009 | 6/20/09 | 8/18/09 | 59 |
| 2008/2009 | 3/4/09 | 6/17/09 | 105 |
| 2007/2008 | 5/6/08 | 5/28/08 | 22 |
| 2007/2008 | 1/23/08 | 5/2/08 | 100 |
| 2006/2007 | 1/9/07 | 1/26/07 | 17 |
| 2005/2006 | 1/4/06 | 7/24/06 | 201 |

Source: Monterey County Water Resources Agency 2018b.

Two general lagoon water quality regimes for closed conditions during the summer and fall emerge from the recent data: a strongly stratified system with reasonably extensive bottom water hypoxia and anoxia and a freshwater system with some, but likely much less by volume, bottom water hypoxia and anoxia. Freshwater conversion appears to be related to freshwater inflows after sandbar closure. This was seen in the water quality data from 2013 through 2017. Freshwater flows reached the lagoon all spring, summer, and fall in 2013 such that by the fall, the system had largely converted to freshwater. This was important in the years that proceeded when the sandbar remained closed with no freshwater inflow during the spring, summer, and fall. While warmer temperatures and dissolved oxygen fluctuations were recorded primarily during the summer, steelhead and goby present in the lagoon during these times would have found suitable conditions. If the lagoon had remained stratified during this prolonged closure, the extent of suitable habitat for steelhead would have been limited to the fresh surface water layer. Though this "freshening" of the lagoon could be perceived as positive, the sandbar remaining in place during times of adult and juvenile steelhead migration for multiple years in a row, as occurred between January 2013 and January 2017, most likely has a negative effect on the local steelhead population; however, prolonged closures likely benefit the tidewater goby and local nesting plover populations.

In addition to low dissolved oxygen in lagoon bottom waters and potential barriers to migration caused by the sandbar, chemical loads from non-point sources also pose additional stresses to lagoon and estuary species. In 2004, a report found concentrations of chlorpyrifos and diazinon (commonly used insecticides) above levels that are acutely toxic to aquatic organisms in the lagoon at Del Monte Road. Without the mixing and flushing of the lagoon, these chemicals can persist in plant material and in the sediment for a year or more (though the typical half-life of these chemicals is less) (Kozlowski et al. 2004).

Degraded water quality and sandbar management present different stresses to the special-status species in the lagoon. Roosting sea and shorebirds, like the brown pelican, are likely only temporarily disturbed by the construction equipment used to create the artificial channel. Western snowy plovers breed and nest between March 1 and September 30; artificial sandbar breaches during this time have potential to disturb nesting or injure or kill individuals (particularly nestlings). However, with the careful implementation of precautions and pre-construction measures by MCWRA (Monterey County Water Resources Agency 2018b, 2013) the threats related to sandbar management are considered reasonably low.

Sandbar management and degraded water quality are unlikely to stress dune species like the northern California legless lizard or Smith's blue butterfly. The sandbar, where management activities occur, is a wet, unvegetated strip that does not provide habitat for these two species. Degraded water quality is isolated to bottom waters, and the dune plant community, which is the habitat niche primarily occupied by most dune species, is only likely to experience exposure to the fresh, surface layer of water.

There is no evidence of California red-legged frog presence in the lagoon or surrounding wetlands areas. This is much more likely to be related to the lack of suitable habitat types than it is to sandbar management and degraded water quality. Relative to other Central Coast lagoon systems and the historical condition, Salinas River Lagoon has only a small extent of natural (undeveloped) upland habitat—where the necessary combination of aquatic and terrestrial habitat types to support California red-legged frog could occur—remaining. These patches of potentially suitable habitat are likely too small to support a population of California red-legged frog and are exposed too frequently to flood flows and increased salinity.

In addition to degraded water quality that may be exacerbated by sandbar management, steelhead populations are also likely threatened from the physical presence of the sandbar. The presence of a sandbar between late December and early May has potential to block riverine access for returning adults and oceanic access to out-migrating juveniles. Steelhead have a life cycle adapted to the variable environmental conditions and access to the upper watershed on the Central Coast but because the population has been so greatly reduced, the threat posed by sandbar presence, reduced river inflows, and the resulting degraded water quality could potentially be considerable. As of 2014, recent fish surveys have not found any rearing steelhead in the lagoon (Hagar Environmental Science 2015); however, summer surveys have been hampered by aquatic vegetation. Past surveys have found a total of five steelhead in the lagoon in May, August, and October of 2011, April 2012, and October 2013 (Hagar Environmental Science 2013).

The productivity of a lagoon can lead to increased growth rates and increased fish sizes compared to growth rates in upstream riverine habitats; increased size of juvenile steelhead at the time of ocean entry increases survivability (Bond 2006). Smith (pers. comm.) has found this to be true primarily of well-mixed, freshwater lagoons. The degradation of water quality in the lagoon likely limits productivity of the macro-invertebrate prey base and the extent of suitable rearing habitat (Smith pers. comm.). In addition, sudden mixing of the water column caused by an artificial or natural sandbar event can create temporary, but lethal water quality events that can cause the mortality of organisms in the lagoon, including steelhead (Sloan 2006). Sudden drops in water surface elevation caused by the breach can also strand fish on previously flooded areas, especially where there are physical barriers that prohibit fish from escaping to the lagoon (Hagar Environmental Science 2010a, 2010b). It is not known what contribution toxic chemical exposure makes to the degradation of steelhead populations rearing in the lagoon, but the effects are likely exacerbated with the reduced frequency of mixing events (that can flush and dilute the lagoon) that occur as the result of decreased river inflows.

Tidewater gobies breed and rear on shallow, sandy habitat in Central and Southern California lagoons and estuaries but rely on backwater, low flow habitats to provide overwintering refuge habitat from high flow, riverine events that can sweep gobies out to the ocean where survivability is greatly decreased. Tidewater goby populations have historically persisted in coastal California systems by taking advantage of calm, warm summer lagoon habitats to fuel population explosions (mating pairs are capable of producing multiple, large broods a season) that create enough individuals to increase the potential for overwinter survivability. The presence of calm, backwater habitat that does not experience high flows is also very important for overwinter survival.

The lack of backwater lagoon habitat is likely the greatest factor that currently limits the persistence of tidewater gobies in the Salinas River Lagoon. Before their recent rediscovery in 2013 (Hagar Environmental Science 2005), tidewater gobies had been absent from the Salinas River Lagoon since 1951 (H. T. Harvey & Associates 2009). The recent increase in the frequency of sandbar presence, and the associated calm lagoon waters that provides, has potential to benefit tidewater goby during the breeding season. Tidewater gobies occupy shallow surface waters during calm conditions, so they are less likely to be threatened by hypoxic or anoxic water conditions; also, tidewater gobies have a high tolerance for low dissolved oxygen conditions.

While the presence of the sandbar may benefit breeding gobies in the summer, over the long-term, the opening of the sandbar during winter storm events may allow dispersing individuals from northerly systems to enter the lagoon (and recolonize if the existing population is extirpated). However, even during periods when the sandbar is present, tidewater gobies do have potential to enter the lagoon through the OSR. Also, thick mats of filamentous algae and rooted aquatic plants that occur in the summer and fall (when the sandbar is typically in place) may limit habitat availability for breeding tidewater gobies, and chemical toxicity may increase the potential for direct (acute toxicity) or indirect (e.g., reduced survivability) effects.

Sandbar management that occurs any time between late spring and early fall has potential to threaten the Salinas River Lagoon tidewater goby population. Breaching events during this time period can result in reduced recruitment due to the low tolerance of juvenile tidewater goby to drastic changes in salinity that may result from such an event. In addition, a reduction in surface water elevation could expose tidewater goby nests and injure or kill individuals. This disruption of the summer-time population "explosion" also likely reduces overwintering survivability by limiting the number of individuals produced during the breeding season.

### 3.5.3 Changes in Climate

Climate change will affect ecological communities and wildlife habitat throughout California (California Department of Fish and Wildlife 2015). Significant recent changes to California's environments as a result of climate change have been documented: sea level rise, prolonged drought, natural community shifts, increased prevalence of invasive species, and increased duration and intensity of wildfires. Climate-induced stresses on wildlife, in combination with other known stresses and pressures, have the potential to affect wildlife species and habitat and must be considered when developing management strategies (California Department of Fish and Wildlife 2015). Sea level rise, prolonged drought, and the factors that contribute to drought—decreased rainfall, changes in storm intensity and frequency, and decreases in fog—are discussed in this section; Section 3.5.1, *Changes in Natural Communities*, discusses how invasive species and changes to the duration and intensity of wildfires as stresses other than climate change, such as development and land management, also influence those pressures.

Many global climate change models have been developed over the years to predict potential changes in ocean and land temperature, rain frequency and intensity, coastal wave exposure, and sea level rise (Regional Water Management Group 2013). The Scripps Institute of Oceanography has used a statistical technique called Localized Constructed Analogs (LOCA) to downscale these low-resolution global projections to high-resolution local projections (Pierce et al. 2016). The California Energy Commission Cal-Adapt website (http://cal-adapt.org/) provides access to projections from 10 of the 32 LOCA downscaled global climate models selected for performance in the California/Nevada region. The website allows users to view and download results of these 10 models for a specific area of interest under the two future greenhouse gas concentration scenarios, Representative Concentration Pathway (RCP) 4.5 and RCP 8.5, as well as a historical modeled scenario through the Cal-Adapt Application Programming Interface (API). Under scenario RCP 4.5, greenhouse gas emissions peak around 2040, after which they begin to decline. Under scenario RCP 8.5, emissions continue to rise strongly through 2050 and plateau around 2100.

Climate patterns can have a profound effect on survival and fecundity of various species, particularly for those whose physiology and behaviors are adapted to local environmental conditions (Ficke et al. 2007). These locally adapted traits may vary systematically among populations and include traits such as age, timing of reproduction, and heat and drought tolerance. These traits often have a significant plastic (non-genetic) component, which allows species to respond to environmental change. Yet these traits also differ genetically among populations (Carlson and Seamons 2008). The interaction of plastic and genetic based traits along with the environment has recently been termed *adaptive capacity* and represents the ability of species and biological communities to adapt to changing environmental conditions (Nicotra et al. 2015). However, rapid directional climate change could still drive many populations to decline in abundance, productivity, and even extirpation, if populations do not possess the necessary genetic and plastic trait diversity to adapt.

In many cases, directional climate change exacerbates existing anthropogenic threats. Examples include streams or rivers where stream temperatures are already elevated due to land-use modifications (Battin et al. 2007) or where flow is reduced due to water diversions (Walters et al. 2013). For example, in the Columbia River, dams have altered the hydrological regime by causing an earlier and smaller freshet, which is the same type of effect expected from climate change (Naik and Jay 2011a, 2011b). Any of these stressors in combination with one another or with climate impacts will present pressures of much greater concern than they would individually.

The California State Wildlife Action Plan (2015) identifies "Species of Greatest Conservation Need." Vulnerability to climate change is an important criterion for identifying these species. The following listed species with potential to occur in the Salinas River system were identified as "climate vulnerable": steelhead, tidewater goby, western snowy plover, California red-legged frog, and California legless lizard (California Department of Fish and Wildlife 2015).

Steelhead and other salmonids have been identified as optimal focal species for examining the effects of climate change because they are vital indicators of overall watershed health due to their use of entire river systems throughout their life cycle and the fact that they require clean, cool water year-round (Penrod et al. 2013). Steelhead can also be a key food resource for vertebrate predators and scavengers in some regions, and can have major effects on the productivity, phenology, and metapopulation dynamics of wildlife and regional biodiversity as a whole (Willson and Halupka 1995).

Climate change is expected to affect steelhead populations though a number of common mechanisms, including both direct and indirect effects. The direct effects of temperature and flow regime are expected to result in mortality from heat stress, as well as changes in growth and development rates, disease resistance, and behavior. Behavioral responses from these effects are thought to include shifts in seasonal timing of important life-history events (i.e., adult migration, spawning, fry emergence, and juvenile migration). In addition, movement patterns of juvenile steelhead between upstream tributary reaches and the estuary may also be disrupted by changes in seasonal base flows (Hayes et al. 2011, Boughton et al. 2009). Indirect effects from changes in the freshwater habitat structure and the invertebrate and vertebrate community are expected to result in changes to steelhead growth rates and movement behavior as well as mortality (Crozier et al. 2008).

The sections that follow relate the climate change projections to anticipated pressures within the study area.

#### 3.5.3.1 Sea Level Rise

The most well-known and demonstrable effect of global climate change is the onset of accelerated sea level rise. The overall effect of this phenomenon varies by location depending on a multitude of factors, including the actual rate of sea level elevation rise, the local rates of land subsidence, and the local rates of tectonic uplift. To aid local jurisdictions in preparing and planning for sea level rise, the California Coastal Commission adopted Sea Level Rise Policy Guidance (California Coastal Commission 2015). In accordance with this document, the City of Monterey has adopted the National Research Council's worst case scenario projections for South of Cape Mendocino, 62.6 inches (5.2 feet) of sea level rise between 2010 and 2100, for coastal planning efforts (Revel Coastal 2016). Current tide levels and projected tide levels by 2100 (based on 5.2 feet of projected sea level rise adopted by the City of Monterey) are presented in Table 3-23.

**Table 3-23. Current and Predicted Future Monterey Tidal Elevations**

| | Tidal Elevations (feet NAVD 88) | |
|---|---|---|
| **Tide** | **Current** | **With Sea Level Rise (by 2100)** |
| Mean High Water | 4.78 | 9.98 |
| Mean Tide Level | 3.01 | 8.21 |
| Mean Sea Level | 2.97 | 8.17 |
| Mean Low Water | 1.23 | 6.43 |
| Mean Lower Low Water | 0.14 | 5.34 |

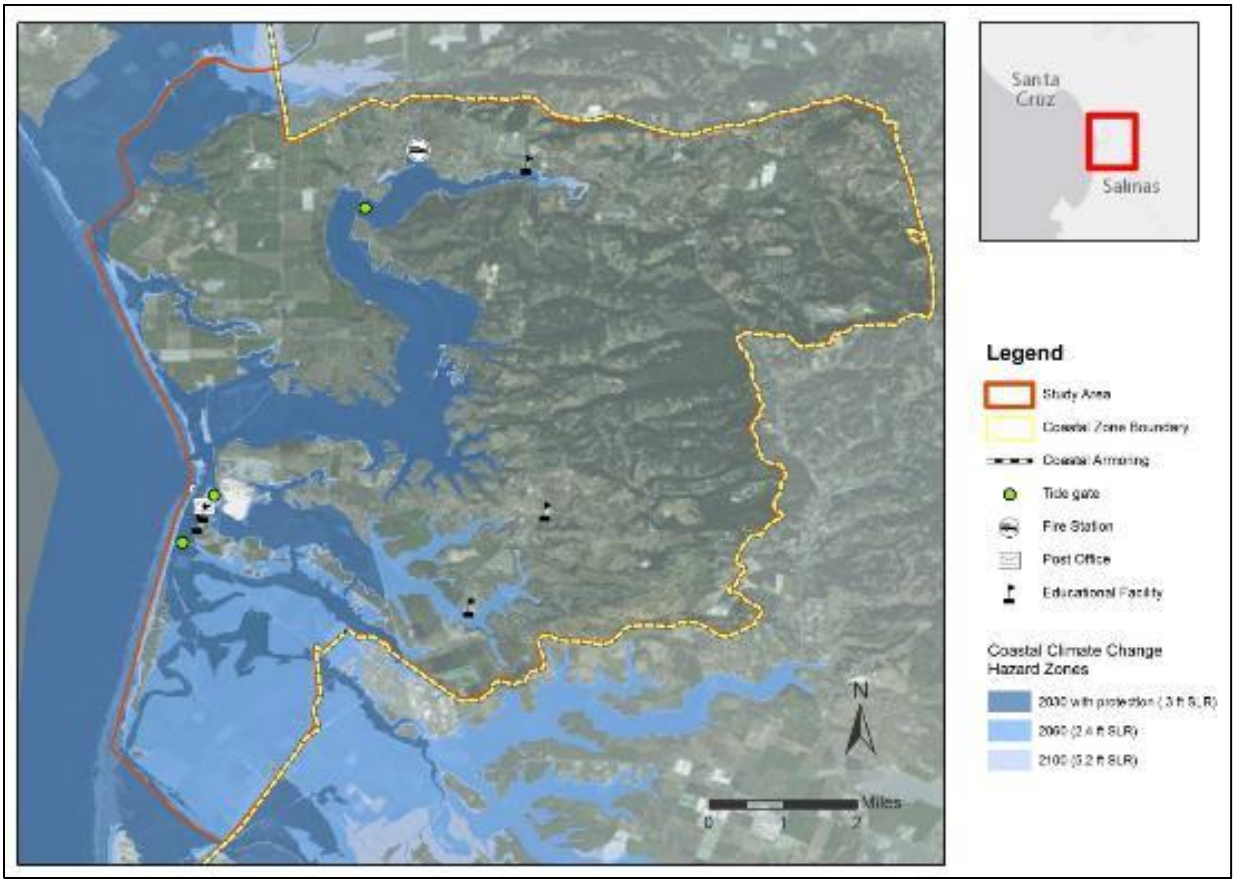
Source: National Oceanic and Atmospheric Administration Tides and Currents datums for station 9413450.

According to a recent assessment of Monterey Bay vulnerabilities to sea level rise, hazards resulting from projected increases in sea level include dune erosion, cliff erosion, coastal flooding, wave run-up, tidal inundation, and storm erosion (Environmental Science Associates and Pacific Watershed Associates 2014, Central Coast Wetlands Group 2017). Under natural conditions, the breaching dynamics of the Salinas River Lagoon are seasonally controlled by two opposing forces—ocean waves that build up the sandy beach, causing lagoon closure and filling during the summer/fall, and river flow that breaches the lagoon berm during the winter/spring allowing impounded water to flow into the ocean. As sea level continues to rise and sediment supplies remain consistent with existing conditions, a commensurate rise in beach berm elevation would be expected (Environmental Science Associates and Pacific Watershed Associates 2014). This means the maximum flood elevation in the closed lagoon would be expected to rise at the same rate as sea level, increasing flooding under natural conditions (Environmental Science Associates and Pacific Watershed Associates 2014). However, water surface elevations in the Salinas River Lagoon are managed by MCWRA to limit flooding of adjacent agricultural lands and homes once the lagoon water surface elevation reaches 6 feet NGVD 29 (8.7 feet NAVD 88)(Monterey County Water Resources Agency and Hagar Environmental Science 2015). Taking into account the sea level rise predictions, more material would need to be excavated from the sandbar to drain the lagoon and maintain the existing level of protection to adjacent lands.

Expected sea level rise may result in more frequent breaching of the sandbar at the mouth of the Salinas River, potentially increasing connectivity for steelhead between the Salinas River and the ocean (Rich and Keller 2011, Jacobs et al. 2010). Habitat conditions for tidewater goby in the lagoon may decline with sea level rise, as the lagoon becomes more brackish and breaches more frequent, two factors that are known to lead to unfavorable habitat conditions for tidewater goby (Hellmair et al. 2014). In addition, the brackish zone preferred by the tidewater goby has been modified in the Salinas River by human-created barriers (e.g., dikes and levees). As a result, the water in the lagoon tends to be saltier than it would be in the absence of these barriers because of reduced freshwater inflow, increased evaporation, opening of the barrier sandbar to the ocean, and saltwater intrusion. The net result is a narrowing of the low-salinity zone of the lagoon, which is expected to increase as ocean levels rise (Swift et al. 1989, Ferren et al. 1995). Information on the economic and social consequences of sea level rise is presented in Section R of the Greater Monterey Integrated Regional Water Management Plan (Regional Water Management Group 2013).

Projected impacts from coastal flooding (wave overtopping dunes and levees causing inland flooding) demonstrate the dire vulnerabilities that agricultural lands, Moss Landing's coastline, and the surrounding area face in the future (Figure 3-35). By 2100 several portions of the protective dunes complex are projected to no longer restrict ocean waves, leading to significant flooding within the lower Salinas Valley (Central Coast Wetlands Group 2017). The long-term preservation of the Salinas State Beach dunes complex and the effective restriction of storm surge inland of Potrero Road are critical to the future viability of the southern Moss Landing region. The potential for inward migration of these dunes is likely but will come in conflict with present land use of those properties.

The Central Coast Wetlands Group report (2017) notes that by 2060 erosion of the dunes near Potrero Road and near the Salinas River mouth are at risk of wave overtopping during storms, leading to ocean waves flowing into the OSR, bypassing the coastal flood protections provided by the tide gates and flood control structures at the lagoon.




Source: Central Coast Wetlands Group 2017.

**Figure 3-35. Coastal Climate Change Hazards in the Coastal Zone**

### 3.5.3.2 Prolonged Drought

According to DWR (2015), climate change is expected to lead to more frequent and extended droughts. Droughts would increase stress on water demand, which could impact both groundwater and surface water supplies (Monterey County Water Resources Agency 2014).

Increased frequency and severity of droughts are predicted over the next 30 to 90 years (Dai 2013) and will pose multiple challenges to terrestrial and aquatic biota. Increased frequency and intensity of wildfires has been documented during past Holocene warming periods (Pierce et al. 2004). Wildfires can have short-term and long-term effects on aquatic species. Short-term negative effects of wildfires include intense temperatures while burning through the riparian corridor, toxicity from flame retardants, and ash and debris sediment flows that reduced dissolved oxygen and cause acute ammonia toxicity. Long-term negative consequences from wildfires can include increased water temperatures from decreased stream shading, increased run-off and flash floods, and reduced woody debris inputs. Although the negative effects of wildfires vary due to proximity to wildfires and post-fire precipitation events, many western salmonid populations evolved physiology and behaviors mechanisms to tolerate wildfires. Habitat fragmentation appears to be a principle component in how salmonids respond demographically and genetically to intense wildfires (Neville et al. 2009). In Mediterranean climates, global warming is expected to increase the numbers of fires, but their impacts on the landscape may be mitigated through fire and landscape management (Turco et al. 2014).

The physical effects of drought on aquatic species include reduced flows and increased water temperatures. In addition to reducing the number of days of migration flows, drought impacts may result in more frequent and prolonged closures of the Salinas River mouth (Rich and Keller 2011, Jacobs et al. 2010). Delayed or prolonged river closures have limited the upstream migration of adults and the downstream emigration of juveniles or adults salmonids; low flows may have also interrupted the natural periodic movement of sub-adults between the estuary and the ocean. Additionally, if smolts migrate at a smaller size because they leave freshwater habitat earlier, they might have lower ocean survival due to size-selective predation (Thompson and Beauchamp 2014). Marine arrival timing has been historically synchronized with the timing and predictability of favorable ocean conditions (Spence and Hall 2010). Extended droughts have, in part, been attributed to the Pacific Decadal Oscillation and Atlantic Decadal Oscillation, which has been a key factor of ocean survival for California salmonids (Lindley et al. 2009). Given the uncertain effects of climate change on upwelling timing and intensity, impacts on juvenile survival from shifts in migration timing are also difficult to predict.

Both freshwater and marine productivity tend to be lower in warmer years for most populations of steelhead. These trends suggest that the Salinas River watershed sub-population might decline as mean temperature rises. According to Boughton (2010), the Interior South-Central California Coast steelhead biogeographic population group will likely be more vulnerable to climatic changes as a result of increased ambient temperatures and less predictable rainfall patterns. However, the persistence of many southern populations is reason for optimism and warrants considerable effort to restore the natural climate resilience and adaptive capacity of these species. The South-Central California Coast Steelhead Recovery Plan recognizes the broad spatial extent of droughts and the inherent difficulty in predicting habitat response to climate changes. Therefore, it takes a precautionary role in protecting key biological parameters needed to ensure long-term resilience of the population through four key principles.

1. Expand opportunities for fish to exploit a wide variety of habitats.
2. Maximize connectivity within and between habitats.
3. Promote the evolutionary potential of populations and metapopulations by restoring natural diversity of habitat types that support a wide diversity of life history expressions.
4. Maintain the capacity to detect and respond sustainably to ecosystem changes as they occur.

### 3.5.3.3 Changes in Average Rainfall

On average, the climate model projections anticipate drier conditions in Southern California and wetter conditions in Northern California, but little change in total annual precipitation statewide (California Department of Water Resources 2015, California Energy Commission 2018). However, local changes in precipitation are more difficult to predict (Regional Water Management Group 2013). According to the California Energy Commission Cal-Adapt website, possible increases in mean annual precipitation ranging from 0.3 to 5 inches might be expected for the Greater Monterey County Integrated Regional Water Management Region by 2100 when considering the high emissions scenario (RCP 8.5) for three out of four models selected by California state agencies as “priority models for research contributing to California’s Fourth Climate Change Assessment” (California Energy Commission 2018). The fourth model (MIROC5) predicts a decrease of approximately 2 inches in mean annual precipitation by 2100. On an average basis, increases in mean precipitation would increase surface water and groundwater supplies. Decreases in mean precipitation would reduce surface water and groundwater supplies.

Numerous climate model projections point to increased frequency of extreme weather events as a result of increasing greenhouse gasses (Stenseth et al. 2003, Kelly and Gore 2008. Mantua et al. 1997). The extreme droughts punctuated by extreme wet years experienced in California during the last decade suggests weather patterns are already transitioning to a "new normal"; however, there is uncertainty in what the "new normal" is expected to look like. Under a low emissions scenario, climate models are predicting about 10% loss of precipitation for the state of California (Cayan et al. 2009, 2006). Yet, these models have shown sensitivity to underlying model assumptions suggesting that both outcomes of a drier or wetter future are possible. This is because California is geographically located in a transition zone between regions that are predicted to experience a net increase and regions that will experience a net loss of water availability (Hayhoe et al. 2004).

According to the U.S. Environmental Protection Agency (1997), it is anticipated that temperatures in California could increase by about 5°F (with a range of 2–9°F) in the winter and summer and slightly less in the spring and fall by 2100. The Salinas River is a precipitation-driven system and it is anticipated that overall precipitation may decrease (Model MIROC5). However, there could be an increase in the number of long wet spells, along with a corresponding increase in storm events and potential flooding. If a decrease in precipitation persists, these conditions are anticipated to truncate the period of time that suitable cool temperatures occur in the system below existing reservoirs and dams. Without the necessary cold-water pool, late summer and fall temperatures below reservoirs may rise above thermal tolerances for juvenile steelhead that rear below the dam over the summer and fall periods. In addition, the period of aquatic connectivity between various habitats in the watershed is expected to decrease because of reduced runoff and higher temperatures.

The combined effects of reduced connectivity and higher temperatures in the Salinas River would truncate the available migration window for both juveniles and adult steelhead, which will affect the timing of smolt migrations and spawning (Crozier and Hutchings 2014, Hayes et al. 2014). Below normal precipitation and reduced runoff would adversely affect aquatic habitats for steelhead in the following ways: (1) depleted groundwater tables, which provide base flows that support critical over-summering habitat for rearing *O. mykiss*; (2) reduced hydrological connectivity between seasonally wet and dry stream sections in intermittent streams; (3) restricted instream movement of rearing *O. mykiss*; and (4) reduced frequency and shorter duration of connectivity to the ocean, affecting water quality, and limiting both the upstream migration of adult *O. mykiss* and the downstream emigration of juveniles and kelts. Riparian habitat may also be adversely affected by the reduction in groundwater levels and the reduction of surface flows, affecting water temperatures and food availability.

### 3.5.3.4 Changes in Storm Intensity and Frequency

There is a general consensus among climate scientists that precipitation patterns (including the intensity and frequency of storms) will change, but there is less agreement regarding the nature of those changes (Regional Water Management Group 2013). According to DWR (2015), climate change can be expected to bring more extreme precipitation events to California with extended, more frequent droughts and more intense rainfall events. In the study area, the effect could be an increase in downstream flooding potential if the water resources infrastructure is unable to capture the increased flow resulting from the higher intensity rainfall events.

Broad-scale climatic factors, such as summer air temperatures, annual precipitation, and severity of winter storms influence the distribution of *O. mykiss* in the region (National Marine Fisheries Service 2013). The severity of winter storms dictates the severity of high flow events, which in turn influence the distribution and extent of instream steelhead habitat. Depending on changes in land-use practices and fire regime, increased storm severity has the potential to alter the geo-fluvial processes including scouring and deposition that maintain steelhead spawning and rearing habitat. The integrity and extent of riparian area will play a key role in moderating the effects of more frequent, intense storms. Unimpacted riparian areas can prevent scouring and erosive forces from degrading spawning substrate while producing large-woody debris that helps to form habitat complexity. Riparian and wetland areas can also act as a filter to prevent run-off from depositing large quantities of fine sediments into streams. This can be particularly important following a wildfire for preventing ash and debris-laden floods, which can cause fish kills (Dunham et al. 2003, Whitney et al. 2015).

Changes to the winter storm regime may also have an effect on species inhabiting the lagoon. Increasing storm severity could result in increased frequency of breaching the Salinas River Lagoon. However, precipitation events will be less predictable, thus flows to the lagoon could become less consistent and predictable. Depending on the timing of lagoon breaches and steelhead response to warming temperatures, there could be a mismatch between when salmon migrate to spawning habitat and connectedness of the lagoon to the bay. On the other hand, increased frequency of breaching could increase connectivity for migrating steelhead. In addition to the effects on connectedness, lagoon resident species will experience more frequent fluctuations in water quality parameters such as temperature and salinity as a result of increased breaching and increased surface run-off.

### 3.5.3.5 Change in Summer Fog

Research conducted by various universities and climate scientists suggests that periods of summertime fog along parts of the California coast have declined significantly over the past century, and climate change may be a contributing factor (Johnstone and Dawson 2010, Regional Water Management Group 2013). Coastal fog occurs primarily in the summer months and plays an important role in preventing evaporation and maintaining cooler temperatures (Regional Water Management Group 2013). Warmer temperatures with increased summer evaporation may lead to an increase in agricultural and landscape water use in the region, putting increased demand on both groundwater and surface water supplies (Regional Water Management Group 2013).

Regional climate projections for the South-Central California watersheds suggest a future of longer, hotter summers, with a potentially higher incidence of fog along the immediate coastline. These projections also suggest more extreme heat waves and droughts, but with perhaps more intense precipitation events in some areas (Karl et al. 2009, Cayan et al. 2008, Snyder and Sloan 2005). However, fog is expected to decrease in inland areas as a result of climate change, which may affect Salinas River watershed species in a variety of ways. Changes in fog frequency and related climate variables may have important implications for plant physiology and ecosystem function. A decrease in the frequency and persistence of fog increases transpiration rates (the rate at which water is lost from a plant), which reduces a plant's ability to conserve water.

The most likely effect of fog decline in inland areas is increased drought sensitivity for native plant species (Fischer et al. 2009). Fog is a dominant climatic factor on the California coastal region, and long-term reductions inland will likely continue to impact the physiology and growth of coastal endemic species. Several kinds of coastal forest, shrub, and desert ecosystems are strongly associated with coastal marine fog. For example, maritime chaparral is a rare vegetation community in California that is dependent on fog (Vasey et al. 2012). In addition, coastal redwoods and 80% of their understory species—including swordferns, California bay, and Douglas-fir—have evolved to move water from coastal moisture directly into their tissues through leaf pores and surfaces using direct foliar uptake (Limm, et al. 2009). These vegetation communities, and the fauna that are associated with them, are expected to decline with the predicted decrease in fog in inland areas.