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 near the 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 (and in turn dissolved salt) throughout the state via the Federal and State Water Projects.

As previously shown in (and Figure 1-2surface 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 practices used to manage salt 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.

Figure 2-1. Central Valley Surface Waters and Surrounding Geography

2.2 Beneficial Uses and Water Quality Objectives

As stated earlier, two Basin Plans have been developed for the Central Valley:

- SRSJR Basin Plan (Central Valley Water Board 2016); and
- 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."[1] 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 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

[3] See Chapter II of the SRSJR and TLB Basin Plans (Central Valley Water Board 1998 and 2015). Note that the Tulare Lake Basin Plan does not include the phrase "(including leaching of salts)"

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),[4] 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 ground 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…*"[5] 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.*"[6]

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…"[7]

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).[8] 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.

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[4] "The specific exceptions include waters with existing high total dissolved solids concentrations (greater than 3000 mg/l), low sustainable yield (less than 200 gallons per day for a single well), waters with contamination that cannot be treated for domestic use using best management practices or best economically achievable treatment practices, waters within particular municipal, industrial and agricultural wastewater conveyance and holding facilities, and regulated geothermal ground waters." Water Quality Control Plan for the Sacramento and San Joaquin River Basin.

[5] SRSJR Basin Plan, Pg. II-3.00; TLB Basin Plan, Pg. II-2.

[6] SRSJR Basin Plan, Pg. II-3.00; TLB Basin Plan, Pg. II-3.

[7] SRSJR Basin Plan, Pg. III-10.0 and TLB Basin Plan, Pg. III-7.

[8] 10 mg/L is the level set by 22 CCR §64431, consistent with the primary maximum contaminant level established under the federal Safe Drinking Water Act.

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 ("*Waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses…*"[Central Valley Water Board 2016]) 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 1-1). 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). 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 and naturally drained north into the San Joaquin River only in years of extreme rainfall. This natural flow was more likely to occur prior to the construction of water management projects. Currently, in most years water moves in and out of the Tulare Lake Hydrologic Region by precipitation, evaporation, and/or water diversions through canals.

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 northernmost 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.

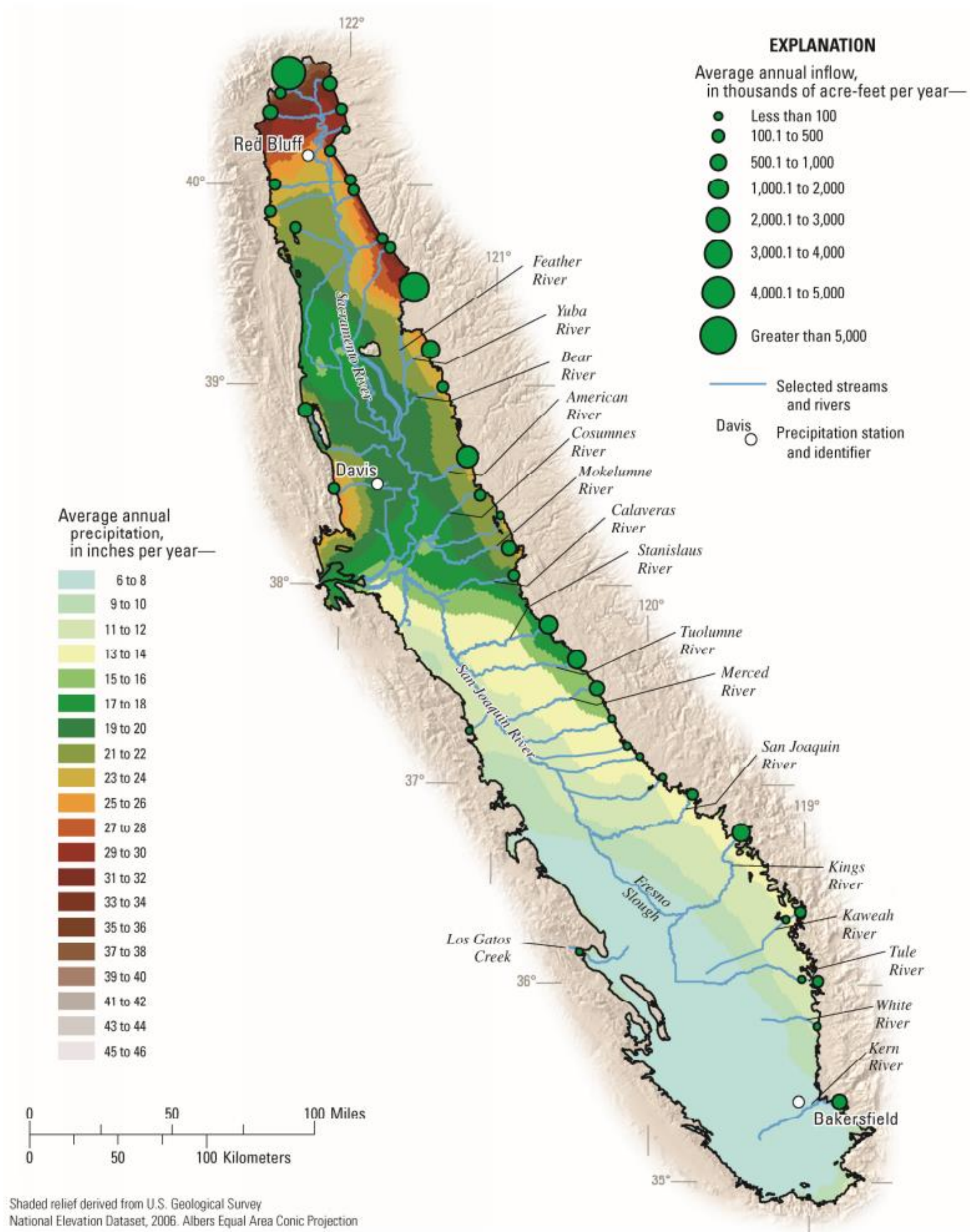

Figure 2-2. Major Surface Waters and Average Annual Precipitation in the Central Valley Region (Sept. 1961-Sept. 2003) (Figure A5(A) in Faunt et al., 2009, used with permission)

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. In 2010, the population of the region was 2.98 million. Main cities include Sacramento, Roseville and Redding. Cities and towns north of Sacramento are located in predominantly agricultural areas (DWR, 2013a)

- 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 Unites 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 land use in the basin, urban land use is increasing. A notable exception to agricultural land use is Bakersfield, a city of with a population of about 332,000 in the southern portion of the region. The area around Bakersfield is well known for its oil fields (DWR 2013c).

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[9]. This includes consumptive use, reuse, and/or outflows.

[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).

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

- 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;*

[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).

  - *About 16 percent is used to meet urban uses; and*
  - *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);
- 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, and 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.2.1.1, Characterization of Hydrologic Regions.

2.4 Groundwater Basin/Subbasin Boundaries

The California Department of Water Resources has defined the groundwater basins/subbasins for the Central Valley 5 Region both within and outside the Central Valley Floor (DWR 2003). For the Kern County groundwater subbasin (5-22.14), the TLB Basin Plan currently divides this subbasin into three hydrographic units: Westside South (northwest portion); Poso (northeast portion) and Kern River (southern portion). **Figure 2-3** illustrates the groundwater basins/subbasins located on the valley floor of the Central Valley Region for which nitrate and salinity conditions have been evaluated for this SNMP.

The entire Region 5 area covered by groundwater basins is about 24,100 square miles; of this area of the basins/subbasins in the Valley Floor comprise about 20,500 square miles, or about 85% of the total groundwater basins/subbasins within Region 5. **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:

- <u>Sacramento River Hydrologic Region</u> – 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.
- <u>San Joaquin River Hydrologic Region</u> – The San Joaquin Groundwater Basin is the main groundwater basin that covers both the San Joaquin River and the Tulare Lake Hydrologic Regions. The portion of the San Joaquin Groundwater Basin within this hydrologic region is divided into nine groundwater subbasins, based on hydrologic, geologic, and political boundaries, covering 5,830 square miles of this portion of the Central Valley Floor.
- <u>Tulare Lake Hydrologic Region</u> –Similar to the San Joaquin River Hydrologic Region, the San Joaquin Groundwater Basin is the main groundwater basin in this hydrologic region. This portion of the San Joaquin Groundwater Basin, which covers approximately 4,783 square miles, is divided into seven groundwater subbasins. As noted above, the TLB Basin Plan further divides the Kern County subbasin into three hydrographic units.
- <u>Delta Region</u> – Within the San Francisco Bay Hydrologic Region are two groundwater basins that are within the Delta Region on the west side of the Central Valley Region: Suisan-Fairfield Valley (2-3) and Pittsburg Plain (2-4). While these basins are not the focus of this SNMP, nitrate and salinity water quality conditions are provided in sections below.

Figure 2-3. Groundwater Basins/Subbasins on the Valley Floor of the Central Valley Region.

Table 2-1. Groundwater Basin and Subbasins in Central Valley Region[12]

Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.	Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.
ALTURAS AREA	SOUTH FORK PITT RIVER	5-2	5-2.01	PITTSBURG PLAIN		2-4	
ALTURAS AREA	WARM SPRINGS VALLEY	5-2	5-2.02	PONDOSA TOWN AREA		5-38	
AMERICAN VALLEY		5-10		**POPE VALLEY**		5-68	
ANTELOPE CREEK		5-91		**REDDING AREA**	ANDERSON	5-6	5-6.03
ASH VALLEY		5-54		**REDDING AREA**	BOWMAN	5-6	5-6.01
BEAR VALLEY		5-64		**REDDING AREA**	ENTERPRISE	5-6	5-6.04
BERRYESSA VALLEY		5-20		**REDDING AREA**	MILLVILLE	5-6	5-6.05
BIG VALLEY		5-4		**REDDING AREA**	ROSEWOOD	5-6	5-6.02
BIG VALLEY		5-15		**REDDING AREA**	SOUTH BATTLE CREEK	5-6	5-6.06
BLANCHARD VALLEY		5-92		**ROCK PRAIRIE VALLEY**		5-43	
BRITE VALLEY		5-80		**ROUND VALLEY**		5-36	
BURNEY CREEK VALLEY		5-48		**SACRAMENTO VALLEY**	ANTELOPE	5-21	5-21.54
BURNS VALLEY		5-17		**SACRAMENTO VALLEY**	BEND	5-21	5-21.53
BUTTE CREEK VALLEY		5-51		**SACRAMENTO VALLEY**	CAPAY VALLEY	5-21	5-21.68
CASTAC LAKE VALLEY		5-29		**SACRAMENTO VALLEY**	COLUSA	5-21	5-21.52
CAYTON VALLEY		5-45		**SACRAMENTO VALLEY**	CORNING	5-21	5-21.51
CHROME TOWN AREA		5-61		**SACRAMENTO VALLEY**	DYE CREEK	5-21	5-21.55
CLEAR LAKE CACHE FORMATION		5-66		**SACRAMENTO VALLEY**	EAST BUTTE	5-21	5-21.59
CLOVER VALLEY		5-58		**SACRAMENTO VALLEY**	LOS MOLINOS	5-21	5-21.56
COLLAYOMI VALLEY		5-19		**SACRAMENTO VALLEY**	NORTH AMERICAN	5-21	5-21.64
COYOTE VALLEY		5-18		**SACRAMENTO VALLEY**	NORTH YUBA	5-21	5-21.60
CUDDY CANYON VALLEY		5-82		**SACRAMENTO VALLEY**	RED BLUFF	5-21	5-21.50
CUDDY RANCH AREA		5-83		**SACRAMENTO VALLEY**	SOLANO	5-21	5-21.66

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[12]

Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.	Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.
CUDDY VALLEY		5-84		**SACRAMENTO VALLEY**	SOUTH AMERICAN	5-21	5-21.65
CUMMINGS VALLEY		5-27		**SACRAMENTO VALLEY**	SOUTH YUBA	5-21	5-21.61
DIXIE VALLEY		5-53		**SACRAMENTO VALLEY**	SUTTER	5-21	5-21.62
DRY BURNEY CREEK VALLEY		5-49		**SACRAMENTO VALLEY**	VINA	5-21	5-21.57
EGG LAKE VALLEY		5-41		**SACRAMENTO VALLEY**	WEST BUTTE	5-21	5-21.58
ELK CREEK AREA		5-62		**SACRAMENTO VALLEY**	YOLO	5-21	5-21.67
FALL RIVER VALLEY		5-5		**SAN JOAQUIN VALLEY**	CHOWCHILLA	5-22	5-22.05
FUNKS CREEK		5-90		**SAN JOAQUIN VALLEY**	COSUMNES	5-22	5-22.16
GOOSE LAKE	FANDANGO VALLEY	5-1		**SAN JOAQUIN VALLEY**	DELTA-MENDOTA	5-22	5-22.07
GOOSE LAKE	GOOSE VALLEY	5-1		**SAN JOAQUIN VALLEY**	EASTERN SAN JOAQUIN	5-22	5-22.01
GOOSE VALLEY		5-47	5-1.02	**SAN JOAQUIN VALLEY**	KAWEAH	5-22	5-22.11
GRAYS VALLEY		5-52	5-1.01	**SAN JOAQUIN VALLEY**	KERN COUNTY	5-22	5-22.14
GRIZZLY VALLEY		5-59		**SAN JOAQUIN VALLEY**	KINGS	5-22	5-22.08
HIGH VALLEY		5-16		**SAN JOAQUIN VALLEY**	MADERA	5-22	5-22.06
HOT SPRINGS VALLEY		5-40		**SAN JOAQUIN VALLEY**	MERCED	5-22	5-22.04
HUMBUG VALLEY		5-60		**SAN JOAQUIN VALLEY**	MODESTO	5-22	5-22.02
INDIAN VALLEY		5-9		**SAN JOAQUIN VALLEY**	PLEASANT VALLEY	5-22	5-22.10
JESS VALLEY		5-3		**SAN JOAQUIN VALLEY**	TRACY	5-22	5-22.15
JOSEPH CREEK		5-86		**SAN JOAQUIN VALLEY**	TULARE LAKE	5-22	5-22.12
KERN RIVER VALLEY		5-25		**SAN JOAQUIN VALLEY**	TULE	5-22	5-22.13
LAKE ALMANOR VALLEY		5-7		**SAN JOAQUIN VALLEY**	TURLOCK	5-22	5-22.03
LAKE BRITTON AREA		5-46		**SAN JOAQUIN VALLEY**	WESTSIDE	5-22	5-22.09
LAST CHANCE CREEK VALLEY		5-57		**SCOTTS VALLEY**		5-14	
LITTLE INDIAN VALLEY		5-65		**SIERRA VALLEY**	CHILCOOT	5-12	5-12.02
LONG VALLEY		5-44		**SIERRA VALLEY**	SIERRA VALLEY	5-12	5-12.01
LONG VALLEY		5-31		**SQUAW FLAT**		5-89	

Table 2-1. Groundwater Basin and Subbasins in Central Valley Region[12]

Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.	Groundwater Basin Name	Subbasin Name	Basin No.	Subbasin No.
LOS BANOS CREEK VALLEY		5-70		STONY GORGE RESERVOIR		5-88	
LOWER LAKE VALLEY		5-30		STONYFORD TOWN AREA		5-63	
MCCLOUD AREA		5-35		SUISUN-FAIRFIELD VALLEY		2-3	
MEADOW VALLEY		5-95		TEHACHAPI VALLEY EAST		6-45	
MIDDLE CREEK		5-94		TEHACHAPI VALLEY WEST		5-28	
MIDDLE FORK FEATHER RIVER		5-87		TOAD WELL AREA		5-37	
MIL POTRERO AREA		5-85		UPPER LAKE VALLEY		5-13	
MOHAWK VALLEY		5-11		VALLECITOS CREEK VALLEY		5-71	
MOUNTAIN MEADOWS VALLEY		5-8		WALKER BASIN CREEK VALLEY		5-26	
NORTH FORK BATTLE CREEK		5-50		YELLOW CREEK VALLEY		5-56	
NORTH FORK CACHE CREEK		5-93		YOSEMITE VALLEY		5-69	
PANOCHE VALLEY		5-23					

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 large 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, which occurred from 82 to 143 million years ago. (Batemen et al. 1963). 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).

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. These deposits are the porous material which contain the major groundwater aquifers within the groundwater basins/subbasins through which salt and nitrate can move. 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-fingering, 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 facilitate the 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, which 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 irrigation wells have been perforated in the aquifers above and below the Corcoran Clay. Perforations that extend across the Corcoran Clay can result 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.

Section B.2.1.2 in Attachment B of this SNMP provides additional detail regarding water balance within the region.

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).

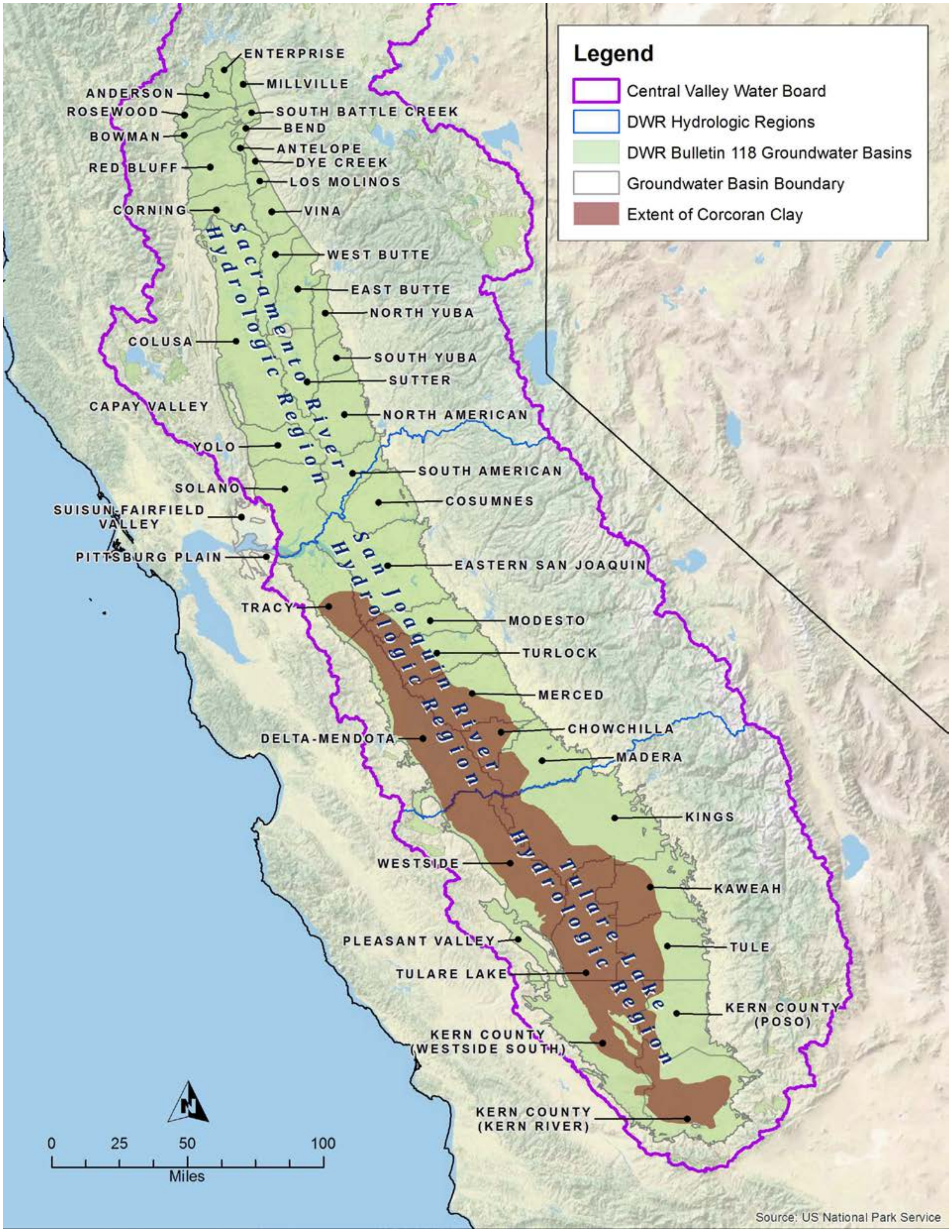

Figure 2-4. Central Valley Groundwater Basins/Subbasins and Underlying Corcoran Clay

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.

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 the Central Valley; 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.

Section B.2.1.2 in Attachment B of this SNMP provides additional detail regarding water balance within the region.

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, the time it takes for groundwater to recharge varies and depends on the volume of water and 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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