Section 2

Central Valley Region

The project area includes all water bodies (surface water and groundwater) within the Central Valley Region. This region encompasses about 40% of the land in California and stretches from the Oregon border to the near Kern County/Los Angeles County line. It is bounded by the Sierra Nevada Mountains on the east and the Coast Range on the west. The Region is divided into three basins (the Sacramento River Basin, the San Joaquin River Basin, and the Tulare Lake Basin), as described in the Basin Plans. This section provides an overview of the physical setting of the Central Valley including the hydrologic and hydrogeologic characteristics of the region.

2.1 Overview

Of California’s nine Regional Water Quality Control Boards (Regional Water Boards), the geographical area under the jurisdiction of the Central Valley Water Board is the largest and most diverse; stretching from the Oregon border to the northern tip of Los Angeles County. In fact, the region contains about 60,000 square miles or almost 40% of the state (Central Valley Water Board 2010b). Four distinct hydrologic regions comprise the Central Valley (Figure 2-1):

- The northern third of the valley falls within the Sacramento River Hydrologic Region and is referred to as the Sacramento Valley.

- The southern two-thirds of the valley is referred to as the San Joaquin Valley, which contains two regions:
  - The San Joaquin River Hydrologic Region in the north.
  - The Tulare Lake Hydrologic Region in the south.

- The fourth region is the Sacramento-San Joaquin Delta, which receives flows from both the Sacramento and San Joaquin Hydrologic Regions and redistributes flows throughout the state via the Federal and State Water Projects.

As shown in Figure 2-1 (and Figure 1-2) surface water from the San Joaquin and Sacramento River Valley’s connects in the Delta where the combined flows of the Sacramento and San Joaquin River basins flow either to the San Francisco Bay and exits to the Pacific Ocean or is diverted into state and federal water projects. Surface water from the Tulare Lake Hydrologic Region only drains north into the San Joaquin River in years of extreme rainfall, essentially making it a closed basin without natural surface water outlets.

The Central Valley, with over 7 million acres of irrigated agricultural land (2010), is one of the world’s most productive agricultural regions (DWR 2013a). In addition, numerous mountain-fed waterways provide crucial habitat for fish and waterfowl. As of 2010, the population in the valley was roughly 7.4 million and is estimated to increase to 12.5 million people by the year 2050 (DWR 2013a). Salts and nitrates greatly impact the economy of the region and are estimated to
cost valley residents $544 million annually for treatment and lost production (DWR 2013a). An economic study focused specifically on salt impacts projected that if current management continued, direct annual costs would exceed $1.5-billion in the Central Valley by 2030 (Howitt et al. 2009). In an area with increased competition between diverse water demands, the beneficial uses of Central Valley water are dependent upon the sustainable management of the region’s limited water resources, including water quality.
2.2 Beneficial Uses and Water Quality Objectives

As stated earlier, two Water Quality Control Plans (Basin Plans) have been developed for the Central Valley:

- Sacramento River and San Joaquin River (SRSJR) Basin Plan (Central Valley Water Board 1998); and
- Tulare Lake Basin (TLB) Basin Plan (Central Valley Water Board 2015).

A separate document, the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Quality Control Plan, covers the San Francisco Bay and Sacramento-San Joaquin Delta and was developed by the State Water Resources Control Board since it covers areas within two Regional Water Boards. The Central Valley Water Board implements components related to water quality in the Delta (State Water Board 2006). For the purposes of the SNMP and the characterization of Central Valley, the primary focus will be on the Sacramento River Hydrologic Region, the San Joaquin River Hydrologic Region, and the Tulare Lake Hydrologic Region.

The California Water Code defines beneficial uses to include, but not be limited to, "...domestic, municipal, agricultural and industrial supply, power generation, recreation, aesthetic enjoyment, navigation, and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves." The protection and enhancement of existing and potential beneficial uses are recognized as primary goals of water quality planning in both Basin Plans.

The Basin Plans identify some surface waters and groundwater basins by name, while others are not specifically identified. Named water bodies are assigned beneficial uses. For water bodies not specifically identified, beneficial uses are either assigned under generally-applicable designations that purport to cover all waterbodies, e.g. MUN, or are assigned beneficial uses on the basis of downstream designations. Table II-1 in each of the Basin Plans identifies surface waters with assigned beneficial uses. The TLB Basin Plan (Table II-2) identifies groundwater basins with assigned existing beneficial uses. Specific groundwater basins have not been identified in the SRSJR Basin Plan; instead, selected beneficial uses apply to all ground waters covered by this Basin Plan.

Studies conducted under CV-SALTS determined that the beneficial uses most sensitive to salt and nitrate were MUN and Agricultural Supply (AGR) (e.g., LWA et al. 2014). The Basin Plans define these uses as follows:

- MUN - "Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply."^2
- AGR - "Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing."^3

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1 California Water Code §13050(f).
2 See Chapter II of the SRSJR and TLB Basin Plans. Note that the Tulare Lake Basin Plan does not include
In the Basin Plans, the Board has made generally-applicable designations that presumptively assign the MUN beneficial use to all waterbodies (with the exception of those waters that the Board had already specifically identified as not supporting the MUN use). Though exception criteria are contained in the Sources of Drinking Water Policy (State Water Board Policy 88-63), these exceptions must be implemented through a Basin Plan amendment.

The SRSJR and TLB Basin Plans consider AGR to be a presumptive beneficial use applicable to all waters. Specifically, “Unless otherwise designated by the Regional Water Board, all ground waters of the Region are considered suitable or potentially suitable, at a minimum, for agricultural supply…” The Basin Plans establish criteria for making exceptions to the presumptive application of the AGR beneficial use. Of relevance to salt management is the potential application of the following exception: “there is pollution, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for agricultural use using either BMPs [Best Management Practices] or best economically achievable treatment practices.”

### 2.2.1 MUN Water Quality Objectives

The Basin Plans include the following water quality objective to protect the MUN beneficial use:

> “At a minimum, waters designated for domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in the following provisions of Title-22 of the California Code of Regulations which are incorporated by reference into this plan…”

The existing nitrate water quality objective for the protection of drinking water supplies in the Central Valley is 10 mg/L (nitrate measured as nitrogen). This SNMP reaffirms that objective for the protection of any waterbody used as a drinking water supply.

For salinity, implementation of this SNMP is based on ensuring protection within a range of TDS or EC concentrations established in 22 California Code of Regulations (CCR) Table 64449-B (“Secondary Maximum Contaminant Levels [SMCL] Ranges”) and incorporated by reference into the Basin Plans as part of the Chemical Constituent water quality objectives. The 22 CCR Table 64449-B specifies a range of potentially applicable SMCLs expressed as either total dissolved solids (TDS) or electrical conductivity (EC): Recommended, Upper, and Short Term. The TDS or EC concentrations applicable to these three categories are 500 mg/L, 1,000 mg/L and 1,500 mg/L respectively for TDS or 900, 1600, 2200 µmhos/cm respectively for EC.
2.2.2 AGR Water Quality Objectives

No numeric water quality objective has been established for nitrate to protect the AGR beneficial use; this SNMP does not change this finding. The narrative objective for Chemical Constituents (Water shall not contain chemical constituents in concentrations that adversely affect beneficial uses...) applies and is interpreted based on scientifically valid criteria.

The Central Valley Basin Plans do not establish explicit numeric water quality objectives for salinity in groundwater for the protection of the AGR beneficial use. Instead, the Basin Plan relies on the same narrative water quality objective for chemical constituents to protect AGR and the same process for interpretation.

2.3 Physical Description

The entirety of the Central Valley region spans approximately 500 miles in length and is approximately 125 miles wide. The valley floor is approximately 40-60 miles wide, 450 miles long, and is bounded by the Cascade and Trinity Mountains to the north, the Sierra Nevada mountain range to the east, the Tehachapi Mountains to the south, and the Coastal mountain ranges and San Francisco Bay to the west (see Figure 2-1). The valley’s fertile soils are the result of millions of years of alluvial and fluvial deposits from the bordering mountain ranges. As a result, the valley floor is close to sea level with the exception of the Sutter Buttes in the Sacramento Valley. Each hydrologic region is further described below:

- **Sacramento River Hydrologic Region** - This region is approximately 27,200 square miles and covers the majority of northern California (DWR 2013a). The area is located between the Sierra Nevada and Cascade Range in the east, and the Coast Range and Klamath Mountains in the west. The southern boundary roughly follows U.S. Highway 50 to the City of Sacramento where the American River meets the Sacramento River, and the northern portion extends into the southern portion of Oregon. From its source waters in the Cascade Range, the Sacramento River flows 400 miles south to meet the San Joaquin River, forming the Sacramento-San Joaquin Delta before exiting west to the Pacific Ocean. The main tributary rivers of the Sacramento River include the Pit, Feather, Yuba, Bear and American Rivers to the east; and Cottonwood, Stony, Cache and Putah Creeks to the west.

- **San Joaquin River Hydrologic Region** - This region is approximately 15,200 square miles and is located between the Sacramento River Hydrologic Region to the north, and the Tulare Lake Hydrologic Region to the south (DWR 2013b). The watershed is bordered on the east by the Sierra Nevada and on the west by the Coast Range mountains. The San Joaquin River begins in the high Sierra Nevada and historically flowed approximately 100 miles to the west then turned north flowing for 260 miles where it joined the Sacramento River to form the Delta. By 1951 and the completion of the Central Valley project, San Joaquin River flows were captured at Friant Dam and diverted south into the Tulare Lake Basin. The portion of the river between Friant Dam and Sack Dam (approximately 85 miles) routinely dries out during much of the year. Continuous flows return for the final 60-miles of river, from Lander Avenue to the Delta and are comprised of ephemeral flows from the Coast Range, fresh water flows from the Sierra Nevada, and agricultural drainage. Main tributary rivers of the San Joaquin River include the Cosumnes, Mokelumne, Calaveras,
Stanislaus, Tuolumne, and Merced to the east and during rare flood years, the Chowchilla, and Fresno Rivers to the southeast.

- **Tulare Lake Hydrologic Region** – This region is approximately 17,000 square miles and is located to the south of the San Joaquin River Hydrologic Region and is bordered on the east by the Sierra Nevada, on the south by the Tehachapi Range and on the west by the Coast Range (DWR 2013c). Surface water from the Tulare Lake Hydrologic Region only drains north into the San Joaquin River in years of extreme rainfall. In general, rivers that drain the Tulare Hydrologic Region do not have a natural surface water pathway out of the watershed; instead, water moves in and out of the Tulare Lake Hydrologic Region by precipitation, evaporation, and/or water diversions through canals. Major rivers in the region include the Kings River, Kaweah River, Tule River and Kern River which historically drained to the center of the basin forming Tulare Lake.

Hydrology within the Central Valley has been highly modified with the Cosumnes River, the only major water body without regulated flow releases. Most river systems have regulating dams to capture snowmelt and meter release to protect against flood and provide stable water supply. Modifications and resulting impacts on salt loads are discussed in more detail in Section 3.

### 2.3.1 Climate

Although the Central Valley is generally characterized by a Mediterranean climate, there is significant variation at various latitudes. Summers are long, hot, and dry throughout the region. On the valley floor, roughly 85% of annual precipitation falls during November through April, with half of it falling in December through February in average years (Figure 2-2) (Faunt et al. 2009).

- **Sacramento River Hydrologic Region** – Precipitation generally decreases from north to south. The mountain regions to the north and the east experience cold, wet winters, with most precipitation falling as snow. The northermmost area is dominated by a high desert plateau and also receives the majority of precipitation as snow. Precipitation on the valley floor varies from an annual average of 33 inches in Redding to 17 inches in Sacramento.

- **San Joaquin River Hydrologic Region** – Precipitation generally decreases from north to south with annual average ranging from 17 inches in Lodi to 11 inches in Madera. Although the Coast Ranges tend to prevent marine temperature effects, the northern portion of the valley receives a Delta breeze, decreasing temperatures during summer evenings. The southern portion of the region does not tend to experience this cooling effect.

- **Tulare Lake Hydrologic Region** – This area experiences scarce amounts of precipitation, ranging from an annual average of 11 inches in Fresno, to 6 inches in Bakersfield. Temperatures on the valley floor are usually mild during the winter months; however, heavy frost occurs during most years, and during cold spells, the air temperature occasionally drops below freezing.
What do you mean by “inflow”? Unimpeded?****
2.3.2 Land Cover and Land Uses

Land use throughout the Central Valley is primarily dominated by agricultural uses and open space, with scattered urban areas.

- **Sacramento River Hydrologic Region** – Of the region’s 27,200 square miles, 11 percent (about 1.97 million acres) is occupied by irrigated agriculture. Crop type varies by location within the region; main crops on the valley floor include rice, walnuts, almonds/pistachios, pasture, alfalfa and grain. Of the region’s 1.97 million acres of irrigated agriculture, roughly 1.58 million acres are located on the valley floor and approximately 370,000 irrigated acres are located in the surrounding mountain valleys which is primarily pasture and alfalfa (DWR, 2013a). In 2010, the population of the region was 2.93 million. Main cities include Sacramento, Roseville and Redding. Cities and towns north of Sacramento are located in predominantly agricultural areas [Faunt et al. 2009].

- **San Joaquin River Hydrologic Region** – Of the region’s 15,200 square miles, 22 percent (about 2.17 million acres) is occupied by irrigated agriculture. Main crops grown in the region include almonds, corn, alfalfa, grapes and processing tomatoes. In 2010, the population of the region was 2.10 million. Main cities include Stockton, Modesto, and Antioch. Urban developments have increased in size over the last two decades, expanding onto the surrounding agricultural lands. Although the valley floor is mostly privately owned agricultural land, much of the Sierra Nevada is national forest and government-owned public lands. National forest and park lands include more than 2.9 million acres while the United States Bureau of Land Management occupies more than 200,000 acres (DWR, 2013b). The region contains roughly 3.5 million acres of valley floor, 5.8 million acres of mountains and eastern foothills, and 900,000 acres of coastal mountains (DWR 2013b).

- **Tulare Lake Hydrologic Region** – Of the region’s 17,000 square miles, 27 percent (about 2.9 million acres) is occupied by irrigated agriculture. Main crops grown in the region include almonds/pistachios, vineyards, corn, grain and cotton. In 2010, the population of the region was 2.27 million. Main cities include Fresno, Bakersfield and Visalia. Although agriculture remains the dominant form of land use in the basin, urban land use is increasing. A notable exception to agricultural land use is Bakersfield, a city of roughly 350,000 residents which is well known for its oil fields (Faunt et al. 2009).

2.3.3 Water Sources and Demands

Throughout the Central Valley, water is utilized for a wide range of uses including agriculture, municipal/domestic use, recreation, managed wetlands, etc. These water demands are primarily met through a combination of local water projects, state and federal water projects, groundwater extraction, and water reuse. A general summary of each Hydrologic Region’s sources and demands is provided below. It is important to note that applied water use is water applied to support a beneficial use. This includes consumptive use, reuse, and/or outflows.

Estimated water use and sources for each of the hydrologic regions is presented below.

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9 Applied water use is met by dedicated and developed water supplies. The total water supply represents the sum of surface water supplies, groundwater supplies, and local reuse (DWR 2013a).
Sacramento River Hydrologic Region – The total applied water use for the region was about 22 million acre-feet (MAF) in 2010 (DWR 2013a). The primary uses included:

- Irrigated agriculture accounted for about 7,900 thousand acre-feet (TAF) (36 percent);
- Required delta outflow accounted for about 5,300 TAF (24 percent);
- Instream flow\(^{10}\) accounted for about 4,100 TAF (19 percent);
- Wild and scenic rivers\(^{11}\) accounted for about 3,100 TAF (14 percent);
- Urban uses and managed wetlands used about 900 TAF (4 percent); and
- Managed wetlands about 600 TAF (3 percent).

Applied uses were met by the following dedicated and developed water supplies:

- Reuse and seepage supplied about 7,700 TAF (35 percent);
- Instream supplied about 6,700 TAF (31 percent);
- Groundwater extraction supplied about 2,600 TAF (12 percent);
- Federal projects supplied about 2,400 TAF (11 percent);
- Local projects supplied about 2,100 TAF (9 percent);
- Inflow and storage supplied about 400 TAF (2 percent); and
- The state project supplied about 33 TAF (0.2 percent).

As estimated from average annual data (2005-2010), the region’s total water supply is estimated to be 9 MAF (DWR 2013a):

- Roughly 5,400 TAF (about 60 percent of total) is surface water;
- 900 TAF (about 10 percent of total) is locally reused water; and
- The remaining 2,700 TAF (about 30 percent of total) is supplied by groundwater. Of the groundwater:
  - About 84 percent is used to meet agricultural uses;
  - About 16 percent is used to meet urban uses; and

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\(^{10}\) Instream flow is defined by DWR as “the use of water within its natural watercourse as specified in an agreement, water rights permit, court order, FERC license or other state or federal requirement.” (DWR 2013a).

\(^{11}\) Wild and scenic river use is defined by DWR as “annual natural flows from the designated State and Federal Wild and Scenic Rivers system” (Water Use Definitions, DWR).
Section 2 • Central Valley Region

- About three-quarters of a percent is used to meet managed wetlands use (DWR, 2013A).

- **San Joaquin River Hydrologic Region** – The total applied water use for the region was about 11 MAF in 2010 (DWR 2013b).
  - Irrigated agriculture accounted for about 7,000 TAF (64 percent);
  - Wild and scenic rivers accounted for about 2,100 TAF (19 percent);
  - Urban uses accounted for about 700 TAF (6 percent);
  - Instream flow accounted for about 650 TAF (6 percent); and
  - Managed wetlands accounted for about 500 TAF (5 percent).

  Applied uses were met by the following dedicated and developed water supplies:
  - Local projects supplied about 2,800 TAF (26 percent);
  - Groundwater extraction supplied about 2,700 TAF (25 percent);
  - Reuse and seepage supplied about 2,400 TAF (22 percent);
  - Federal projects supplied about 1,600 TAF (14 percent); and
  - Instream supplied about 1,400 TAF (13 percent).

  As estimated from average annual data (2005-2010), the region’s total water supply is estimated to be 8.3 MAF (DWR 2013b):
  - Roughly 4,300 TAF (about 52 percent of total) is surface water;
  - 800 TAF (about 10 percent of total) is locally reused water; and
  - The remaining 3,200 TAF (about 38 percent of total) is supplied by groundwater. Of the groundwater:
    - About 81 percent is used to meet agricultural uses;
    - About 13 percent is used to meet urban uses; and
    - About 6 percent is used to meet managed wetlands use in the region (DWR, 2013b).

  - During years of drought, the quantity of extracted groundwater increases.

- **Tulare Lake Hydrologic Region** – The total applied water use for the region was about 13.4 MAF in 2010 (DWR 2013c).
  - Irrigated agriculture accounted for about 10,700 TAF (80 percent);
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- Wild and scenic rivers accounted for about 2,000 TAF (15 percent);
- Urban uses accounted for about 700 TAF (5 percent); and
- Managed wetlands accounted for about 80 TAF (0.6 percent).

Applied uses were met by the following dedicated and developed water supplies:
- Groundwater extraction supplied about 5,500 TAF (41 percent);
- Local projects supplied about 2,800 TAF (21 percent);
- Reuse and seepage supplied about 2,100 TAF (16 percent);
- Federal projects supplied about 2,000 TAF (15 percent); and
- The state water project supplied about 1,000 TAF (7 percent).

As estimated from average annual data (2005-2010), the region’s total water supply is estimated to be 11.6 MAF (DWR 2013c):
- Roughly 5,500 TAF (about 47 percent of total) is surface water; and
- 6,200 TAF (about 53 percent of total) is supplied by groundwater. Of the groundwater
  - Almost 90 percent is used to meet agricultural uses;
  - About 9 percent is used to meet urban uses; and
  - About one-half a percent is used to meet managed wetlands use (DWR, 2013c).

- Periods of drought and cutbacks in surface water deliveries to the region result in increased reliance on groundwater.

2.3.4 Surface Water, Delivered Water, Imported Water, Recycled Water

An extensive array of reservoirs, channels, aqueducts, and pumps create a network of managed surface water storage and delivery systems to supply both a portion of the water needed throughout the valley as well as supply water needs throughout California. The Central Valley Project (CVP) and State Water Project (SWP) bring water from the Sacramento and San Joaquin Rivers through the Delta for delivery to users in the San Joaquin and Tulare Lake Basins as well as to the South Bay, Central Coast and Southern California.

Local water agencies then distribute state allocated water deliveries along these conveyance systems to their users. In other cases, local agencies operate their own water supply system, including the reservoirs and canals, that store and move water as needed. Local agencies can also supplement their water supplies by producing or purchasing recycled water.

A more detailed description of the region’s surface, delivered, imported and recycled water is provided in Attachment B-1, Characterization of Hydrologic Regions.
2.4 Groundwater Basin and Sub-Basin Boundaries

There are 126 basins/subbasins in Region 5, including 41 groundwater basins/subbasins (as defined by the California Department of Water Resources Bulletin 118 overlying the Central Valley Floor) and 85 basins/subbasins that are located outside the Central Valley Floor. The entire Region 5 area covered by groundwater basins is about 24,100 square miles; the area of the 41 basins/subbasins in the Valley Floor is about 20,500 square miles, or about 85% of the total groundwater basins/subbasins within Region 5. Figure 2-3 illustrates the 44 groundwater basins/subbasins located on the valley floor of the Central Valley Region. Table 2-1 lists all Central Valley Region groundwater basins/subbasins both those on and outside of the valley floor. More information about each basin can be found in DWR's Bulletin 118 (DWR 2003). In general:

- **Sacramento River Hydrologic Region** – The Sacramento Valley Groundwater Basin is the main groundwater basin located in the Sacramento River Hydrologic Region, and is divided into 18 groundwater subbasins, based on hydrologic, geologic, and political boundaries, covering 6,057 square miles of the Central Valley Floor.

- **San Joaquin River Hydrologic Region** – The San Joaquin Groundwater Basin is the main groundwater basin that covers both the San Joaquin River and the Tulare Lake Hydrologic Regions, and is divided into 16 groundwater subbasins, based on hydrologic, geologic, and political boundaries, covering 10,591 square miles of the Central Valley Floor.

- **Tulare Lake Hydrologic Region** – In terms of groundwater basins, the majority of this region is actually part of the San Joaquin Groundwater Basin, as the Tulare Lake, Kings, Westside, Tule, Kern County, and Kaweah Groundwater Subbasins of the San Joaquin Valley Groundwater Basin, covering 4,783 square miles.

2.5 Geology

The Central Valley, containing the Sacramento and San Joaquin Groundwater Basins, is a geologic trough, bounded by the Coast Range Mountains on the west and the Sierra Nevada Mountains on the east. The Sierra Nevada, which forms the eastern side of the valley, is the eroded edge of a huge tilted block of crystalline rock. The sediments filling the valley overlie a westward-sloping surface of basement rocks that are the subsurface continuation of the Sierra Nevada Emplacement of the Sierra Nevada batholith, from about 85 million years ago in the Mesozoic Era. The northeast portion of the Central Valley contains the southern edge of the Cascade Range, which is made up of volcanic rocks and is relatively younger (volcanic activity occurred mostly during the late Tertiary to Holocene time, within the last 10 million years). The only prominent non-sedimentary feature in the entire Central Valley is the Sutter Buttes, a Pliocene and Pleistocene volcanic plug, located in the Sacramento Valley (Faunt et al. 2009).
Figure 2-3. Groundwater Basins/Subbasins in the Valley Floor of the Central Valley Region.
Table 2-1. Groundwater Basin and Subbasins in Central Valley Region\textsuperscript{12}

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\textsuperscript{12} For maps of the location of all of these groundwater basins, see DWR’s website:  
http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm#
Table 2-1. Groundwater Basin and Subbasins in Central Valley Region

<table>
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<th>Groundwater Basin Name</th>
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Section 2 • Central Valley Region

Table 2-1. Groundwater Basin and Subbasins in Central Valley Region

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The valley is filled with extensive volumes of deep marine, shallow marine, deltaic, and continental sediments. The valley fill deposits range in thickness from zero on the eastern edge of the valley to more than 50,000 feet on the western edge and provide the materials for which salt and nitrate can move within each groundwater basin and subbasin. Depending on the location, deposits of fine-grained materials (clay and silt) can compose up to 50% of the thickness of the valley fill deposits. Alluvial fans can be found on all sides of the Central Valley, which carry fine-grained materials farther than coarse grained materials. For this reason, channels of coarse-grained materials can be related to ancient stream channels, shifting over time and resulting in broad sheets of inter-fingered, wedge-shaped lenses of gravel, sand, and finer sediments (Faunt et al. 2009). These coarse-grained materials found in the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions provide the materials for movement of salt and nitrate.

2.6 Hydrogeology/Hydrology

Three main references contain detailed descriptions of the physical hydrogeology of the Central Valley: Page (1986), Farrar and Bertoldi (1988), and Williamson et al. (1989). Generally, the
sediments of the Central Valley compose an aquifer system comprising confining units and unconfined, semi-confined, and confined aquifers. The main source of groundwater in the Central Valley is typically located within the upper 1,000 feet of deposits, which contains the sediments that are a main focus of this SNMP. In some places, saline water is found at shallow depths in continental deposits, which can result from upward migration of connate water, evaporative concentration, or estuarine water trapped during sedimentation.

The largest, most significant confining unit in the Central Valley is the Corcoran Clay, a member of the Tulare Formation and is located mostly in the south central to southern portion of the Central Valley (Figure 2-4). This clay unit is also referred to as the E-clay, and is a low-permeability, areally extensive, lacustrine (deposited in a lake) deposit as much as 200 feet thick, that divides the groundwater flow system of the western San Joaquin Valley into an upper semi-confined zone and a lower confined zone. Since development, thousands of large-diameter irrigation wells perforated in the aquifers above and below the Corcoran Clay. These perforations that extend across the Corcoran Clay have resulted in a hydraulic connection between these aquifers thereby increasing the vertical hydraulic conductivity of the aquifer system in some areas.

As a whole, the valley deposits compose an aquifer system with large variability in coarseness and texture, which translates to variability in the water-transmitting abilities (hydraulic conductivity, vertical anisotropy) (Faunt et al. 2009) and therefore the movement and residence of salt and nitrate. Outside the valley floor, alluvial aquifers exist, but are typically much smaller and less thick than those found in the valley floor.

The Water Balance Section, located in Attachments B-2 and B-3 of this SNMP, provides additional detail regarding each region’s hydrology.

2.7 Aquifers

Generally, the Central Valley has unconfined, semi-confined, and confined aquifer units of various thicknesses and lateral extent. The inter-fingering and inter-layering of fine-grained and coarse-grained materials resulting from the depositional environments govern the heterogeneity of the subsurface in the Central Valley. Pre-development, water level trends and flow directions were controlled by the balance between recharge from higher elevations (from rain, snowmelt, and stream leakage) and discharge to lower elevations (to rivers or surface water expressions such as marshes, and out through the delta).

The aquifers containing groundwater in the Sacramento and San Joaquin Valleys of the Central Valley drain following the patterns of the Sacramento River and the San Joaquin River through the Delta to the Bay and the Pacific Ocean. Pre-development groundwater flowed from the foothills centrally toward the trough of the valley, and discharged into the surface water features in order to leave the system. The hydrologic budget (inflows and outflows) during pre-development are assumed to have been in balance, meaning that there was no change in storage. Once groundwater production developed, groundwater levels, trends, flow directions, and changes in storage reflected the spatial variability of hydrologic stresses including groundwater...
use and availability. This stress on the aquifer systems resulted in changes in the movement of water, salt, and nitrate in the Central Valley.

***For Figure 2-4: Recommend using a transparent layers with dots or cross-hatches for the Corcoran Clay as it covers boundaries for several of the sub-basins and blurs the lines between major basins. Similar issue with the blue overlay for the Sac Valley***
Section 2 • Central Valley Region

Figure 2-4. Extent of Corcoran Clay with Groundwater Basins and Subbasins

Commented [A19]: Is there a reference for this figure? It also appears areas outside RB5 are included such as the Carrizo Plain and part of the Salinas Valley. This areas should not be colored.
Some differences between the aquifers in the Sacramento Valley and San Joaquin Valley Groundwater Basins include the role of precipitation and streamflow. Precipitation is greater in the Sacramento Valley than in the southern areas of California, streamflow interaction is a much larger percentage of the water budget in the Sacramento Valley than the San Joaquin Valley, with more occurrences of losing stream conditions in the San Joaquin Valley than in the Sacramento Valley. More agriculture and irrigation occur in the warmer and drier San Joaquin Valley, relying on surface water deliveries from the Sacramento Valley in addition to diversions from the San Joaquin River and groundwater production (Faunt et al. 2009), putting stress on the subsurface aquifers. Climate also plays a key role in the water level trends and changes in storage; groundwater levels in shallow and deep aquifers reflect times of drought or high precipitation while storage drops when drier hydrologic years occur and reliance on groundwater increases.

Aquifers can be divided vertically and horizontally based on hydraulic barriers or different aquifer units based on subsurface depositional materials. The uppermost portion of the aquifer that is under atmospheric pressure is referred to as the water table. Most public water supply wells are completed below the water table, many times in lower portions of the aquifer, which are under confined or semi-confined conditions. These deeper aquifers can be delineated using local hydrogeologic techniques, and also by observing the patterns of well depths and well completions in particular areas. The division of the aquifer materials aids in the understanding of water, salt, and nitrate movement and ambient conditions.

The Water Balance Section, located in Attachments B-2 and B-3 of this SNMP, provides additional detail regarding each region’s water budget.

### 2.8 Recharge Areas

Prior to development, recharge in the Central Valley predominantly occurred from rain and snowmelt in the mountains that became stream leakage at the valley margins in the northern and eastern parts of the valley (Faunt et al., 2009). In the Central Valley, groundwater recharge can take decades to centuries to occur, depending on the spatial and vertical location of recharge areas. Outside the valley floor, the alluvial aquifers are thinner and recharge occurs on a shorter time frame (days to months), fed from higher elevations (snowmelt, rainfall, and stream leakage). The patterns of recharge for areas within the Central Valley help dictate the movement and contributions of salt and nitrate due to surface loadings.

The Water Balance Section, located in Attachments B-2 and B-3 of this SNMP, provides additional detail regarding each region’s recharge areas.
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