Eastern San Joaquin Subbasin Groundwater Sustainability Plan

Draft Deliverable 1

May 2019

TABLE OF CONTENTS

List of Tables

List of Figures

ACRONYMS

1,2,3-TCP	1,2,3-Trichloropropane
AB	Assembly Bill
ACP	agricultural conservation program
AF	acre-feet
AF/year	acre-feet per year
ALOS	Advanced Land Observing Satellite
AWMPs	Agricultural Water Management Plans
bgs	below ground surface
BMP	best management practice
B.P.	before present
CA	California
Cal Water	California Water Services Company Stockton District
California State Parks	California Department of Parks and Recreation
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	Consumer Confidence Reporting
CCWD	Calaveras County Water District
CDEC	California Data Exchange Center
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEDEN	California Environmental Data Exchange Network
cfs	cubic feet per second
CGPS	continuously operating Global Positioning System
CNRA	California Natural Resources Agency
CSJWCD	Central San Joaquin Water Conservation District
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CVRWQCB	Central Valley Regional Water Quality Control Board
CWC	California Water Code
DACs	Disadvantaged Communities
DDW	Division of Drinking Water
DER	Department of Environmental Resources
DMS	data management system
DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	Department of Pesticide Regulations
DWR	Department of Water Resources
ED	Economic Development
ESJWRM	Eastern San Joaquin Water Resources Model
ETo	evapotranspiration
EWMPs	efficient water management practices
FB	Financing and Budgeting
GAMA	groundwater ambient monitoring and assessment

GBA	Groundwater Basin Authority
GDE	groundwater dependent ecosystem
GICIMA	Groundwater Information Center Interactive Mapping Application
GIS	Geographic Information System
GMP	Groundwater Management Plan
gpm	gallons per minute
GPS	Global Positioning System
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWA	Groundwater Authority
GWA Board	Groundwater Authority Board of Directors
HCM	Hydrogeologic Conceptual Model
ICU Program	Integrated Conjunctive Use Program
IGC	Inter-governmental Coordination
ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
IRGMP	Integrated Regional Groundwater Management Plan
IRWMP	Integrated Regional Water Management Plan
IS	infrastructure and services
JP	Joint Partnerships
JPA	Joint Powers Agreement
LLNL	Lawrence Livermore National Laboratory
LU	land use
Ma	millions of years ago
MAC	Mokelumne-Amador-Calaveras
mg/L	milligrams per liter
MHI	median household income
MOA	memorandum of agreement
MokeWISE	Mokelumne Watershed Interregional Sustainability Evaluation
MS	Microsoft
MUD	Municipal Utilities Department
MWH	Montgomery Watson Harza
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NDWA	North Delta Water Agency
NRCS	Natural Resource Conservation Service
NSJWCD	North San Joaquin Water Conservation District
NWIS	National Water Information System
OID	Oakdale Irrigation District
OSWCR	Online System for Well Completion Reports
PDF	portable document format
PFIP	Public Facilities Implementation Plan
PFOA	perfluorooctantoic acid
PFOS	perfluorooctanesulfonic acid

PG&E	Pacific Gas and Electric Company
PI	Public Information
PS	persistent scatter
PSP	Plans, Strategies, and Programs
PSR	Planning Studies and Reports
RDR	Regulation and Development Review
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCDER	Stanislaus County Department of Environmental Resources
SCWSP	South County Water Supply Program
SDACs	Severely Disadvantaged Communities
SDWA	South Delta Water Agency
SEWD	Stockton East Water District
SGMA	the Sustainable Groundwater Management Act
SJCFCWCD	San Joaquin County Flood Control and Water Conservation District
SJV	San Joaquin Valley
SMCL	secondary maximum contaminant levels
SNMP	Salt and Nutrient Management Plan
SO	Services and Operations
SRA	State Recreation Area
SS	specific storage
SSJID	South San Joaquin Irrigation District
State ID	State Well Numbering System identification
SVRA	State Vehicular Recreation Area
SWRCB	State Water Resources Control Board
SY	specific yield
TDS	total dissolved solids
UNAVCO	University NAVSTAR Consortium
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFW	United States Fish & Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UWMPs	Urban Water Management Plans
WDL	Water Data Library
WDR	Waste Discharge Requirement
WID	Woodbridge Irrigation District
Workgroup	Groundwater Sustainability Workgroup

This document includes the working drafts of Chapter 1: Administrative Information, Chapter 2: Plan Area, the Hydrogeologic Conceptual Model (HCM) section of Chapter 3: Basin Setting, and Chapter 5: Data Management System that will be included as part of the Eastern San Joaquin Subbasin Groundwater Sustainability Plan (Eastern San Joaquin GSP). These sections satisfy § 354.6, § 354.8, and § 354.14 of the Sustainable Groundwater Management Act (SGMA) Regulations. Note that the Basin Settings chapter contains three main subsections:

- **Hydrogeologic Conceptual Model –** This section, presented here, provides the geologic information needed to understand the framework in which water moves through the basin. It focuses on geologic formations, aquifers, structural features, and topography.
- **Current and Historical Conditions –** This section describes and presents groundwater trends, levels, hydrographs and level contour maps; estimates changes in groundwater storage; identifies groundwater quality issues; and addresses subsidence and surface water interconnection.
- **Water Budget –** This section provides information used in water budget development, discusses how the budget was calculated, and provides water budget estimates for historical conditions, current conditions, and projected conditions.

The Water Budget and Current and Historical Conditions sections are currently under administrative review and will be released for review on June 1.

Appendix C (DWR Preparation Checklist) and Appendix D (Relevant General Plan Goals and Policies) are included as attachments to this document. The remaining appendices will be included in the full draft GSP document.

1. INTRODUCTION

1.1 PURPOSE OF THE GROUNDWATER SUSTAINABILITY PLAN

The purpose of this GSP is to meet the regulatory requirements set forth in the three-bill legislative package consisting of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). SGMA defines sustainable groundwater management as "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results", which are defined by SGMA as any of the following effects caused by groundwater conditions occurring throughout the basin (CA DWR, 2018):

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

The Eastern San Joaquin Groundwater Subbasin (Eastern San Joaquin Subbasin or Subbasin) has been identified by DWR as critically overdrafted. The Eastern San Joaquin Groundwater Sustainability Plan (Eastern San Joaquin GSP or the Plan) has been developed to meet SGMA regulatory requirements by the January 31, 2020, deadline for critically-overdrafted basins while reflecting local needs and preserving local control over water resources. The Eastern San Joaquin GSP provides a path to achieve and document sustainable groundwater management within 20 years following Plan adoption, promoting the long-term sustainability of locally-managed groundwater resources now and into the future.

While the Eastern San Joaquin GSP offers a new and significant approach to groundwater resource protection, it was developed within an existing framework of comprehensive planning efforts. Throughout the Eastern San Joaquin Region, several separate yet related planning efforts are concurrently proceeding. The following figure (Figure 1-1) shows flagship reports from these efforts, which include Integrated Regional Water Management, Urban Water Management, watershed, and Habitat Conservation Plans. The Eastern San Joaquin GSP fits in with these prior planning efforts, building on existing local management and basin characterization. A description of prior planning efforts can be found in Section 2.2.1 of this document.

Figure 1-1: Interconnected Planning and Modeling Efforts for Water Resource Protection in the Eastern San Joaquin Subbasin

1.2 SUSTAINABILITY GOAL

TO BE COMPLETED FOLLOWING IDENTIFICATION OF THRESHOLDS AND OBJECTIVES

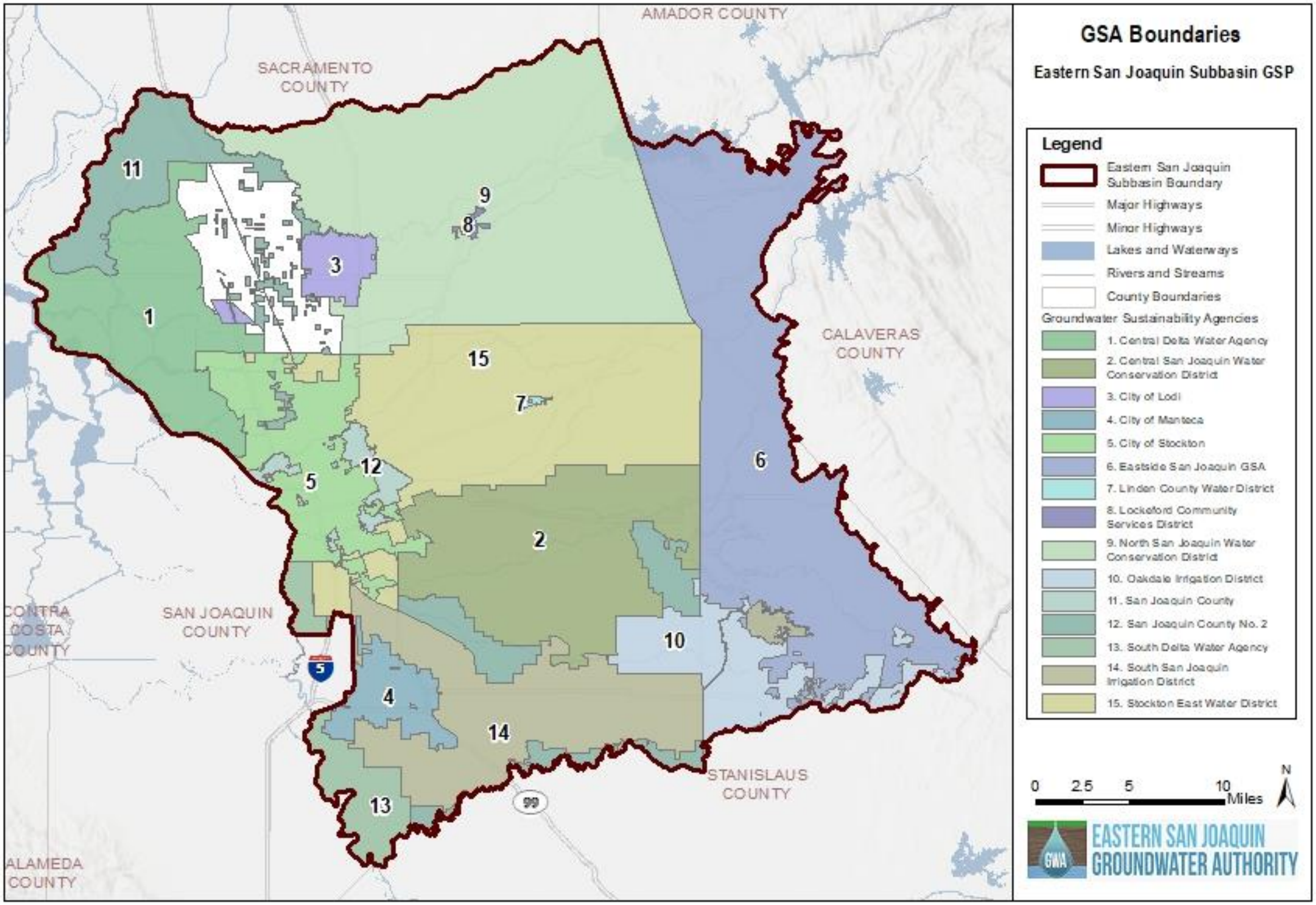
1.3 AGENCY INFORMATION

The Eastern San Joaquin GSP was developed jointly by the Eastern San Joaquin Groundwater Authority (GWA), which is a joint powers authority formed by the Central Delta Water Agency, Central San Joaquin Water Conservation District (CSJWCD), City of Lodi, City of Manteca, City of Stockton, Eastside San Joaquin Groundwater Sustainability Agency (GSA) (comprised of Calaveras County Water District, Stanislaus County, and Rock Creek Water District), Linden County Water District, Lockeford Community Services District, North San Joaquin Water Conservation District (NSJWCD), Oakdale Irrigation District (OID), San Joaquin County, San Joaquin County No. 2, South Delta Water Agency (SDWA), South San Joaquin GSA (comprised of South San Joaquin Irrigation District (SSJID) including Woodward Reservoir, City of Ripon, and City of Escalon), and Stockton East Water District (SEWD). Collectively, these 15 GSAs will be referred to as "GSAs". Figure 1-2 below indicates the jurisdictional boundaries of the individual GSAs.

The GSAs represent a diverse range of water management organizations. The agencies include water agencies, irrigation districts, water conservation districts, and local governments at the city and county level. The GSAs will work through the GWA to implement this GSP to cover the entire geographic extent encompassed by the boundaries of the Eastern San Joaquin Subbasin.

California Water Services Company Stockton District (Cal Water) has formed a partnership with San Joaquin County to participate in the process as part of the San Joaquin County No. 2 GSA, since its status as an investor-owned utility prohibits it from forming its own GSA under SGMA regulations. As a major purveyor of water in the Stockton region, Cal Water's participation is considered essential to the development of a comprehensive plan for sustainable groundwater management in the Subbasin.

Figure 1-2: Eastern San Joaquin Groundwater Sustainability Agencies



1.3.1 Eastern San Joaquin Groundwater Authority Joint Powers Agreement

The Joint Powers Agreement (JPA) provides the basis for forming the GWA. The GWA submitted an Initial Notification to jointly develop a GSP for the Eastern San Joaquin Subbasin on February 8, 2017. The agreement and bylaws are provided in Appendix A. Eastern San Joaquin Groundwater Authority JPA Agreement and Bylaws (CA DWR, 2016d).

The purpose of the GWA is to act as the coordinating agency and cooperatively carry out the purposes of SGMA in the Eastern San Joaquin Subbasin. The GWA is a public entity separate from the member organizations and holds the authority to coordinate and exercise the common powers of its members within the geographical area of the Eastern San Joaquin Subbasin consistent with the terms and conditions of the JPA.

Since its formation, the GWA has employed a consensus-based approach in its goal to provide a dynamic, cost-effective, and collegial organization to achieve initial and ongoing SGMA compliance within the Basin. Collaboration among the GWA member agencies has strengthened the potential for broad public support for groundwater management activities as well as the ability to leverage local, State, and federal funds (Eastern San Joaquin GWA, 2017b).

1.3.2 Agency Contact Information

The GWA designated San Joaquin County as Plan Administrator and record keeper. As Plan Administrator, San Joaquin County is tasked with submitting a single, jointly-composed GSP to DWR on behalf of the GWA. Contact information for the submitting agency and Plan Administrator is provided below in Figure 1-3.

Figure 1-3: Plan Administrator and Agency Contact Information

Agency Contact

Eastern San Joaquin Groundwater Authority
1810 E. Hazelton Avenue,
P.O. Box 1810
Stockton, CA 95201
info@esjgroundwater.org
www.esjgroundwater.org

Plan Administrator

Public Works Director
San Joaquin County
(209) 468-3000
info@esjgroundwater.org

1.3.3 Organization and Management Structure of the GSAs

The governing body of the GWA, the GWA Board of Directors (GWA Board), convenes every second Wednesday of the month at 11:00 a.m. to formulate the GSP by debating and finalizing key discussion points and decisions incorporated into the Plan. Each of the 15 GSAs has a voice on the GWA Board and have appointed two representatives to serve: one Board member and one Alternate member to attend in the Board member's absence.

The GWA Board is tasked with developing actions including, but not limited to, the following:

- Approval of budget(s) and appropriate cost sharing for any project or program that requires funding from the GSAs;
- Proposing guidance and options for obtaining grant funding;
- Adoption of rules, regulations, policies, and procedures related to the JPA;
- Approval of any contracts with consultants or subcontractors that would undertake work on behalf of the GSAs and/or relate to Basin-wide issues and, if applicable, recommend the funding that each GSA should contribute towards the costs of such contracts;
- Reporting to the GSAs' respective governing boards when dispute resolution is needed to resolve an impasse or inability to make a consensus recommendation;
- Approval and implementation of a GSP.

The GWA Board is guided by an Advisory Committee that is made up of one representative from each GSA and convenes every second Wednesday of the month at 9:00 a.m. The Advisory Committee is responsible for developing recommendations on technical and substantive Subbasin-wide issues and coordinating with the governing board of each GSA's respective organization. The Advisory Committee is tasked with developing actions including, but not limited to, the following:

- Recommend the action and/or approval of technical or policy elements for the development of a GSP, including groundwater conditions, thresholds, and projects and management actions;
- Recommend action and/or approval of a GSP.

The GWA Board is also informed by a Groundwater Sustainability Workgroup (Workgroup) which consists of 23 community representatives of agricultural communities, groundwater users, environmental groups, businesses, industry, and the community at large. The Workgroup is tasked with reviewing groundwater conditions, management issues and needs, and projects and management actions to improve sustainability in the basin. The Workgroup meets approximately monthly in sessions that provide a forum for the exchange of information and feedback from members and their respective organizations. An application to join the Workgroup was disseminated in early 2018. 22 applications were received, and all applicants were approved based on their ability to represent the broad interests and geography of the region. An additional member was added with approval of the Workgroup members after attending the first meeting, totaling to 23 members. Additional information on the Workgroup can be found in Section 2.5.2.3.2.

Decisions of the GWA Board are made by an affirmative majority of Board members, except in the following cases which require a two-thirds supermajority vote: approval or modification or amendment of the GWA annual budget; decisions related to the levying of taxes, assessments, or property-related fees and charges; decisions related to the expenditure of funds by the GWA beyond expenditures approved in the annual budget; adoption of rules, regulations, policies, bylaws, and procedures related to the function of the GWA; decisions related to the establishment of the members' percentage obligations for payment of the GWA's operating and administrative costs; approval of any contract over $250,000 or contracts for terms that exceed two years; decisions regarding the acquisition and the holding, use, sale, letting, and disposal of real and personal property including water rights, and the construction, maintenance, alteration, and operation of works or improvements; decisions related to the limitation or curtailment of groundwater pumping; and approval of a GSP. Each member of the GWA Board has one vote. A process for dispute resolution and noncompliance, including internal resolution and mediation prior to judicial or administrative remedies, is set forth in the GWA Bylaws in Appendix A. Eastern San Joaquin Groundwater Authority JPA Agreement and Bylaws.

GSAs share in the general operating and administrative costs of the GWA in accordance with percentages determined by the GWA Board.

1.3.3.1 Description of Participating Agencies

A brief description of each of the agencies that make up the GWA is provided in the sections below.

Central Delta Water Agency – The Central Delta Water Agency service area encompasses a total of 52,000 acres in the northwestern portion of the Eastern San Joaquin Subbasin. The primary land use in this area is agriculture with crops such as vineyards, trees, row crops, and field crops. The Central Delta Water Agency protects water supply within its service area of 120,000 acres, assists landowners and reclamation districts with water issues, and represents landowners in flood control matters. The Central Delta Water Agency does not own any facilities, and surface water from the Delta is the area's only source of water, along with limited private groundwater pumping. Approximately 5,000 acres of the GSA overlap with the sphere of influence of the City of Stockton (Eastern San Joaquin County GBA, 2014).

Central San Joaquin Water Conservation District – CSJWCD was formed in 1959 under provisions of the California Water Conservation Act of 1931. The CSJWCD includes approximately 73,000 largely agricultural acres, of which 6,300 acres are within the sphere of influence of the City of Stockton. To mitigate declining groundwater levels, the CSJWCD contracted with the US Bureau of Reclamation (USBR) for 80,000 acre-feet per year (AF/year) from New Melones Reservoir on the Stanislaus River. Irrigation facilities have been installed and operated by individual landowners through a surface water incentive program sponsored by the CSJWCD. At the regional level, CSJWCD has participated as a member agency of the Eastern Water Alliance and the Groundwater Basin Authority (GBA), two preceding efforts to the GWA that focused on groundwater management (Eastern San Joaquin County GBA, 2014).

City of Lodi – The City of Lodi is located northeast of the City of Stockton along Highway 99. The City relies on both groundwater and surface water to satisfy customer needs. In 2003, Lodi entered into a 40-year agreement with Woodbridge Irrigation District (WID) for up to 6,000 AF/year of Mokelumne River Water. The City of Lodi built the Lodi Surface Water Treatment Plant and associated conveyance facilities necessary to deliver this supply, which were completed and operational at the end of 2012. The City of Lodi currently provides up to 3,000 AF/year of treated wastewater to agricultural land in the vicinity of the wastewater treatment plant, White Slough Water Pollution Control Facility. The GSA for the City of Lodi includes the White Slough Water Pollution Control Facility area (City of Lodi, 2015).

City of Manteca – The City of Manteca straddles Highway 99 south of the City of Stockton. Potable water supplies consist of a combination of groundwater and treated surface water from the South County Water Supply Program (SCWSP). Manteca currently receives up to 11,500 AF/year and ultimately can receive up to 18,500 AF/year in Phase II of the SCWSP. Up to 4,000 AF/year of reclaimed wastewater is applied to fodder crops on City-owned and leased lands. The City of Manteca is a signatory to the California Urban Water Conservation Council (City of Manteca, 2015).

City of Stockton – The City of Stockton Municipal Utilities Department (MUD) service area generally encompasses portions of the City of Stockton north of the Calaveras River and south of the Cal Water service area. Water use measured in 2015 shows approximately 27 percent of the Stockton MUD's water deliveries come from groundwater, with 73 percent from treated surface water from SEWD and the Delta Water Supply Project. The Delta Water Supply Project came online in 2012 and utilizes surface water both from the San Joaquin River (City of Stockton water right) and Mokelumne River through a 40-year agreement with WID initiated in 2008 for up to 6,500 AF/year with more water as the City grows. The City of Stockton GSA overlaps with the extent of the Cal Water service area (City of Stockton, 2015).

Eastside San Joaquin GSA – Eastside San Joaquin GSA is comprised of a partnership between Calaveras County Water District, Stanislaus County, and Rock Creek Water District. The area covers over 126,000 acres, stretching into the western portion of Calaveras County and northern portion of Stanislaus County.

- Calaveras County Water District – The Calaveras County Water District serves a population of 20,700 through 17,000 service connections and shares the same boundaries as Calaveras County. However, not all customers in the county are served by Calaveras County Water District. Supply for the District comes from reservoir releases on the Calaveras, Stanislaus, and Mokelumne Rivers for a total of approximately 6,000 AF/year for primarily agricultural and residential use. Though not a reliable source of supply in Calaveras County, groundwater does provide the sole supply for residential use in some areas. Calaveras County Water District also relies heavily on recycled water to reduce potable water demand. Calaveras County had one of the fastest growing annual percent increase in populations in California between 2000 and 2010 (CCWD, 2015). For the portion of Calaveras County that falls within the Eastern San Joaquin Subbasin, the land is mostly unirrigated with the few crops irrigated by either riparian rights along Calaveras River or private groundwater wells. The population is estimated to be small and served by private residential pumping.

- Stanislaus County – Stanislaus County has a total area of 1,521 square miles and nine incorporated cities. There are approximately 30 water suppliers that serve water to Stanislaus County for domestic, commercial, and agricultural uses. The majority of the County's population resides in incorporated cities due to urban development and steady population growth within city boundaries. The portions of Stanislaus County that fall within the Eastern San Joaquin Subbasin not already included in a GSA have partnered with the Calaveras County Water District and Rock Creek Water District as the Eastside San Joaquin GSA. The land is mostly unirrigated, and water needs are met by private pumping.

- Rock Creek Water District – Rock Creek Water District was formed in 1941 and covers approximately 1,844 acres in northeastern Stanislaus County. Through the Salt Spring Valley Reservoir in Calaveras County, the District delivers agricultural water for irrigation (Stanislaus LAFCO, 2018).

Linden County Water District – Linden County Water District provides water and wastewater services to the unincorporated community of Linden, located approximately 12 miles northeast of the City of Stockton along State Route 26. The District lies entirely within the boundaries of the SEWD. Between 2000 and 2010, the population in Linden increased by 61 percent from approximately 1,100 to 1,800 residents. The Linden County Water District relies on groundwater to meet residential demands in Linden (SJC, 1992).

Lockeford Community Services District – Lockeford Community Services District was established in 1976 and superseded the San Joaquin County Water Works District No. 1 and Lockeford Sanitary District. The District currently provides water and wastewater services to approximately 3,200 residents in 2010 in the unincorporated urban community of Lockeford located 17 miles northeast of the City of Stockton on State Routes 12 and 88. The District lies within the boundaries of the NSJWCD; however, the District's jurisdiction area is its own GSA and is not part of the NSJWCD GSA. The District's GSA area is approximately 800 acres and encompasses primarily residential and agricultural land uses. The District anticipates that, as community build-out occurs, it may serve over 5,000 residents. Groundwater from the Eastern San Joaquin Subbasin is the District's only source of potable water (SJC, 2016a).

North San Joaquin Water Conservation District GSA – NSJWCD, organized in 1948 under provisions of the Water Conservation District Act of 1931, includes approximately 150,000 acres east of the City of Lodi, including about 70,000 acres of irrigated agriculture. NSJWCD also includes approximately 4,740 acres within the Lodi city limits and the community of Lockeford. Pursuant to agreements between NSJWCD, Lockeford and Lodi, the Lodi and Lockeford acreage is excluded from the NSJWCD GSA. NSJWCD straddles the Mokelumne River and has Dry Creek as its northern boundary. Prior to a basin boundary modification approved in 2016, the District was located in both the

Cosumnes and the Eastern San Joaquin Subbasins. The District has a 20,000 AF Mokelumne River surface water right which is generally available in normal to wet years. NSJWCD provides surface water deliveries to irrigated acreage and conducts groundwater recharge, but much of the NSJWCD area relies on private groundwater pumping. At the regional level, NSJWCD has participated as a member agency of the Eastern Water Alliance and the GBA, two preceding efforts to the GWA that focused on groundwater management (Eastern San Joaquin County GBA, 2014).

Oakdale Irrigation District – OID comprises about 81,000 acres, primarily located in the northern portion of Stanislaus County, but with a small portion located within San Joaquin County. A little less than 40 percent of the District's area overlies the Eastern San Joaquin Subbasin, and the remaining portion overlies the Modesto Subbasin. SSJID and OID jointly own facilities to provide water from the Stanislaus River for agricultural use (Eastern San Joaquin County GBA, 2014).

San Joaquin County – The San Joaquin County GSA is comprised of areas within the Eastern San Joaquin Subbasin not covered by the other 14 GSAs. Overlapping agencies include North Delta Water Agency (NDWA), unincorporated county, riparian land along Stanislaus River, and City of Stockton MUD areas. In collaboration with the Northeast San Joaquin County Groundwater Banking Authority, San Joaquin County led the development of the Eastern San Joaquin Groundwater Basin Groundwater Management Plan in 2004 to review, enhance, and coordinate existing groundwater management policies and programs in the region and to develop new policies and programs for the long-term sustainability of groundwater resources. Additionally, San Joaquin County has supported the development of studies and plans in the region, such as the Groundwater Basin Authority System Plan and San Joaquin County Water Management Plan.

- <u>North Delta Water Agency</u> – The NDWA was formed by a special act of the Legislature in 1973 to protect the water supply against sea water intrusion and to ensure a reliable water supply to meet current and future water needs. The NDWA service area now includes approximately 277,000 acres within the counties of Sacramento, San Joaquin, Solano, and Yolo. Most of the land is devoted to agriculture use and supplied with surface water from the Delta (NDWA, 2015).

San Joaquin County No. 2 (Cal Water) – San Joaquin County No. 2 GSA is comprised of San Joaquin County and Cal Water. Cal Water is an investor-owned public utility regulated by the California Public Utilities Commission; it is a signatory to the California Urban Water Conservation Council. Cal Water has approximately 42,000 connections in the greater Stockton area, primarily south of the Calaveras River. Cal Water utilizes surface water delivered from SEWD and groundwater pumped by Cal Water wells to meet customer demands. Cal Water's Stockton District was formed in 1927 with the purchase of the water system from Pacific Gas and Electric Company (PG&E).

South Delta Water Agency – The SDWA was originally formed to address local water supply and water quality concerns in the south Delta area. The SDWA encompasses a total of approximately 150,000 acres within its boundaries, and almost 18,000 acres overlap with the southwestern portion of the Eastern San Joaquin Subbasin. The SDWA does not own any facilities or water rights. Instead, the Agency protects property owners who have individual water rights. Surface water is the primary source of water used within the agency boundaries given that most of the groundwater is unusable due to high salinity (Eastern San Joaquin County GBA, 2014).

South San Joaquin GSA – South San Joaquin GSA is comprised of SSJID (including Woodward Reservoir and canals leading to the District), City of Ripon, and City of Escalon.

- <u>South San Joaquin Irrigation District</u> – SSJID was formed in 1909 under the Irrigation District Act and covers approximately 72,000 acres in the southeastern portion of San Joaquin County located within the Eastern San Joaquin Subbasin boundaries. The cities of Manteca, Ripon, and Escalon comprise approximately 20,000 acres of the District area. SSJID in 2005 began the delivery of up to 32,000 AF/year currently (and up to 43,000 AF/year in Phase II) of treated surface water from Woodward Reservoir to the cities of Escalon, Manteca, Lathrop, and Tracy for the SCWSP (Eastern San Joaquin County GBA, 2014).

- City of Ripon – The City of Ripon is located at the southern edge of San Joaquin County along Highway 99. The population in 2015 was approximately 14,700 and is expected to grow to about 30,800 by 2040. The City's potable water is provided by City groundwater wells and supplied over 4,000 acre-feet (AF) in 2015. Non-potable groundwater and surface water from SSJID are used for irrigation purposes and recharge (City of Ripon, 2015).

- City of Escalon – The City of Escalon is located within the San Joaquin County boundaries along State Route 120. Incorporated in 1957, the City of Escalon was home to approximately 7,400 residents in 2015. The City of Escalon has an allotment of 2,015 AF of treated water from the SSJID and the SCWSP; however, the City is not utilizing its allotment and currently relies solely on groundwater wells to serve the City's population as well as commercial customers. The City of Escalon is selling its allotment of treated water to the City of Tracy but intends to construct a pipeline to convey SSJID water to meet domestic and industrial needs in the City (SSJID, 2015b).

Stockton East Water District – SEWD was formed in 1948 and includes a total of 143,300 acres, with overlaps with portions of WID, and includes the entire City of Stockton and the entire Cal Water service area. The District is guaranteed 56.5 percent of New Hogan Reservoir's yield and provided a total amount of 75,000 AF annually from New Melones Reservoir through agreements with USBR. SEWD delivers wholesale drinking water to the City of Stockton, Cal Water, and San Joaquin County areas in the Stockton MUD (Eastern San Joaquin County GBA, 2014). At the regional level, SEWD has participated as a member agency of the Eastern Water Alliance and the GBA, two preceding efforts to the GWA that focused on groundwater management (Eastern San Joaquin County GBA, 2014).

1.3.4 Legal Authority of the GSAs

Under SGMA, any local public agency that has water supply, water management, or land use responsibilities in a basin can decide to become a GSA. A single local agency can become a GSA, or a combination of local agencies can decide to form a GSA by using either a JPA, a memorandum of agreement (MOA), or other legal agreement (CA DWR, 2016a).

In the Eastern San Joaquin Subbasin, the GWA has legal authority to jointly prepare, adopt, and implement a GSP consistent with the terms of the JPA Agreement and the GWA Bylaws (Eastern San Joaquin GWA, 2017a).

The GWA's JPA describes the following powers granted to GSAs:

- Become a GSA individually or collectively;
- Approve any portion, section, or chapter of the GSP adopted by the GWA;
- Act through GSAs to implement SGMA and the GSP;
- Exercise the powers conferred to GSAs by SGMA.

Each GSA that is a member of the GWA has its own legal authorities. For example, NSJWCD has the legal authorities granted to a GSA under the Water Code as well as the legal authorities granted a Water Conservation District pursuant to Water Code sections 74000 et seq. The legal authorities of each GSA are listed in Appendix B. Legal Authority of Eastern San Joaquin GSAs.

1.3.5 Estimated Cost of Implementing the GSP and Approach to Meeting Costs

SECTION TO BE COMPLETED FOLLOWING IMPLEMENTATION PLAN DEVELOPMENT

1.4 GSP ORGANIZATION

This GSP is organized according to DWR's "GSP Annotated Outline" for standardized reporting (CA DWR, 2016b). The Preparation Checklist for GSP Submittal in DWR formatting can be found in Appendix C. DWR Preparation Checklist (CA DWR, 2016d).

2. PLAN AREA

2.1 DESCRIPTION OF THE PLAN AREA

Description of the Plan Area provides a detailed description of the Eastern San Joaquin Subbasin, including major streams and creeks, institutional entities, agricultural and urban land uses, locations of groundwater wells, and locations of state lands. The Plan Area document also describes existing surface water and groundwater monitoring programs, existing water management programs, and general plans in the Plan Area.

2.1.1 Summary of Jurisdictional Areas and Other Features

The Eastern San Joaquin Subbasin falls within the larger San Joaquin Valley Groundwater Basin (see Figure 2-1). Basin and Subbasin designations by DWR were first published in 1952 in Bulletin 118, and subsequently updated in 1975, 1980, and 2003. The San Joaquin River Hydrologic Region contains 11 distinct subbasins, where the Eastern San Joaquin Subbasin (Bulletin 118 Basin Number 5-022.01) is bordered to the north by the Cosumnes Subbasin (Bulletin 118 Basin Number 5-022.16), the South American Subbasin (Bulletin 118 Basin Number 5-021.65), and the Sacramento Subbasin (Bulletin 118 Basin Number 5-021.66); to the south by the Modesto Subbasin (Bulletin 118 Basin Number 5-022.02); and to the west by the Tracy Subbasin (Bulletin 118 Basin Number 5-022.15) (see Figure 2-2).

The Eastern San Joaquin Subbasin includes lands south of Dry Creek between the San Joaquin River on the west and the crystalline basement rock of the Sierra Nevada foothills on the east. The Eastern San Joaquin Subbasin boundary to the south stretches along the San Joaquin County line and continues along the Stanislaus River into Calaveras County to the east. Geologic units in the Eastern San Joaquin Subbasin consist of consolidated rocks and unconsolidated deposits (CA DWR, 2006).

No adjudicated areas or areas covered by an Alternative Plan exist within the Eastern San Joaquin Subbasin.

Figure 2-1: San Joaquin Valley Groundwater Basin

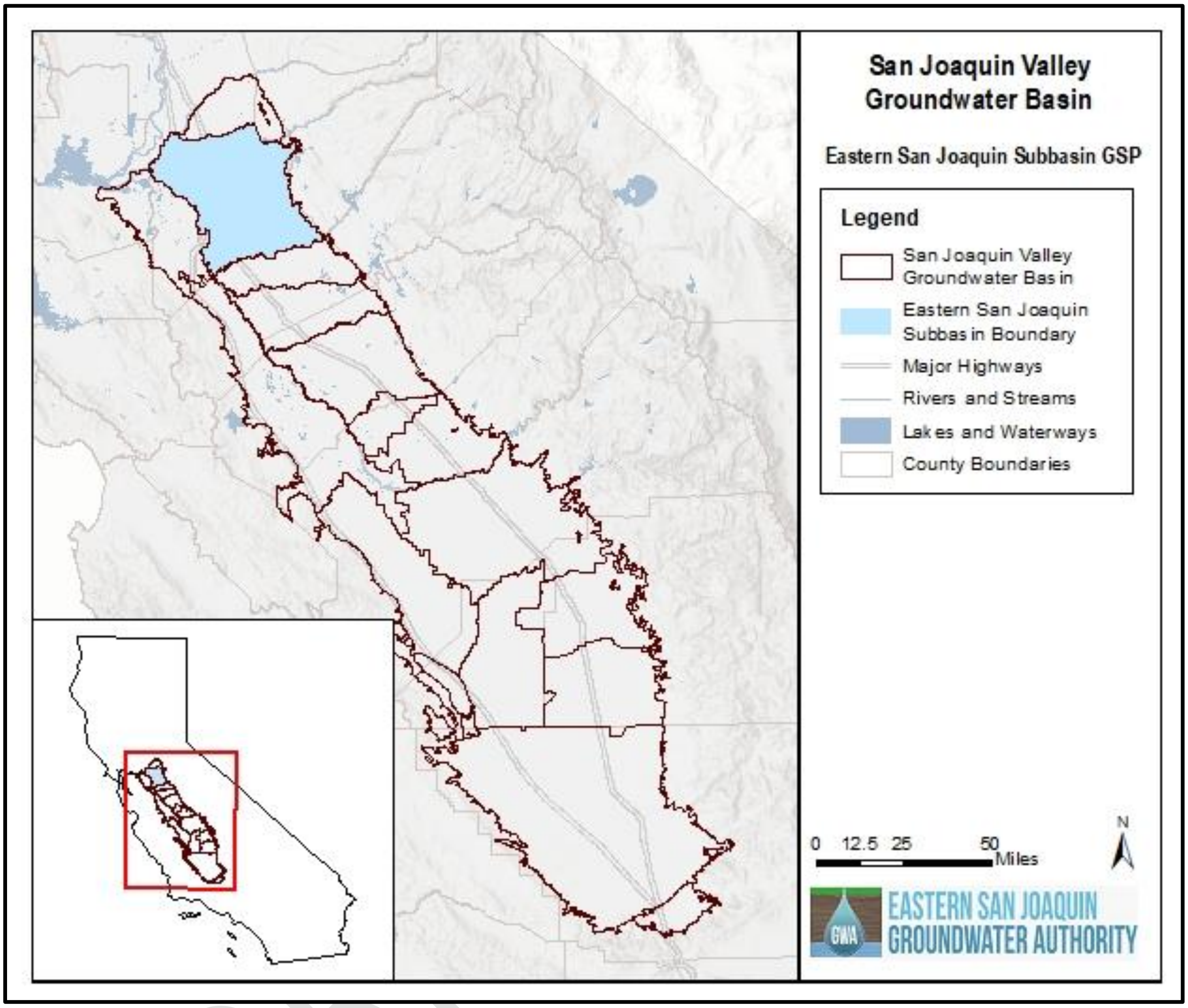
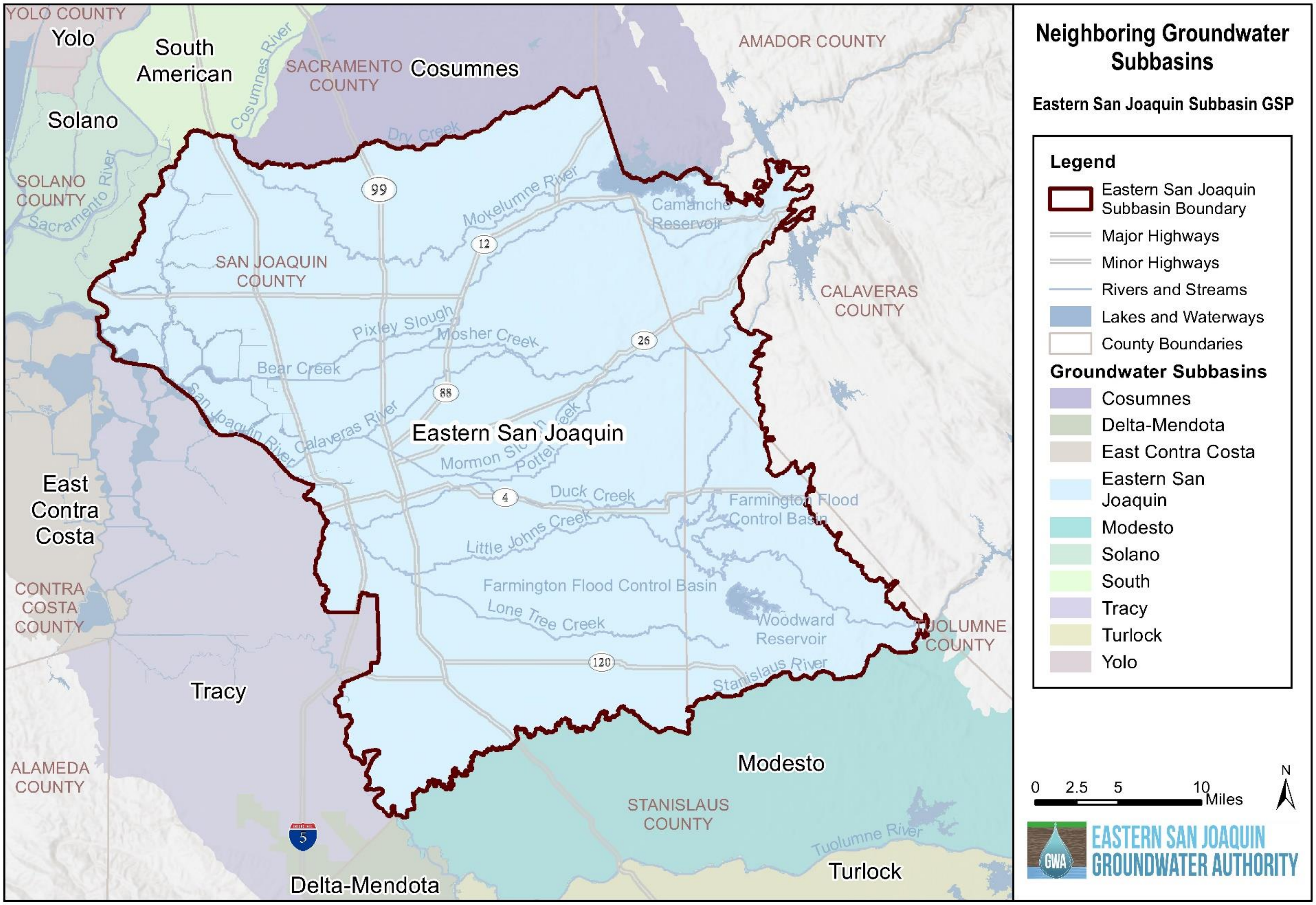


Figure 2-2: Neighboring Groundwater Subbasins



The Eastern San Joaquin Subbasin underlies areas of San Joaquin, Stanislaus, and Calaveras counties. Figure 2-3 shows the location of these three counties within the State of California as well as the three other counties bordering the Eastern San Joaquin Subbasin: Sacramento, Amador, and Contra Costa.

Figure 2-3: Surrounding Counties

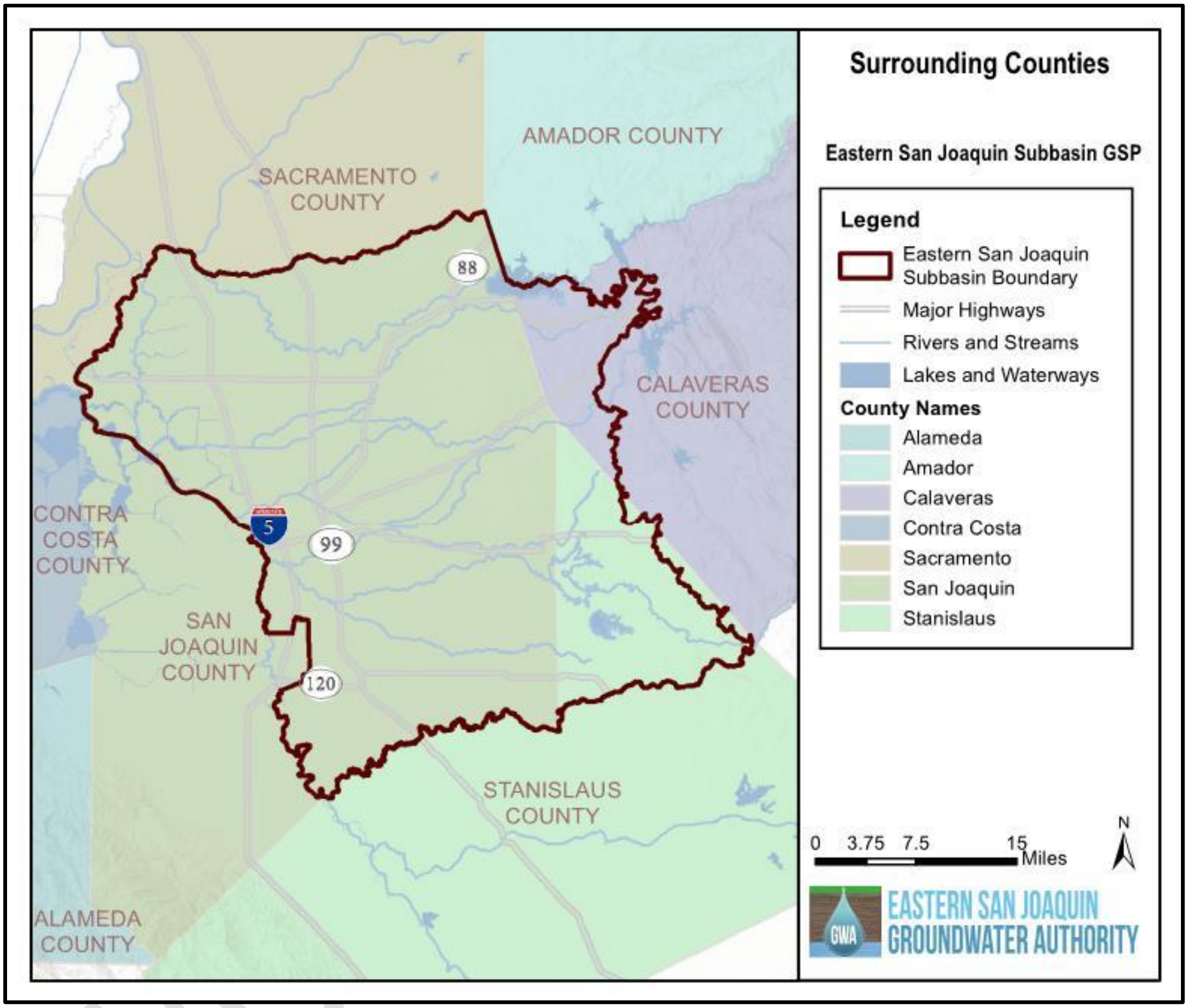


Figure 2-4 shows the Eastern San Joaquin Subbasin and the basin's key geographic features. The Subbasin encompasses an area of about 1,207 square miles. There are eight entities within the region with land use jurisdiction: the County of San Joaquin, the County of Calaveras, the County of Stanislaus, the City of Stockton, the City of Lodi, the City of Manteca, the City of Escalon, and the City of Ripon. The cities of Lodi, Escalon, Manteca, and Ripon are contained entirely within the Subbasin, while eastern portions of San Joaquin County and City of Stockton, and western portions of Calaveras and Stanislaus counties, lie in neighboring subbasins. The Eastern San Joaquin Subbasin encompasses the following unincorporated communities: Clements, Farmington, French Camp, Glenwood, Linden, Lockeford, Morada, Nobel Acres, Peters, Victor, Wallace, and Woodbridge.

Figure 2-4: City Boundaries

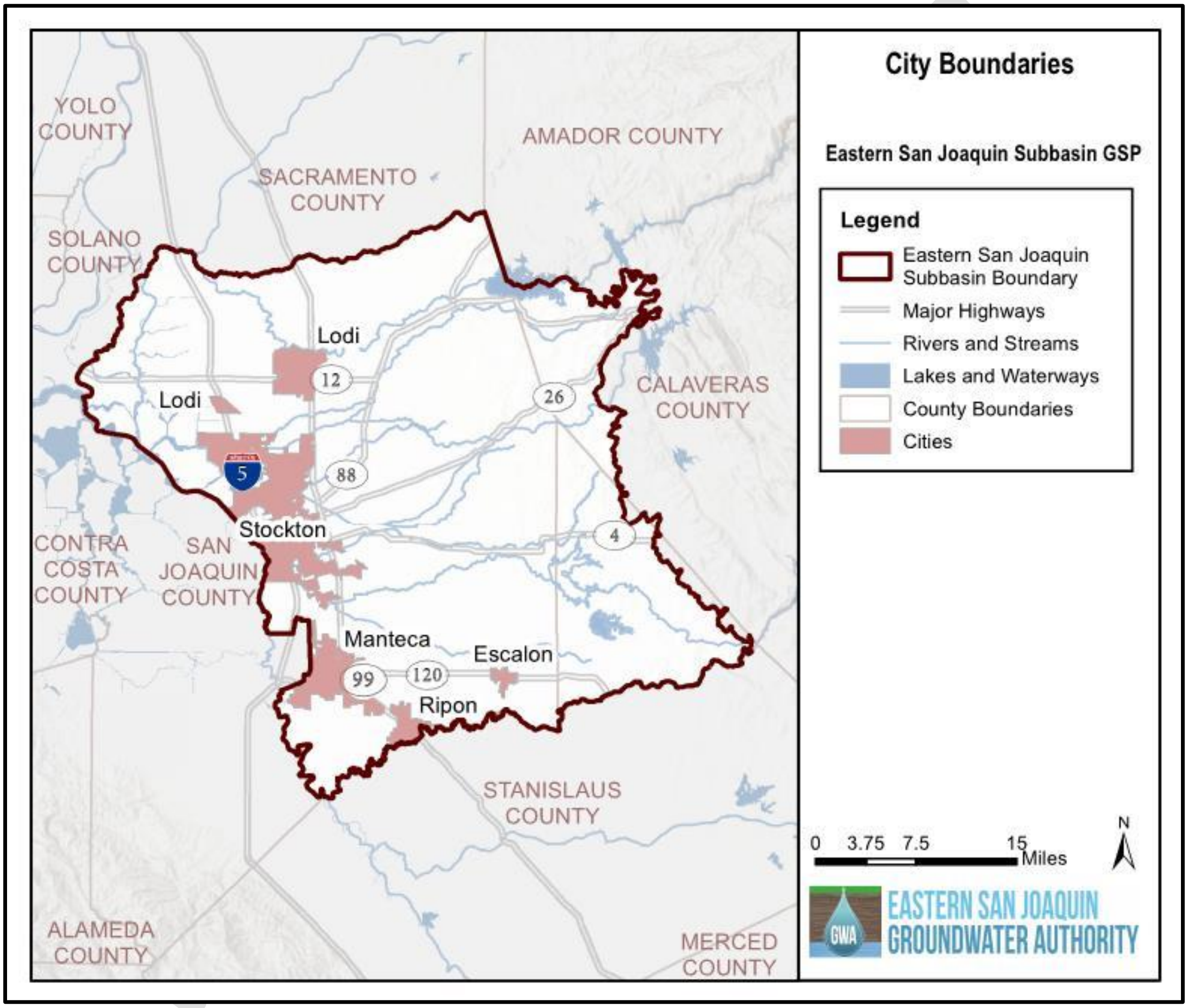


Figure 2-5 shows the spatial extent of Disadvantaged Communities (DACs) and Severely Disadvantaged Communities (SDACs) in the Eastern San Joaquin Subbasin. DWR defines DACs as census geographies (census tracts, census block groups, and census-designated places) with an annual median household income (MHI) that is less than 80 percent of the Statewide annual MHI. SDACs are defined as census geographies with an MHI less than 60 percent of the Statewide annual MHI. DWR uses the most recently available 5-Year American Community Survey (ACS) dataset to identify these areas. For this GSP, the 2012-2016 ACS dataset was used, establishing statewide MHI as $63,783 (CA DWR, Mapping Tools).

Figure 2-5: Disadvantaged Communities (DACs)

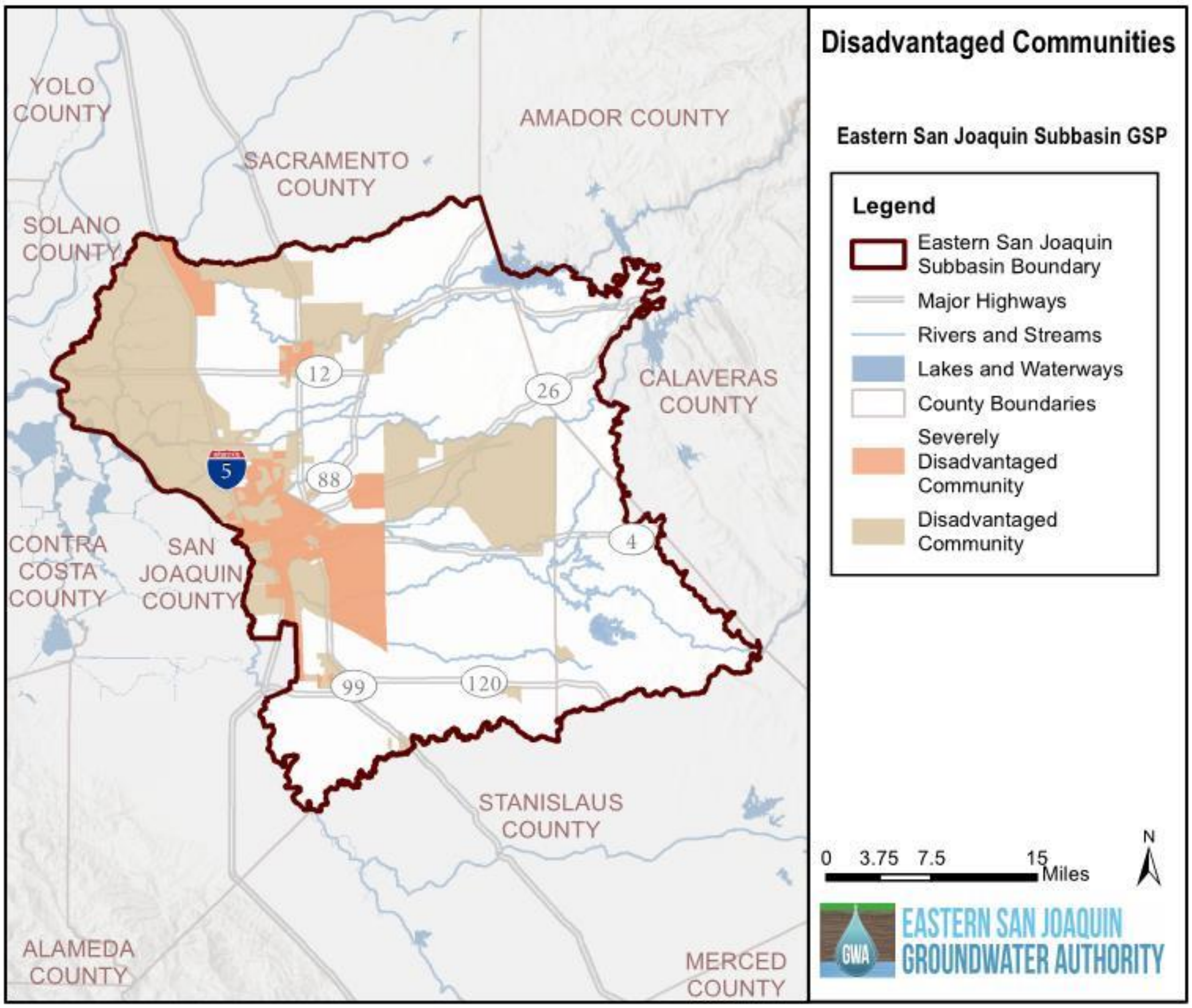


Figure 2-6 shows the extent of the 15 GSAs which together encompass the entire Eastern San Joaquin Subbasin. See Section 1.3 for a description of the agencies making up each GSA.

Figure 2-6: GSA Boundaries

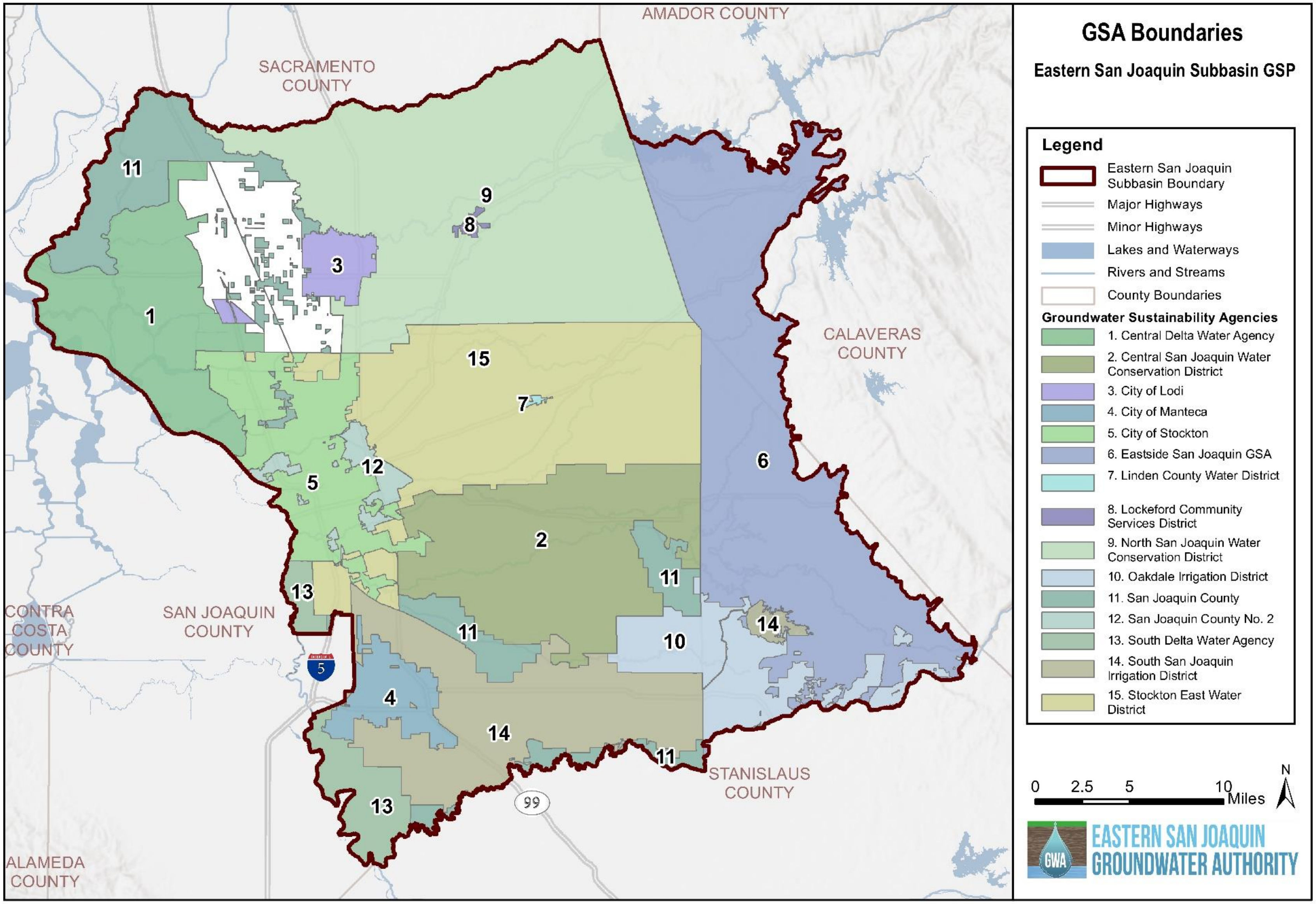
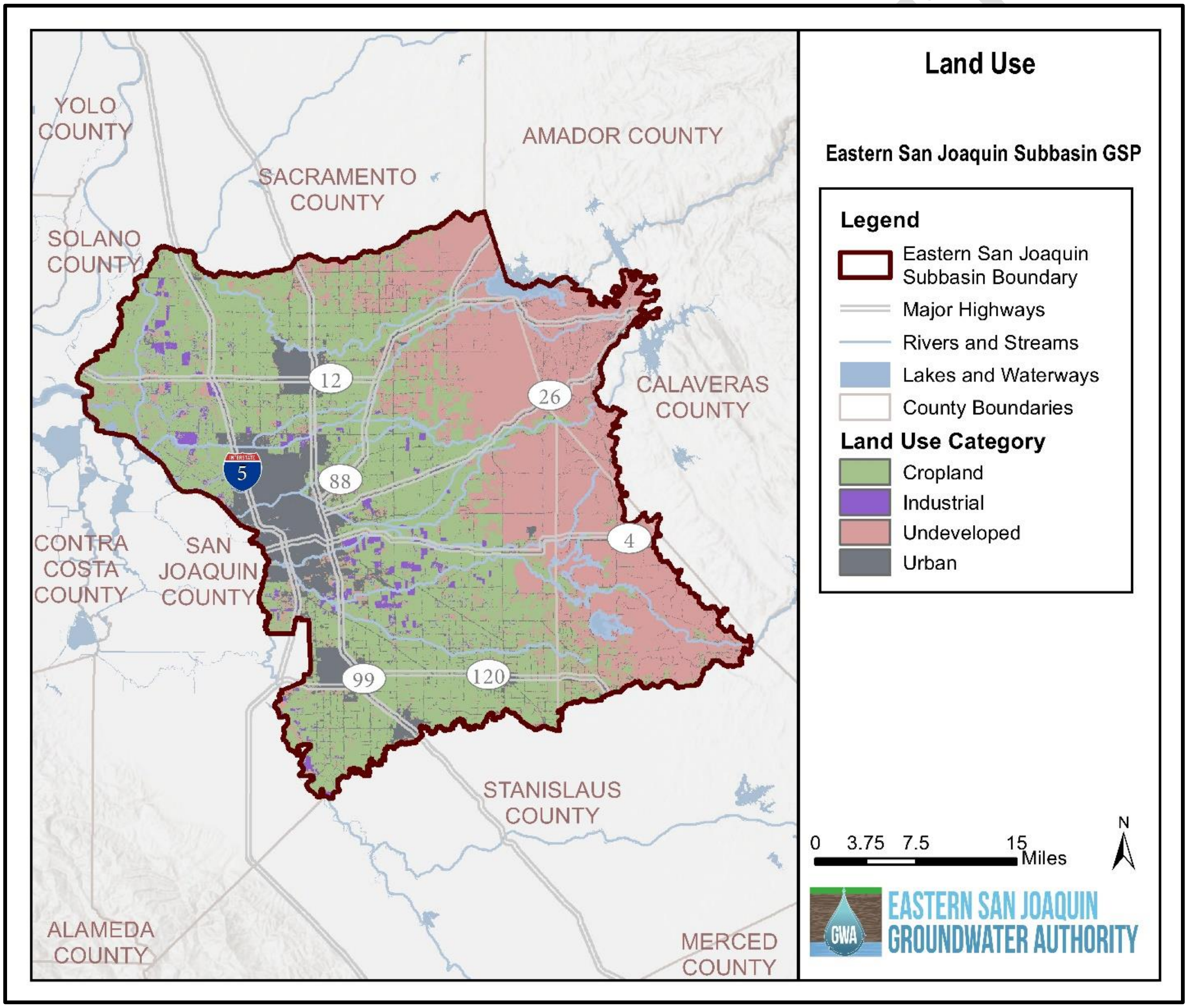


Figure 2-7 shows a map of land use in the Eastern San Joaquin Subbasin across four general categories: cropland, industrial, undeveloped, and urban. These categories were mapped based on categories provided by 2015 land use from the CropScape 2015 dataset.

Land use patterns in the Eastern San Joaquin Subbasin are dominated by agricultural uses, including nut and fruit trees, vineyards, row crops, grazing, and forage. These uses rely heavily on purveyors or districts, private groundwater wells, and surface water sources in some areas. Urban land use relies on a combination of surface water and groundwater. Land use is primarily controlled by local agencies. Land use patterns in the mountainous areas to the east are dominated by native vegetation and unirrigated pasture lands (USDA, 2015).

Figure 2-7: Land Use



Crop type varies by region, with orchards and vine crops comprising the majority of agriculture in the Subbasin. Almond orchards dominate the southern portion of the Subbasin, cherry and walnut orchards dominate the central portion of the Subbasin, and vineyards dominate the northern portion (Figure 2-8). In 2015, fruit and nut trees comprised 37 percent, and vineyards comprised 24 percent, of the irrigated crops in the Subbasin. Alfalfa and irrigated pasture were the next most dominant crop type, comprising 11 percent of irrigated crops in the Subbasin (USDA, 2015).

Figure 2-8: Land Use by Crop Type

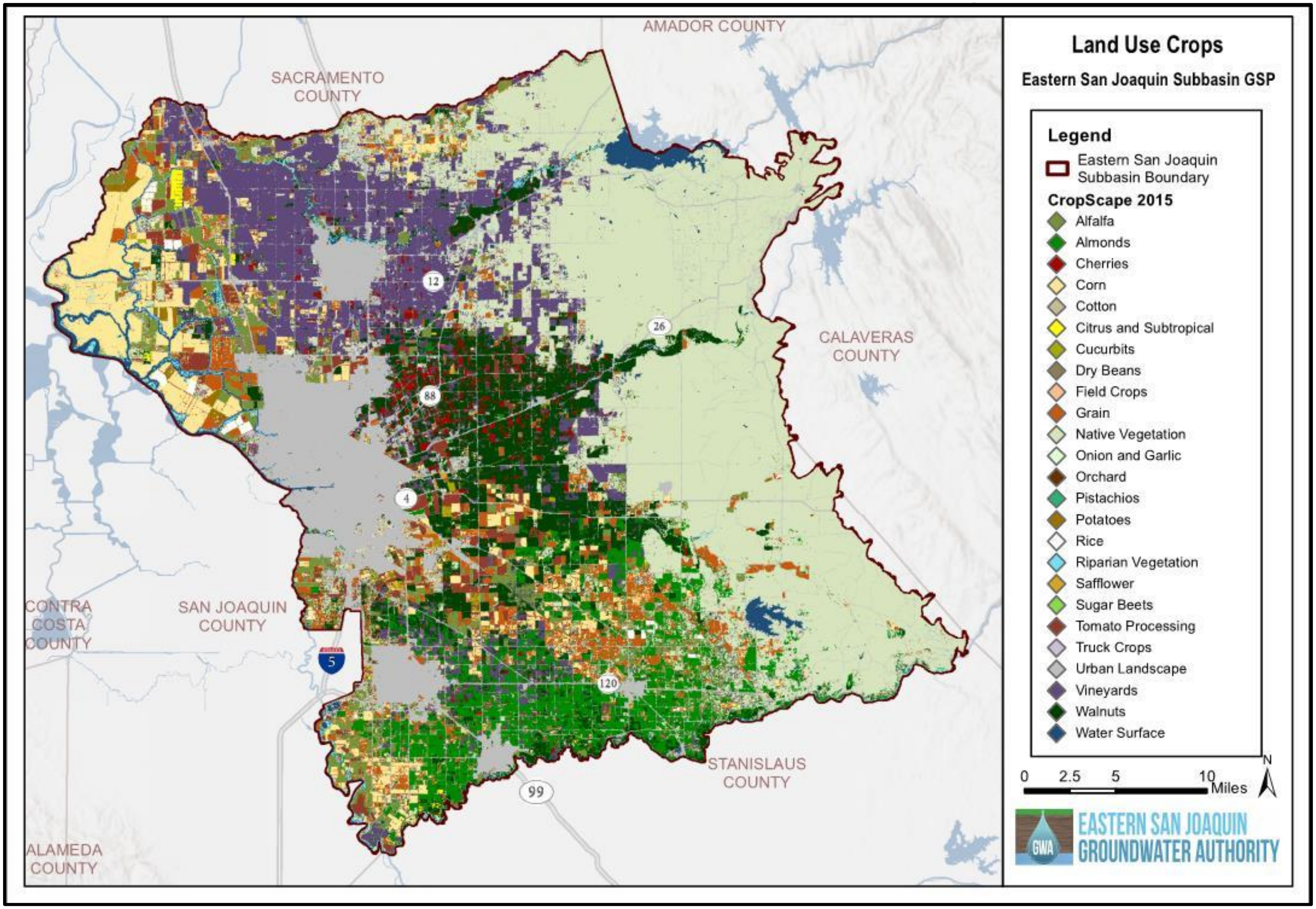


Figure 2-9 shows a map with boundaries of federal and state parks within the Eastern San Joaquin Subbasin. The United States Fish & Wildlife Service (USFW) manages the San Joaquin River National Wildlife Refuge situated in Stanislaus County where the Tuolumne, Stanislaus, and San Joaquin rivers meet. Established in 1987 to provide habitat for migratory birds and endangered species, the Refuge is 7,000 acres and is located just outside the southern boundary of the Subbasin (USFW, 2012).

The California Department of Parks and Recreation (California State Parks) also maintains the Caswell Memorial State Park located along the Stanislaus River near Ripon. The Caswell Memorial State Park protects a riparian oak woodland and is home to the riparian brush rabbit, an endangered species (California State Parks). This is the only State Park within the Eastern San Joaquin Subbasin boundary. The Franks Tract State Recreation Area (SRA) and the Carnegie State Vehicular Recreation Area (SVRA) are also managed by California State Parks; however, both of these areas are located outside of the Subbasin boundary.

Figure 2-9: US Fish & Wildlife Service and CA State Park Boundaries

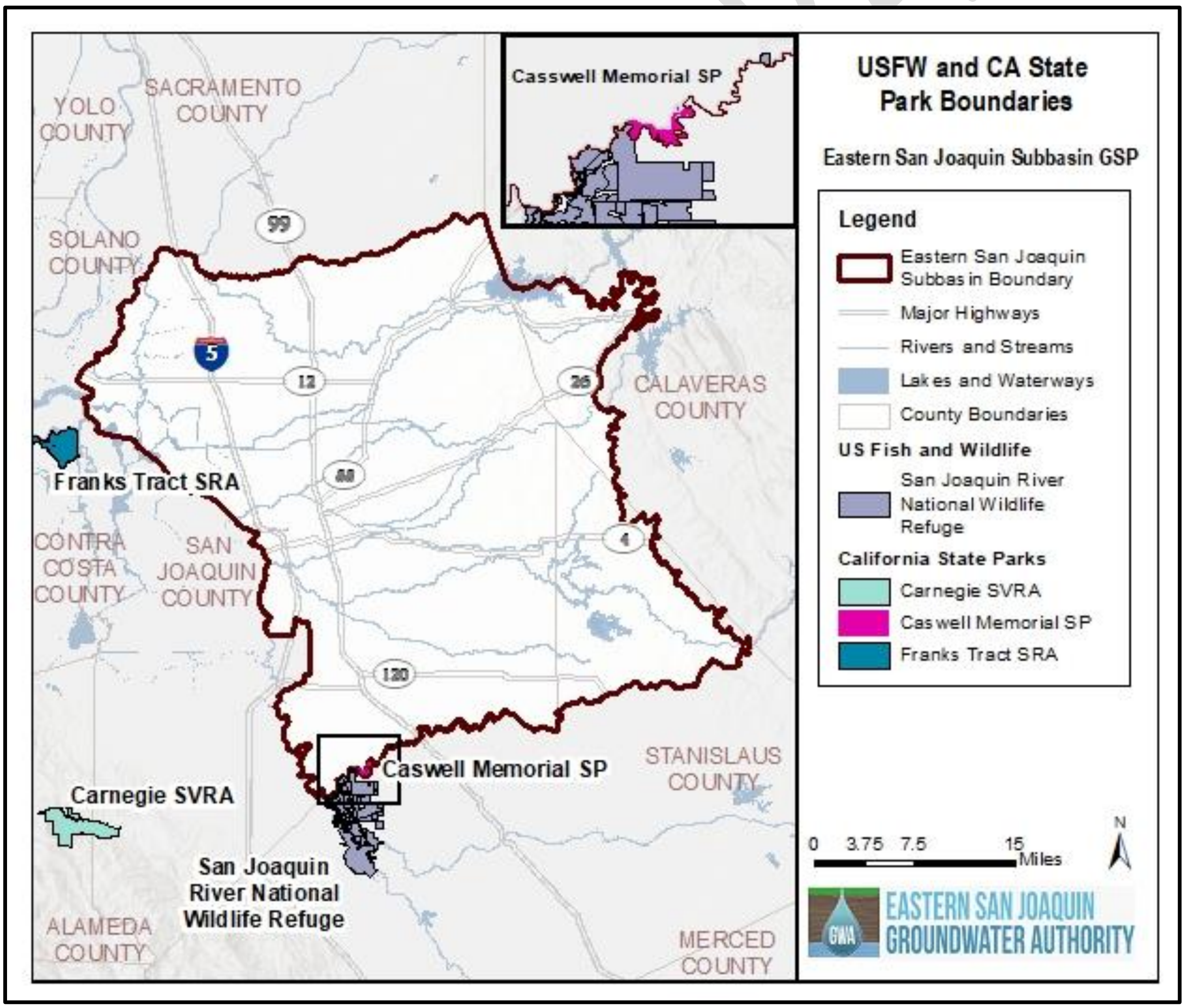


Figure 2-10 - Figure 2-12 shows the density of domestic, public, and production wells per square mile in the Eastern San Joaquin Subbasin, as available from the DWR. This includes approximately 1,000 unique wells collected primarily from DWR's Water Data Library (WDL), but also other state, regional, and local monitoring entities (CA DWR, Water Data Library). DWR recommends a suggested well density of 0.2-10 monitoring wells per 100 square miles. While the majority of the Eastern San Joaquin Subbasin meets this threshold, data gaps exist, particularly the northwestern corner of the Subbasin and to the east. Wells containing groundwater level data are described further in Section 2.2.1.1.

Figure 2-10: Density of Domestic Wells per Square Mile

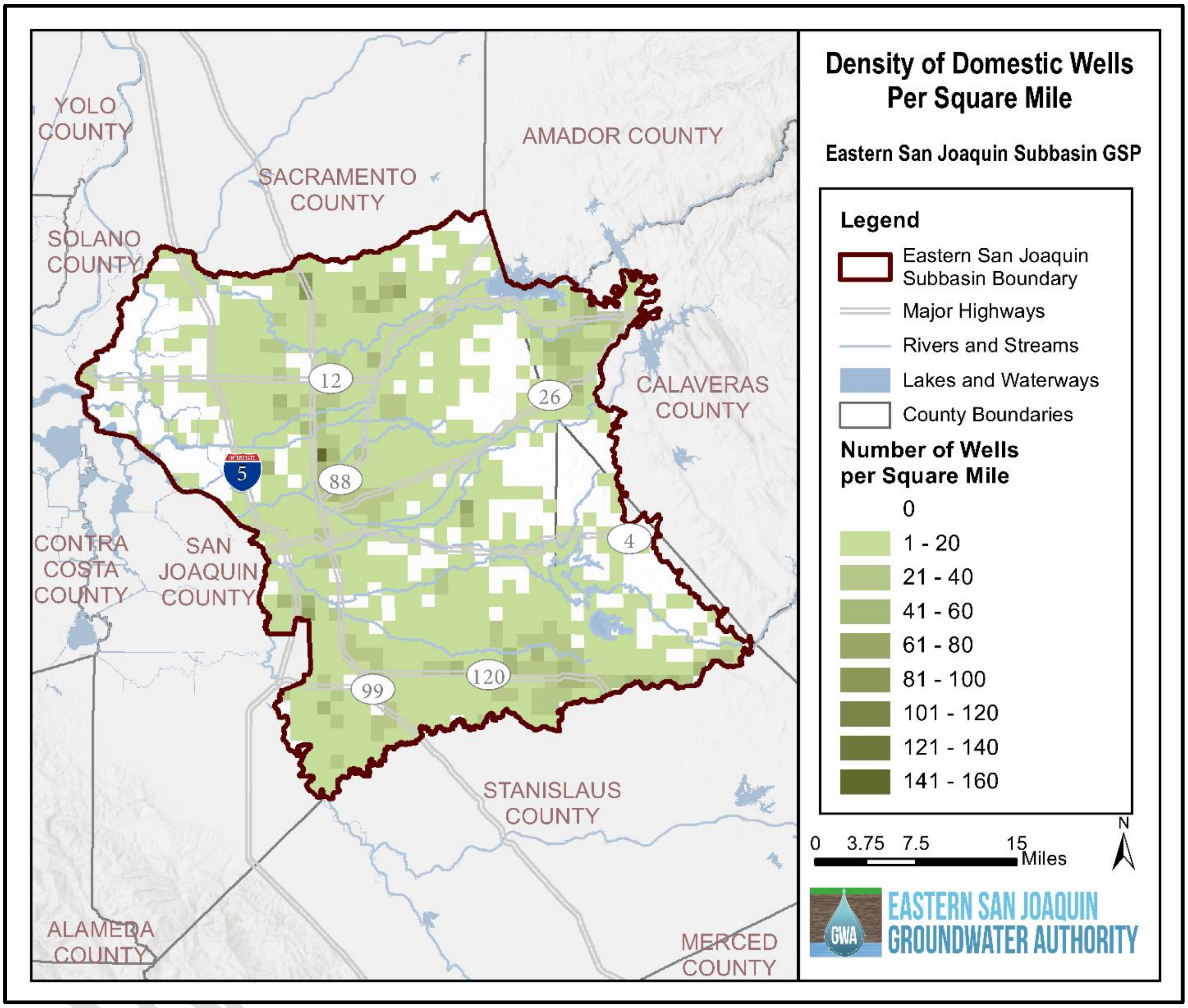


Figure 2-11: Density of Public Wells per Square Mile

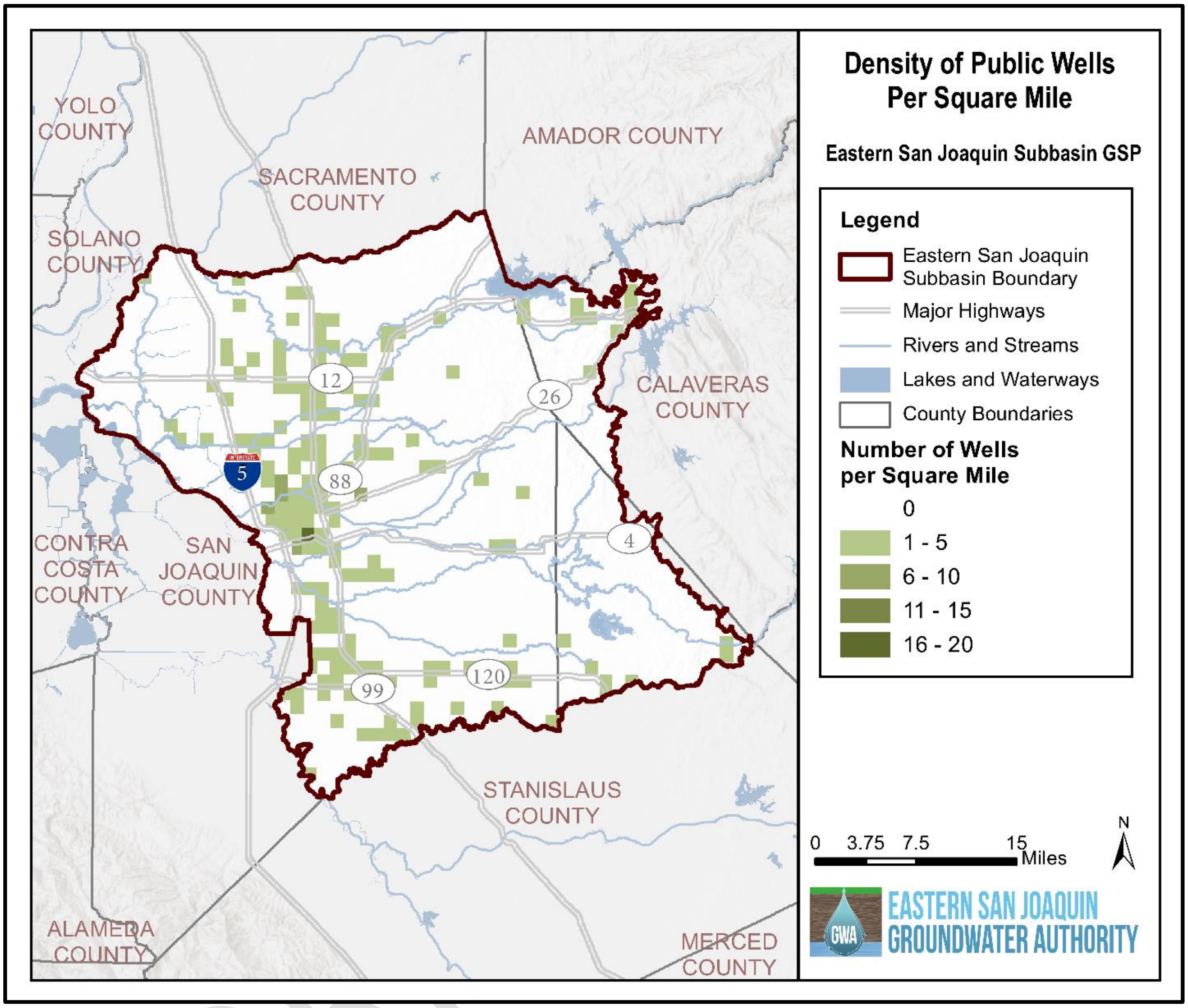
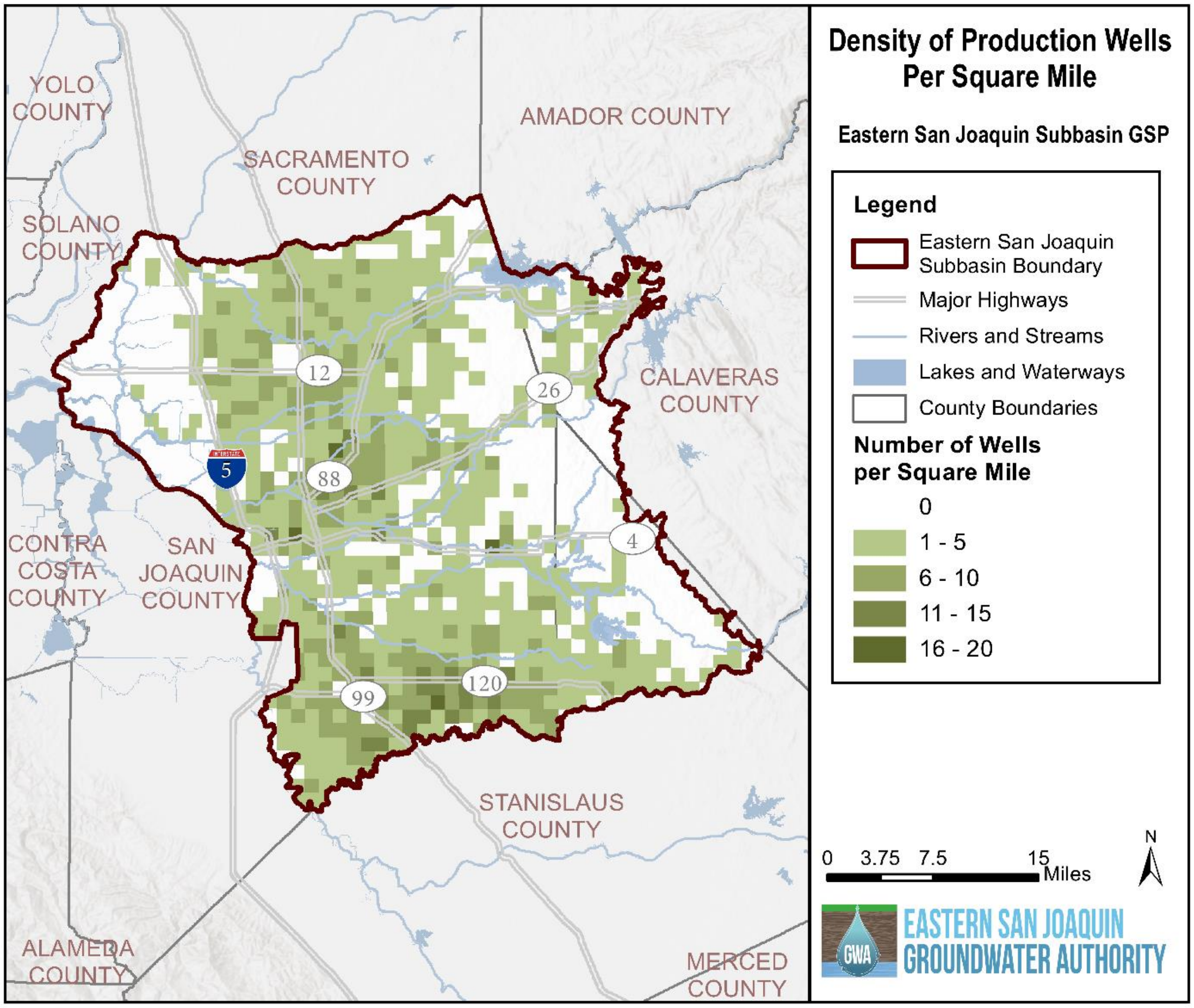


Figure 2-12: Density of Production Wells per Square Mile



2.2 PLAN AREA MONITORING

2.2.1 Existing Water Resources Monitoring and Management Programs

The existing monitoring and management landscape within the Eastern San Joaquin Subbasin is a patchwork of local, regional, state, and federal programs, each serving its own specific function. This patchwork provides valuable data that has supported past needs and will assist in meeting monitoring needs under SGMA. This patchwork of programs includes redundancies, inconsistent protocols, and inconsistent timing of monitoring that will need to be improved under SGMA.

Existing monitoring within the Eastern San Joaquin Subbasin is extensive, complex, and performed for a variety of purposes by a variety of entities. During a review of existing groundwater monitoring data and programs, data were collected from the following agencies and programs:

Statewide Monitoring Programs (Agencies and Databases):

- California Data Exchange Center (CDEC)
- California Department of Pesticide Regulation (CDPR)
- California Environmental Data Exchange Network (CEDEN)
- California State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW)
- Department of Water Resources:
  - California Statewide Groundwater Elevation Monitoring Groundwater Information Center Interactive Mapping Application (GICIMA)
  - WDL
- GeoTracker
- Groundwater Ambient Monitoring and Assessment Program (GAMA)
- Online System for Well Completion Reports (OSWCR)
- University NAVSTAR Consortium (UNAVCO)
- United States Bureau of Reclamation (Reclamation)
- United States Geological Survey (USGS)

Regional Monitoring Programs:

- Central Valley Salinity Alternatives for Long-Term Sustainability
  - California Department of Public Health (CDPH)
  - DDW
  - DWR
  - Central Valley Regional Water Quality Control Board (CVRWQCB) Waste Discharge Requirement (WDR) dairy data, Dairy CARES
  - USGS's National Water Information System (NWIS)
- Central Valley Dairy Representative Monitoring Program
- EnviroStor
- Groundwater Quality Trend Monitoring Program through SWRCB Irrigated Lands Regulatory Program (ILRP)
- San Joaquin River Restoration Program

Local Monitoring Agencies

- Cal Water
- Calaveras County Water District
- City of Lodi
- City of Manteca
- City of Stockton
- Linden County Water District

- Lockeford Community Services District
- North San Joaquin Water Conservation District
- Oakdale Irrigation District
- San Joaquin County
- South San Joaquin Irrigation District

DESCRIPTION OF THE MONITORING PROGRAMS THAT WILL BE USED IN THE GSP, AND HOW THEY WILL BE USED, TO BE COMPELTED FOLLOWING COMPLETION OF THE MONITORING NETWORK SECTION

2.2.1.1 Groundwater Level Monitoring and Data Sources

2.2.1.1.1 CASGEM

DWR maintains several groundwater level monitoring programs, tools, and resources covering California. The California Statewide Groundwater Elevation Monitoring (CASGEM) Program is DWR's primary resource for groundwater level data, and it has been used extensively in the development of this GSP. The CASGEM Program was authorized in 2009 by SB X7-6 to establish collaboration between local monitoring parties and DWR to collect and make public statewide groundwater elevation data. The program provides the framework for local agencies or other organizations to "assume responsibility for monitoring and reporting groundwater elevations in all or part of a basin or subbasin" (CA Water Code Section 10927). Three CASGEM monitoring agencies exist in the Eastern San Joaquin Subbasin: Calaveras County Water District (CCWD), San Joaquin County Flood Control and Water Conservation District (SJCFCWCD), and Stanislaus County. These three agencies have completed separate CASGEM Monitoring Plans, which are included in the references section.

CCWD CASGEM Monitoring Plan: CCWD adopted a CASGEM Monitoring Plan in November 2012, with the following objectives:

- Collect semi-annual groundwater levels from a selected monitoring well network
- Upload groundwater levels to the CASGEM website after data quality steps have been completed
- Maintain and update the monitoring well network plan documents including additions and removals from the monitoring network

These objectives are helpful to this planning effort, as they include regular monitoring of groundwater levels and data upload to CASGEM. The CCWD plan also includes a description of the CASGEM monitoring network and groundwater level measurements. The monitoring network includes two USGS nested monitoring wells equipped with pressure transducers, which continuously monitor groundwater levels. The monitoring network also includes seven other wells that are not USGS wells. These wells are not equipped with pressure transducers, and manual groundwater elevation measurements are gathered at all wells twice a year. As stated in the CCWD CASGEM plan, the non-USGS wells are owned by private landowners, and additional wells may need to be added in the future if owners opt out of the monitoring network (CCWD, 2012). This monitoring network covers the portion of Calaveras County within the Eastern San Joaquin Subbasin.

SJCFCWCD CASGEM Monitoring Plan: The SJCFCWCD CASGEM Monitoring Plan provides a description of the CASGEM monitoring network and groundwater conditions in San Joaquin County. This plan covers the portions of the Eastern San Joaquin and Tracy Subbasins within San Joaquin County. The SJCFCWCD has been taking water level measurements since 1971 at wells owned by a variety of entities and by private individuals. A large portion of wells in the District's network are privately owned (SJCFCWCD, 2006). The District sent out consent forms to these private well owners to release well information to CASGEM, about forty of these forms were signed and returned, and construction information for these wells was uploaded to CASGEM. This information includes attributes such as well depth, coordinates, reference point elevation, depth of screened interval.

Stanislaus County CASGEM Monitoring Plan: The Stanislaus County Department of Environmental Resources (SCDER) established a CASGEM monitoring plan in 2016 to cover the portion of Stanislaus County within the Eastern San Joaquin Subbasin, often referred to as the northern triangle. This plan details the groundwater level monitoring history, protocols, and network for the northern triangle portion of Stanislaus County. This area is largely rural and most of the development exists between the Stanislaus River and near the Woodward Reservoir. Wells selected for the CASGEM program are in the developed areas. 17 wells are included in this CASGEM plan, consisting of one domestic and ten irrigation wells, plus six wells that are of unknown type. Similar to the SJCFCWCD and Calaveras County CASGEM plans, well information such as depth and screened interval was uploaded to CASGEM for these wells. (Stanislaus County DER, 2016).

2.2.1.1.2 San Joaquin County

San Joaquin County publishes semi-annual groundwater reports, covering groundwater conditions in San Joaquin County. These reports include tables, hydrographs, and maps on groundwater levels. Groundwater level results from each semi-annual report are compared with values from the previous period. Groundwater level data collected by the county includes the data mentioned in the CASGEM section, above, and additional data that is not incorporated into CASGEM. The data are maintained by the San Joaquin County Department of Public Works.

2.2.1.1.3 Water Data Library

DWR's WDL contains measurements of groundwater elevations from water supply and monitoring wells monitored by numerous entities, such as DWR and local agencies. Groundwater level measurements available from the WDL are either continuously or periodically measured. Continuous measurements are provided by automatic water level measuring devices that take readings at wells; periodic measurements are manual recordings typically occurring at semi-annual or more frequent time intervals. Measurements displayed through the WDL are taken through other programs, such as CASGEM. The WDL lists the organization responsible for collecting each water level measurement. The WDL water level measurements are available through the California Natural Resources Agency (CNRA) Open Data website as a bulk download, or through the WDL website on a per station basis. In this GSP, WDL water level measurements are utilized for basin characterization but are acquired from the other programs.

2.2.1.1.4 National Water Information System

The NWIS is a USGS program comprising several water datasets, including groundwater level measurements. Like the WDL, NWIS contains continuous and periodic water level measurements for recent and historical conditions. Within the Eastern San Joaquin Subbasin, there are only a few active NWIS groundwater sites and a large number of inactive sites with historical records. NWIS includes the monitoring organization for each well.

2.2.1.1.5 Data Received Directly from GSAs

A number of the GSAs collect water level and water quality information within their GSAs of varying frequencies and detail. These data were provided as part of the ESJWRM data collection effort and were compared with and included in groundwater level and water quality datasets analyzed for the preparation of this GSP.

The development of the ESJWRM took place in an open and transparent process. Coordination efforts took place with the Eastern San Joaquin County GBA, the organizational structure for agency coordination that proceeded SGMA regulations and the formation of the GWA. Through this effort, many of the GWA agency members participated in a Technical Review Committee, which acted as a forum to review model input data and assumptions. The Technical Review Committee facilitated major modeling decisions, and provided input data, including groundwater pumping records, surface water delivery records, urban demand, and local water levels and quality data.

Local agencies with consistent representation at the Technical Review Committee meetings included San Joaquin County, WID, City of Lodi, NSJWCD, LCSD, CCWD, City of Stockton, Cal Water, SEWD, City of Lathrop, City of Manteca, SSJID, City of Escalon, OID, and Stanislaus County. Other agencies contributed local data to information collection efforts later in the GSP development process.

2.2.1.1.6 Online System for Well Completion Reports

The OSWCR is a DWR program used to document and compile boring or well completion records throughout California. There are as many as 2 million domestic, irrigation, and monitoring water wells in California included in this dataset, including approximately 10,000 domestic wells located in the Eastern San Joaquin Subbasin. When a well is constructed, modified, or destroyed, drilling contractors are required to submit a Well Completion Report to DWR for upload to the interactive OSWCR web site. OSWCR is used a data source for wells identified for monitoring. In this GSP, the OSWCR data base was used to evaluate Plan Area and identify sustainable management criteria.

2.2.1.2 Groundwater Quality Monitoring and Data Sources

2.2.1.2.1 Groundwater Ambient Monitoring and Assessment Program

The GAMA Program is an extensive groundwater quality monitoring program that was established by the SWRCB in 2000. The program compiles groundwater quality data from several agencies including the DWR, USGS, Department of Pesticide Regulations (DPR), Lawrence Livermore National Laboratory (LLNL), and others. Agencies submit data from monitoring wells for 258 constituents including total dissolved solids (TDS), nitrates and nitrites, arsenic, and manganese. GAMA data for the Eastern San Joaquin Subbasin contains water quality results collected by the SWRCB-DDW (formerly DHS-DDW), DPR, DWR, LLNL, and USGS from the 1940s to present. Figure 3-3 in the Basin Setting chapter shows the GAMA monitoring network throughout the Eastern San Joaquin Subbasin, which consists of roughly 6,800 monitoring points.

2.2.1.2.2 Water Data Library

In addition to the groundwater level records described previously, DWR's WDL contains groundwater quality data. This information includes discrete samples collected by DWR of current and historical groundwater quality measurements. These water quality results list the entity responsible for taking the sample but do not specify what program the sample was taken under. The WDL water quality measurements are available through the CNRA Open Data website as a bulk download, or through the WDL website on a per-station basis. In this GSP, WDL water quality measurements are utilized for basin characterization but are acquired from the other programs.

2.2.1.2.3 National Water Information System

The USGS NWIS contains groundwater quality data, in addition to the groundwater level measurements previously discussed. Groundwater quality results in NWIS relate to GAMA records, but there is no direct link between the two databases. Some NWIS sites have a State ID listed, which is a common identifier used for wells. This indicates these wells can be connected to other databases using the State ID information. However, differences in the format of the State ID between NWIS and other databases creates challenges in cross referencing between databases. In this GSP, NWIS water quality measurements are utilized for basin characterization but are acquired from the other programs.

2.2.1.2.4 Division of Drinking Water

The SWRCB DDW monitors public water system wells for Title 22 requirements such as organic and inorganic compounds, metals, microbial, and radiological analytes. Data are available for active and inactive drinking water sources for water systems that serve the public – defined as wells serving 15 or more connections or more than 25 people per day. Data are electronically transferred from certified laboratories to DDW daily. Data generated from this program become part of the Consumer Confidence Reporting (CCR) program and GAMA. DDW data was used in the development of this GSP to identify point-source contamination areas.

2.2.1.2.5 GeoTracker

GeoTracker, operated by the SWRCB, is a subset program of the GAMA program. GeoTracker GAMA does not regularly monitor for general groundwater quality constituents. Instead, GeoTracker contains records for sites that require cleanup, such as leaking underground storage tank sites, Department of Defense sites, and cleanup program sites. GeoTracker also contains records for various unregulated projects as well as permitted facilities including: ILRP, future CV-SALTS, oil and gas production, operating permitted underground storage tanks, and land disposal sites. GeoTracker receives records and data from SWRCB programs and other monitoring agencies.

2.2.1.2.6 Irrigated Land Regulatory Program and CV-SALTS

The IRLP is a program established by the CVRWQCB focused on monitoring and regulating the concentration of pesticides, toxicity, and nutrients (such as TDS and nitrates) in surface and groundwater. General orders under the ILRP require agricultural users in the Central Valley to prevent sediment, fertilizer, pesticides, manure and other materials used in farming from leaving the field in irrigation or stormwater and entering surface waters or leaching below the root zone to groundwater. Biannually, agricultural users sample and submit data for irrigation and domestic wells. As part of the ILRP, the San Joaquin County and Delta Water Quality Coalition members monitor drinking water wells on enrolled parcels for nitrates, with results submitted to GeoTracker. This requirement began January 1, 2019, based on the February 7, 2018, revision of ILRP Waste Discharge Requirements (Order) for the Eastern San Joaquin River Watershed by the SWRCB. In addition, there are several representative monitoring sites for the monitoring of dairies. The ILRP program is in the process of developing a comprehensive monitoring network for future use to address the ILRP data objectives. The San Joaquin County and Delta Water Quality Coalition members also monitor domestic wells for nitrate in high vulnerability areas.

The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) program was launched by the CVRWQCB in 2006 in an effort to develop sustainable salinity and nitrate management plans and solutions to the salinity problem in the Central Valley. CV-SALTS is a coalition of agricultural, business, and industry parties along with local, regional, and state governments which facilitate and fund efficient management systems of salinity, technical studies, and the 2017 Final Salt and Nutrient Management Plan (SNMP). The 2017 SNMP was developed based off a detailed water quality analysis conducted for salinity (represented by TDS) and nitrates using measurements from wells across multiple agencies from 2000-2016. Appendices to the SNMP and supporting documents contain summary information about these constituents by Subbasin, including Eastern San Joaquin. Basin Plan Amendments identify specific actions and recommendations for individual basins in the Central Valley. Efforts are underway to implement a salinity monitoring program and the CV-SALTS program will likely require monitoring and data submittal to GeoTracker.

2.2.1.3 Interconnection of Databases

Several of the databases discussed above and in the Data Compilation Section (refer to HCM Section 3.1) utilize the same water level or water quality data. These records often specify the monitoring entity responsible for the measurement. Although these data overlap between databases, the correlation between databases is not specified. For example, water level data in the WDL is also in CASGEM, but this link is not mentioned in WDL records. This lack of connection poses problems for gathering water level and quality data in the Eastern San Joaquin Subbasin and throughout California. For instance, if certain water level data is gathered through CASGEM but not uploaded to NWIS, users who gather water level measurements through NWIS would miss the CASGEM data. Efforts have been made in the development of this Plan to overcome the issue related to overlap and poor correlation between databases, but the issue remains. It is recommended that agencies work together to utilize a common unique identifier to ease use of multiple datasets.

2.2.1.4 Land Subsidence Monitoring

Subsidence monitoring in San Joaquin County is performed using continuous global positioning system (GPS) stations and has been reported by the University NAVSTAR (Navigation Satellite Timing and Ranging) Consortium Plate

Boundary Observatory since 2004. Periodic subsidence reporting within the Eastern San Joaquin Subbasin is not known to occur. However, ad-hoc analyses have been conducted using satellite-based methods over limited time periods, as described below. With these two subsidence monitoring methods combined, about 100 square miles of the southwestern corner of the Eastern San Joaquin Subbasin is monitored.

2.2.1.4.1 United States Geological Survey

Eleven continuously operating GPS (CGPS) stations are used to monitor subsidence in the Central Valley. The monitoring station closest to the Eastern San Joaquin Subbasin is station P781 located west of Modesto in Stanislaus County. This location will be used to assess the impact from subsidence associated with the occurrence of expansive clays below ground (Corcoran Clay) in this area.

The USGS report *Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-10* (Sneed et al., 2013) presents land subsidence data in the southwestern portion of the Eastern San Joaquin Subbasin from 2007 to 2010. Data for about 100 square miles of the Subbasin were recorded using Interferometric Synthetic Aperture Radar (InSAR) processing, a satellite-based remote sensing technique that can detect ground-surface deformation. Two InSAR techniques were used: conventional InSAR and persistent scatterer (PS) InSAR. Both sources of data were collected from the Japanese Aerospace Exploration Agency's Advanced Land Observing Satellite (ALOS). Periodic reporting of InSAR-derived ground displacement maps to a single member agency is not known to occur.

2.2.1.5 Groundwater Storage Monitoring

There are no existing programs that conduct regular monitoring specific to groundwater storage in the Eastern San Joaquin Subbasin. The ESJWRM historical model was used to generate estimates for historical groundwater storage based on a series of inputs including historical groundwater elevation data. The ESJWRM generated estimates for current and projected volumes of groundwater in storage based on assumptions for how future conditions may change relative to historical conditions.

2.2.1.6 Interconnected Surface Water Monitoring

There are no existing programs that conduct regular monitoring specific to the interconnection of surface water to groundwater in the Eastern San Joaquin Subbasin. However, surface water monitoring and groundwater level monitoring will be integrated to characterize spatial and temporal exchanges between surface water and groundwater and to estimate potential depletions of surface water caused by groundwater extractions. Additional information on how the depletions monitoring network was developed, monitoring frequency, and summary protocols is provided in the Sustainable Management Criteria chapter.

2.2.1.7 Canal Diversions and Seepage

Canal seepage in the Eastern San Joaquin Subbasin is tracked on a district-by-district basis. All of the major irrigation districts utilize natural watercourses and/or canals to distribute surface water diversions to their customers.

OID diverts water from the Stanislaus River at Goodwin Reservoir through the Joint Main Canal on the north side and the South Main Canal on the south side. Approximately 330 miles of laterals carry water to landowners off of the main canals. While this entire lateral system was historically comprised of open, unlined ditches, 100 miles of the laterals have been converted to pipelines; 105 miles are inconsistent, non-continuous open concrete-lined ditches; and the rest remain unlined. Approximately 40 percent of the OID service area is within the Eastern San Joaquin Subbasin. According to the District-wide water balance developed by OID in 2016 as part of the 2015 Agricultural Water Management Plan, canal seepage is calculated to be 33,746 AF on average in wet years and 37,647 AF in dry years. Drain seepage is estimated to be 5,579 AF and 6,219 AF for wet and dry years, respectively. Deep percolation of applied water contributes about 27,474 AF of recharge on average overall. Within OID, approximately 44 percent of all recharge is due to canal seepage, and an additional 33 percent of all recharge is due to deep percolation of applied water. (OID, 2015).

In SSJID, similarly, the primary source of recharge in the groundwater system is conveyance seepage and deep percolation of applied water. SSJID diverts from the Stanislaus River initially and then sends the water through a system of lateral canals to its customers. Like OID, the entire system was open and unlined, but over time it has been slowly concrete lined and replaced with PVC pipelines. By 2015, the District used 312 miles of piped laterals and 38 miles of concrete-lined ditches. The 18 miles of the Main Distribution Canal is the only unlined portion. Recharge from canal seepage and deep percolation are estimated to be 144,000 AF/year, with 34 percent of total recharge from canal seepage and 66 percent from deep percolation (SSJID, 2015a).

SEWD uses two unlined canal systems to deliver water from Stanislaus River: Upper Farmington Canal and Lower Farmington Canal. SEWD also uses natural watercourses to distribute their water, such as rivers, creeks, and sloughs. SEWD's two canals are considered to lose about 5 percent of their flow to seepage, and natural water courses within the district may lose as much as 40 percent of their flow to seepage during the irrigation/delivery season. CSJWCD also uses the Upper Farmington Canal for transport, as well as natural watercourses within its boundaries. SEWD estimates that overall 26,000 AF is recharged through canal and natural watercourse seepage within district boundaries for an average year (SEWD, 2015).

Throughout its history, WID has also made efforts to improve the efficiency of the delivery infrastructure it maintains. Water for WID is diverted from the Mokelumne River and from the Delta at the end of Beaver Slough. In 2015, WID had about 100 miles of lined and unlined canals, and pipelines. Approximately 60,000 AF/year of Mokelumne River water is recharged through deep percolation and in-lieu recharge in the District. To counter these losses, the District has imposed a $2 per acre fee on land benefiting from the use of unlined portions of the canal network (WID, 2016).

Canal seepage, generally considered a loss to Districts in the short term, has played and will continue to play a crucial role in the long-term sustainability of groundwater resources in the Eastern San Joaquin Subbasin.

2.2.1.8 Conjunctive Use Programs

Conjunctive use is the use of surface water to allow the basin to recharge and store additional water supply, either through either in-lieu use or direct recharge. This section describes conjunctive use programs in the Eastern San Joaquin Subbasin, including both in-lieu recharge and direct recharge projects.

In-lieu recharge occurs for both agricultural and municipal purposes wherever surface water is being delivered to offset the use of groundwater. Agencies conducting in-lieu recharge include CCWD, City of Lodi, City of Manteca, City of Stockton, CSJWCD, OID, SEWD, SSJID, and WID. Riparian users of surface water are also benefitting from in-lieu recharge.

Direct recharge projects exist in NSJWCD and SEWD. NSJWCD's Tracy Lake Groundwater Recharge Project includes direct recharge of 500 to 1,000 AFY by placing surface water in the bed of South Tracy Lake to allow for percolation. The Cal-Fed/Costa Recharge project includes direct recharge of about 300 AFY by flooding about 20 acres of vineyards post-harvest. NSJWCD is in the process of looking to expand all of these programs and add additional in-lieu and direct recharge projects in its service area. SEWD's Farmington Groundwater Recharge Program was developed in 2001 with a conceptual plan to recharge surface water via field flooding on about 1,200 acres. Since 2003, SEWD operated a 60-acre recharge site as a result of the Farmington Program with additional 73 acres coming online in 2019. The observed recharge amount ranges from 2,800 AF/Y to 5,800 AF/Y with an average of 4,400 AF/Y for a total recharge volume about 65,000 AF. SEWD also has several wells to pump some of this recharged water for municipal supply during especially dry years.

2.2.1.9 Existing Water Management Programs and Plans

The subsections below contain descriptions of existing water management programs and plans, including Integrated Regional Water Management Plans, Agricultural Water Management Plans, and Urban Water Management Plans that apply to the Eastern San Joaquin Subbasin.

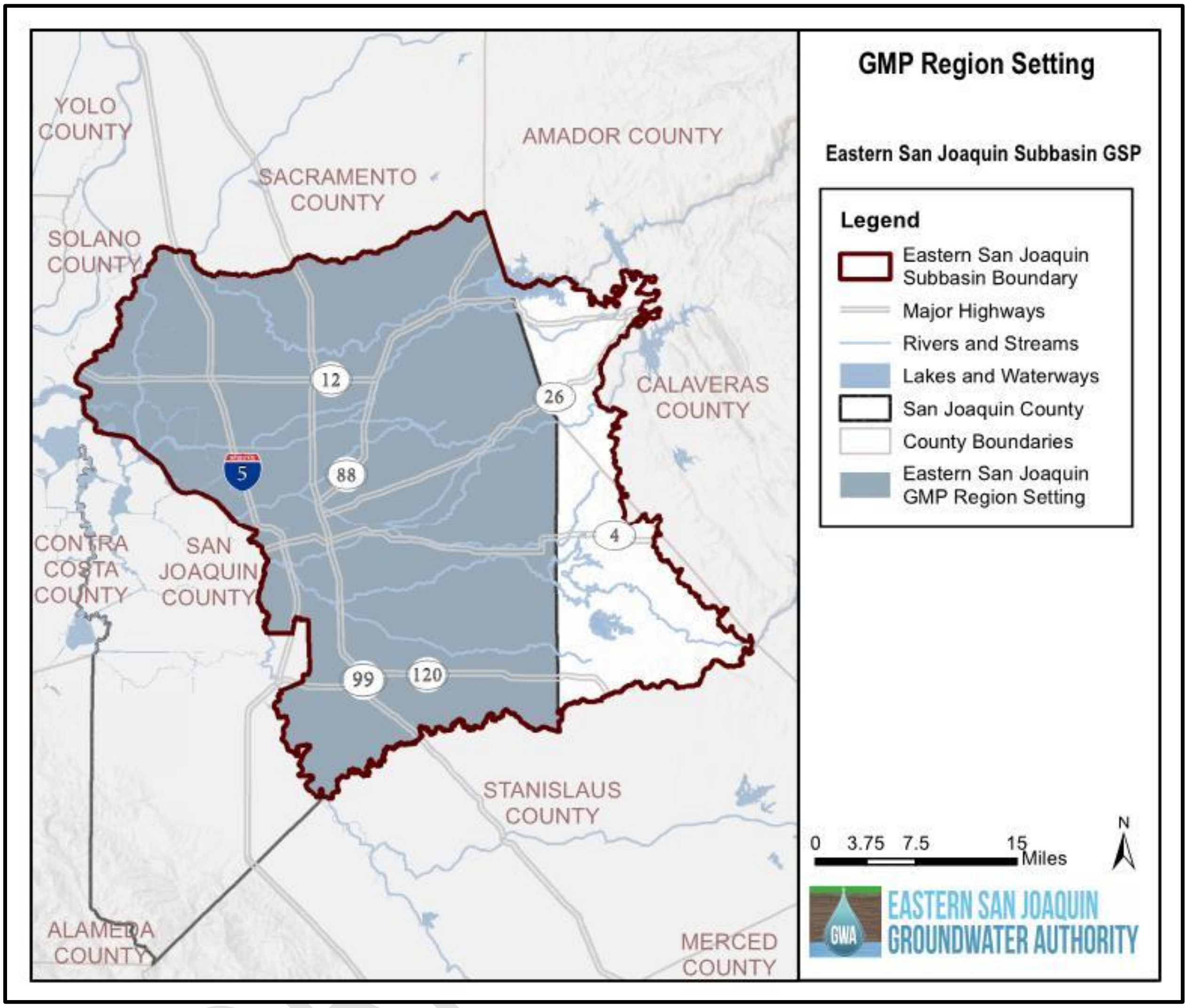
2.2.1.9.1 Groundwater Management Plan

The Eastern San Joaquin Groundwater Basin Groundwater Management Plan (GMP), developed by the Northeastern San Joaquin County Groundwater Banking Authority in September 2004, was a collaborative effort between local water interests with historically diverse viewpoints to reinforce local control and provide direction for the sustainable development of groundwater resources. The GMP covers a geographic region that includes the entirety of the Eastern San Joaquin Subbasin that falls within San Joaquin County but excludes portions within Calaveras and Stanislaus counties to the east. The GMP boundaries are generally defined by the San Joaquin County line to the east, the San Joaquin River to the west, Dry Creek to the north, and the Stanislaus River to the south. See Figure 2-13 for a map of the Eastern San Joaquin GMP Region.

The 2004 GMP provides valuable resources related to potential concepts, projects, and monitoring strategies that are leveraged in this GSP (Northeastern San Joaquin County Groundwater Banking Authority, 2004). The following management objectives would potentially influence implementation of the GSP:

- Maintain or enhance groundwater elevations to meet the long-term needs of groundwater users within the Groundwater Management Area
- Maintain or enhance groundwater quality underlying the Basin to meet the long-term needs of groundwater users within the Groundwater Management Area
- Minimize impacts to surface water quality and flow due to continued Basin overdraft and planned conjunctive use
- Prevent inelastic land subsidence due to continued groundwater overdraft

Figure 2-13: Eastern San Joaquin GMP Region Setting



2.2.1.9.2 Integrated Regional Water Management Plan

The Eastern San Joaquin Integrated Regional Water Management Plan (Eastern San Joaquin IRWMP) is a collaborative regional planning document that was published in June 2014. The IRWMP defines and integrates key water management strategies to establish protocols and courses of action to implement the Eastern San Joaquin Integrated Conjunctive Use Program (ICU Program). The ICU Program was designed to implement a comprehensive, prioritized set of projects and management actions to meet adopted Best Management Objectives, moving the Eastern San Joaquin County Region toward the goal of sustainable and reliable water supplies (Eastern San Joaquin County GBA, 2014).

The following 2014 IRWMP objectives related to groundwater use would potentially influence implementation of the GSP:

- Minimize adverse impacts to agriculture, communities, and the environment
- Maximize efficiency and beneficial use of supplies

- Protect and enhance water rights and supplies

An update to the 2014 Plan is currently underway.

2.2.1.9.3 Mokelumne Interregional Sustainability Evaluation Program Report

The Mokelumne Watershed Interregional Sustainability Evaluation (MokeWISE) was formed following efforts made by the Mokelumne River Forum over seven years by a diverse set of stakeholders in the Upper and Lower Mokelumne River watersheds, with the objective to develop and evaluate alternatives to optimize water resources management within the Mokelumne-Amador-Calaveras (MAC) and Eastern San Joaquin IRWM planning regions. The plan offers a bi-regional approach by bringing together stakeholders, and it brings together the interregional sections of two IRWM regions identified as the Mokelumne River Forum (San Joaquin GBA, 2015).

The following MokeWISE objectives related to groundwater use would potentially influence implementation of the GSP:

- Groundwater is not considered a viable additional source in Amador and Calaveras counties
- The Eastern San Joaquin Subbasin is considered critically overdrafted
- Groundwater is not considered a viable additional supply source, although conjunctive use and recharge opportunities may be available

2.2.1.9.4 Agricultural Water Management Plans

Agricultural Water Management Plans (AWMPs) were developed and adopted by OID, SEWD, SSJID, and WID in 2015 in compliance with SB X7-7 of 2009, which requires certain agricultural water suppliers to prepare an AWMP and implement Efficient Water Management Practices (EWMPs). The Critical EWMPs include:

- Measure the volume of water delivered to customers with sufficient accuracy
- Adopt a pricing structure based at least in part on quantity delivered (Volumetric Pricing)

Applicable Conditional EWMPs that have the benefit of less applied water or increasing system efficiency include:

- Facilitate alternative land use for lands with exceptionally high water duties
- Facilitate use of available recycled water
- Facilitate financing of capital improvements for on-farm irrigation systems
- Implement an incentive pricing structure that promotes one or more of the goals identified in the California Water Code (CWC)
- Expand line or distribution systems, construct regulating reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage
- Increase flexibility in water ordering by, and delivery to, water customers within operational limits
- Construct and operate supplier spill and tailwater recovery systems
- Increase planned conjunctive use of surface water and groundwater
- Automate canal control structures

- Facilitate or promote customer pump testing and evaluation
- Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report
- Provide for the availability of water management services to water users
- Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage
- Evaluate and improve the efficiencies of the supplier's pumps

The 2015 AWMPs provide a framework of management practices to help meet water management goals that align with the goals of the Eastern San Joaquin GSP.

2.2.1.9.5 Urban Water Management Plans

Urban Water Management Plans (UWMPs) were developed by Cal Water, CCWD, City of Lodi, City of Manteca, City of Ripon, City of Stockton, SSJID, and SEWD, according to requirements of the CWC.

Agencies acting as GSAs use the following actions to encourage conservation and efficient use of water:

- Water waste prohibition ordinances
- Metered distribution systems
- Tiered water rates and conservation pricing
- Public education and outreach efforts
- Water conservation program coordination and staffing support
- Free residential plumbing retrofit devices
- Washing Machine Rebate program

2.3 LAND USE ELEMENTS OR TOPIC CATEGORIES OF APPLICABLE GENERAL PLANS

2.3.1 Existing General Plans

San Joaquin County has jurisdiction over land use planning for the majority of the surface area of the Subbasin. The incorporated cities of Stockton, Manteca, Lodi, Ripon, and Escalon make up the remaining area. Implementation of the Eastern San Joaquin GSP may be affected by the policies and regulations outlined in the San Joaquin County General Plan, as well as the General Plans for the five cities, given that the long-term land use planning decisions that would affect the Subbasin are under the jurisdiction of the County and respective cities.

This section describes how implementation of the various General Plans may change water demands in the basin, how the General Plans may influence the GSP's ability to achieve sustainable groundwater use, and how the GSP may affect implementation of General Plan land use policies. Policies outlined in the General Plans that will potentially influence implementation of the GSP are discussed below and listed in Appendix D. Relevant General Plan Goals and Policies

2.3.1.1 San Joaquin County General Plan

The San Joaquin County General Plan describes the official County "blueprint" on the location of future land use, type of development encouraged, and decisions regarding resource conservation. Stakeholders informed the development of the County's vision and guiding principles, which represent the County's core values and establish benchmarks for the General Plan's goals and policies (SJC, 2016b). The General Plan encourages preservation of the County's groundwater resources and states that future urban and agricultural growth should occur within the sustainable capacity of these resources.

2.3.1.2 Calaveras County General Plan

The Calaveras County General Plan has provided a framework for growth and development in Calaveras County. The Calaveras County General Plan was developed in 1996 in collaboration with local stakeholders and policymakers to understand the challenges facing the community and to enact a common vision for the future. The Calaveras County Planning Commission has been working since 2008 to revise the General Plan, which is now more than 20 years old.

The Calaveras County General Plan recognizes that water is a limited and valuable resource and that the region is experiencing localized problems with both water supply and quality. To mitigate these issues, the General Plan delineates policies and goals that promote sustainable water resources management in the region (Calaveras County, 1996).

2.3.1.3 Stanislaus County General Plan

The Stanislaus County General Plan provides a comprehensive, long-term plan to guide development within the Stanislaus County boundaries through 2035. The General Plan was updated and adopted in 2016 to reflect the evolving conditions of the region. While Stanislaus County's economic base remains predominantly agricultural, the County's land use and economy continue to diversify in response to increased pressure to convert productive agricultural lands to non-agricultural uses. To address the region's changing water needs, the Stanislaus County General Plan supports goals, policies, and implementation measures that promote sustainable water management and protect the local groundwater sources (Stanislaus County, 2016).

2.3.1.4 City of Stockton General Plan

The City of Stockton General Plan establishes the City's 2040 vision and provides supporting goals, policies, and actions needed to achieve it. The General Plan for the 2040 vision was built upon the prior 2035 Stockton General Plan (adopted in 2007) and was a collaborative process that involved a diverse group of stakeholders and interests. The General Plan update incorporated feedback from City Council study sessions, Planning Commission study sessions, community workshops, and numerous other public meetings and outreach events (City of Stockton, 2016).

The City of Stockton's General Plan recognizes that groundwater supplies are vital to Stockton's ability to meet current and future water demands. The City has focused attention on optimizing available surface water supplies and cooperating with agencies in the region to manage the groundwater resources at a sustainable yield and to address regulatory pressures, droughts, and saline intrusion (City of Stockton, 2016).

2.3.1.5 City of Lodi General Plan

The City of Lodi General Plan Update, published in 2010, outlines a vision for Lodi's future and provides a set of policies and programs that guide community growth and development. The 2010 General Plan Update replaced the 1991 General Plan and was informed by community members and stakeholders who participated in the planning process through different avenues, including public workshops and meetings, mail surveys, interviews, presentations, and newsletters (City of Lodi, 2010).

As the primary source of water supply for the City of Lodi, the General Plan recognizes that groundwater contamination and overdraft in the Eastern San Joaquin Subbasin can threaten the City's ability to meet current water demands and limit future development (City of Lodi, 2010).

2.3.1.6 City of Manteca General Plan

The City of Manteca adopted the first Manteca General Plan in 2003 and is currently working on the Manteca General Plan Update to reflect the current conditions of the City. The Manteca General Plan Update is anticipated to conclude in 2019 and is a collaborative process between community members, City staff, and decision-makers to produce a General Plan that is current, progressive, flexible, and viable. The General Plan Update also reevaluates the existing vision for Manteca through 2040, incorporates new planning strategies, and brings the General Plan into compliance with recent social and environmental policies (City of Manteca, 2017).

The Manteca General Plan Update recognizes that groundwater is a large source of potable water supply for the City and that the Eastern San Joaquin Subbasin is in overdraft. To address groundwater overdraft in the City, a significant number of policies in the General Plan promote increased understanding of the Eastern San Joaquin Subbasin.

2.3.1.7 City of Escalon General Plan

The Escalon General Plan was developed for the City in 1994 and updated in 2010 to reflect the most current conditions of the City and to provide comprehensive planning for future development. The Escalon General Plan was developed through a cooperative effort involving the City Council and Planning Commission, City staff and their consultants, and stakeholders in the City (City of Escalon, 2010). The Escalon General Plan delineates policies that support the long-term preservation of water supplies and water quality in the Eastern San Joaquin Subbasin (City of Escalon, 2010).

2.3.1.8 City of Ripon General Plan

The City of Ripon's General Plan was updated in 2006 to guide the use of private and public lands within the community's boundaries through 2040. The General Plan update provides a framework for promoting growth and reevaluates where growth should be located. The General Plan development process was informed by community members representing a wide variety of interests, city department heads, and staff representatives of public agencies (City of Ripon, 2006).

The General Plan supports the preservation of groundwater quantity and quality as it is an important source of water supply for the City of Ripon. Future development within the planning area is expected to have minimal effects on groundwater supplies, although it is unknown how development will impact groundwater quality. The General Plan predicts that the City of Ripon may have to abandon a large number of wells as sources of potable water due to contamination, and, as a result, additional development may be prohibited until an adequate source of potable water can be identified. Surface water is expected to meet water demands for surrounding agricultural uses (City of Ripon, 2006).

2.3.1.9 Effect of GSP Implementation on Applicable General Plans

The General Plans in the Subbasin provide the regions with a guideline to facilitate anticipated growth within the sustainable capacity of existing resources. Successful land use planning also promotes sustainable water supply and use within the regions. Due to the complementary nature of the General Plans and the GSP, the goals and policies in the General Plans support the ability of the GSAs to achieve sustainability.

Implementation of the GSP, including changes in groundwater management, may influence the type of land use and location of future development, depending on the level of changes set forth by the GSP, such as enacted programs, plans, and policies. While General Plan implementation may result in land use changes and changes in water consumption, minimal change in water demand is expected from GSP implementation. Most of the land within the Eastern San Joaquin Subbasin is currently developed to some use, and conversion from agricultural uses to urban uses is not anticipated to increase water demand. However, conversion from agriculture to urban use may have an effect on water source, depending on the location in the Subbasin, and may shift supply from groundwater to surface water.

2.3.2 Land Use Plans Outside the Subbasin

Land use decisions in neighboring areas experiencing overdraft are likely to affect groundwater conditions in the Eastern San Joaquin Subbasin. The portions of the Tracy and the Delta-Mendota Subbasins that are adjacent to the Eastern San Joaquin Subbasin are also located within San Joaquin County. These land use planning areas are covered by the San Joaquin County General Plan described in Section 2.3.1.1.

The cities of Tracy, Lathrop, Modesto, and Elk Grove are the largest urban areas neighboring the Eastern San Joaquin Subbasin. The City of Tracy, located within San Joaquin County, updated its General Plan in 2011. The City of Tracy General Plan identifies the Tracy Subbasin as a source of water supply for the city, though available groundwater supplies are projected to decrease by 2025. The City of Tracy is working towards reducing its reliance on groundwater and reserving its use for emergency situations and droughts (City of Tracy, 2011).

The City of Lathrop, located within San Joaquin County, relies on potable water supplies consisting of a combination of groundwater and treated surface water from the South County Water Supply Program. The General Plan for the City of Lathrop was first adopted in 1991 and last amended in 2004.The General Plan reflects the City's long-range aspirations by defining goals and policies for current and future development and by providing guidance on proposed projects.

The City of Modesto, located in Stanislaus County, relies on the Modesto and Turlock Subbasins for its groundwater supplies. The City of Modesto General Plan identifies declining groundwater levels as an environmental concern for the City of Modesto as a result of increased urban demands. The General Plan calls for continued protection and conservation of groundwater sources while pursuing additional water supplies (City of Modesto, 2008).

The City of Elk Grove, located in Sacramento County, relies heavily on groundwater from the Sacramento Valley subregion of the Central Valley aquifer system. To address years of drought conditions and low precipitation, the City of Elk Grove Draft General Plan outlines several goals and policies to protect groundwater supplies while meeting increased water demands from agricultural production and a growing population (City of Elk Grove, 2018).

2.3.3 Well Permitting

2.3.3.1 San Joaquin County

San Joaquin County oversees a well permitting program for any new, replacement, back-up, and De Minimis well construction. The purpose of this program is to prevent groundwater contamination and safety hazards by regulation of the location, construction, repair, and destruction of water supply, monitoring, and geophysical wells and borings. Pursuant to CWC, Section 13808, all new wells that do not meet the exemption criteria must submit additional information prior to the issuance of a permit by the Environmental Health Department. The permit program is enforced by Ordinance Code of San Joaquin County Section 9-1115, and Municipal Codes of Stockton, Lodi, Manteca, Tracy, Escalon, and Ripon. Applicants must provide information about groundwater elevation estimates, land elevation estimates, extraction volume estimates, depth of Corcoran Clay, and other basic well characteristics.

San Joaquin County has established water well standards that define property line setbacks, casing perforations, gravel packing, well seals, backflow prevention, disinfection requirements, sampling taps, and more, as well as the requirement for installing monitoring device(s) for groundwater extraction, elevation, and/or water quality.

The San Joaquin County Well Standards outline well grouting and construction standards to prevent contamination, pollution, and degradation of water wells and of the groundwater by intrusion of poor-quality water. Wells must have a watertight annular seal near the land surface to keep surface water and other potential contamination out of the well.

The minimum depth of the annular seal for wells in San Joaquin County is summarized in Table 2-1 (San Joaquin County, 1993).

Table 2-1: Minimum Depth of Seal Below Ground Surface for Wells in San Joaquin County

Well Type	Feet
Public Water Supplies	100
Individual Domestic Well	100
Industrial Wells	100
Agricultural Wells	50

2.3.3.2 Calaveras County

The Calaveras County Board of Supervisors adopted a well construction and destruction ordinance in 1998. The ordinance mandates that a permit must be obtained from the Calaveras County Environmental Health Department prior to development or modification of any well within the Calaveras County boundaries. The purpose of the program is to regulate the construction, alteration, abandonment and destruction of wells such that groundwater will not be contaminated and that groundwater supplies will not jeopardize the health, safety, or welfare of Calaveras County residents.

To prevent polluted or contaminated water from entering the well, the Well Program established a minimum depth at which the annular space should be filled. The annular seal depths for wells in Calaveras County are summarized in Table 2-2 (Calaveras County Board of Supervisors, 2008).

Table 2-2: Minimum Depth of Seal Below Ground Surface for Wells in Calaveras County

Well Type	Feet
Public drinking water well	50
Commercial well	50
Industrial well	50
Individual domestic well	20
Agricultural well	20
Vertical geothermal exchange wells	20
Wells within 25 feet of a water way	20 feet below the bed of the water way

2.3.3.3 Stanislaus County

Pursuant to Chapter 9.36 of the Stanislaus County Code, well owners must first receive a valid permit from the Stanislaus County to construct, install, repair, or destroy any well or well seal within the County. The Stanislaus County Department of Environmental Resources (DER) is responsible for reviewing the applications and issuing permits. The Stanislaus County Code also states that all wells must have an annular seal, except for agricultural wells that are not used for domestic purposes and are located more than 300 feet from a domestic well. The Stanislaus County Code does not specify the minimum annular seal depths for wells in Stanislaus County (Stanislaus County, 2019).

In 2014, the DER adopted a Groundwater Ordinance to prohibit unsustainable extraction of groundwater in unincorporated areas of the County. The DER reviews each Well Permit Application and determines whether the well is subject to, or exempt from, the prohibitions in the Groundwater Ordinance. Permit Applications for wells intended to extract 2 AF/year of groundwater or less are exempt from the prohibitions in the Groundwater Ordinance (Stanislaus

County Department of Environmental Resources, 2014). The annular seal depths for wells in Calaveras County are summarized in Table 2-3 (Stanislaus County, 2019).

Table 2-3: Minimum Depth of Seal Below Ground Surface for Wells in Stanislaus County

Well Type	Feet
Community water supply well	50
Industrial well	50
Individual domestic well	20
Agricultural well	20
Air conditioning well	20
All other types	20

2.4 ADDITIONAL GSP ELEMENTS

TO BE COMPLETED FOLLOWING THE DEVELOPMENT OF SUBSEQUENT GSP SECTIONS

2.5 NOTICE AND COMMUNICATION

2.5.1 Beneficial Uses and Users in the Basin

The California Regional Water Quality Control Board (RWQCB) Central Valley Region designates all groundwaters in the Sacramento River Basin and San Joaquin River Basin as suitable or potentially suitable, at a minimum, for municipal and domestic water supply, agricultural supply, industrial service supply, and industrial process supply (CA RWQCB Central Valley Region, 2016)).

Groundwater users in the region include municipalities, utilities, or other public water districts that provide groundwater as a drinking water supply, agricultural purveyors, individual private supply wells, and the environment. For the environment, instream flow requirements support the migration of anadromous fish species. Depending on water year type, dam operators in the Subbasin are required to meet minimum surface water flow requirements to maintain flows for the environment downstream. There are additional wetlands and other groundwater-dependent ecosystems throughout the Subbasin but are primarily concentrated in the western portion.

2.5.2 Communications

2.5.2.1 Decision-Making Processes

The GWA Board is tasked with the vote and approval of policy decisions for the development and implementation of this GSP. As described in Section 1.3.3, the GWA Board receives input from an Advisory Committee, the Workgroup, and the public.

The governing bodies of each of the individual GSAs take action and provide direction to their Board member representatives and must individually approve the final GSP. A description of the agencies that comprise the GSAs can be found in Section 1.3.3.1.

2.5.2.2 List of Public Meetings

During the development of this GSP, meetings of the GWA Board, Advisory Committee, and Workgroup were open to the public, with meeting information noticed, as appropriate, and posted to the GWA website (discussed below in Section 2.5.2.3.1). In addition, public informational open house events were held throughout GSP development (discussed below in Section 2.5.2.3.5). A list of public meetings that were held as part of the GSP development process is provided in Appendix E. List of Public Meetings.

2.5.2.3 Public Engagement and Active Involvement

Throughout the process of GSP development, the GWA has engaged stakeholders and the public in the development of the GSP, including the actions listed below. This effort has been greatly aided by the facilitation support provided through DWR.

2.5.2.3.1 GWA Website

The GWA website has been online since 2018 and continues to be maintained on a regular basis at **www.esjgroundwater.org**. It contains an introduction of the SGMA background, Member agencies, and GWA Board updates with meeting information and materials posted regularly. There are detailed sections for project descriptions, education materials, and meeting notices with the accompanying presentation materials and minutes. As a major purpose in creating accessible information online, there is a section devoted to press releases, newsletters, public notices, and other major events and accomplishments. As distribution of information to the public and interested parties is important, there is also an area to access the complete project reports relative to the GWA and its member agencies. Contact information is readily available for interested parties to communicate with GWA members and staff.

2.5.2.3.2 Groundwater Sustainability Workgroup

The GWA developed a Workgroup in order to promote stakeholder input was relied upon when developing the GSP. The Workgroup began with an application process to ensure a diverse cross section of populations were represented to serve on the Workgroup. Workgroup members participated and provided valuable input throughout the GSP development process.

Applications were distributed to organizations within every GSA to establish a Workgroup that represented the region's broad interests, perspectives, and geography. The Workgroup included members from a variety of organizations, and who represent one or more of the interested parties' groups. Table 2-4 lists the organizations and interests represented on the Workgroup.

Table 2-4: Groundwater Sustainability Workgroup Interests

Eastern San Joaquin Groundwater Authority
Groundwater Sustainability Workgroup – Interests Represented

AG	Agricultural	**BUS**	Business
CM	Community Neighborhood	**DAC**	Disadvantaged Communities
ENV	Environmental	**INST**	Institutional
FM	Flood Management	**NA**	Native American
GU	Groundwater User		

Role/Organization	AG	BUS	CM	DAC	ENV	FM	GU	INST	NA	Application Notes
2Q Farming	✓		✓			✓				2Q Farming is interested in making a difference for agriculture and communities, and in preserving water rights for future generations so they will have the ability to irrigate and access the water necessary for life.
Agricultural Business – Farmer Representative	✓	✓	✓	✓	✓	✓	✓			As a representative of agricultural business, this member sees SGMA as an opportunity to manage the Subbasin while keeping jurisdiction, implementation, monitoring, and oversight at the local level.
Calaveras County Resource Conservation District	✓		✓	✓	✓	✓	✓	✓		Calaveras RCD hopes to partner with groundwater users in the Western part of Calaveras County to address sustainability and recharge.
California Sportfishing Protection Alliance	✓				✓	✓	✓	✓		California Sportfishing Protection Alliance, longtime Mokelumne River stakeholder, is interested in reducing groundwater overdraft, managing surface water responsibly, and resolving longstanding conflicts. Representative is interested in the technical aspects of groundwater management and gaining a better understanding of recharge.

Eastern San Joaquin Groundwater Authority Groundwater Sustainability Workgroup – Interests Represented			
AG	Agricultural	**BUS**	Business
CM	Community Neighborhood	**DAC**	Disadvantaged Communities
ENV	Environmental	**INST**	Institutional
FM	Flood Management	**NA**	Native American
GU	Groundwater User		

Role/Organization	AG	BUS	CM	DAC	ENV	FM	GU	INST	NA	Application Notes
Catholic Charities of the Diocese of Stockton			✓	✓	✓	✓	✓			The Environmental Justice Program of the Catholic Charities of the Diocese of Stockton works with disadvantaged communities. Some of these communities have concerns regarding drinking water quality and toxic contamination of groundwater supplies.
Environmental Justice Coalition for Water			✓	✓		✓	✓			The Environmental Justice Coalition for Water is interested in ensuring that environmental justice interests are present, informed, and meaningfully engaged in a process that bears considerable importance for health, wealth, and growth.
J.R. Simplot Co.	✓	✓			✓					As a local industry representative with a stake in ground water quality, this representative sees benefit in being part of the stakeholder process.
Lima Ranch	✓	✓			✓	✓	✓			Lima Ranch views water as a precious commodity that must be conserved and used sustainably. Representative values preserving water rights and using water efficiently.
Machado Family Farms	✓		✓				✓			Representative manages a family farm and brings agricultural experience and experience with the California Public Utilities Commission to provide a balanced perspective.
Manufacturers Council of the Central Valley	✓	✓			✓	✓	✓			Through their involvement as a stakeholder, Manufacturer's Council of the Central Valley provides resources to manufacturers impacted by the implementation of GSPs and to GSAs looking to work with the sector.

Eastern San Joaquin Groundwater Authority
Groundwater Sustainability Workgroup – Interests Represented

AG	Agricultural	**BUS**	Business
CM	Community Neighborhood	**DAC**	Disadvantaged Communities
ENV	Environmental	**INST**	Institutional
FM	Flood Management	**NA**	Native American
GU	Groundwater User		

Role/Organization	AG	BUS	CM	DAC	ENV	FM	GU	INST	NA	Application Notes
Restore the Delta			✓	✓	✓	✓	✓			Representative is interested in the link between surface water flows for the San Joaquin Delta and groundwater management. Additionally, this member brings connections for broad environmental justice outreach.
San Joaquin Audubon					✓					San Joaquin Audubon is interested in overall water use and environmental issues.
San Joaquin County Environmental Health Department			✓		✓		✓			The San Joaquin County Environmental Health Department plays a role in protecting the area's groundwater resource, drinking water, and public health.
San Joaquin Farm Bureau	✓	✓	✓			✓	✓			The San Joaquin Farm Bureau is interested in helping manage and utilize the groundwater reservoir to better supply all needs for the short and long term.
Sequoia ForestKeeper					✓					Sequoia ForestKeeper has been submitting comments on water-related issues to the SWRCB since 2015.
Sierra Club - Delta-Sierra Group	✓		✓	✓	✓	✓	✓			Sierra Club cares about the future of the Eastern San Joaquin Subbasin and sustainability. They believe that representation of individuals is lacking and there is insufficient outreach.
Spring Creek Golf & Country Club		✓	✓		✓	✓	✓			Representative is golf course Superintendent at Spring Creek Golf & Country Club, is interested in groundwater rights and contributing to the stakeholder Workgroup.

Eastern San Joaquin Groundwater Authority
Groundwater Sustainability Workgroup – Interests Represented

AG	Agricultural	**BUS**	Business
CM	Community Neighborhood	**DAC**	Disadvantaged Communities
ENV	Environmental	**INST**	Institutional
FM	Flood Management	**NA**	Native American
GU	Groundwater User		

Role/Organization	AG	BUS	CM	DAC	ENV	FM	GU	INST	NA	Application Notes
The Hartmann Law Firm	✓	✓	✓			✓	✓			Representative is Advisory Water Commissioner, District Counsel for multiple reclamation districts.
The Wine Group	✓	✓			✓		✓			The Wine Group has technical knowledge and provides a unique viewpoint that supports the successful development of a GSP for the Eastern San Joaquin Subbasin.
Trinchero Family Estates and Sutter Home Winery	✓	✓	✓		✓		✓			Trinchero Family Estates and Sutter Home Winery is interested in helping develop a balanced approach for communities and businesses.
University of the Pacific		✓	✓			✓				Representative is an Emeritus Professor of Operations/Engineering Management at the University of the Pacific and is engaged in research on stream flow diversion for groundwater recharge.

The Groundwater Sustainability Workgroup meetings were held approximately monthly, typically on the second Tuesday or Wednesday of each month. The meetings were open to the public and provided opportunities for attendees to learn more about the process and provide input.

2.5.2.3.3 Stakeholder Outreach and Engagement Plan

With the support of the Workgroup, the GWA developed a Stakeholder Outreach and Engagement Plan for the San Joaquin Subbasin detailing stakeholder engagement strategy has been developed to achieve the following goals:

- Keep interested list of stakeholders informed and aware of opportunities for involvement through email communications and/or their preferred communications
- Engage DWR for facilitated support to aid in the development of the GSP
- Open GWA planning efforts to the public with agendas and meeting minutes published on the GWA website
- Inform and obtain comments from the general public through public meetings held on an approximately quarterly basis
- Facilitate productive dialogue among participants at Advisory Committee, Workgroup, and public meetings through the use of qualified facilitators to obtain, consider, and integrate feedback accordingly throughout the planning process
- Seek the input of interest groups during the implementation of the GSP and any future planning efforts
- Obtain input from the Workgroup about preferred locations to conduct public informational meetings to reach diverse audiences and disadvantaged communities
- Provide timely and accurate public reporting of planning milestones through the distribution of outreach materials and posting of materials on the GWA website for the GSP
- Secure quality media coverage that is accurate, complete, and fair
- Maintain an active communications tracking tool to capture stakeholder engagement and public outreach activities and to demonstrate the reporting of GSP outreach activities

2.5.2.3.4 Stakeholder Database

The GWA developed a database of stakeholders who represent the region's interests, perspectives, and geography. The database was developed by leveraging existing stakeholder lists and databases from prior GWA engagement efforts, conducting new research, and obtaining referrals from key stakeholders and stakeholder groups.

During the initial development of the stakeholder database, the GWA worked with those responsible for implementing the GSP to obtain contact lists of interested parties within the basin as well as other diverse contact lists they maintain.

This robust stakeholder list of interested parties includes, but is not limited to, the following:

- Community water systems
- Agricultural well owners
- Domestic well owners
- Municipal well operators

- Groundwater users (including agricultural)
- Local land use planning agencies
- Government agencies
- Nonprofit organizations
- Environmental organizations
- Higher education institutions
- Community based organizations
- Neighborhood organizations
- California Native American Tribes
- Disadvantaged communities
- Private citizens

The Stakeholder Database was regularly updated by adding additional parties who expressed interest as including public meetings and through website signups. As needed, contacts were updated or removed. It served as the foundation for targeted outreach and communication throughout the project. Additionally, the database was used to:

- Provide a single repository to collect, store, and organize information on basin stakeholders
- Allow individuals to self-identify their SGMA interests when they sign up as an interested stakeholder
- Identify the interests and concerns of organization contacts and individual stakeholders
- Plan meetings and send notices to stakeholders based upon their identified interests and role
- Document all stakeholders invited to GSP development meetings and their primary input at the meetings
- Post meeting agendas and minutes
- Produce communication and engagement summary reports

Table 2-5 provides a summary breakdown of the number of parties and interests represented in the Stakeholder Database.

Table 2-5: Stakeholder Database Summary

Eastern San Joaquin Groundwater Authority Stakeholder Database	
Interest Represented	**Number of Stakeholders**
Agricultural	31
Government Agency	19
Groundwater	152
Business	33
Nonprofit	5
Higher Education	1
Community Based Organization/Neighborhood Association	14
Disadvantaged Communities	21
Environmental	30
Flood Control	6
Community Water Systems	433
Native American Tribe	4
Private Citizen	17
Total	**766**

2.5.2.3.5 Stakeholder Education and Outreach

Recognizing that an inclusive outreach and education process supports the success of a well-prepared GSP, the GWA has prioritized Stakeholder involvement and outreach in plan development and implementation, dedicating staff and financial resources for this high-priority effort.

- The GWA held four public informational open house events devoted to SGMA outreach and providing information to the public on the GSP development process. The purpose was to provide participants with information on GSP development, seek feedback from stakeholders and the public, provide a forum for the public to interact with their GSA representatives, and address questions in a transparent manner. These events were held on an approximately quarterly basis in different locations throughout the Subbasin, as listed below.
    - **August 2018 –** Robert J. Cabral Agricultural Center, Stockton, CA (51 attendees)
    - **November 2018 –** Manteca Transit Center, Manteca, CA (25 attendees)
    - **February 2019 –** Lockeford Community Center, Lockeford, CA (61 attendees)
    - **TBD 2019 –** [to be added following fourth public open house]
- Targeted outreach presentations were given at community meetings including:
    - Manteca Kiwanis Sunrise Club
    - Manufacturer's Council of the Central Valley
    - North San Joaquin Water Conservation District
    - San Joaquin County Hispanic Chamber of Commerce

- San Joaquin Farm Bureau
- Sierra Club

- Individually, member GSAs provide targeted outreach materials to their constituencies through the distribution of outreach and informational materials.
- SGMA outreach materials were distributed at various programs and events to reach growers. Outreach flyers containing information on SGMA and GSA contact information were distributed at the San Joaquin County Pesticide Applicator Permitting meetings in November 2018.
- Factsheets and e-blasts were used to raise awareness about topics and events relevant to the GSP development process. Outreach included providing overviews of participation opportunities for GSP planning processes.
- Social media channels, such Facebook, were used to distribute targeted information relevant to the GSP planning process and ways to get involved. A GWA Facebook page was developed, and social media templates were distributed to members of the GSA Board, Advisory Committee, and Workgroup for use on their agency social media accounts.
- Comment cards, provided in postcard format at every public informational open house, allowed the public and stakeholders to contribute written comments, solicit additional information, make suggestions, and submit other feedback as appropriate.
- News releases were distributed to regional media agencies, including local newspapers and radio stations, to draw attention to important GWA events such as workgroup and public meetings.

2.5.2.3.6 Situation Assessment

The GWA applied for and received DWR facilitation to conduct a Situation Assessment, the purpose of which was to facilitate the stakeholder engagement process. The facilitation services supported third-party interviews conducted with the members of the Workgroup as part of a Situation Assessment. The Situation Assessment was conducted in Q4 2018 with the goal of facilitating stakeholder input into the GSP development process. All Workgroup members were invited to participate in the Situation Assessment, and 17 were interviewed during a series of in-person and phone interview sessions. Assessment summary and highlights are available on the GWA website.

Situation Assessment questions covered topics including:

- Outreach and engagement approach
- Meeting presentations
- Meeting discussions
- Strengthening the Workgroup process
- Decision making and input
- GSP development and plan content
- Resource and management conditions data
- Implementation considerations

2.5.2.4 Incorporation of Stakeholder Feedback

The development of this GSP was informed and supported by stakeholder feedback, which was documented, addressed, and incorporated at numerous points throughout the development process. The public was invited to provide input at each Advisory Committee and GWA Board meeting, including the Projects and Management Actions Workshop, which featured a public feedback survey. Information provided for GSP development was refined based on input from public meetings. Stakeholder involvement was additionally supported through monthly meetings of the Workgroup, a 23-member multidisciplinary stakeholder group that was formed for the specific purpose of soliciting input on GSP development from a wide range of beneficial users of groundwater in the Subbasin. Questions raised by participants at these meeting were addressed, with follow-up content presented and discussed at subsequent meetings.

Ideas generated at the Workgroup meetings were directed to decision makers at the GWA Board meetings. Input was captured in monthly meeting summaries, which were reviewed by Workgroup members prior to being presented to the GWA Board in meeting agenda packets and posted to the GWA website. In addition, summaries of prior month Workgroup meetings, as well as highlights and key takeaways from those meetings, were presented regularly as a standing agenda item at GWA Board meetings.

In addition to influencing GSP development and decisions related to groundwater management, feedback from stakeholders played a key role in enhancing education and outreach efforts, and the stakeholder involvement process more broadly. Changes were made to the Open House format following stakeholder comment, and outreach events with community groups (as referenced in Section 2.5.2.3.5 above) were added based on feedback to further spread the word about SGMA and local GSP development efforts. Additionally, changes to the Workgroup meeting structure and process were made based on findings of the Situation Assessment.

3. BASIN SETTING

This section describes the HCM for the Eastern San Joaquin Subbasin. The regulatory framework is based on the California Code of Regulations, Title 23, Division 2 Department of Water Resources § 354.14. The HCM presents the physical characteristics used to define water movement throughout the Eastern San Joaquin Subbasin.

3.1 DATA COMPILATION

Data supporting development of the Eastern San Joaquin Subbasin HCM is available to the public from a variety of local, State, and federal agencies, as well as from non-governmental entities. The data presented herein was compiled from numerous studies conducted in the eastern portion of the San Joaquin Valley (SJV). Information from several online databases that support ongoing monitoring and development of the groundwater resources within the Eastern San Joaquin Subbasin and across California were amassed, digitized, evaluated, and reconfigured in support of the HCM. To accomplish the data compilation task, software programs such as Microsoft (MS) Excel, ArcGIS, QGIS and CrossView provided platforms for entering, storing, displaying, and evaluating the volume of data available. The following subsections describe the online programmatic databases from which much of the data was sourced and provides insight on the unique obstacles within each.

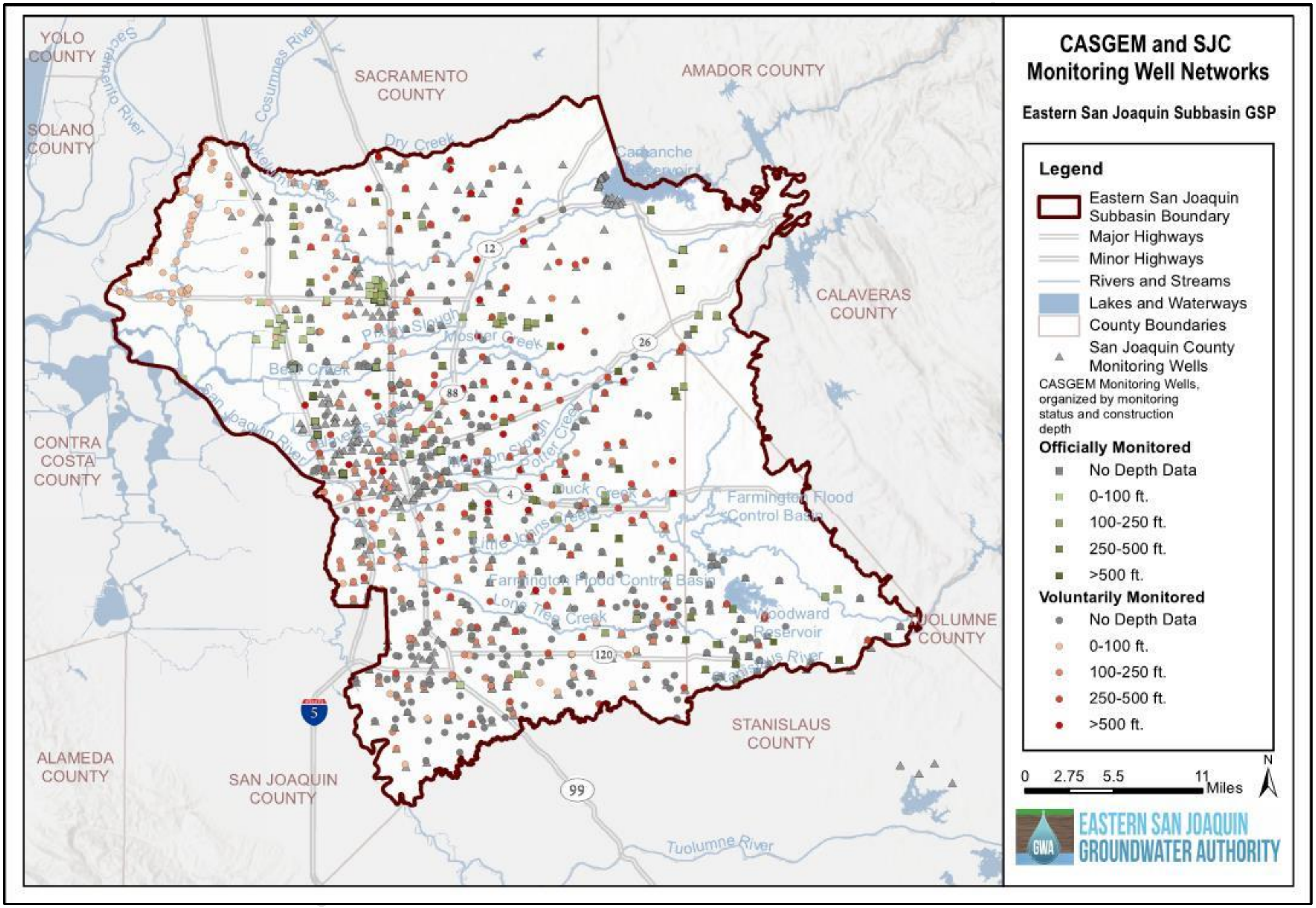
3.1.1 Groundwater Level Data

The CASGEM and San Joaquin County monitoring well networks provide the basis for determining groundwater levels across the Eastern San Joaquin Subbasin. CASGEM maintains a website that allows users to download site locations and water level information. San Joaquin County's monitoring well data comes from the San Joaquin County Public Works Division and was gathered as part of the data compilation efforts.

The two monitoring networks have substantial overlap, thus combining the databases was a necessary step in the data compilation effort. Because CASGEM uses the local, State, and CASGEM ID, whereas the San Joaquin County network uses the local and State ID, correlating or joining these two databases required manipulating or changing the State ID to a consistent format during the data compilation effort. Additionally, the databases cannot be merged based on well location because wells are often clustered together in close proximity and location information for the same well can vary between datasets.

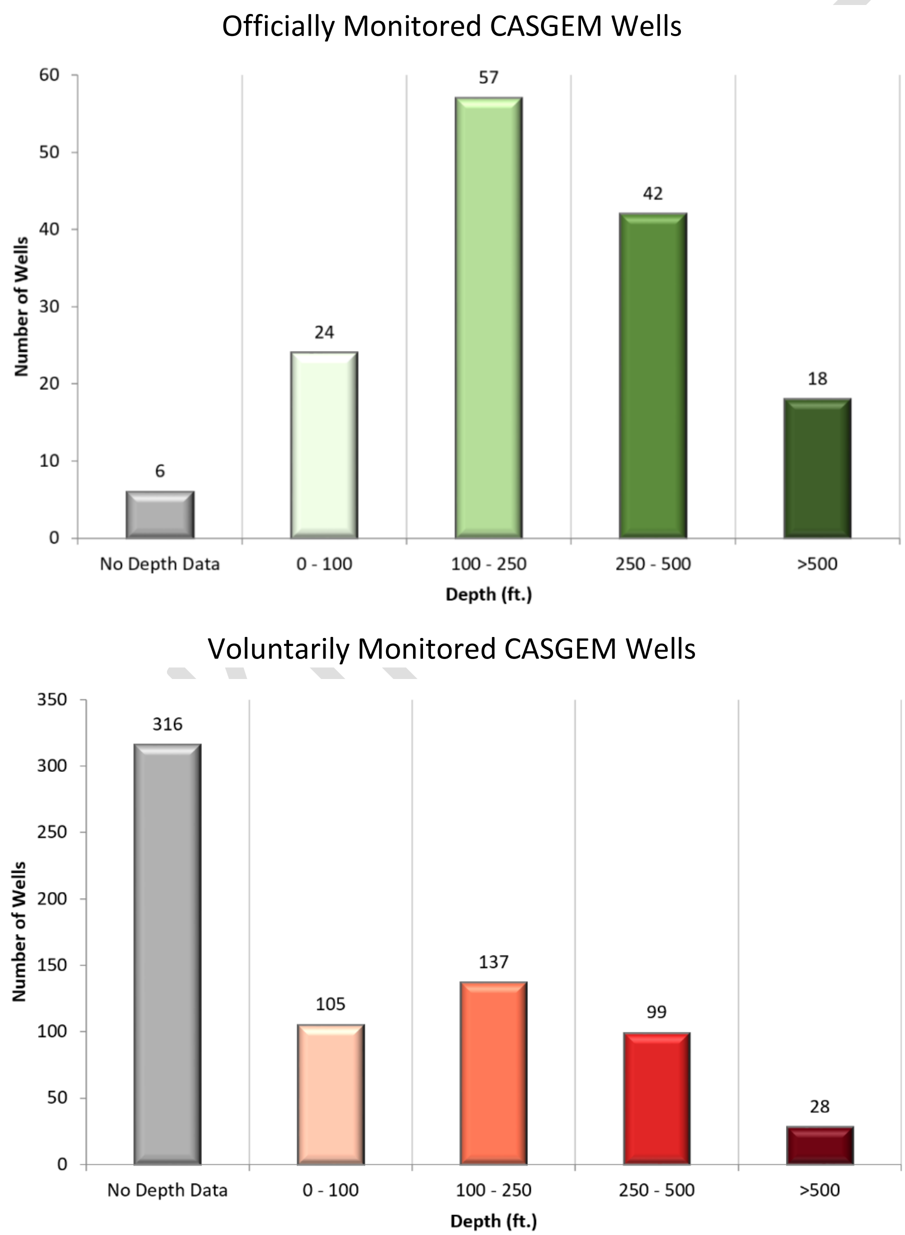
Together, the CASGEM and San Joaquin County monitoring well networks include approximately 1,000 unique wells across the Eastern San Joaquin Subbasin. Despite the large number of wells, data gaps still exist, both horizontally and vertically. As depicted on Figure 3-1, large areas of the subbasin contain very few wells, particularly in the northwest and southeast portions of the Subbasin.

Figure 3-1: CASGEM and San Joaquin County Monitoring Well Networks



Vertical data gaps are even more pronounced, as lack of construction data is an obstacle. Figure 3-2 shows the distribution of well depths of officially and voluntarily monitored CASGEM wells, a large number of which do not have construction depth or screen interval information. This makes determining groundwater levels for depth-discrete aquifer intervals impossible. Groundwater elevation contour maps were prepared of each principal aquifer, consistent with CCR § 354.16 Groundwater Conditions requirements. Despite uncertainties due to limited construction information, this GSP presents maps that provide a useful description of groundwater conditions.

Figure 3-2: Depth Distribution of Wells in the CASGEM Network



3.1.2 Groundwater Quality Data

This GSP relies on groundwater quality data from the GAMA Program (GAMA Data Download). GAMA includes water quality data from numerous sources, such as USGS and DWR. The GAMA database contains approximately 6,800 well sites throughout the Eastern San Joaquin Subbasin with over 1.6 million water quality measurements (Figure 3-3).

Although GAMA provides data on a large number of groundwater parameters and wells throughout the Eastern San Joaquin Subbasin, significant data gaps remain. For instance, there are inconsistencies in the parameters measured, as well as in the sampling periods. Some wells are sampled at regular intervals (i.e., quarterly or annually), while others are sampled irregularly. Such assorted schedules make analysis over a given period of time difficult. Data gaps are also apparent when looking at parameters over a longer time frame. For example, chloride, an important and commonly measured groundwater quality parameter, is reported in only a small fraction of the total number of GAMA wells. As shown in Figure 3-4, out of the over 6,800 wells listed in GAMA for the Eastern San Joaquin Subbasin, no more than 700 chloride measurements were taken during any year since 2005.

Figure 3-3: GAMA Monitoring Well Network

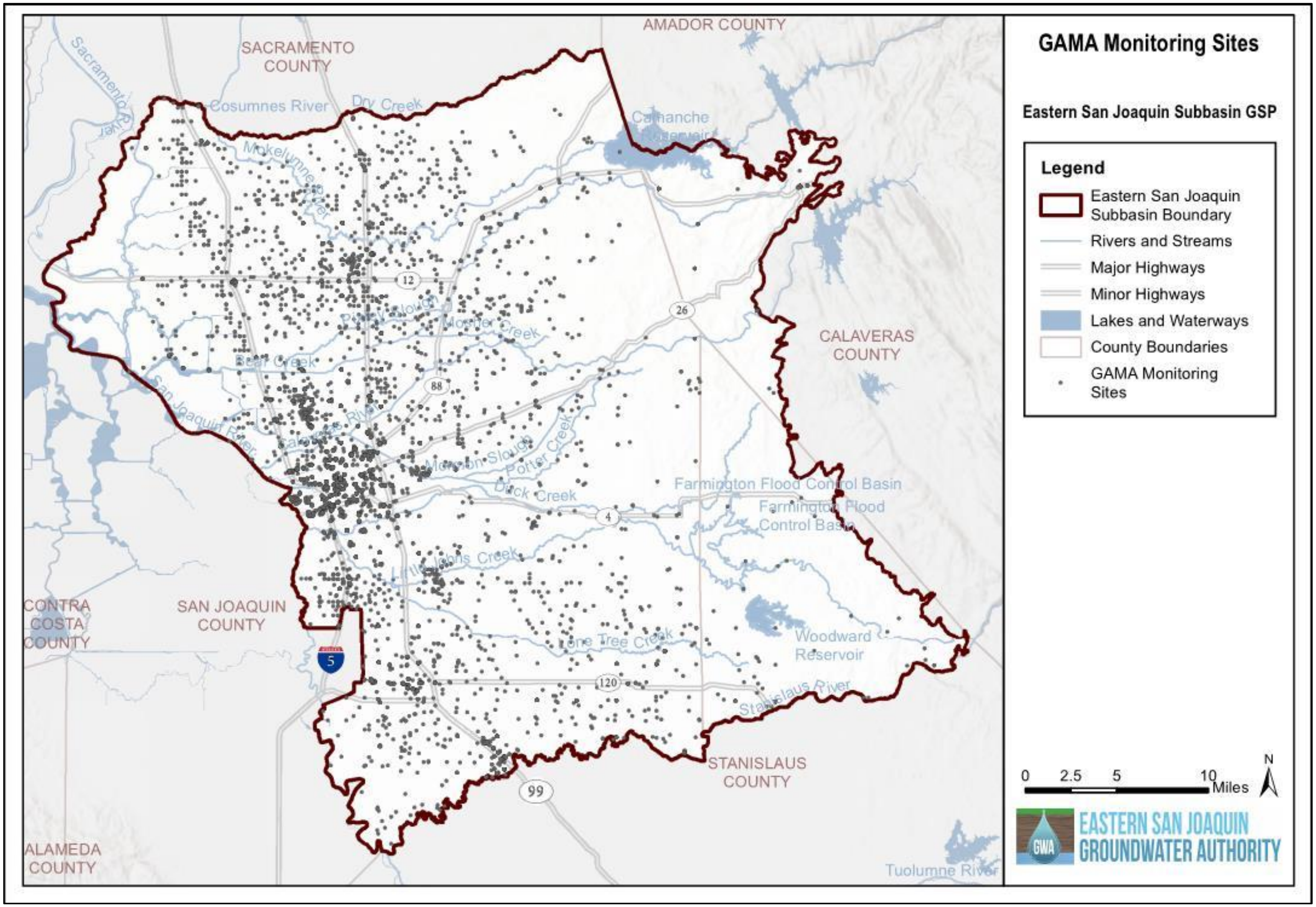
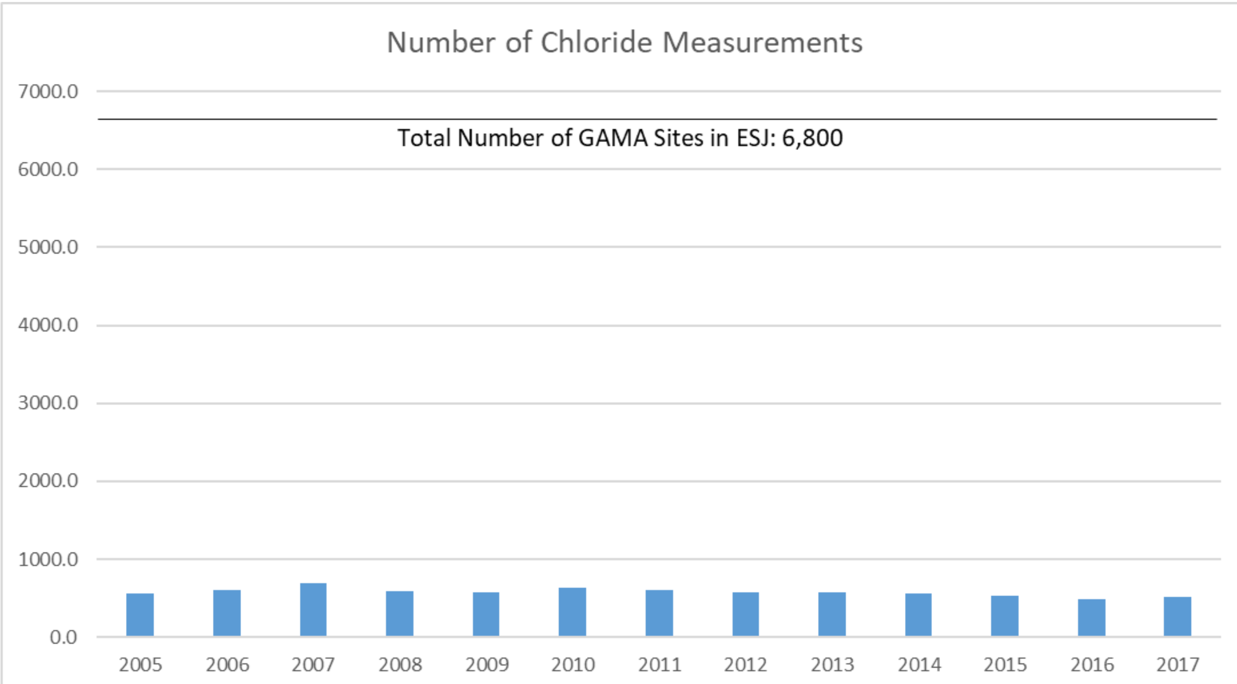


Figure 3-4: Number of Chloride Measurements Taken at GAMA Monitoring Sites (2005-2017)



Below is a list of attributes for each well in GAMA:

- Well ID
- Results
- Chemical
- Units
- Qualifier
- RL (Reporting Limit)
- Approximate Latitude
- Approximate Longitude
- Well Type
- Well Depth
- Top of Screen
- Screen Length
- Source
- Source Name
- Other Names

The attributes of each well in the GAMA database are not always complete or accurate. Well depths and screen interval data, where available, promotes vertical analysis of groundwater quality data because these data can be correlated to depth-discrete aquifer zones. Additional depth-specific water quality monitoring is a focus of the monitoring network for this GSP, as discussed in the monitoring network section of this GSP.

3.1.3 Stratigraphic Data

The OSWCR provided a majority of the groundwater well logs used in developing the HCM. This online database, developed and maintained by DWR, is a compilation of well completion reports accessible to the public for viewing and downloading. Tables of water well records are also available which contain attributes such as construction depth and well type (e.g., domestic or agricultural). However, not every well record is complete within the tables or only a few attributes may be listed. None of the stratigraphic or geologic data are provided in the tables. Stratigraphic or geologic data must be obtained from the individual well completion reports, which are only available as scanned images downloadable in portable document format (pdf). Once the well completion reports are retrieved from the database, the geologic information can then be manually digitized into MS Excel or other database software.

Critical information needed from the well completion reports are construction depth, screen interval, and borehole stratigraphy. The quality and completeness of the reports are, however, highly variable. Very few well logs contain all of the critical data; many more list only a few of the key attributes or none at all. Descriptions of the borehole stratigraphy also vary widely, from comprehensive geologic descriptions to single-word captions (e.g., sand, sandstone, or clay). Given the volume of wells in the Eastern San Joaquin Subbasin and the critical importance of the data being retrieved, great attention was paid to this aspect of the data compilation effort.

Once compiled, the well construction and stratigraphic data from OSWCR was correlated with well data available from the CASGEM and San Joaquin County monitoring well databases. To accomplish this task, individual well logs from OSWCR were assigned a unique location and then matched to a specific well within the CASGEM and San Joaquin County datasets (DWR, 2000).

Although the State ID format does not allow for matching between OSWCR, CASGEM, and San Joaquin County databases, well completion reports from OSWCR were correlated to wells in the other databases. This connection was made by plotting CASGEM/San Joaquin County well locations in Geographic Information System (GIS) software and correlating well completion reports to nearby wells with similar attributes. For instance, the State ID of the CASGEM/San Joaquin County wells and the modified State ID of the OSWCR were used to locate the features within the same Township/Range/Section. Well completion reports were matched to wells by attributes such as screen interval and seal depth or based on written location descriptions or hand drawn sketches of the location.

To further support spatial analysis, well completion reports from OSWCR with no corresponding well in any database were added to the data set. Well completion reports for wells from other sources, including USGS nested wells and municipality wells, were also added. Well completion reports from OSWCR that did not correspond to wells in a different database were plotted using latitude and longitude coordinates listed in OSWCR. These coordinates are often approximations of the actual location; many latitude and longitude values are the centroid of the section containing each well. All totaled, the borehole stratigraphy from approximately 330 groundwater wells was digitized to provide horizontal spatial coverage.

While groundwater wells provide valuable data in the shallower portion of the basin that is most accessed for groundwater use, the hydrostratigraphic units within the Eastern San Joaquin Subbasin are much deeper, reaching a maximum depth of approximately 1,000 feet. The Division of Oil, Gas, and Geothermal Resources (DOGGR) wells were used to assess the geologic strata at the depths important to the HCM, as these wells are typically much deeper than groundwater wells.

Interpretation of geologic formations from the well completion reports and DOGGR well logs was undertaken after digitizing stratigraphic data from the various sources. This process relied heavily on the distinguishing features of each formation (Section 3.2.4), surficial geologic maps (Section 3.2.4), location and depth of borehole (Section 3.2.6), and professional judgement.

3.1.4 GIS Data

In accordance with CCR § 354.14, maps of various basin attributes are required as part of the HCM. To produce these maps, GIS software was used to store, manage, and analyze spatial and tabular data. GIS software was also used to extrapolate data through complex processes in cases where information or guidance was limited. For example, in accordance with CCR § 354.16, groundwater elevation contour maps are required based on the best available information. This requirement does not specify methods to use for producing the data, but the DWR Best Management Practice (BMP) for HCM suggests techniques used in Tonkin, M. and Larson, S. (2002), which uses geostatistical methods in conjunction with logical interpretations of groundwater level data to provide an adequate level of detail and accuracy.

Certain GIS software programs, including QGIS and ArcGIS, were relied on heavily. QGIS is a powerful open-source program, whereas ArcGIS is the industry standard. Both are capable of completing the required elements for the GSP. QGIS provided the graphical capabilities for final map production. ArcGIS was specifically utilized because of a third-party extension, CrossView, which is capable of generating hydrogeologic cross-sections that are presented in Section

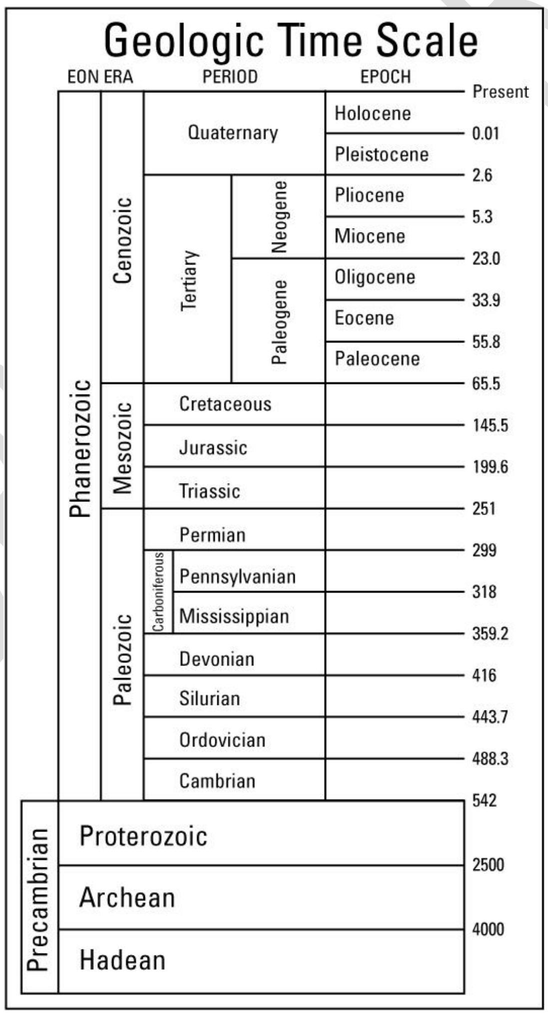
3.2.6. The Universal Transverse Mercator (UTM) coordinate system and North American Datum of 1983 (NAD 83) were utilized along with the North American Vertical Datum of 1988 (NAVD 88) for all spatial data.

3.2 HYDROLOGIC CONCEPTUAL MODEL

3.2.1 Regional Geologic and Structural Setting

The Eastern San Joaquin Subbasin lies within the San Joaquin Valley and part of the Central Valley of California. The Central Valley is a 400-mile-long, 50-mile-wide, northwestward trending asymmetrical structural trough filled with geologic units deposited over a long period of time. See Table 3-2 (Section 3.2.4) for the generalized stratigraphic column and Figure 3-5 below for the geologic time scale. The Sierra Nevada Mountain Range, east of the Central Valley, is comprised of pre-Tertiary continental rocks. The Coast Ranges, to the west, is comprised of pre-Tertiary and Tertiary semi-consolidated to consolidated marine sedimentary and continental rocks. The material source for the continental deposits are the Coastal Ranges and Sierra Nevada, which are composed primarily of granite, related plutonic rocks, and metasedimentary and metavolcanic rocks from Late Jurassic to Ordovician age (Bertoldi et al., 1991).

Figure 3-5: Geologic Time Scale



3.2.2 Geologic History

The origin of geologic formations within the Eastern San Joaquin Subbasin vary in geologic time ranging from recent to Pre-Cretaceous bedrock or basement. Six to 10 miles of sediment have been deposited within the Central Valley and include both marine and continental deposits consisting of gravels, sands, silts, and clays. During the middle Cretaceous (~100 million years ago), parts of the Central Valley were inundated by the Pacific Ocean resulting in deposition of marine deposits. Marine conditions persisted through the middle to late Tertiary period after which time sedimentation changed from marine to continental deposits due to the retreat of the sea and the regional rising of the land mass. Intermittent volcanism dominated with the deposition of rhyolites and andesites (DWR, 1967).

3.2.3 Near-Surface Conditions

3.2.3.1 Topography

Ground surface elevations vary extensively across the Eastern San Joaquin Subbasin from approximately 1,000 feet above mean sea level to sea level, from the distinct upland areas in the east and flat lying valley floor to the west. The Eastern San Joaquin Subbasin topographic map is provided as Figure 3-6, and the major hydrologic features within the Eastern San Joaquin Subbasin are shown in Figure 3-7.

Figure 3-6: Topography

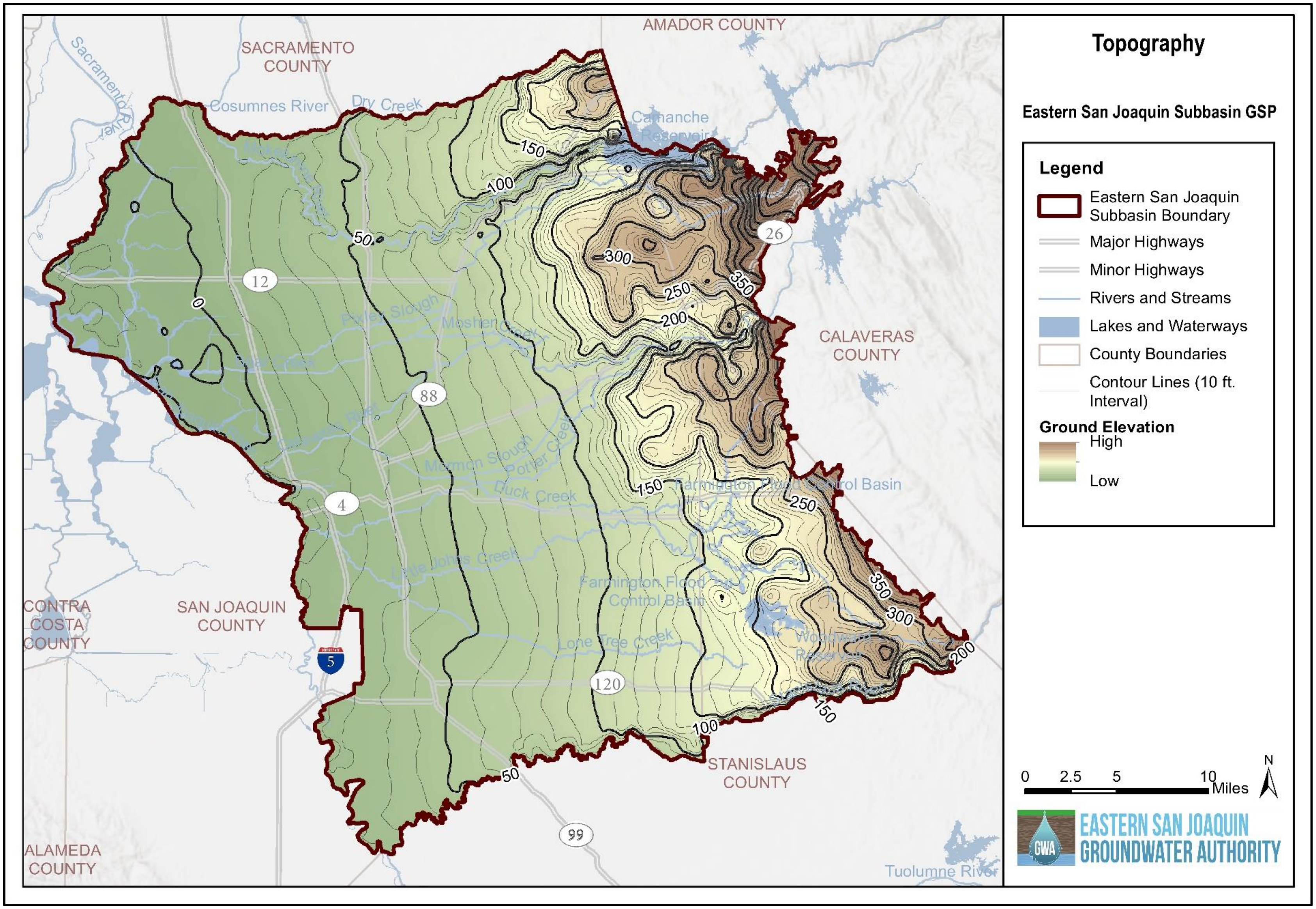
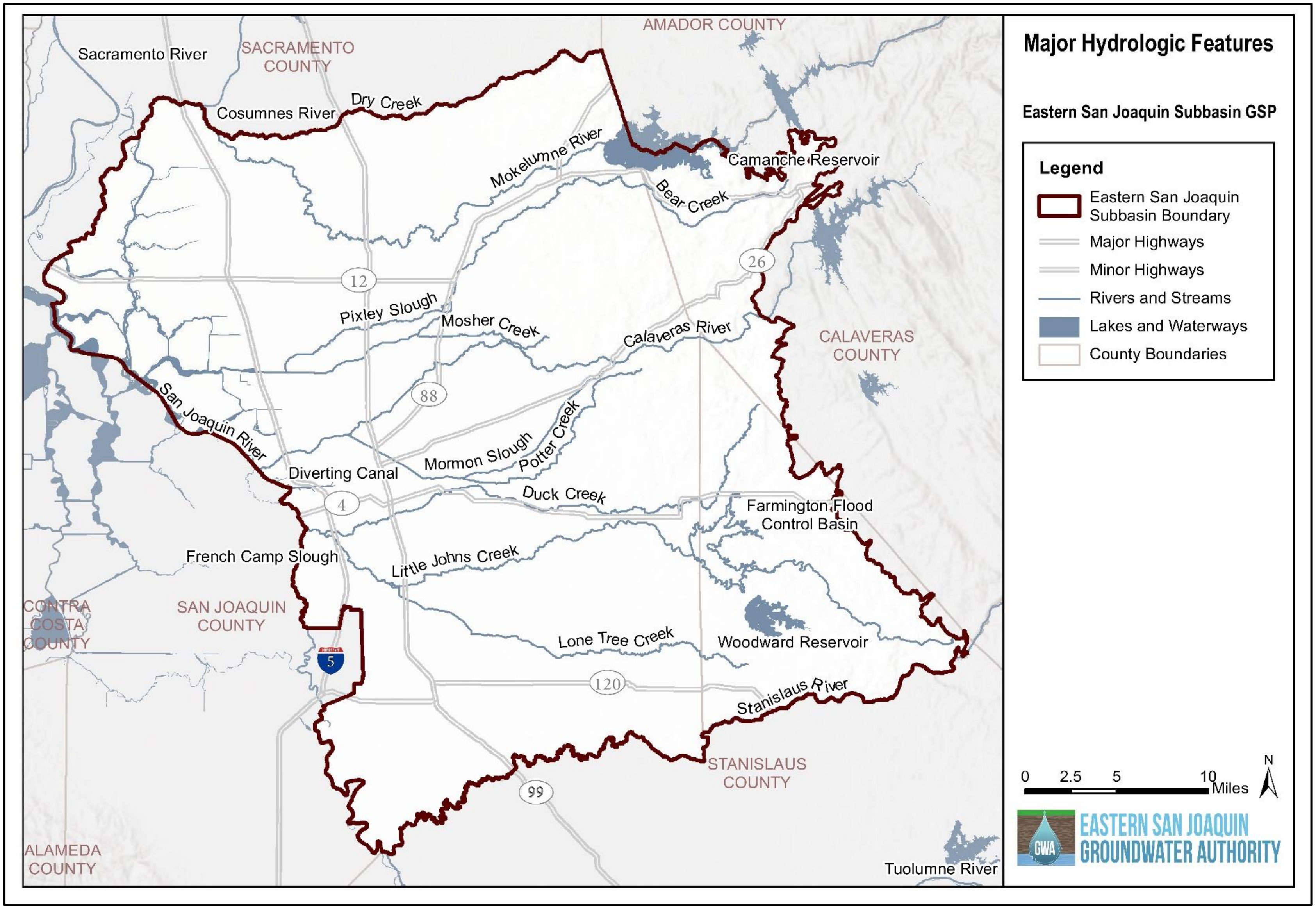


Figure 3-7: Major Hydrologic Features



The modern-day physiographic features are a direct result of the geologic history of the region. Surficial features on the valley floor in the Eastern San Joaquin Subbasin can be divided into physiographic units as described by CA DWR (1967) and Burow and others (2004): river flood plains, channels, and overflow lands; low alluvial plains and fluvial fans; and dissected uplands. The dissected uplands lie along the flanks of the valley between the Sierra Nevada to the east and the alluvial plains and fluvial fans to the west. Local relief ranges in excess of 100 feet in the form of dissected hills and gently rolling lands. The most extreme slopes are observed in Calaveras County, which are steeper than 25 percent. West of the dissected uplands is a belt of coalescing fluvial fans of low relief (less than 10 feet) that forms the low alluvial plains and fans that range in width from about 14 to 20 miles. These fans lie between the dissected uplands and the nearly flat surface of the valley trough. River floodplains and channels occur as narrow, disconnected strips along the channels of the major rivers. Overflow lands of the valley trough tributary to the San Joaquin River define the area inundated by rivers when floods are highest under natural conditions.

3.2.3.2 Major Hydraulic Features

In the Eastern San Joaquin Subbasin, the major rivers running east-west have headwaters high in the Sierra Nevada and flow west toward the axis of the valley (Figure 3-6). Little deposition is taking place currently, and the rivers are cutting downward on the upper reaches of the fans where the river floodplains are commonly entrenched to depths of 50 to 80 feet. However, toward the lower ends of the fans where river gradients are low, many small streams and tributaries of the major rivers are actively aggrading their beds.

The San Joaquin River is the principal drainage outlet of the northern San Joaquin Valley, flowing northward on the west margin of the Eastern San Joaquin Subbasin to its confluence with the Sacramento River in the San Joaquin-Sacramento Delta (Burow et al., 2004). Two major westerly flowing tributaries to the San Joaquin River within the Eastern San Joaquin Subbasin are: (1) Stanislaus River (south boundary) and (2) Mokelumne River (north portion). The Stanislaus River drains a watershed of about 1,040 mi^2 (Burow et al., 2004) and flows through the dissected uplands between Knights Ferry and Oakdale, along the low alluvial plains and fans near the City of Riverbank to the confluence with the San Joaquin River near Vernalis. The flow in the Stanislaus River varies seasonally from less than 134 AF/day during the dry season in early fall to over 16,400 AF/day during wet season in winter. These volumes correlate to discharges from 68 to over 8270 cubic feet per second (cfs) recorded at the Orange Blossom Bridge gauging station approximately 1 mile east of East Oakdale (CA DWR, 2019).

The Mokelumne River drains a watershed of about 5,550 km^2 (2,140 mi^2) and flows through the dissected uplands between Jackson and San Andreas into Pardee Reservoir where it is released to flow downstream into Camanche Reservoir and out along the alluvial plains and fans toward its confluence with the San Joaquin River near Isleton. On the north boundary of the Eastern San Joaquin Subbasin is Dry Creek and the Lower Dry Creek Watershed. Dry Creek is mapped as an ephemeral drainage and is tributary to the Mokelumne River with its confluence near Thornton. Flow in the Mokelumne River below the Camanche Reservoir varies seasonally and is dependent on discharges from the on-stream reservoir, from 733 AF/day during the dry season to 57,100 AF/day during the wet season. These volumes correlate to discharges from 370 to over 28,800 cfs collected by the USGS below the Camanche Dam.

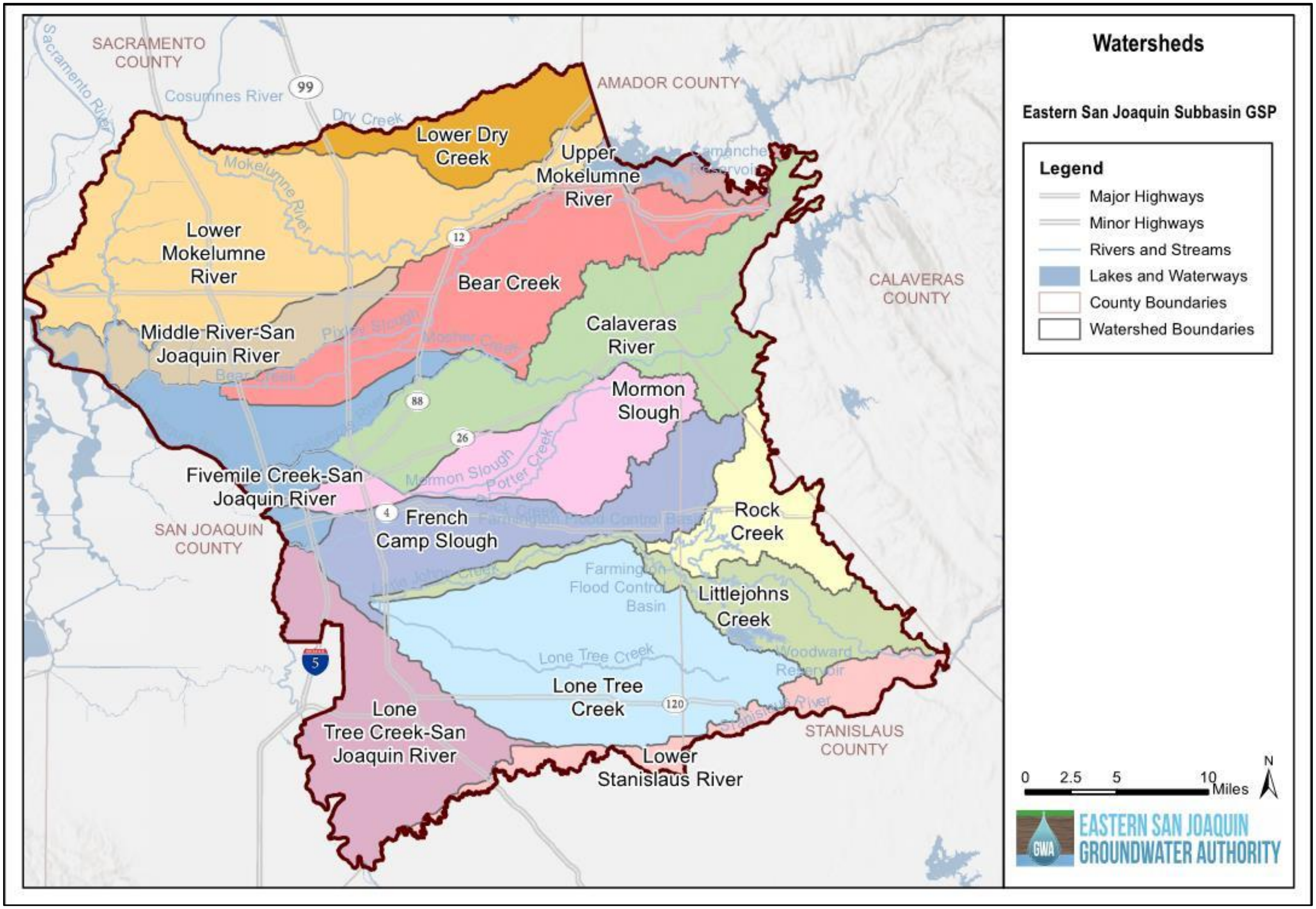
The Calaveras River, also with headwaters in the Sierra Nevada, drains a watershed of about 1,370 km^2 (530 mi^2) and flows across the Subbasin to its confluence with the San Joaquin River on the northwest side of Stockton. Flow in the Calaveras River below the New Hogan Reservoir varies seasonally and is dependent on discharges from the on-stream reservoir, from 608 AF/day to 19,800 AF/day. These volumes correlate to discharges from 223 to over 10,000 cfs collected by the USGS below the New Hogan Reservoir.

In addition to the Stanislaus, Mokelumne, and Calaveras Rivers, the ten watersheds extend into and across the Eastern San Joaquin Subbasin. Three of these watersheds extend beyond the western boundary of the Eastern San Joaquin Subbasin into the Tracy Subbasin: Middle River-San Joaquin, Five Mile Creek-San Joaquin, and Lone Tree Creek-San Joaquin. The Lone Tree Creek-San Joaquin watershed has its headwaters in the Coast Range foothills. Figure 3-8 depicts the Eastern San Joaquin Subbasin and the watersheds that overlie the Subbasin. Table 3-1 is a list of watersheds that overlie the Subbasin.

Table 3-1: Eastern San Joaquin Subbasin Watershed Details

Watershed Name	Total Area (square miles)	Area Within Subbasin (square miles)	Percentage of Watershed within Subbasin
Lower Mokelumne River	223	202	91
Lower Dry Creek	88	47	53
French Camp Slough	88	88	100
Upper Mokelumne River	93	15	16
Lone Tree Creek	158	158	100
Little Johns Creek	122	63	52
Rock Creek	107	44	41
Calaveras River	224	133	60
Middle River-San Joaquin River	213	49	23
Mormon Slough	75	75	100
Lower Stanislaus River	218	37	17
Lone Tree Creek-San Joaquin River	169	110	65
Five Mile Creek-San Joaquin River	154	62	40
Bear Creek	127	127	100

Figure 3-8: Eastern San Joaquin Subbasin Watersheds



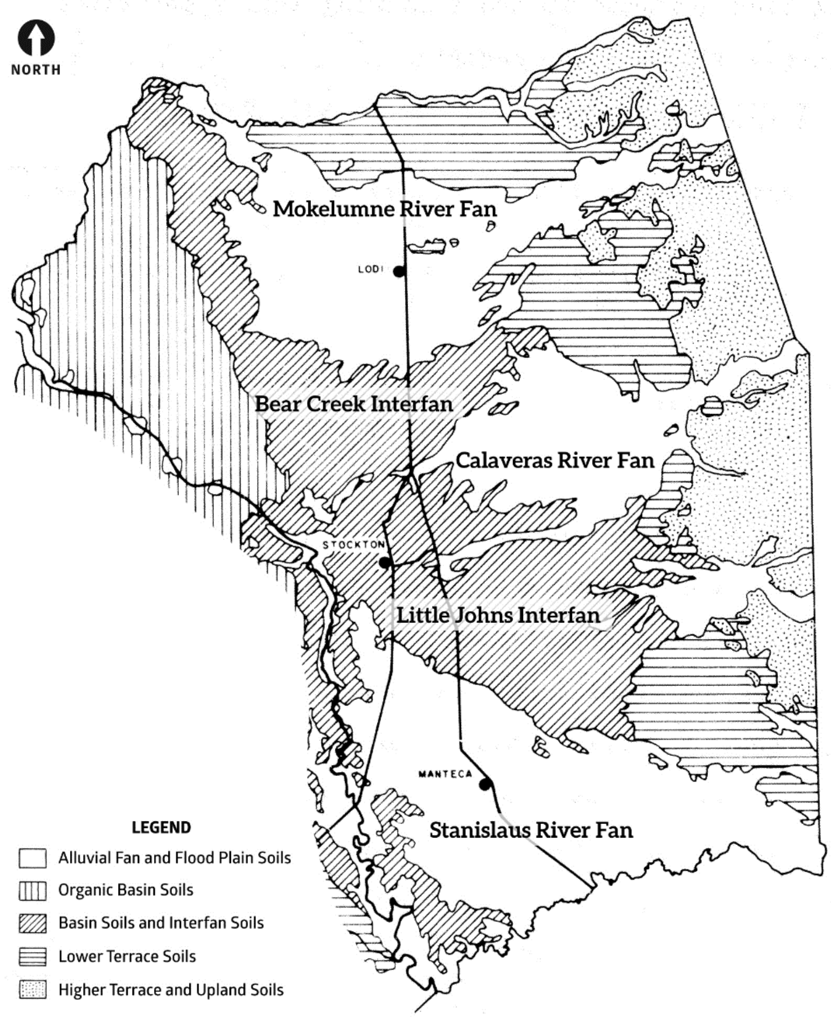
3.2.3.3 Surface Soils

Soils in the Eastern San Joaquin Subbasin are one of the primary controlling factors on surface water percolation rates through the vadose zone down to the groundwater table. As described in CA DWR (1967), soils in the region of the Eastern San Joaquin Subbasin can be grouped into five main categories:

1. Alluvial fan and flood plain soils
2. Organic basin soils
3. Basin soils
4. Lower terrace soils; and
5. Higher terrace and upland soils

These groupings, in part, coincide with the geologic formations in that the oldest soils are found on the nearly level high terraces and old fluvial fans in the eastern part of the area. The oldest soils typically have claypan or hardpan layers at depths of 2 feet or less. The youngest soils are forming on the recently deposited alluvium along stream bottoms and on recently exposed surfaces. These soils are generally deep and rich in nutrients. The soils at intermediate stages of development are on the low terraces. Figure 3-9 shows the areal distribution of the five soil types in San Joaquin County (CA DWR 1967).

Figure 3-9: Soil Depositional Areas



Alluvial fan and floodplain deposits are present in three areas of the Eastern San Joaquin Subbasin bounding major east-west rivers: Mokelumne, Calaveras, and Stanislaus Rivers. Figure 3-9 depicts soil depositional areas within the Subbasin. These areas have the best infiltration rates, exclusive of the peat locales in the Delta (northwest portion adjacent to the Mokelumne River). Soils of the Mokelumne and Stanislaus River fans have young soil profiles of sandy loam to loam. Infiltration rates of the soils are predominantly between 0.6 to 2 inches per hour. Areas of silt loam are also common especially in the floodplain and have a lower infiltration rate of less than 0.6 inches per hour. Soils in the alluvial fans tend to coarsen toward the apex of the fan. The soil types show little compaction and slight accumulation of lime or clay. Hardpan development, which would preclude infiltration, is minimal.

The soils of the Calaveras fan have deeper profiles of loam and clay loam with an infiltration rate of less than 0.6 inches per hour. These soils tend to be darker and heavier than the Stanislaus and Mokelumne River fan soils likely due to the source area being restricted to metamorphic or pre-Tertiary sedimentary material and that, whereas the Mokelumne and Stanislaus Rivers received large contributions from a granitic source (CA DWR 1967).

The organic basin soils are restricted to the lower Delta portion of the Eastern San Joaquin Subbasin. Peat, muck, and clay loam are terms commonly applied to soils in this group. The organic basin soils have variable infiltration capacity. Where peat is the dominant soil constituent, infiltration is high (greater than 2 inches per hour); where clay loam or muck occurs, infiltration is low (less than 0.6 inches per hour) (CA DWR, 1967).

The interfan and basin soils lie between the Mokelumne, Calaveras, and Stanislaus River fans in a northwesterly trending belt and around the periphery of the organic basin soils. These soils generally have well-developed profiles, medium-to-heavy textures, and fairly well compacted subsoils. Locally, hardpan overlies silty to silty clay loams. Consequently, these soils have low infiltration rates (less than 0.6 inches per hour).

The terrace and upland soils have profiles containing moderately dense accumulation of clay and claypan, relatively near the surface. These layers are impervious barriers to the local downward movement of water, except where root holes and other breaks permit infiltration.

The Natural Resource Conservation Service (NRCS) categorizes soils by hydrologic soil groups. The hydrologic soil group is an estimation of the infiltration rate of the first 5 feet of soil based on depositional characteristics (mostly grain size and sorting) and secondary characteristics (compaction, lithification, and weathering). Hydrologic Soil Groups and their relative infiltration rates are listed below:

- A (high)
- B (medium)
- C (slow)
- D (very slow)

Figure 3-10 shows the distribution of soils mapped by hydrologic soil group across the Eastern San Joaquin Subbasin. The broad geologic features of the Eastern San Joaquin Subbasin reflecting the river drainage elevations, areas, and percent above snowline are also apparent in the map of soils distribution. The Stanislaus and Mokelumne River alluvial fans have the overall highest infiltration rate followed by the Calaveras River fan. The smaller foothill watersheds have the lowest average infiltration rates. The relatively high permeability of windblown sands on the Mokelumne and Stanislaus River fans and the recent alluvium of the current Mokelumne and Calaveras River floodplains are also recognizable (Figure 3-10).

Hardpan is a strongly cemented weathering profile that limits infiltration unless it is modified by ripping or excavating. Some hardpan is discontinuous and relatively shallow (located at a depth of 5 feet or less) and often is ripped with a bulldozer for agricultural purposes. However, in other areas, particularly in the older pre-Modesto formations, the hardpan is more continuous and extends to depths that cannot be reached by ripping methods.

The Farmington Groundwater Recharge/Seasonal Habitat Study Final Report, prepared by Montgomery Watson Harza (MWH), dated August 2001, overlaid the NRCS's interpretation of where hardpan soils would be found under natural conditions. The extent of the thickest hardpan is shown in Figure 3-11 in dark blue cross hatching.

Figure 3-10: Hydrologic Soil Groups

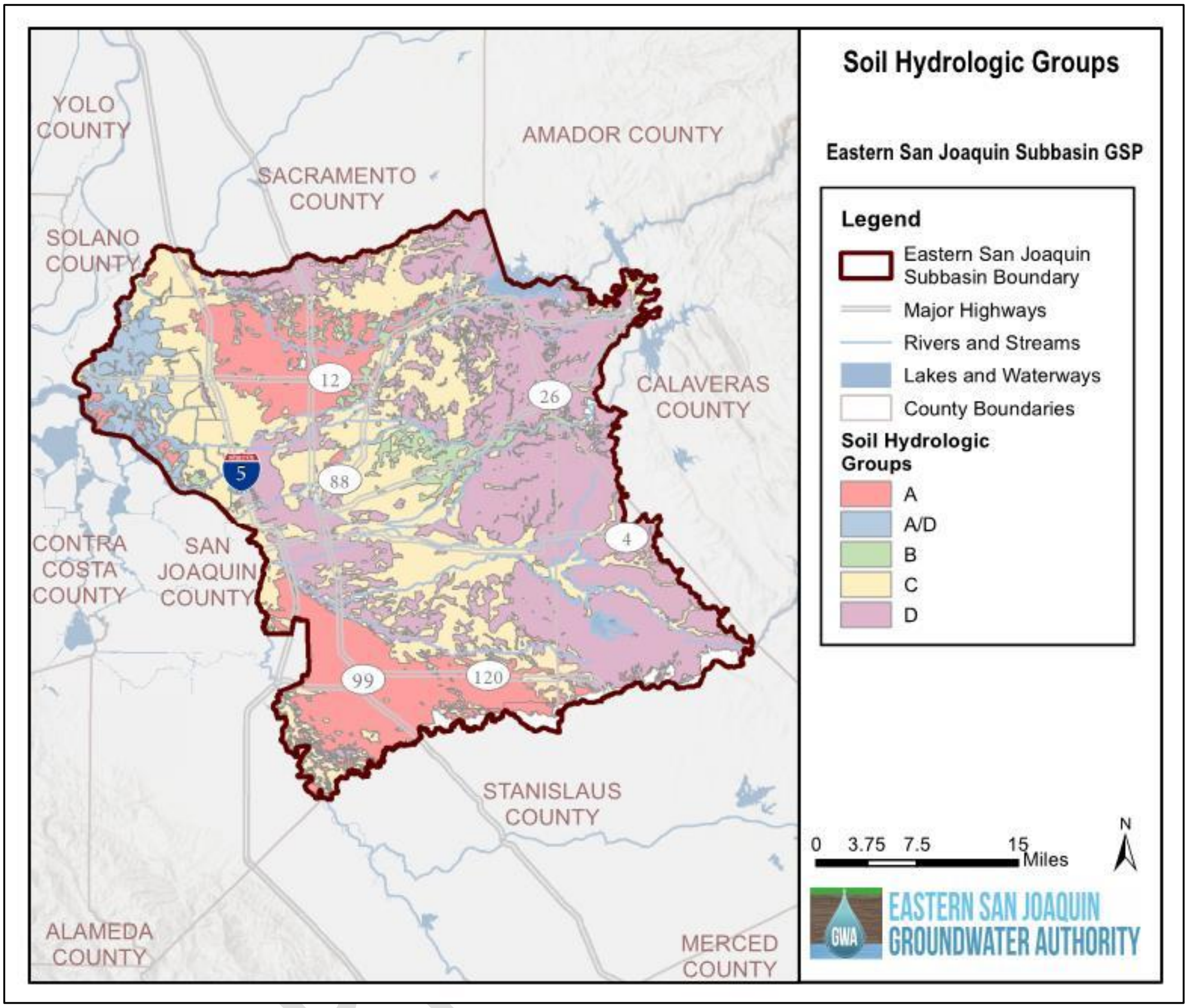
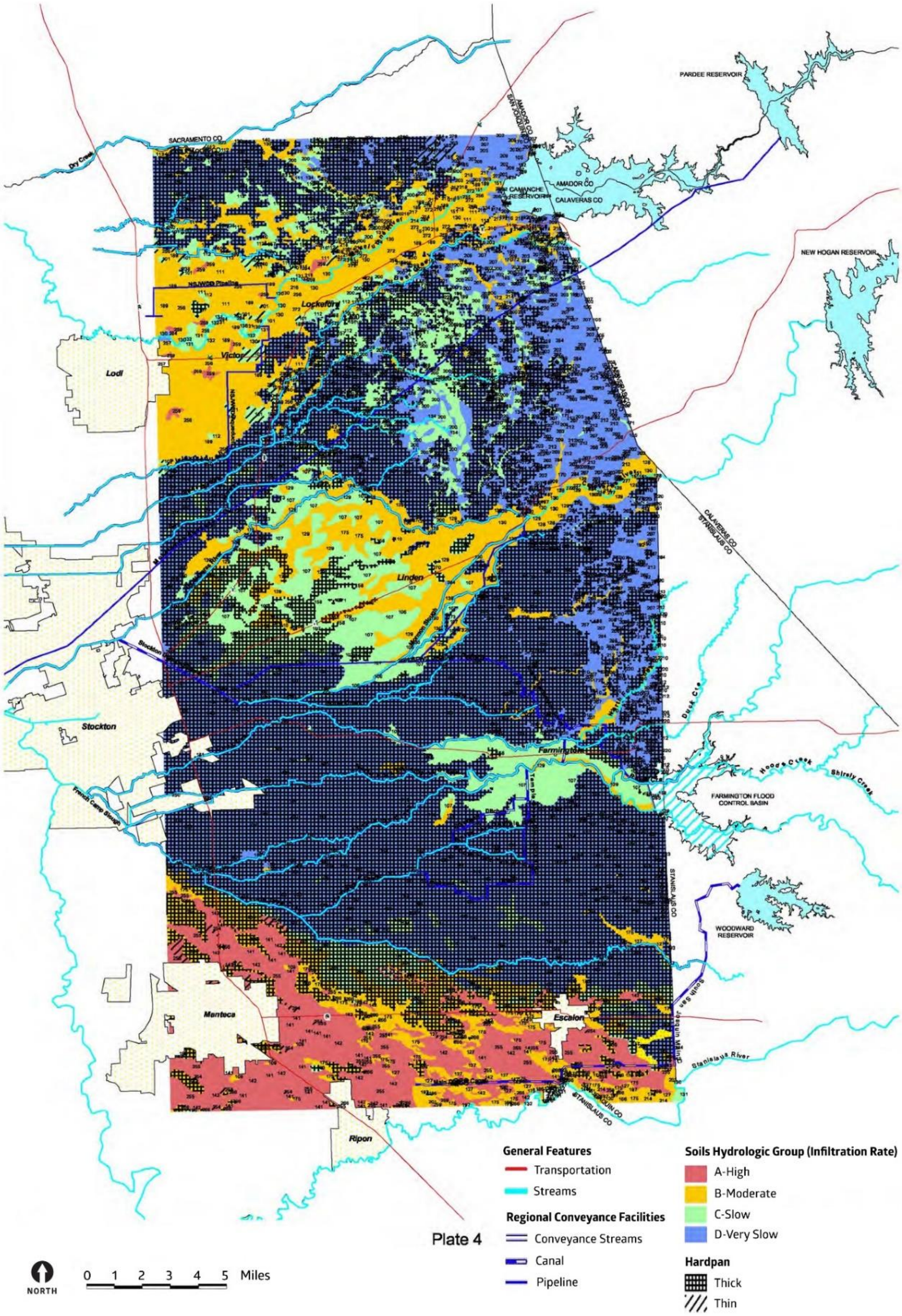


Figure 3-11: Occurrence of Hardpan within the Eastern San Joaquin Subbasin



3.2.3.4 Imported Water

The Eastern San Joaquin Subbasin does not rely on imported water supplies. All surface water used within the Subbasin originates from sources either within or directly tributary to the Subbasin. Several districts receive surface water from Stanislaus River with a point of diversion approximately four miles upstream of the eastern boundary of the Subbasin (located in the Sierra Nevada foothills and not part of a Bulletin 118 groundwater basin). While this diversion point occurs outside of the Subbasin boundary, this water naturally enters the Subbasin by diversion or by surface-groundwater interaction.

3.2.3.5 Groundwater Recharge and Discharge Areas

Groundwater recharge and discharge is driven by both natural and anthropogenic (human-influenced) factors. Areas of recharge and discharge within the Eastern San Joaquin Subbasin are discussed below. Quantitative information about all natural and anthropogenic recharge and discharge is provided in the Water Budget section of the Basin Setting chapter.

3.2.3.5.1 Description of Recharge Areas

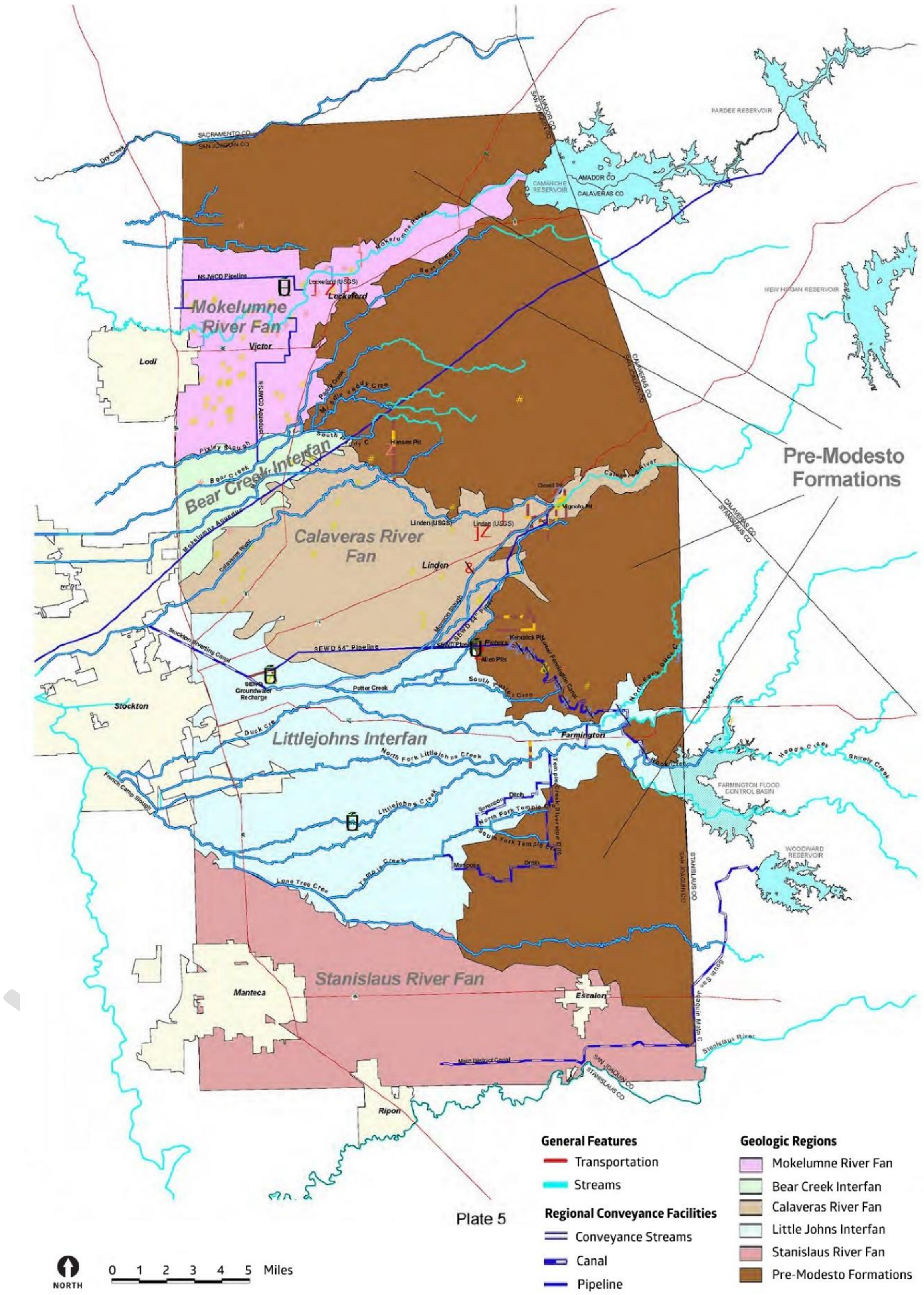
The recharge potential of soils encountered in the Eastern San Joaquin Subbasin varies considerably and is dependent on primary and secondary geologic effects. Primary geologic patterns that influence permeability relate to grain size and sorting, which is a result of depositional characteristics. Secondary geologic effects that influence soil recharge characteristics are associated with post-depositional events such as consolidation, lithification, and weathering, including the development of hardpan soils (MWH, 2001).

The primary (original) geologic permeability of the pre-Modesto formations is variable depending on grain size, but in general is low due to secondary (post-depositional) effects including the development of hardpan soils. However, the units are heterogeneous (variable), and permeable channels are common beneath the hardpan. The primary permeability of the Modesto Formation varies both east-west and north-south due to grain size differences in the original depositional environments. On any given drainage, the alluvium is generally coarsest (and most permeable) in the east where the gradient is steepest, and the relatively high energy stream carries and deposits a high proportion of coarse bedload sand and gravel (the proximal fan). Suspended sediment (clay and silt) is generally not deposited until it is carried farther west to a lower energy environment (the distal fan). As a result, the average permeability, and thus the average recharge rates, of the alluvial fan decreases overall from east to west (MWH, 2001).

The grain size distribution produced from each watershed depends on several characteristics, including the type of geologic materials in the source area, the watershed's gradient and total area, and the portions of the watershed subject to rainfall and snowmelt runoff.

During the Pleistocene Epoch when the Modesto and Riverbank formations were deposited (approximately 1 million to 10,000 years ago), a colder, wetter climate produced a lower snowline than at present, and coarse glacial outwash dominated the major streams originating in the interior of the Sierra Nevada (Mokelumne and Stanislaus River fans). Alluvium of the smaller foothill watersheds consists primarily of fine-grained material in interfan areas (Bear Creek and Little Johns/Rock Creek drainages). The Calaveras River drainage is intermediate between the two, forming a moderately coarse alluvial fan between the Calaveras River and Mormon Slough (MWH, 2001). Figure 3-12 depicts the aerial extents of the alluvial fans, interfan areas, and pre-Modesto formations.

Figure 3-12: Areal Extents of Alluvial Fans, Interfans and Pre-Modesto Formations



Within this overall framework, the alluvial fans of each drainage contain coarse-grained channel and levee deposits of relatively high permeability within finer-grained overbank and floodbasin deposits of low permeability. In this depositional environment, stream channels migrate and abruptly jump to new locations over time, creating deposits that are heterogeneous both laterally and vertically. As a result of this depositional environment, localized silt and clay lenses are common even in the alluvial fan areas. However, no regional clay layer is expected to exist that would severely reduce or inhibit vertical migration of water. The recent (Holocene) alluvium in the current incised river floodplains (Mokelumne and Calaveras Rivers) and windblown (eolian) sand deposits are of limited extent but relatively permeable (MWH, 2001).

These present and historic alluvial depositional factors are critical in understanding:

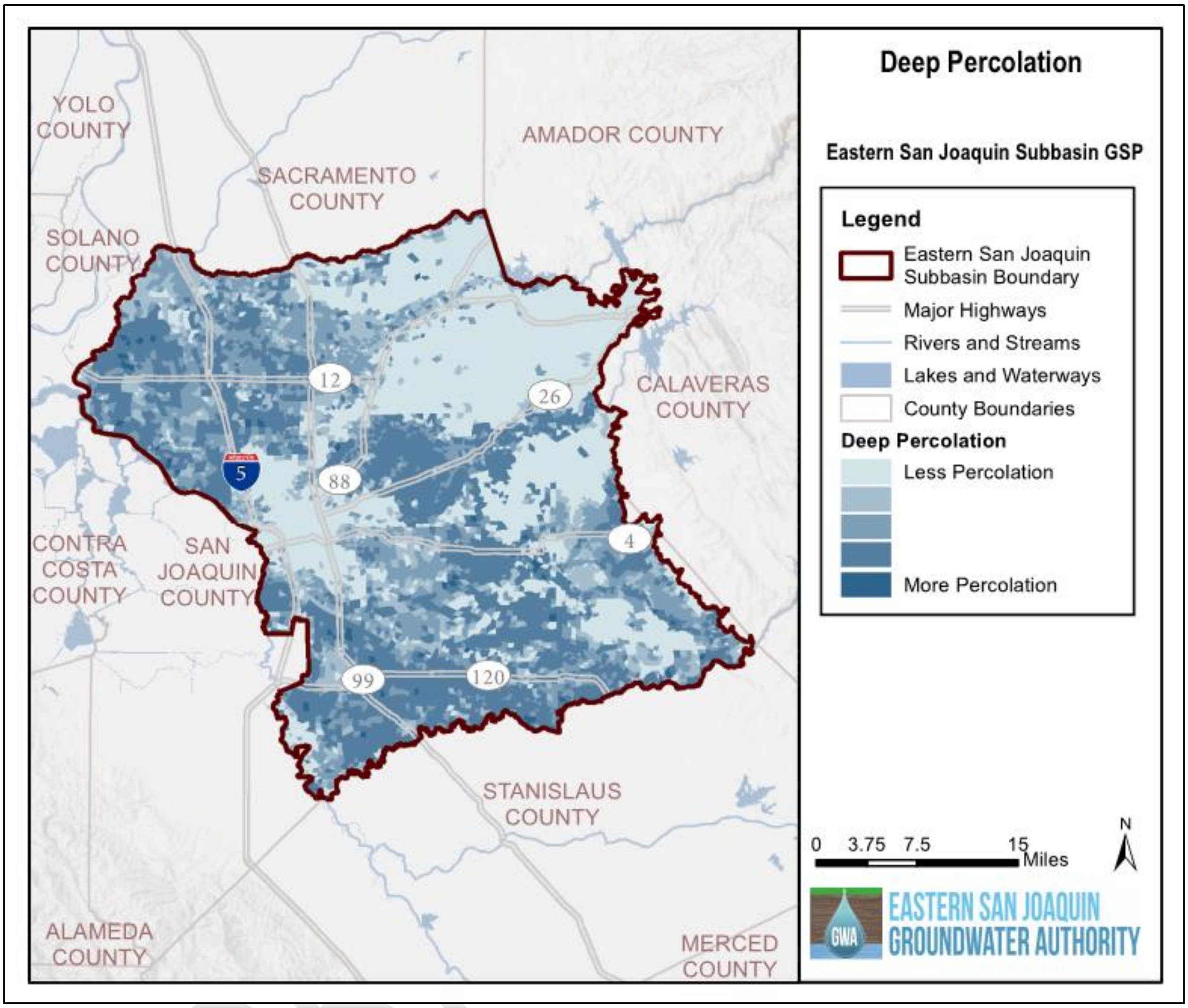
- Rainfall percolation rates when the soil moisture deficit is zero and groundwater recharge occurs;
- Groundwater system preferential vertical movement pathways through the Principal Aquifer and Aquitards;
- Future groundwater management alternatives.

The Eastern San Joaquin Water Resources Model (ESJWRM) estimates the recharge that occurs in different areas of the Eastern San Joaquin Subbasin, largely due to the percolation of rainfall and applied irrigation water. Figure 3-13 shows the spatial distribution of percolation in the Subbasin, with generally less percolation occurring in finer soil areas (e.g., Hydrologic Soil Group D) and areas without extensive irrigation (i.e., native landscape).

3.2.3.5.2 Description of Discharge Areas

Groundwater discharge primarily occurs through groundwater production wells. Groundwater production in ESJ Subbasin is discussed further in the Basin Setting Chapter under the presentation of the Water Budgets (Section 3.3). Groundwater also discharges to rivers and streams where groundwater elevations are higher than river stage. This is described more in Section 3.4.6 of the Basin Setting Chapter. Figure 3-43 indicates where these stream nodes indicate gaining conditions (groundwater contributing to streamflow) and where they indicate losing conditions (surface water recharging groundwater). This analysis was based on modeling results from the ESJWRM for approximately 900 stream nodes in the Eastern San Joaquin Subbasin. The stream nodes within the ESJWRM contain information on the quantity of stream gains and losses on a monthly basis. Using the historical simulation (see Appendix F: Eastern San Joaquin Water Resources Model (ESJWRM) Report), the median value of monthly stream gains and losses was calculated over the 1996 to 2015 time period.

Figure 3-13: Areas of Groundwater Recharge



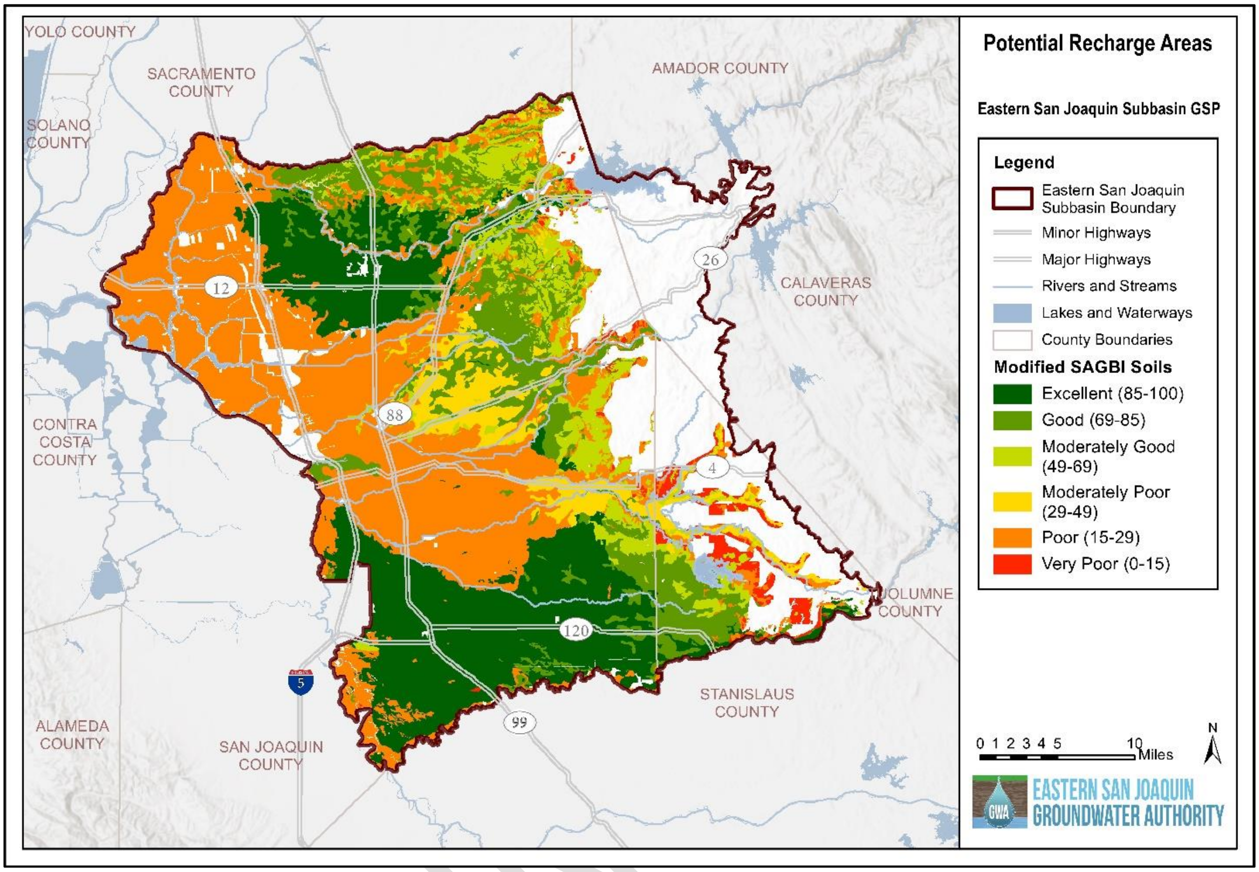
3.2.3.5.3 Description of Potential Recharge Areas

Agricultural and open space lands are considered areas of potential recharge. Figure 3-14 shows areas with their potential for groundwater recharge, as identified by the Soil Agricultural Groundwater Banking Index (SAGBI). SAGBI provides an index for the groundwater recharge for agricultural lands by considering deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition.

SAGBI data is derived from "modified" SAGBI data. "Modified" SAGBI data show higher potential for recharge than unmodified SAGBI data because the modified data assume that the soils have been or will be ripped to a depth of 6 feet, which can break up fine grained materials at the surface to improve percolation. Modified SAGBI data categorizes 310,098 acres out of 610,890 acres (51 percent) of agricultural and grazing land within the Subbasin as moderately good, good, or excellent for groundwater recharge (University of California, Davis, 2018).

Agricultural and open space lands are considered areas of potential recharge.

Figure 3-14 Potential Recharge Areas



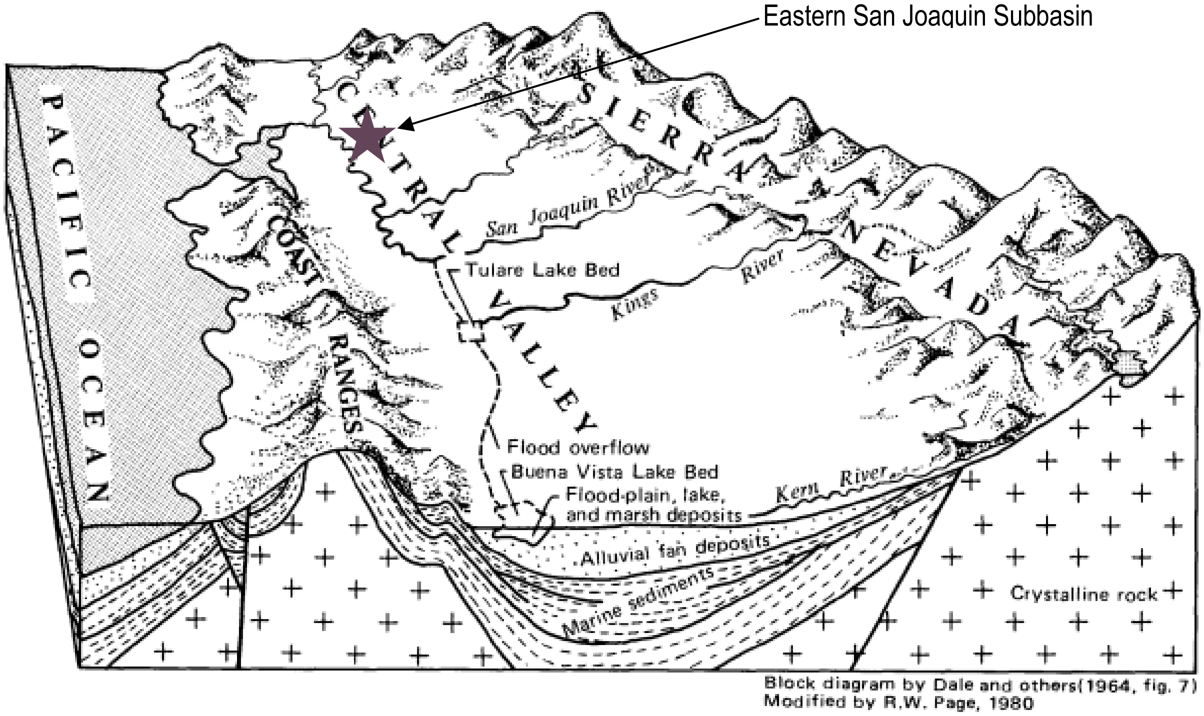
3.2.4 Geologic Formations and Stratigraphy

Geologic formations within the Central Valley and Eastern San Joaquin Subbasin are generally grouped as either eastside or westside formations based on their location relative to the San Joaquin River and the source of the sedimentary material of which they are composed. Generally, eastside formation material originates from continental deposits from the Sierra Nevada and westside formation material originates from the continental Coastal Ranges. Rising land masses contributed to the erosion and deposition of alluvial sands and fan deposits. Glaciation in the Pleistocene also contributed to the steepening of streams during melt water periods (CA DWR, 1967).

The block diagram of the Central Valley (Figure 3-15), provides a generalized geologic cross-sectional view of the geologic setting. The Eastern San Joaquin Subbasin is located in the foothills margin between the roughly horizontal alluvial sediments of the Central Valley geomorphic province and the granitic Sierra Nevada geomorphic province.

Sediment deposits can be subdivided into consolidated and unconsolidated deposits, with the consolidated sediments underlying the unconsolidated sediments. The most important fresh water-bearing formations in the Eastern San Joaquin Subbasin are the sands within the consolidated Mehrten and Laguna Formations and the unconsolidated younger alluvial deposits consisting of the Riverbank and Modesto Formations.

Figure 3-15: Generalized Geologic Section and Eastern San Joaquin Subbasin Setting



With depth, the stratigraphy of unconsolidated sediments consists initially of Recent to Pleistocene Age alluvial deposits of the Post-Modesto deposits and the Modesto and Riverbank Formations. The sediments of these units are typically unconsolidated sands and gravels interbedded with considerable silts and clays. These clays separate the upper sediments over the lower Late Plio-Pleistocene Age Laguna Formation and the older Eocene to Pliocene Age Mehrten Formation. The Laguna and Mehrten are poorly consolidated sediments and are differentiated based on color and sand type. The Laguna Formation is typically light brown and the differentiating characteristic of the Mehrten is black sands derived from volcanic detritus. The Valley Springs and Ione Formations are encountered below the Mehrten Formation. The formations have a distinct geologic dip and thickness to the west.

The geologic map shown in Figure 3-16 illustrates the surface deposits of the Pleistocene-aged Modesto Formation and Turlock Lake Formation largely within the valley floor (Wagner et al., 1981; Wagner et al., 1991). The knolls and ridges to the east represent outcrops of the Tertiary-aged Laguna, Mehrten, Valley Springs, and Ione Formations. The geologic stratigraphic column is provided on Table 3-2.

Figure 3-16: Geologic Map

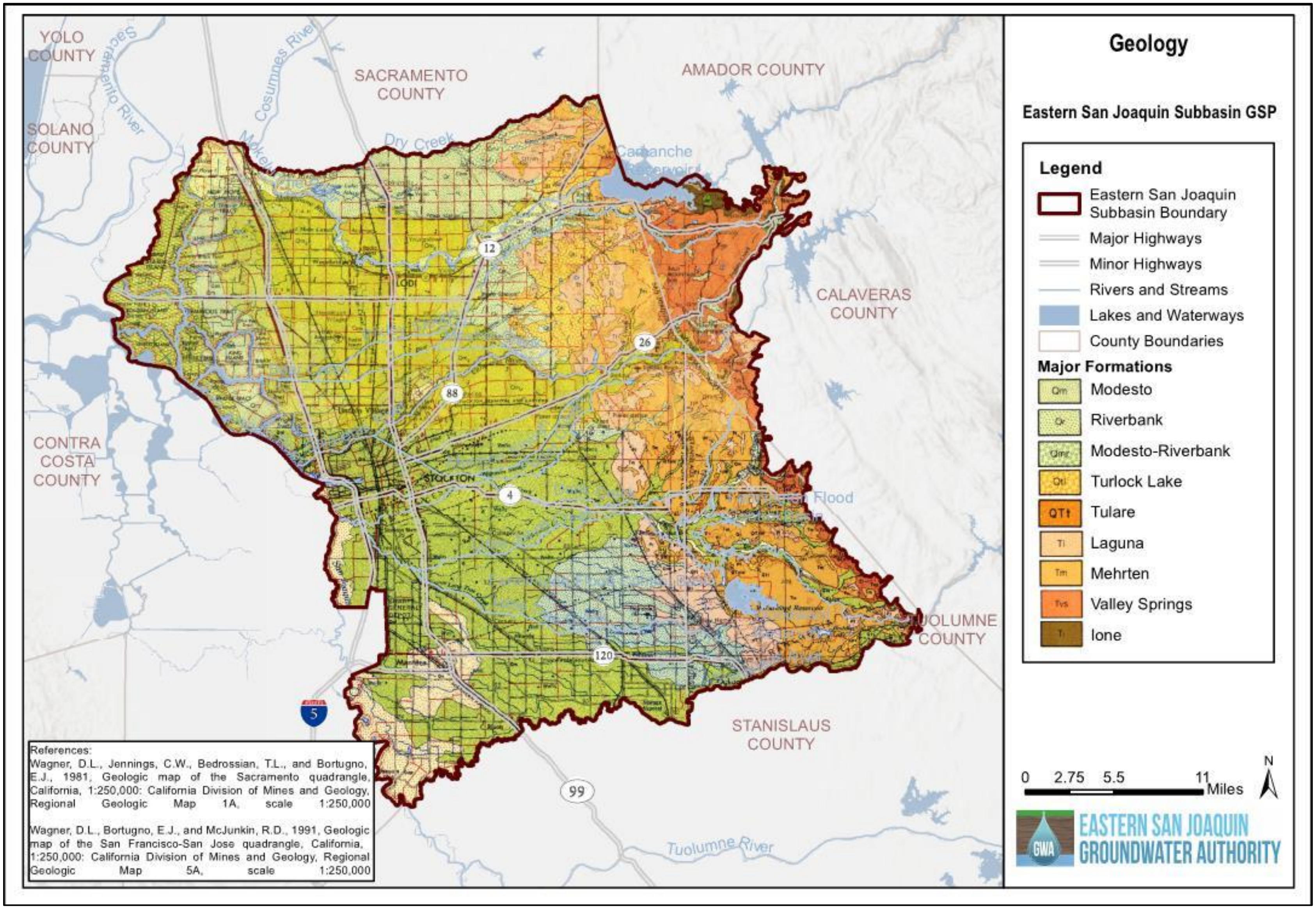


Table 3-2: Generalized Stratigraphic Column, Formation Descriptions, and Water-Bearing Properties

	System	Series	Formation & Map Symbol	Thickness Maximum (feet)	Rock Characteristics and Environment	Water-Bearing Properties
CENOZOIC	*Quaternary*	Holocene	Stream Channel Deposits (Qsc)	50±	Continental unconsolidated gravel and coarse to medium sand deposited along present stream channels.	High permeability, significant avenue for percolation to underlying formations. Generally, not saturated except by the San Joaquin River
		Late Pliocene	Modesto	65-130±	Continental fan and interfan material, locally some basin types, lenticular gravel, sand, silt, clay.	Moderate permeabilities. Unconfined aquifer.
		Pliocene	Riverbank	150 to 250	Continental fan and interfan material, locally some basin types, lenticular gravel, sand, silt, clay. Reddish clay-rich duripan caps the unit.	Moderate permeabilities. Unconfined aquifer.
		Recent to Plio-Pleistocene	Flood Basin Deposits (Qb) Turlock Lake Fm	0-1,000±	Continental basinal equivalent of Laguna, Tulare & younger formations. Clay, silt & sand, organic in part.	Generally low permeabilities, saturated environment, unconfined to confined.
		Plio-Pleistocene	Laguna (QTl)	0-1000±	Continental, semi-to unconsolidated silt, sand & gravel, poorly sorted, includes Arroyo Seco Gravel pediment of Mokelumne R. area.	Moderate permeability, Unconfined to locally semi-confined. Restricted perched bodies in some areas.
	Tertiary	Mio-Pliocene	Mehrten (Tm)	0-600±	Continental andesitic derivatives of silt, sand and gravel & their indurated equivalents; tuff; breccia; agglomerate.	Moderate permeability to high where "Black Sands" occur. Confined to unconfined. Saline west of Stockton.
		Miocene	Valley Springs (Tvs)	0-500±	Continental rhyolitic ash, clay, sand & gravel and their indurated equivalent.	Low permeability. Saline in Stockton area. Not considered as significant in groundwater studies.

	System	Series	Formation & Map Symbol	Thickness Maximum (feet)	Rock Characteristics and Environment	Water-Bearing Properties
		Eocene	Ione (TI)	0-500±	Light colored clay and sand. Marine shale, siltstone and sandstone	Contains saline waters except where flushed in outcrop areas. Unimportant to fresh water basin except as possible contaminant source.
MESOZOIC	*Cretaceous*	Cretaceous Jurassic	Undifferentiated Bedrock		Igneous, metamorphics and ultramafics.	Contains saline waters. Unimportant to fresh water basin except as possible contaminant source.
	Pre-Cretaceous					
Notes: DWR, 1967; Burow et al, 2004						

3.2.4.1 Geologic Formation Descriptions

The Tertiary-age units that overlie the basement rocks and generally outcrop within the Eastern San Joaquin Subbasin are discussed in the following sections, from oldest to youngest.

3.2.4.1.1 Pre-Ione Eocene Rocks

The pre-Ione Eocene rocks, as described by Chapman and Bishop (1975), were deposited in a pre-Ione bedrock paleochannel system. Their composition includes sedimentary rocks of marine origin with biotite, chlorite, and muscovite. Feldspar is a significant component of this unit (Creely & Force, 2007). The thickness of this unit is highly variable in the foothill area as it is controlled by basement complex topography. The unit “wedges out” to the east and assumes a more uniform regional thickness to the west in the Central Valley Mesozoic-Cenozoic sediment pile (Creely & Force, 2007). Depictions and full geologic formation detail are provided in Table 3-2. The Tertiary volcanic and sedimentary rocks and terrace deposits are separated from the Jurassic volcanic/metamorphic basement by an angular unconformity from small-scale faulting. The Franciscan Group, Cretaceous, and Eocene Undifferentiated deposits have been impacted by the east-west Stockton Fault (CA DWR, 1967)

3.2.4.1.2 Ione Formation

The Eocene Age Ione Formation has been mapped along the eastern margin of the Eastern San Joaquin Subbasin, and, as described by Loyd (1983), contains interbedded kaolinitic clay, quartz sand, sandy clay, and lignite. The Ione Formation is characteristically light in color, with color influenced by iron oxide, lignite, and carbonaceous mud rocks and shale (Creely & Force, 2007). Pask and Turner (1952) subdivided the Ione Formation into upper and lower members based on mineralogy. The upper and lower members contain kaolinite (anauxite) clays. Deposits can include coarse-grained sand (up to 2 mm diameter). This kaolinite sand is commonly called Ione sand.

Ione sand is one of the most important sources of commercial clay and silica sand in the Ione Formation (Creely & Force, 2007). Ione sand has a white color with a pearly luster and appears massive; however, closer examination usually reveals cross stratification, heavy mineral laminae, and burrows (Creely & Force, 2007). Quartz is abundant with varying feldspar content in both members.

The lower member contains 8 to 10 percent feldspar with the upper member containing 20 to 25 percent feldspar. The minerals biotite and chlorite are rare in the lower member and common in the upper member. Heavy mineral deposits vary. The lower member contains mature minerals like zircon and ilmenite. The upper member contains hornblende and epidote. Chromite is also commonly found in the Ione Formation. The upper member is largely absent north of Jackson Valley due to erosion and deposition during the development of the overlying Valley Springs Formation. The Ione Formation is deposited in both marine and fluvial continental environments (Creely & Force, 2007).

3.2.4.1.3 Valley Springs Formation

The Oligocene-Age Valley Springs Formation is described by Loyd (1983) as stream channel and alluvial deposits derived mainly from rhyolitic volcanic rocks including some white, welded tuffs, and ash flows. The basal contact of the Valley Springs Formation is characterized, locally, by the presence of rhyolitic conglomerate. These tuffs may display alteration to clays, and, in extreme cases, only a claystone bed with relict tuffaceous texture remains. Pure deposits of rhyolitic ash exist in areas, while many sand and ash beds are present. In general, the clay beds of the Valley Springs Formation are greenish in color, may contain silt, sand, and large pumice fragments. The sandstones range in grain-size from fine to coarse and are typically well cemented. Predominantly composed of quartz and pre-Cretaceous material, the relatively sparse conglomerate lenses within the tuff, clay, and sandstone may also contain pumice fragments. In general, the Valley Springs Formation is predominantly fine-grained, containing less coarse-grained deposits. In the Central Valley, the Valley Springs Formation is considered to be largely non-water-bearing. This is likely due to the great depths beneath the valley floor and the proximity to the base of freshwater (Sections 3.2.6 and 3.2.7.2).

3.2.4.1.4 Mehrten Formation

Overlying the Valley Springs Formation is the Miocene Age Mehrten Formation, described as being stream channel, alluvial, and mudflow deposits derived mainly from andesitic volcanic rocks. The Mehrten Formation is considered the oldest significant fresh water-bearing formation within the Eastern San Joaquin Subbasin.

Bartow (1992) generally describes the Mehrten in the east-central portion of the Central Valley as being sandstone composed of amphiboles, pyroxenes, and pebbles (mostly volcanic) with lenticular bedding and gray to blue color. Bartow discusses a major change in regional volcanism as the rhyolitic pyroclastic deposits of the Late Oligocene and earliest Miocene were replaced near the end of the Early Miocene by reestablished andesitic arc volcanism in the northern Sierra Nevada. This andesitic volcanism provided the source materials for the Mehrten Formation.

Ferriz (2001) discusses how the Mehrten Formation outcrops discontinuously along the eastern flank of the Valley and was laid down in the Mokelumne area by streams carrying andesitic debris from the Sierra Nevada. The Mehrten thickens in the northeastern part of the San Joaquin Valley; generally, it can be more than 700 to 1,200 feet thick at depths ranging from more than 300 feet below ground on the east side of the valley to depths exceeding 1,400 feet along the central portion of the valley. The contact between the Mehrten Formation and underlying Valley Springs Formation is an unconformity.

The formation is subdivided into upper and lower units. The upper unit contains finer grained deposits (black sands interbedded with brown-to-blue clay) and the lower unit consists of dense tuff breccia. Deep wells in the Stockton area indicate the upper portion of the Mehrten Formation contains a high percentage of clay, suggesting that the upper portion of the unit may be finer grained than the middle or lower portions, with resulting semi-confined conditions (CA DWR, 1967).

The black sands of the Mehrten Formation (black andesite detrital grains) generally have moderate to high permeability and yield large quantities of fresh water to wells, which makes them a preferred exploration target for groundwater supply in the eastern half of the Central Valley (Davis & Hall, 1959; CA DWR, 1967). East of Jack Tone Road, a large number of wells produce from the relatively permeable “black sands” commonly described as hard sandstones (CA DWR, 1967).

3.2.4.1.5 Laguna Formation

The Pliocene to Pleistocene Laguna Formation is composed of discontinuous lenses of unconsolidated to semi-consolidated alluvial sands, gravels, and silts and is typically light brown. These poorly exposed stream-laid alluvial deposits form high terraces and are associated with the last major uplift in the Sierra Nevada.

The Laguna Formation outcrops in the northeastern part of the County and dips at 90 feet per mile and reaches a maximum thickness of 1,000 feet, with the thickest areas (400 to 1000 feet) observed near the Mokelumne River in the Stockton Area (CA DWR, 1967). The Laguna Formation is moderately permeable with some reportedly highly permeable coarse-grained fresh water-bearing zones.

Some studies suggest that an extensive aquitard, namely the Corcoran Clay member of the Tulare Formation, extends into the Laguna Formation or separates the Laguna and Mehrten Formations. Corcoran Clay is further discussed in the following section.

3.2.4.1.6 Turlock Lake Formation

The Turlock Lake Formation as consisting primarily of arkosic alluvium, mostly fine sand, silt, and in places clay, at the base grading upward into coarse sand and occasional coarse pebbly sand or gravel (Marchand & Allwardt, 1981). The age of the Turlock Lake Formation is about 600,000 to greater than 730,000 years old, but younger than about 1 million years. The Turlock Lake commonly stands topographically above the younger fans and terraces throughout the northeastern San Joaquin Valley in a broad band between the Merhten, Laguna, and the younger Riverbank and Modesto alluvial fans to the west. A buried soil separates the Turlock Lake Formation into two units (Upper and Lower) in the northeastern San Joaquin Valley. The thickness of the Turlock Lake is variable and appears to increase toward the valley. Estimates of thickness in the subbasins to the south range from 295 to 850 feet for eastern Stanislaus County, 1,000 feet for northern Merced County, and 160 to 720 feet in the Chowchilla area.

The Turlock Lake Formation is differentiated from the west to east by its Corcoran Clay member that is present in the southwest corner of the Subbasin near Manteca and dominates the area west of Highway 99 south of the Eastern San Joaquin Subbasin. The Corcoran Clay becomes interbedded with the sands and silt of the upper Tulare and is not found in the central and northern portions of the Subbasin. This member is found ranging in thickness from a feather edge to 160 feet beneath the present bed of Tulare Lake. The Turlock Lake Formation is dominant within the basins to the south.

3.2.4.1.7 Riverbank Formation

The Riverbank Formation consists primarily of arkosic sediment derived mainly from the interior Sierra Nevada, which forms at least three sets of terraces and coalescing alluvial fans along the eastern San Joaquin Valley (Marchand & Allwardt, 1981). The Riverbank Formation is about 130,000 to 450,000 years old. The Riverbank, as exposed in the northeastern San Joaquin Valley, is primarily sand, containing some scattered pebbles, gravel lenses, and some interbedded fine sand and silt. The Riverbank unconformably overlies the Laguna Formation, and its terraces and fans truncate or are cut into Turlock Lake alluvium or fill post-Turlock Lake gullies and ravines, which, in turn, are cut and filled near the foothills by terraces of the lower member of the Modesto Formation. The Riverbank Formation is informally subdivided into three units (lower, middle, and upper) which appear to coarsen upward, like those of the older Turlock Lake Formation. The Riverbank Formation also shows a variable thickness that tends to increase toward the major river channels; 150 to 200 feet is reported in northern Merced and eastern Stanislaus Counties, 260 feet along the Merced River, and about 65 feet along the Chowchilla River.

3.2.4.1.8 Modesto Formation

The Modesto Formation is composed of mainstream arkosic sediments and associated deposits of local derivation laid down during the last major series of aggradation events in the eastern San Joaquin Valley (Marchand & Allwardt, 1981). Gravel, sand, and silt were deposited as a series of coalescing alluvial fans extending continuously from the

Kern River drainage on the south to the Sacramento River tributaries in the north. They occur in a wide band immediately east of the San Joaquin Valley axis and to the west of the Riverbank and older fan remnants. Radiocarbon dating estimates the age of the Modesto to be older than 9,000 years before present (B.P.) to 42,000 years B.P. Most of the prime agricultural land and many of the major cities are located in the young alluvial soils associated with the undissected Modesto terrace and fan surfaces. Modesto deposits overlie late Riverbank alluvium and older units and are locally incised or covered along modern channels by post-Modesto deposits.

The materials of the Modesto Formation are virtually identical to those of the Laguna, Turlock Lake, and Riverbank Formations, but their association with low terraces and young fans and their moderate to slight degree of erosional modification and soil profile development clearly differentiate them from older alluvium. The total thickness of the Modesto deposits is reported to be 50 to 100 feet in eastern Stanislaus County, 130 feet along the Merced River, and about 65 feet along the Chowchilla River fan. The Modesto Formation also thickens toward each river channel and toward the south; there is significant evidence of local facies changes laterally. Exposed sections toward the basin differ substantially from exposures near the foothills and from exposures along the westward draining rivers.

3.2.4.1.9 Post-Modesto Deposits – Recent Alluvium and Basin Deposits

In general, these younger units are less consolidated and sedimentary in nature, representing a sequence of young alluvial fills including alluvial fans, channel, point bar, levee, crevasse splay, interdistributary, and floodbasin alluvium. The alluvial fan deposits are much smaller than the late Modesto fans. The age of these deposits ranges from 9,000 years B.P to modern time. Lacustrine, swamp, and marsh deposits are presently accumulating in poorly drained areas on the alluvial fan toes. In oxbow lakes on river flood plains, near the edge of the Delta where Holocene sea level rise caused alluviation of the lower Mokelumne and Cosumnes Rivers, lakes and swamps have formed where tributary gullies have been blocked by mainstream aggradation (Marchand and Allwardt, 1981).

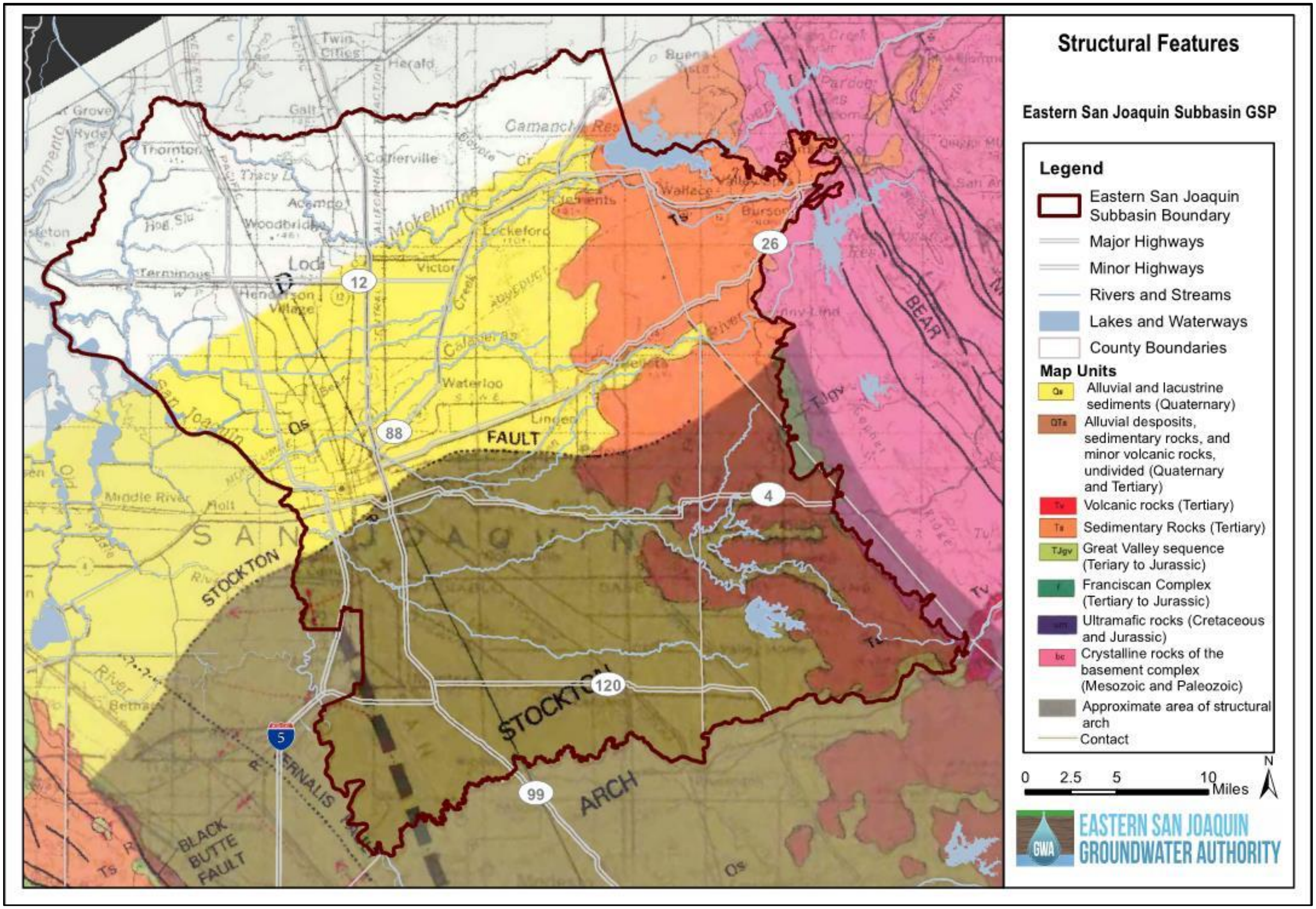
3.2.5 Faults and Structural Features

The Stockton Fault – The Stockton Fault is the largest fault in the Eastern San Joaquin Subbasin, shown in Figure 3-17. It is a large reverse fault with displacements of up to 3,600 feet (1,100 m) that trends transverse to the regional structure and bounds the Stockton Arch on the north. Bartow (1985) shows relative movement along the fault as north side down. The timing of the vertical movement is predominantly post-Eocene (Hoffman, 1964), and the latest movements appear to have been subsequent to deposition of the basal part of the Valley Springs Formation probably during Miocene time. See the geologic time scale (Figure 3-5) for the relative ages (in millions of years ago [Ma]) of the referenced chronostratigraphic units (e.g., Tertiary age spans from 65.5 to 2.6 Ma).

The Vernalis Fault – The Vernalis Fault is a major reverse fault with northwest-southeast trend that bounds the Tracy-Vernalis anticlinal trend that is mapped outside of the west boundary of the Eastern San Joaquin Subbasin. East-side-down movement of as much as 1,500 feet (460 m) probably took place at the same time as the major movements on the Stockton Fault (Bartow, 1985). The relative thickness of sediments can be inferred from the elevations of the base of the freshwater aquifer system shown in Figure 3-5. The freshwater aquifer system on the north side of the Stockton fault extends approximately 600 feet deeper than the aquifer system south of the fault. Relative movement along the fault is north-side-down, thus allowing for greater accumulation of the continental Tertiary sediments and deepening of the aquifer materials in this area.

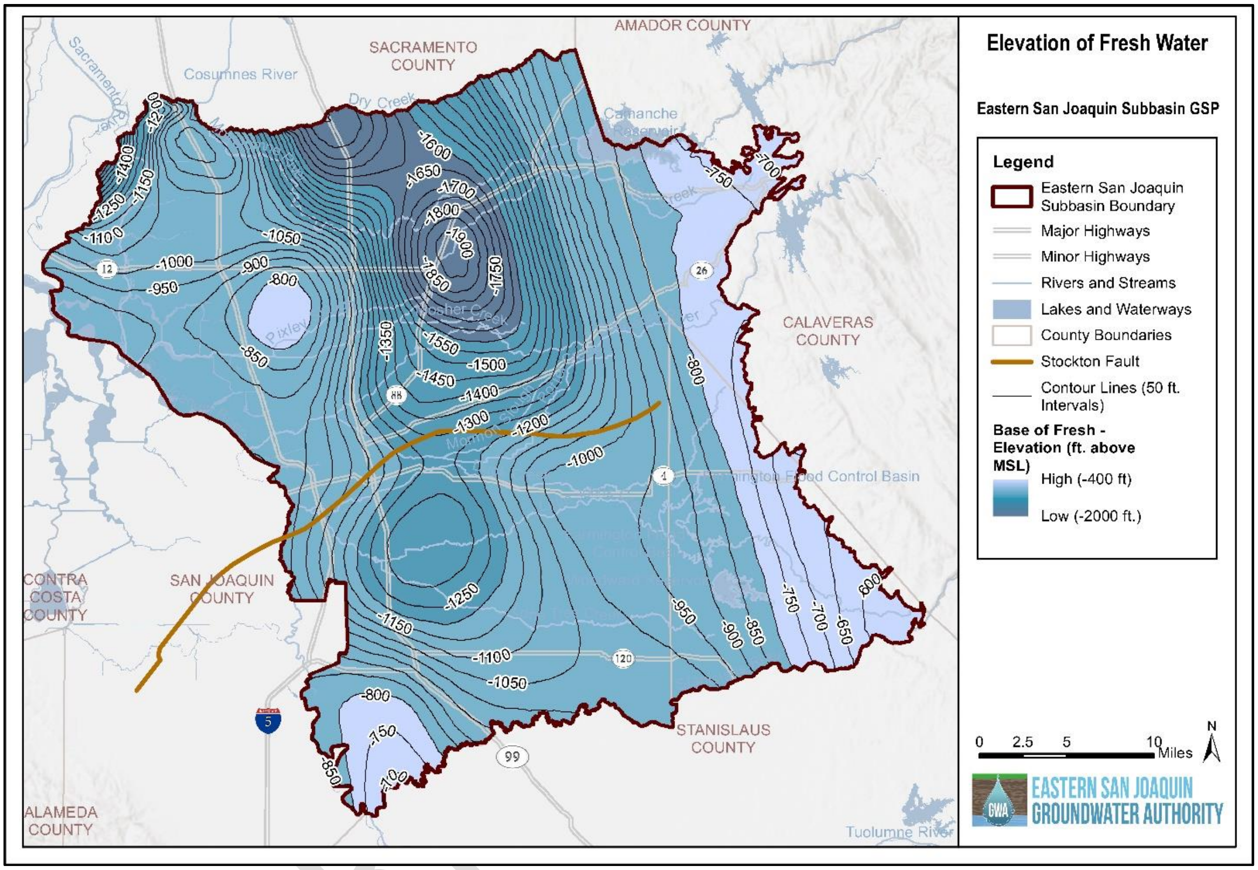
Stockton Arch – The Stockton Arch is a broad transverse structure that underlies the southern half of the Eastern San Joaquin Subbasin. The arch is bounded on the north by the Stockton Fault, and the southern limit is the line of truncation of Paleogene strata south of Modesto (Bartow, 1985). Indications of northward-shallowing marine facies in the lower Paleogene sequence suggests that the arch was present by Paleocene time. Erosion during the Oligocene time apparently reduced whatever physiographic expression the arch may have had and left a nearly flat plain prior to deposition of the later Tertiary units.

Figure 3-17: Faults and Structural Features



As a result of the north-side-down movement along the Stockton Fault, the Tertiary sediments are thicker north of the fault and thinner south of the fault. This feature also influences the location, depth, and thickness of the "base of the fresh water" at the bottom of the Principal Aquifer, as shown below in Figure 3-18.

Figure 3-18: Base of Fresh Elevation Contours and Stockton Fault



There are a series of angular unconformities formed during the Cenozoic related to uplift of the Sierra Nevada to the east (Bartow, 1985). The Cenozoic history of the Sierra Nevada is one of progressive westward tilting, perhaps episodic, with an increasing rate in the late Cenozoic. The subtle angular unconformities that separate the Tertiary units are evidence of this progressive tilting. The Tertiary units rarely have dips of more than 2 degrees; the difference in dip between the Ione and the Valley Springs Formations, for example, may be less than 1 degree. The discordances are most apparent in terms of gradients of depositional surfaces measured in distances of several miles. The largest discordances are between the Ione Formation (about 1,500 ft/mile) and the Valley Springs Formation (94 - 120 ft/mile), between the Mehrten Formation (99 - 131 ft/mile) and the Laguna Formation (52 - 79 ft/mile), and between the Laguna Formation and the Quaternary deposits (less than 18 ft/mile). The Ione-Valley Springs unconformity represents the Oligocene regression that affected most of central and southern California, and the Mehrten-Laguna unconformity probably marks the accelerated uplift of the Sierra Nevada beginning 3 to 5 Ma (Huber, 1981) in the central part of the range. The Sierra Nevada was relatively stable through the Miocene with only a minor discordance between the Valley Springs and Mehrten Formations; their lithological difference reflects primarily a change from rhyolitic to andesitic volcanism in the source area. Uplift of the Sierra Nevada continued through the Quaternary, but the record is complicated by Quaternary climatic events (e.g., glaciation) which were the principal controlling factor in Quaternary sedimentation for the east side of the Great Valley.

3.2.6 Geologic Cross-Sections

Five Geologic cross-sections (A-A', B-B', C-C', D-D', and E-E') were developed for the Eastern San Joaquin Subbasin based on the stratigraphic information amassed as part of the data compilation efforts. A geologic cross-section is an interpretive diagram of the lateral and vertical subsurface relationships of geologic formations. A cross-section location map with locations of groundwater and oil and gas wells reviewed in the development process is provided as Figure 3-19. Three of the cross-sections (A-A' through C-C') are along east-west transects in the north, central, and southern portion of the Subbasin, respectively; two of the cross-sections (D-D' and E-E') are generally along north-south transects. Cross-section D-D' generally transects the cities of Lodi, Stockton, and Manteca in the west portion of the Subbasin, and cross-section E-E' transects the Eastern San Joaquin Subbasin along the alignment of Jack Tone Road from the northeast to the southwest portion of the Subbasin. Each of the five geologic cross-sections are provided in Figure 3-20, Figure 3-21, and Figure 3-22.

Figure 3-19: Cross-Section Location Map

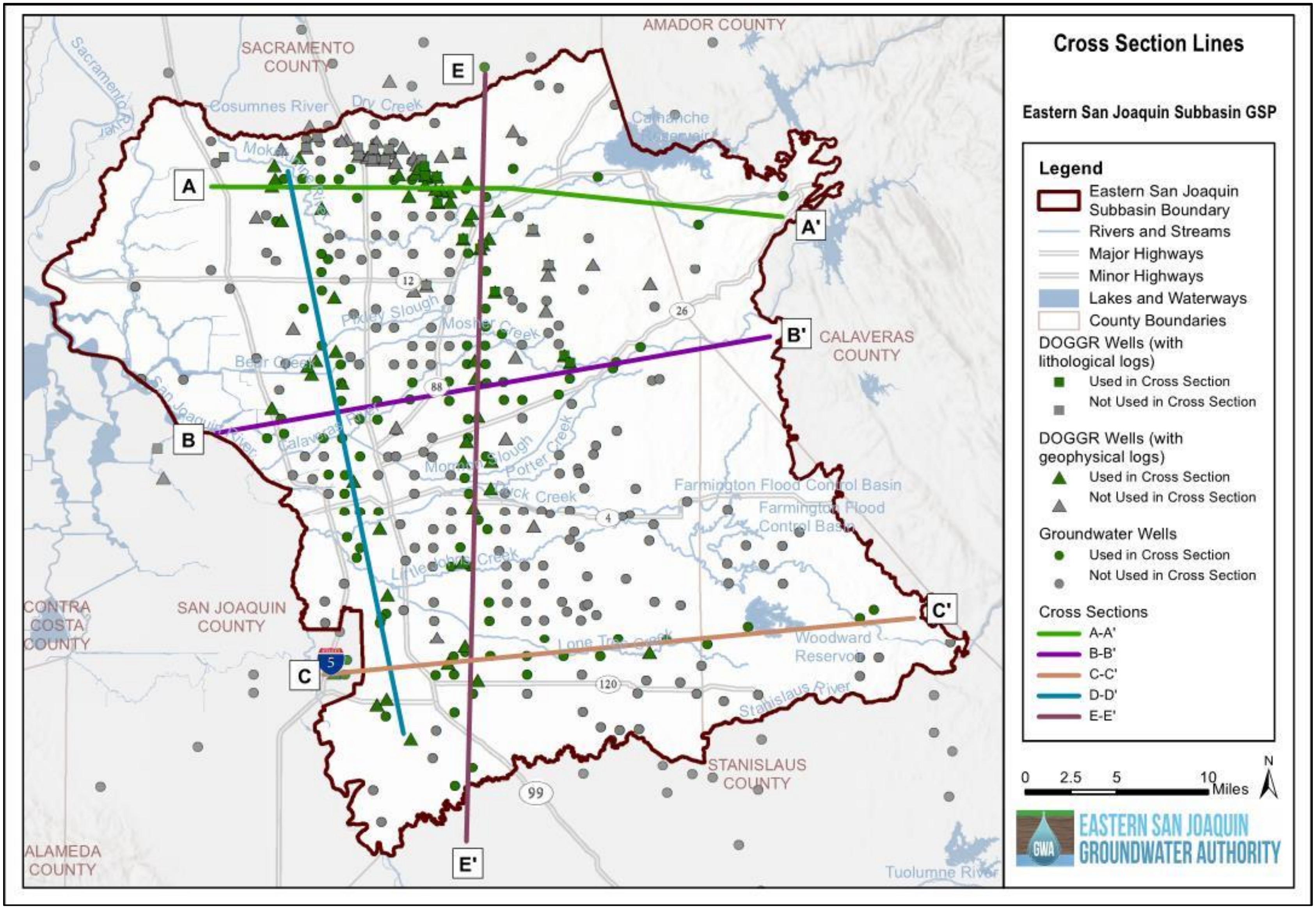


Figure 3-20: Hydrogeologic Cross-sections A-A' and B-B'

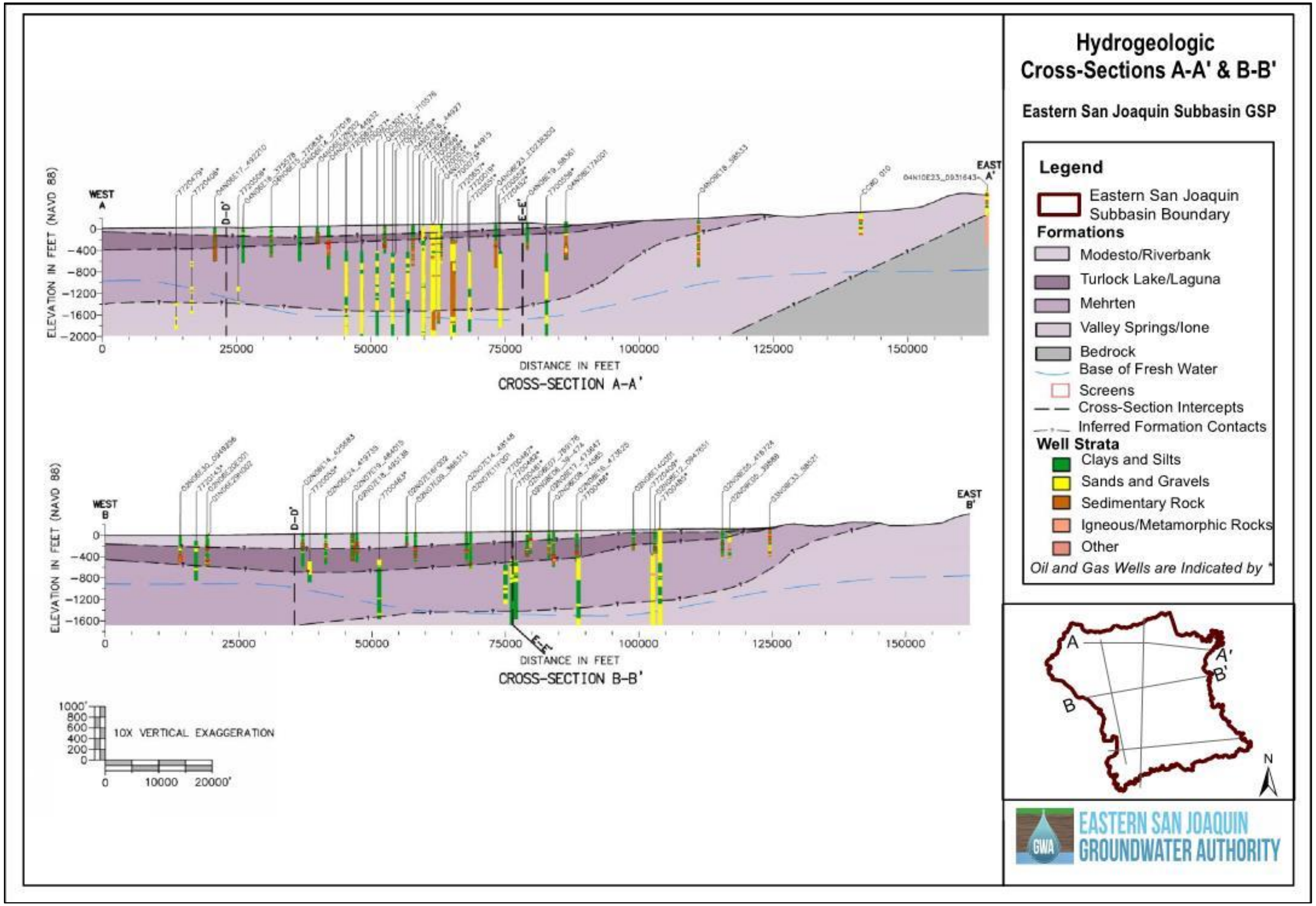


Figure 3-21: Hydrogeologic Cross-sections C-C’ and D-D’

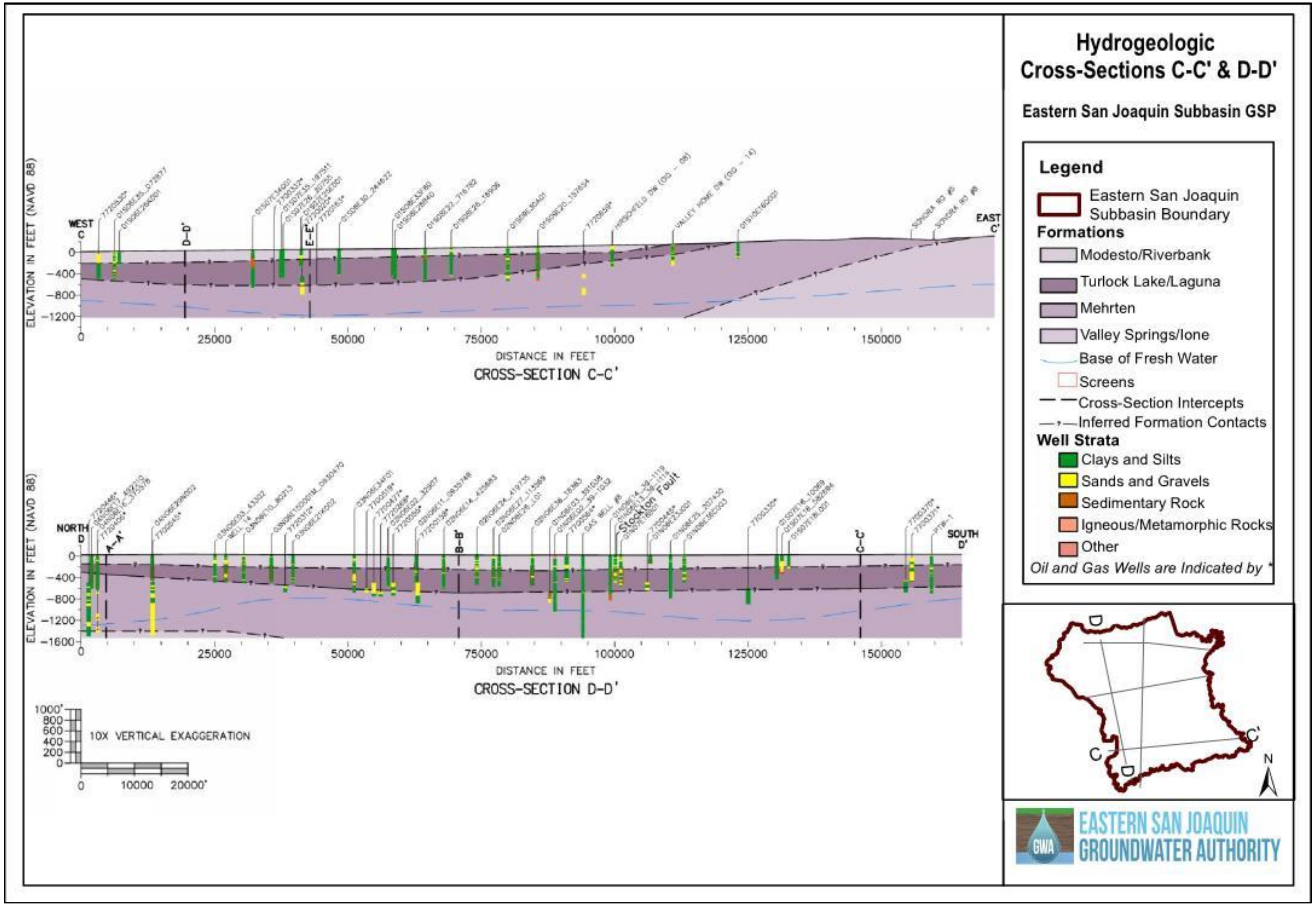
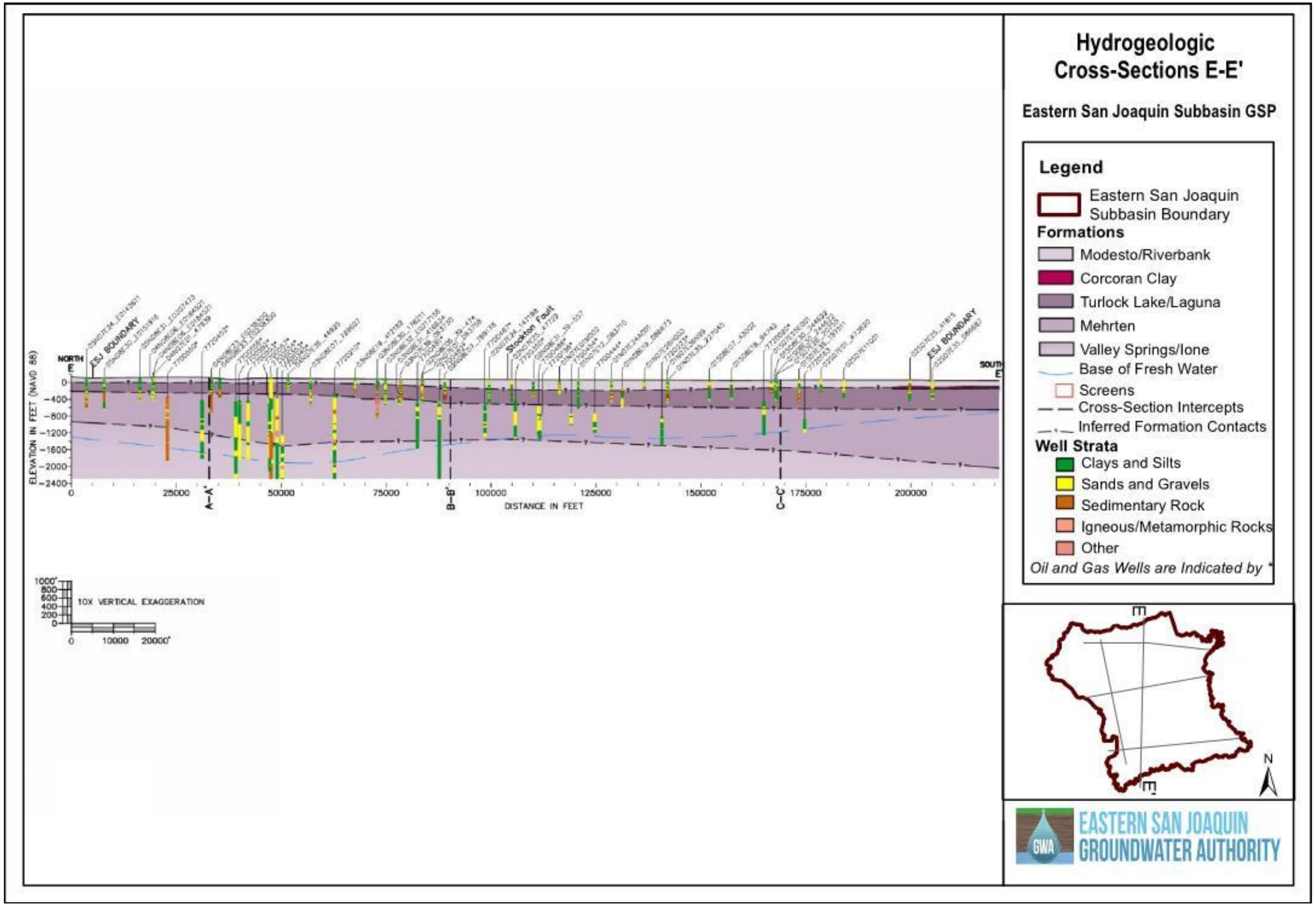


Figure 3-22: Hydrogeologic Cross-section E-E'



The analysis for this GSP used stratigraphic data from well completion reports of hundreds of water wells and oil and gas wells (indicated by an asterisk on the cross-sections) to develop the geologic cross-sections. Stratigraphy (i.e., clays and silts, sands and gravels, sedimentary rock, metamorphic and igneous rock, and others) is presented directly on the cross-sections along with the well screen interval (shown in red). The deeper oil and gas wells are shown extending to the bottom depth of the cross-sections, but many extend several hundred to thousands of feet beyond the depictions provided.

The analysis interpreted geologic formations from the borehole data after digitizing stratigraphic data from the various well log sources. This process relied heavily on the distinguishing features of each formation. Particularly, the black sands prevalent in the Mehrten Formation and evidence of shells noted in the descriptions that likely indicated a change to marine sediments of the Ione Formation were often mentioned in well logs. The analysis used superficial geology, location, and depth of the borehole to determine geologic formations. The analysis inferred formation contracts in places where this data was limited, including areas on the east and west limbs of the cross-sections, as well as vertically throughout.

As evident on the east-west geologic cross-section transects, the oldest formations are present on the east side of the Eastern San Joaquin Subbasin, shown overlapping the older sedimentary and/or basement rocks of the Sierra Nevada (A-A'), with progressively younger formations present to the west and vertically occupying shallower depth intervals. The east-west depictions also show the contacts of the formations steeply dipping in the east and nearly flat lying or at low gradients to the west. The northwest-southeast trending cross-section D-D' shows the formations in their relatively flat-lying positions, with oldest formations on the bottom and progressively younger formations above. This cross-section transect is essentially normal to the dip of the beds. In slight contrast to D-D', the transect of cross-section E-E' is somewhat oblique to the dip of the beds, thus there is an apparent down-dip toward the south. This effect is seen because the transect is moving into younger materials from the south toward the north.

The base of fresh water, as represented in Figure 3-18, is superimposed on the cross-sections as supported by works from Page (1974) and Williamson and others (1989). The base of the fresh water represents the vertical extent of fresh non-saline groundwater within the Eastern San Joaquin Subbasin Principal Aquifer. As shown on cross-sections A-A' and B-B', the sands of the Mehrten Formation are thickest in the northeast portion of the basin and there is a corresponding deepening of the freshwater aquifer on the north side of the Stockton Fault. The depth of the base of fresh water is shallower south of the Stockton Fault in the southern portion of the Eastern San Joaquin Subbasin. Further discussion of the Principal Aquifer is provided in Section 3.2.8.

Well depths generally decrease in termination depth from north to south across the Subbasin and locally within proximity of the major surface water drainages. In general, coarser sands are found at shallower depths within the lower unit of the Laguna Formation and upper Mehrten Formation (C-C') in the area of the Stanislaus River Drainage. Similarly, shallow well completions evident on cross-section D-D' and the southern portion of E-E' are indicative of the sandier nature of the recent alluvial deposits, the Turlock Lake, and Laguna Formations near the San Joaquin River.

3.2.7 Basin Boundaries

3.2.7.1 Lateral Boundaries and Boundaries with Neighboring Subbasins

The Eastern San Joaquin Subbasin is within the larger San Joaquin Valley, which comprises the southernmost portion of the Great Valley Geomorphic Province of California. Groundwater subbasins bounding the Eastern San Joaquin Subbasin include:

- Sacramento River Basin to the northwest;
- Cosumnes Subbasin to the north;

- Modesto Subbasin to the south;
- Tracy Subbasin to the west of the San Joaquin River.

Foothill and bedrock highs are to the east within Calaveras and Amador Counties.

3.2.7.2 Definable Bottom of the Basin

The base of the fresh water defines the bottom of the basin, the maximum vertical extent of fresh non-saline groundwater within the Eastern San Joaquin Subbasin. While water-bearing materials exist below this depth, the saline nature of the groundwater, in addition to the depth itself, generally makes accessing deeper groundwater not economically viable.

Because of the extreme depths to the base of fresh water, efforts by the USGS have been used to define the "base of fresh water" through the interpretation of the California DOGGR well logs and deep oil well geophysical logs as depicted on maps and cross-sections above. Base of fresh water (encountered saline) has been observed as shallow as 650 feet bgs in the eastern part of the basin to over 2,000 feet bgs in the northern part of the basin as depicted on the surface contour map and supported by work completed by Williamson et al, 1989.

3.2.8 Principal Aquifer

The Eastern San Joaquin Subbasin HCM has one Principal Aquifer that provides water for domestic, irrigation, and municipal water supply and that is composed of three water production zones. The zones have favorable aquifer characteristics that deliver a reliable water resource because of their basin location and sand thickness.

The zones are:

- Shallow Zone that is comprised of the alluvial sands and gravels of the Modesto, Riverbank, and Upper Turlock Lake Formations;
- Intermediate Zone that is comprised of the Lower Turlock Lake and Laguna Formations;
- Deep Zone that consists of the consolidated sands and gravels of the Mehrten Formation.

Details on the formations are provided in Section 3.2.4.

3.2.8.1 Zones within Principal Aquifer

As discussed in Section 3.1 Data Compilation, the GSP is based on the compilation of five hydrogeologic cross-sections (refer to Figure 3-22). From the review of over 330 well logs in the Eastern San Joaquin Subbasin and DWR Bulletin 118, the depth of municipal and irrigation wells ranges from 75 to over 800 feet bgs, with an average of 350 feet bgs. The GSP closely documents the following items specific to the number of well logs and depth of each boring:

- Groundwater saturation;
- Thickness and type of saturated fine to coarse grained sand and gravel layers;
- Depth discrete layers of the sands with horizontal and vertical connectivity across the basin;
- Depth discrete clay or silt layers that locally confine groundwater;
- Stratigraphy of the Deep Zone aquifer materials (e.g., sands and gravels) down to the base of fresh water and deeper, where available.

Analysis identified significant permeable zones with high production rates and good water quality at relatively shallow depths (less than 700 feet bgs) due to the following conditions:

- The relatively shallow depths of production wells had high specific capacity that met the water supply demand and reduced the cost associated with drilling deeper;
- The base of fresh groundwater is deep; ranging from depths of 700 to 1,900 feet bgs;
- Deeper water is saline and not considered suitable for potable or agricultural use.

Figure 3-23 and Figure 3-24 depict the number of wells, log information, horizontal and vertical distribution, and cross-sectional information used during this hydrogeologic characterization effort. Information compiled was used to detail the three permeable water-bearing zones described from surface downward in the following sections.

Figure 3-23: Bottom Elevation of Water-Bearing Zones (Shallow)

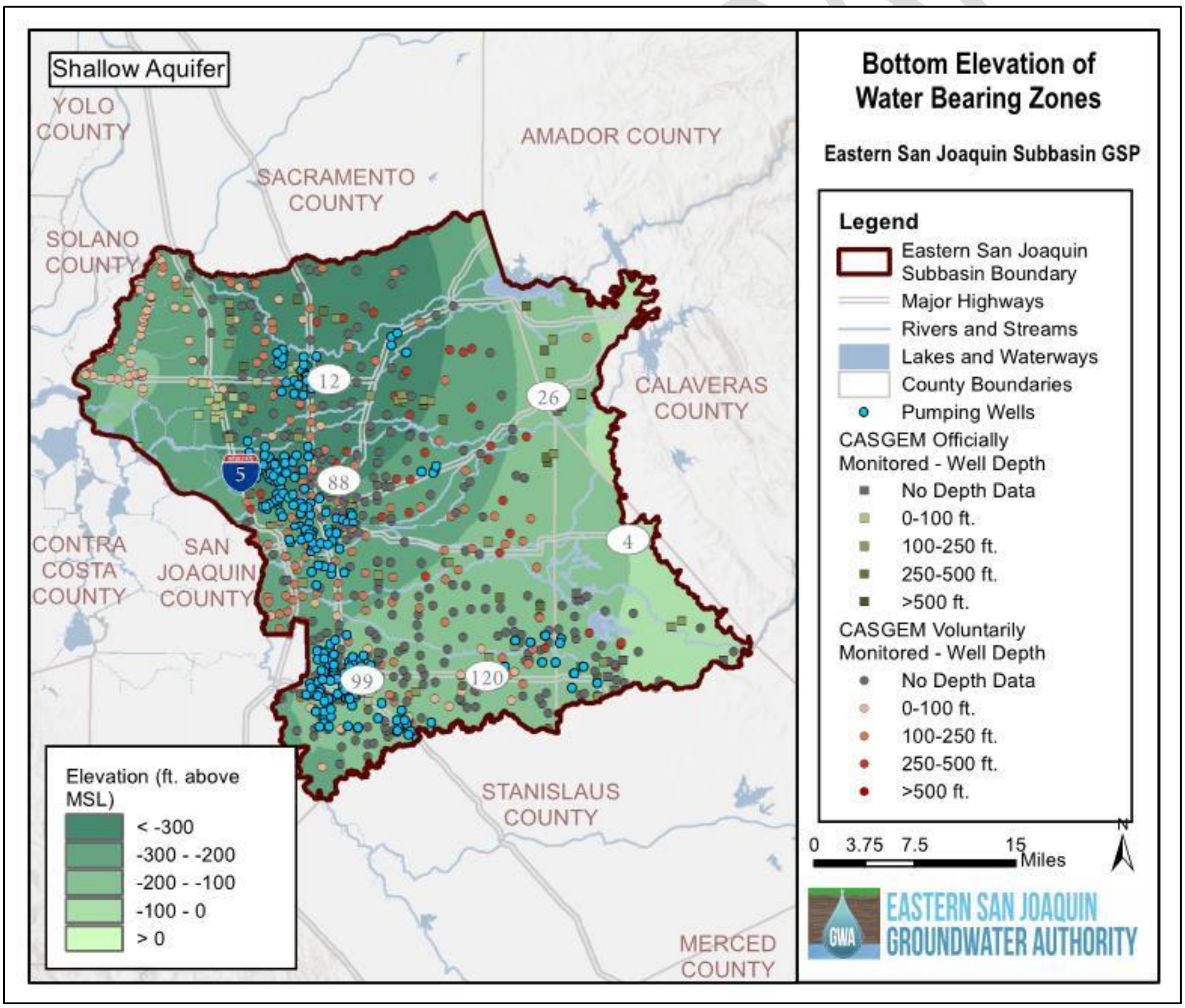
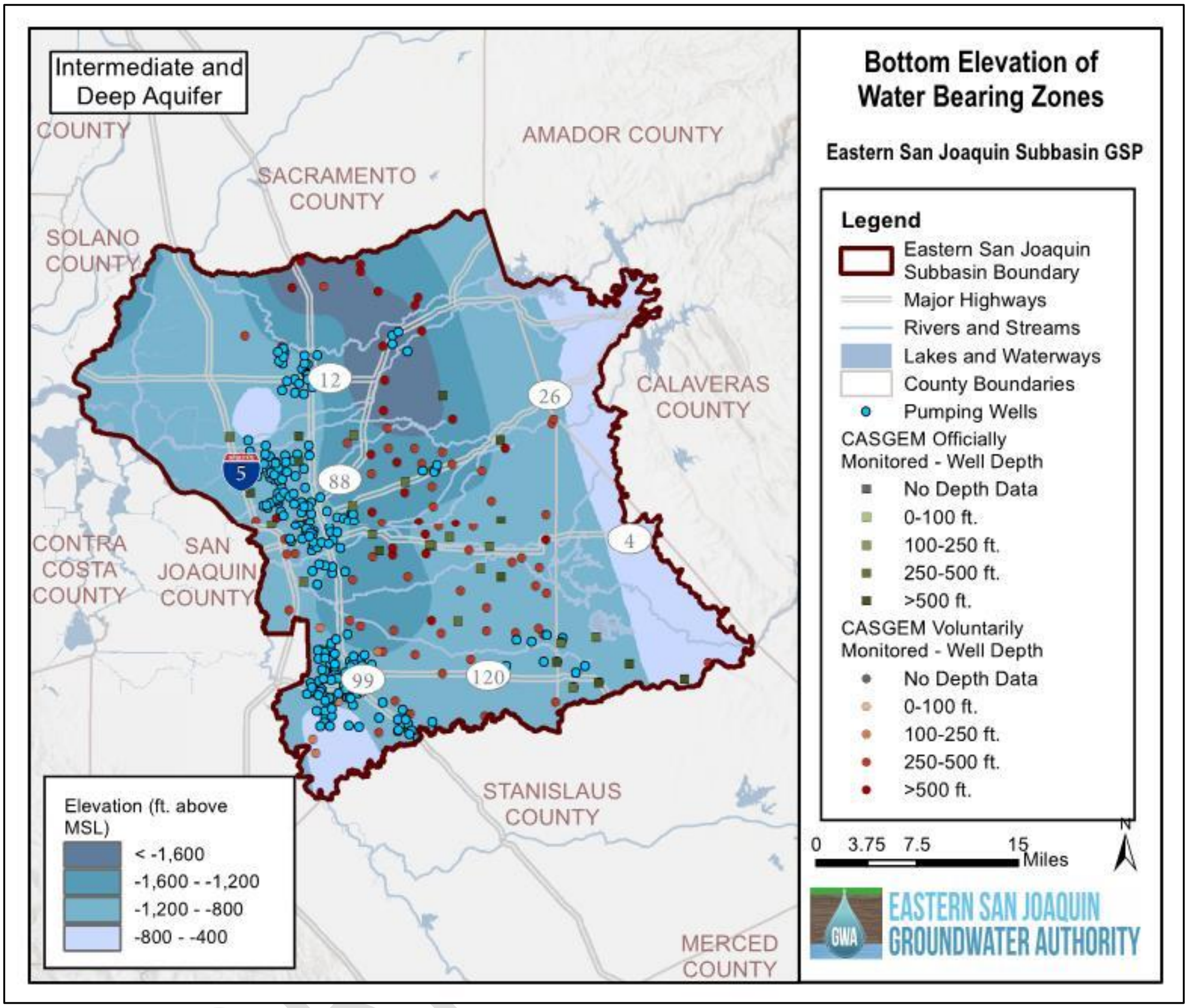


Figure 3-24: Bottom Elevation of Water-Bearing Zones (Deep and Intermediate)



3.2.8.1.1 Shallow Zone

The shallow water-bearing zone is composed of permeable sediments from recent alluvium, Modesto/Riverbank Formations, and the upper unit of the Turlock Lake Formation that are present west of the older geologic formations extend across the majority of the Eastern San Joaquin Subbasin. This zone is generally unconfined above the aquitards (Corcoran clay, other clays/silts, and old soil horizons/hardpan layers).

The depositional structure on the eastern side of the valley trough is depicted on the hydrogeologic cross-sections A-A' through E-E' (refer to Figure 3-20, Figure 3-21, and Figure 3-22). This structure results in the groundwater flow that follows both the dip of the beds and hydraulic head differentials. Erosional and depositional features dominate aquifer characteristics. The cross-sections also depict the aquifer thickness from 30 feet to greater than 300 feet.

The Shallow Zone characteristics are supported by the sand thickness information detailed below along with review of basin aquifer parameters. This zone has high yielding wells. Area groundwater numerical models support the CA DWR (1967) and Burow and others (2004) aquifer characteristic values range as follows:

- Transmissivities up to 90,000 gpd/ft;
- Storage coefficients up to 17 percent; and
- Vertical permeability estimates up to 0.1 ft/day.

3.2.8.1.2 Intermediate Zone

As depicted on the hydrogeologic cross-sections A-A' through E-E' (refer to Figure 3-20, Figure 3-21, and Figure 3-22), sands, typically from 10 to over 60 feet thick, are found below the low permeable clay layers or aquitards. The sands and gravels are developed with one relatively continuous sand unit at 350 feet bgs, within the top of the lower unit of the Turlock Lake Formation and Laguna Formation, thinning out at topographic highs to the east. Eastern basin depositional structure shows a pinching, wedging, and combination water-bearing zones with the surficial alluvium.

The aquifer characteristics are supported by the sand thickness information detailed herein for the Principal Aquifer. The eastern distribution of this water-bearing zone near surface suggests unconfined groundwater conditions. Typically, this zone is found semi-confined with high yielding wells and is considered the current primary production zone. Area groundwater numerical models support the CA DWR (1967) and Burow and others (2004) aquifer characteristic values range as follows:

- Transmissivities up to 59,500 gpd/ft;
- Storage coefficients typically 0.00001 (unitless);
- Vertical permeability estimates up to of 0.07 ft/day.

3.2.8.1.3 Deep Zone

The water-bearing "black sands" of the semi-consolidated Mehrten Formation are considered a significant source of water for Eastern San Joaquin Subbasin production wells. The formation is thick in the west with a limited number of deep wells that penetrate the entire depth of this unit as depicted on the hydrogeologic cross-sections A-A' through E-E' (refer to Figure 3-20, Figure 3-21, and Figure 3-22). This water-bearing zone is confined due to the thick overlying clay units, consolidation, and basin location. Semi-confined conditions are more likely to the east because of the dipping of beds and stratigraphic layer thinning and erosion of clay/silt beds. The dipping beds of the Mehrten Formation dip are at a steeper slope of 90 to 180 feet per mile westward. Consolidated sediments of the Mehrten and Valley Springs Formations are at valley bottom depth and exposed on the eastern foothills. Recharge to these aquifer formations occurs because of the high topographic setting with increased rainfall and exposure of weathered surface and runoff from the adjacent fractured Sierran bedrock.

As depicted on the hydrogeologic cross-sections A-A' through E-E' (refer to Figure 3-20, Figure 3-21, and Figure 3-22), boring logs indicate a significant 30-foot thick gravel encountered at a depth from 140 to 170 feet. Thickly bedded sands were found to exceed 250 feet. At the eastern margins of the basin, consolidated portions of the Mehrten, Valley Spring, and Ione Formations are important for low-yielding bedrock wells and are considered aquifer recharge sources for the Eastern San Joaquin Subbasin. The relatively low permeable and consolidated nature of the Valley Springs and Ione Formations act as the bottom of the Deep Zone (Burow et al., 2004).

The aquifer characteristics are supported by the sand thickness information. The well yields are high in this zone, over 1,000 gallons per minute (gpm). Area groundwater numerical models support the CA DWR (1967) and Burow and others (2004) aquifer characteristic values range as follows:

- Transmissivities up to 250,000 gpd/ft;
- Storage coefficients that are typically 0.0001;
- Vertical permeability estimates up to of 0.05 ft/day.

3.2.8.1.4 Limited Aquitards

The Corcoran Clay member of the Turlock Lake Formation and other interbedded clay/silts are aquitards that inhibit groundwater flow. The Corcoran Clay (found at the base of the upper unit of the Turlock Formation) is present at a depth of about 200 feet bgs. Corcoran Clay has a limited distribution in the extreme southwestern extent of the Subbasin, southwest of the City of Manteca. The clay is typically 20 to over 100 feet thick and is locally eroded and interfingered with coarser materials at its margin, as depicted on Figure 3-22. Groundwater below the Corcoran Clay is confined. The Corcoran Clay is found more significantly in the greater San Joaquin Basin south of the Stanislaus River and is a significant vertical barrier to flow.

Thick clay and silt layers are found within the Laguna and Mehrten Formations. These two formations each have two documented upward coarsening alluvial sequences (Burrow et al., 2004). Significant clay and paleosols divide the water-bearing zones at the base of each sequence. The cross-sections (Figure 3-20, Figure 3-21, and Figure 3-22) show both the clay and silt horizons range in thickness from less than 10 feet to over 150 feet. The vertical permeability estimates range from 0.01 to 0.007 feet per day (Burow et al., 2004).

Discontinuous clay horizons have been eroded significantly by the movement of the ancestral rivers. As depicted on the cross-sections, thickest sequences of uppermost permeable units and overbank fines below these layers has been observed. The general thickness and depth are supported by a southeast to northwest movement of river channels to the existing channel location.

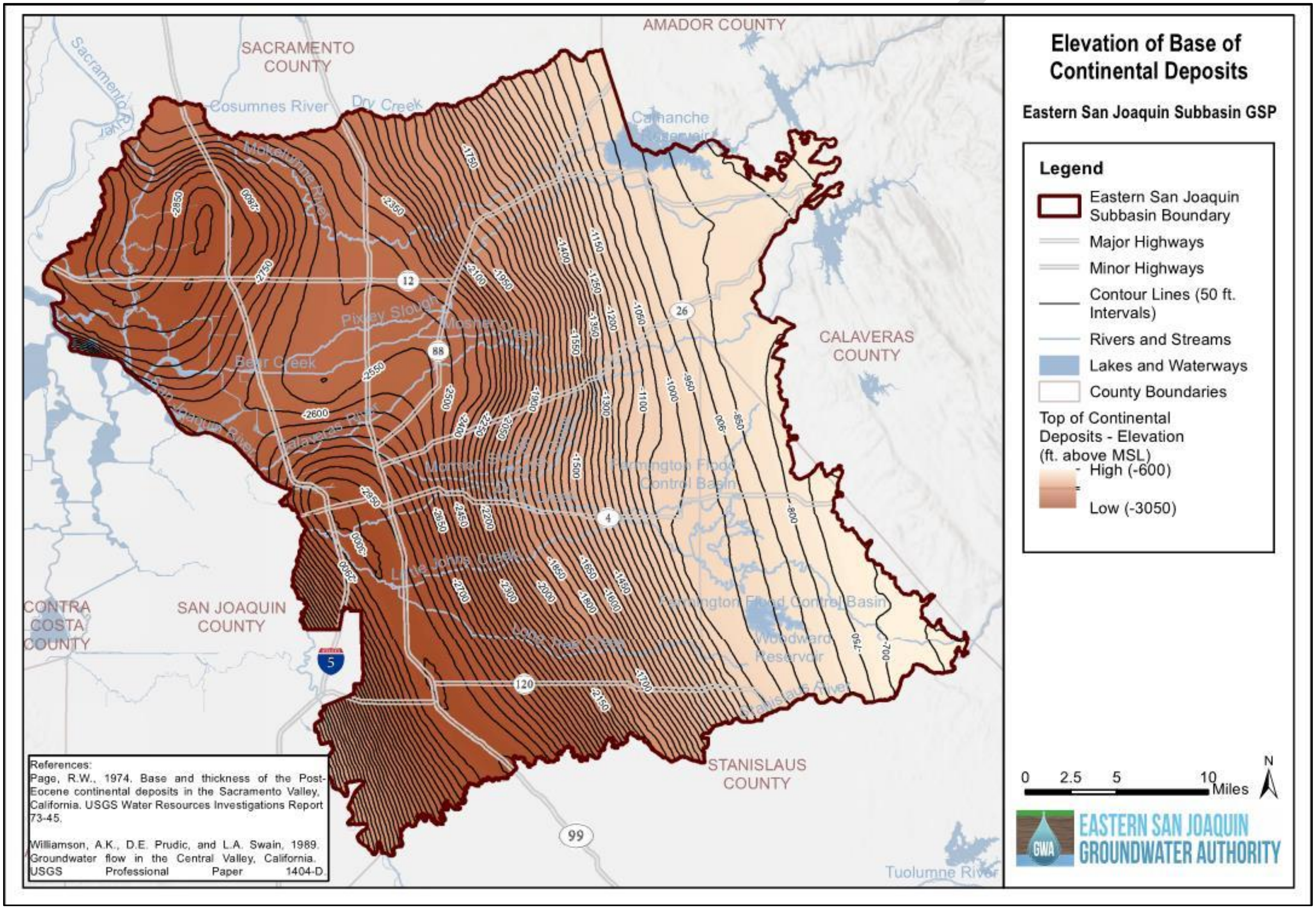
Hydraulic connection for the entire depth of the Principal Aquifer is supported by cross-section depictions that indicate the laterally extensive interbeds of high and low permeable layered deposits. The historical erosional and depositional history supports the referenced hydraulic interconnection. This observation is consistent with the possible thinning and wedging out of the regional clay units due to reworking or ancestral erosion (Davis et al., 1959).

In addition to the natural connectivity, the number of water wells drilled through these zones also indicates additional hydraulic connection because of the construction of long well gravel packs that connect the water-bearing zones.

3.2.8.1.5 Deep Saline Groundwater

Connate or saline water occurs from the base of fresh water (shown in Figure 3-18) to the base of continental deposits (shown in Figure 3-25), forming a saline layer that ranges in thickness from 50 to 2,250 feet from the east to the west across the Subbasin. The deep saline layer is not currently a water production zone for consumption or land application. Information used in developing the thickness of the saline water above continental deposits is from Page's 1974 *Base and Thickness of the Post Eocene Continental Deposits in the Sacramento Valley* and the thickness of the aquifer developed by Williamson and others (1989).

Figure 3-25: Elevation of Base of Continental Deposits



3.2.8.2 Aquifer Characteristics and Groundwater Quality

Because of the horizontal and vertical distribution of sediments and hydraulic connection between the water-bearing zones, one Principal Aquifer is defined.

An important step in aquifer characterization includes the completion of sand and gravel thickness (isopach) maps. An isopach map illustrates thickness variations within a tabular layer or stratum. Isopachs are contour lines of equal thickness over an area. The combined isopach map for the Principal Aquifer is depicted on Figure 3-26. The isopach map details are as follows;

- Over 313 water supply well logs with depths to 1,000 feet were used, with an average depth of 540 feet bgs;
- Average sand and gravel thickness is 140 feet;
- The thickest sand and gravel sequences ranged from 500 to 700 feet in the foothills located near Dry Creek, south of Camanche Reservoir and Northeast of Oakdale;
- Thicknesses from 200 to 400 feet were observed west of Morada along Bear Creek and toward the Delta;
- The 200 to 500 feet thickness contours were observed near Stockton along the Duck Creek historic drainage;
- Recognition of the sand and gravel thickness and the relative hydraulic conductivity of these permeable units, a more comprehensive understanding of the aquifer transmissivity can be made detail in Section 3.2.8.2.1.

As discussed in Section 3.2.3.3, soils facilitate rainfall infiltration which is a significant recharge source for the Shallow Zone. Other recharge takes place through infiltration and percolation of surface water bodies and via groundwater flow from upgradient areas to the zones within the entire Principal Aquifer. The Intermediate and Deep Zones are recharged via infiltration near sand and gravel layers that are typically thicker near historical river beds. Vertical movement of water through sand deposits is more rapid compared to the confining clay deposits. In the high topographic areas along the east margin of the Subbasin, water-bearing zone sediments are exposed at the surface and considered significant to recharge.

3.2.8.2.1 Aquifer Parameters and Production Zone Well Capacities

The GSP uses several sources to summarize the field-tested aquifer characteristics and production zone well capacity information for the Principal Aquifer.

For depiction purposes, Table 3-3 includes four investigation areas comprised of the entire basin: Calaveras County, Farmington, Manteca, and near the Stanislaus Triangle Area (Riverbank). For these examples, the maximum well yields range from greater than 100 to 2,800 gpm. The range in specific capacity is 27 to 90 gpm/ft of drawdown. These numbers relate to the testing of individual well capacities and the anticipated pumping water level related to the pumping rate. Transmissivity and storage values relate to the aquifer character anticipated at a distance away from a pumping well. Specific yield (SY) is defined as a unit volume of water released from an aquifer per unit decline in water table. Specific storage (SS) of a saturated aquifer is defined as the amount of water released from storage per unit decline in hydraulic head (Freeze and Cherry, 1979).

Figure 3-26: Sand and Gravel Isopach Map

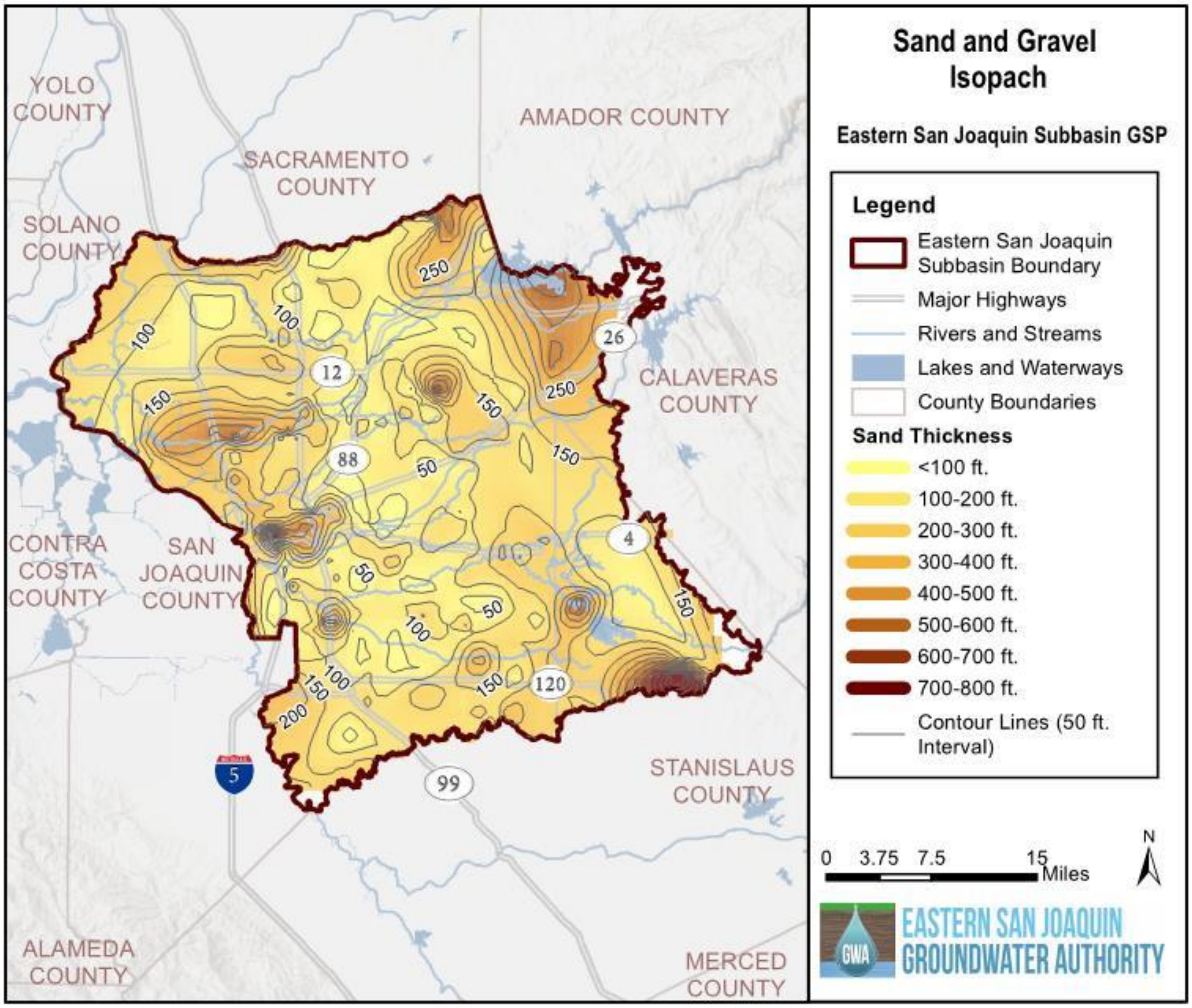


Table 3-3: Combined Aquifer Field Production Zone Capacities

Sources/Well Information	Maximum Well Yield (gpm)	Maximum Well Specific Capacity (gpm/ft drawdown)	Maximum Transmissivity (gpd/ft)	Maximum Specific Yield Unconfined % Specific Storage Confined Unitless	Sand and Gravel Thickness/ Encountered Mehrten Depth, feet
Entire Eastern San Joaquin Subbasin (CA DWR 1967)	1,000	40	68,000	17 >0.00001	>150 Dip to the West
Calaveras County (WRIME 2003)	>100	>10	>35,000	>6	>120 At Surface
Farmington (DE 2012)	800	27	19,600	>5 0.001	>110 230
Manteca (NV5 2017)	2,500	90	61,000	>10 unconfined 0.0001	>130 350
Stanislaus Triangle (Stanislaus and Tulume Rivers Groundwater Basin Association, 2005; (Bookman 2005)	>2,800	>40 (Riverbank 2012)	35,000	17 0.001	>150 Dip to the West

Using the basic physical properties of ground water flow, a confined aquifer transmissivity is defined by:

$$T = Kb$$

Where: T is transmissivity
K is the hydraulic conductivity
b is the aquifer thickness.

Using a typical clean sand hydraulic conductivity value of 500 gpd/ft^2 and a thickness of 120 feet, the aquifer transmissivity averages approximately 60,000 gpd/ft which is similar to the documented values reported above (Freeze and Cherry, 1979).

For additional comparison, the basin data for the four layers of the ESJWRM are provided in the ESJWRM Model Report (Woodard & Curran, 2018), presented in Appendix F: Eastern San Joaquin Water Resources Model (ESJWRM) Report:

The distribution of production wells and monitoring networks are provided on Figure 3-23 and Figure 3-24. Table 3-4 provides descriptors for the three water-bearing zones:

- Number of wells for each zone;
- Well depths;
- Wells used on the cross-sections;
- Wells used for monitoring and future model calibration.

Additional aquifer parameter confirmation is provided by the ESJWRM as follows (Woodard & Curran, 2018):

- Horizontal Hydraulic Conductivity – The horizontal hydraulic conductivity varies across the non-saline model layers ranging from 1.1 ft/day to 72.7 ft/day or 0.148 to 10 gal/day/ft^2; these values are considered to be low.

- Specific Storage and Yield – Specific Storage (SS) and Yield (SY) are used to represent the available storage at nodes in confined and unconfined aquifers. SS values range from 4.18 x 10^{-6} to 2.05 x 10^{-4}. SY values range from 4 to 10 percent.

Table 3-4: Wells within Water-Bearing Zones

CASGEM Wells				
Water-Bearing Zone	Well Type	Number of Wells	Average Construction Depth	Average Construction Bottom Elevation
Shallow	CASGEM	124	174	-64
	Voluntary	328	155	-100
Intermediate and Deep	CASGEM	79	538	-397
	Voluntary	122	540	-424

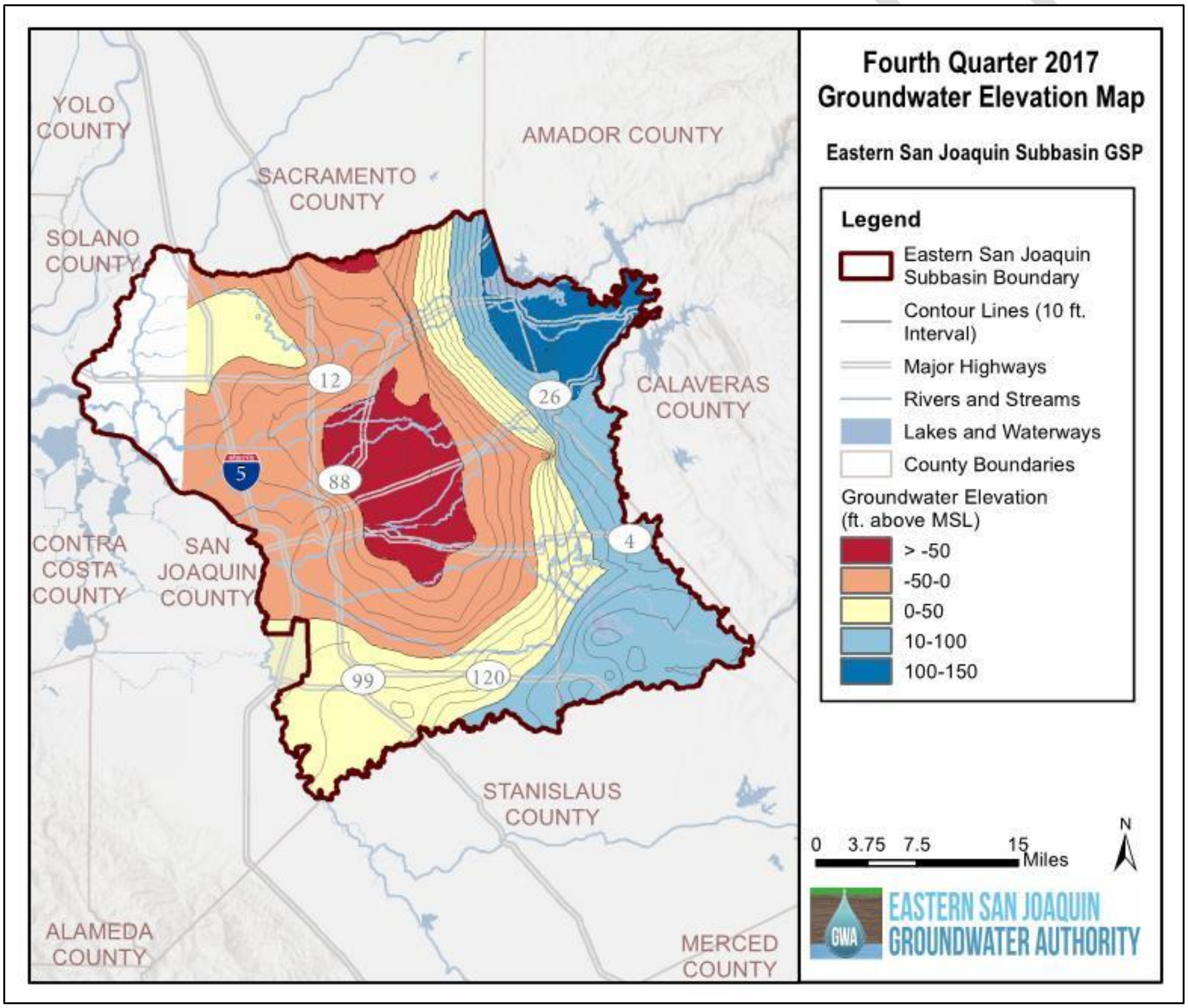
Pumping Wells			
Water-Bearing Zone	Number of Wells	Average Bottom of Screen Depth	Average Bottom of Screen Elevation
Shallow	148	270	-238
Intermediate and Deep	113	369	-300

Groundwater Wells Used in Cross-Sections			
Water-Bearing Zone	Number of Wells	Average Bottom of Borehole Depth	Average Bottom of Borehole Elevation
Shallow	39	234	-144
Intermediate and Deep	273	672	-566

3.2.8.2.2 Regional Historic Groundwater Flow and Surface Water Interaction

The horizontal groundwater flow direction for the Eastern San Joaquin Subbasin is typically from east to west. In general, the flow mirrors topography and is the same over time. The flow direction follows the overall east dipping gradient of the geologic formations. Higher groundwater elevations are in the foothills on the east side of the Subbasin, and the elevations decrease following the topography. In the western portion of the Subbasin, groundwater flows towards areas pumping depressions with relatively lower groundwater elevation, such as conditions during the fourth quarter 2017 (Figure 3-27). Horizontal groundwater flow is further discussed in the Current and Historical Groundwater Conditions section.

Figure 3-27: Fourth Quarter 2017 Groundwater Elevation Map



The GSP evaluates vertical groundwater gradients using the USGS nested wells in the Eastern San Joaquin Subbasin. Clark and others (2012) drilled and assessed several nested wells or multiple well sites in the Eastern San Joaquin Subbasin. These nested well sites include three to five monitoring wells per borehole, with screen intervals at depths of approximately 100 to 900 feet (Clark et al., 2012). Groundwater elevation in these monitoring wells, measured from 2006 to 2008, usually indicate the same trend. Groundwater elevation is typically lower in monitoring wells with deeper screen placement. The difference in groundwater elevations from the shallowest to deepest monitoring wells, within each borehole, is typically between 5 and 20 feet (Clark et al., 2012). Additional discussion regarding differences and distribution across the basin is provided in Current and Historical Groundwater Conditions section.

3.2.8.2.3 General Groundwater Quality

3.2.8.2.3.1 Geologic Formation Water Quality

The USGS and other government agencies completed several major studies concerning water quality in the Central Valley of California, which encompass the Eastern San Joaquin Subbasin. Repeatedly mentioned in these studies is the natural geochemical effects on groundwater quality that is specific to geologic formations (Creely & Force, 2007; Faunt, 2009; CA DWR, 1967). This natural effect is of great interest for the GSP implementation because groundwater level fluctuations from overdraft and recharge may result in water quality changes that are specific to geologic formations.

Natural geochemical reactions can be highly variable, even from well to well, as reactions depend on a number of factors, including the amount of: 1) reactive surface area of the formation sediments; 2) available oxygen in the formation as affected by fluctuations in groundwater elevation, depth to groundwater, and oxygenated near-surface recharge; and 3) potentially inorganic-oxidizing bacteria. The natural geochemical effects on water quality results to mobilize the elemental makeup of sediments (i.e., metals and other ions).

For the Eastern San Joaquin Subbasin, igneous and metamorphic rocks of the Sierra Nevada Mountains underlie the upstream drainages. These rocks predominately contain oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium (Creely & Force, 2007). Rivers draining areas of granitic rocks also have better water quality than metamorphic or volcanic rocks (CA DWR, 1967). For example, the Mokelumne River drains areas of granitic origin and has a lower salt content than the Calaveras River, which drains an area of primarily metamorphic rocks (CA DWR, 1967). Streams originating from either igneous or metamorphic rocks have relatively low amounts of dissolved solids, compared to marine sedimentary rocks that make up the Coast Ranges west of the Subbasin (Faunt, 2009). However, marine formations also underlie continental deposits in the Eastern San Joaquin Subbasin and have considerable amounts of chlorine, sulfur, bromine, and boron from connate water (Creely & Force, 2007). Connate water originates from fluids that are trapped in the pores of the sedimentary rocks as they are deposited and can contain many mineral components as ions in solution. Above these marine formations are continental deposits described in Section 3.2.4.

Groundwater quality of wells in Calaveras County is characterized by Metzger and others (2012) study, *Test Drilling and Data Collection in the Calaveras County Portion of the Eastern San Joaquin Groundwater Subbasin, California, December 2009 – June 2011*. These wells are in the Eastern San Joaquin Subbasin, in an area underlain by the Ione and Valley Springs Formations. This study assessed groundwater samples and identified three water types present: calcium-magnesium-bicarbonate, sodium-bicarbonate, and mixed cation-mixed anion water. The mixed cation-mixed anion group consisted mostly of sodium and chloride. These groundwater samples also showed high levels of arsenic, which were attributed to pH level variation or redox potential (Metzger et al., 2012). The Ione formation, for instance, is known to have high sulfate levels in groundwater related to the pH influence on pyrite-sulfide rich coal deposits.

Arsenic is of particular concern because it is naturally occurring in the Eastern San Joaquin Subbasin and hazardous to human health. Izbicki and other's (2008) study, *Source, Distribution, and Management of Arsenic in Water from Wells, Eastern San Joaquin Groundwater Subbasin, California*, assesses the concentration and sources of arsenic in various wells. Arsenic was detected mostly in San Joaquin County, and the largest concentrations were in the western portion of the subbasin (Izbicki et al., 2008). The surficial geology in this area consists of the Modesto and Riverbank Formations, which are underlain by the Turlock Lake and Laguna Formations (see Figure 3-16, Figure 3-20, Figure 3-21, and Figure 3-22). Sources of arsenic include weathering of minerals containing arsenic, desorption of arsenic under certain pH values, and release of arsenic in redox conditions (Izbicki et al., 2008).

Another element of great importance is nitrogen, as it is included in many compounds that are by-products of agriculture, which heavily dominates the landscape of the Eastern San Joaquin Subbasin. Nitrogen, most commonly occurring as Nitrate, is well understood as a result of fertilizer application and artificial influence on the natural environment. Naturally occurring nitrogen must also be discussed to have a complete understanding of the natural conditions in the Eastern San Joaquin Subbasin. Extensive work by Holloway and others (1998) showed the Mokelumne River watershed contained significant quantities of nitrogen from bedrock lithology. The upper part of the watershed, outside the Eastern San Joaquin Subbasin, is underlain by igneous and metamorphic rock, but the metasedimentary and metavolcanic rocks contained the highest levels of nitrogen (Holloway et al., 1998).

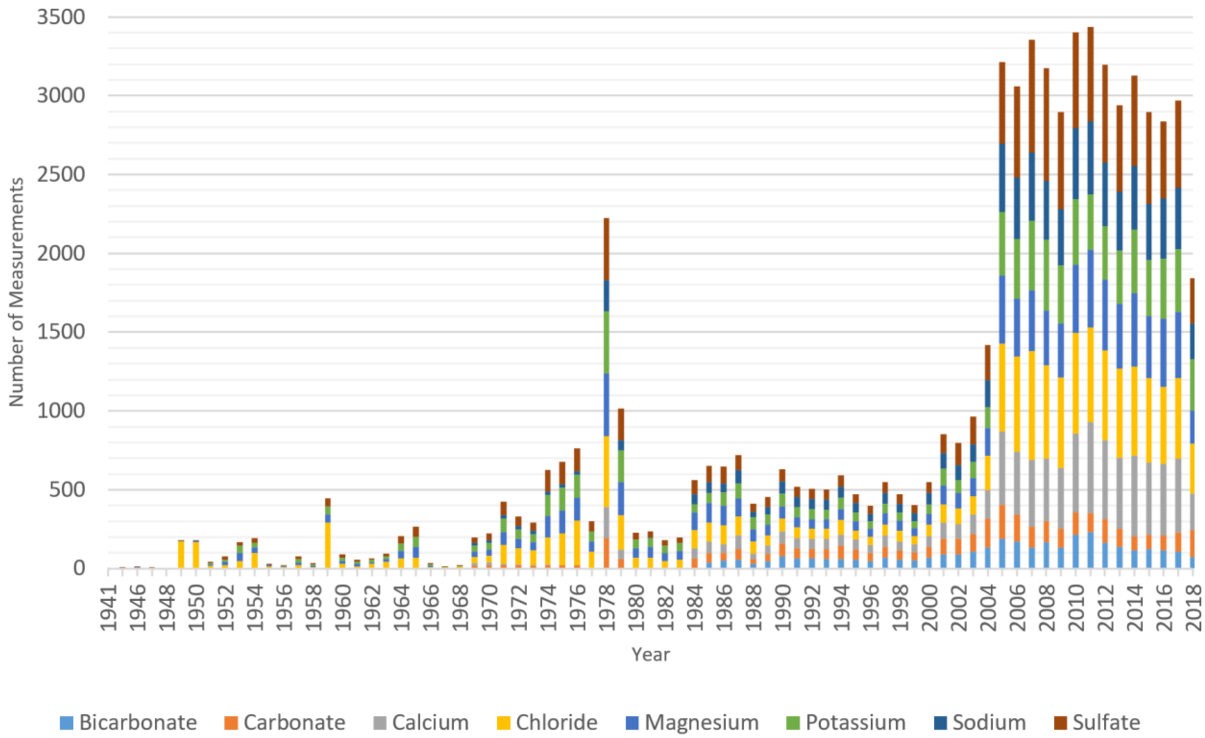
Per 23 CCR § 354.14, general water quality of principal aquifers shall be summarized. General water quality can be determined by assessing commonly measured inorganic parameters as indicators of change. Evaluating these inorganic parameters involves looking at historical trends and comparing results to certain thresholds, as well as determining water types. These parameters include major cations and anions, listed below:

Anions	Cations
Bicarbonate	Calcium
Carbonate	Magnesium
Chloride	Potassium
Sulfate	Sodium

3.2.8.2.3.2 Ion Composition

Evaluating the historical trends of these parameters is not straightforward. GAMA records include groundwater quality results going back to the 1940s in the Eastern San Joaquin Subbasin. However, a thorough analysis can only be performed as far back as a sufficient amount of groundwater quality data exists. This sufficient amount of data means a large number of measurements of all the major cations and anions mentioned above. From 2005 to 2017, a relatively large amount of the major cation and anion measurements occurred (see Figure 3-28). Data from 2018 are excluded because at the time of this writing the data were incomplete.

Figure 3-28: Total Number of Cation/Anion Measurements in the Eastern San Joaquin Subbasin



General water quality of the Subbasin can be determined by assessing water type over specific years within the time frame of 2005 to 2017. Evaluating the years 2005, 2011, and 2017 provides an even spread over the selected time frame and gives a better idea of possible water type trends. Trilinear diagrams for each of these years show relative concentrations of the major cations and anions (see Figure 3-29).

Due to the difference in sampling locations, the years 2005 and 2011 show carbonate and bicarbonate-rich waters, and 2017 displays increased chloride and sulfate concentrations in some wells. These dates correlate to both data size increases and heavier rainfall periods. Chloride concentrations in 2017 are generally less than 150 mg/L, with some higher measurements reaching 2,000 mg/L. Sulfate concentrations in 2017 are mostly under 300 mg/L, but a few extremely high levels up to 100,000 mg/L exist near City of Manteca.

The increased chloride concentrations apparent in 2017 may not be indicative of a long-term trend. Chloride concentrations are higher in more wells in 2017 when compared to 2005 and 2011, but there is little fluctuation in the range of values for each year (Figure 3-30). Sulfate concentrations are also increased in 2017 compared to 2005 and 2011. Similar to chloride, the range of sulfate results for each year between 2005 and 2017 does not show any obvious trends (Figure 3-31).

Higher chloride and sulfate concentrations during 2017 are apparent near the cities of Manteca and Stockton (Figure 3-32 and Figure 3-33). A further discussion and assessment of chloride measurements in the Eastern San Joaquin Subbasin is included in the Current and Historical Groundwater Conditions section.

Figure 3-29: Trilinear Diagrams

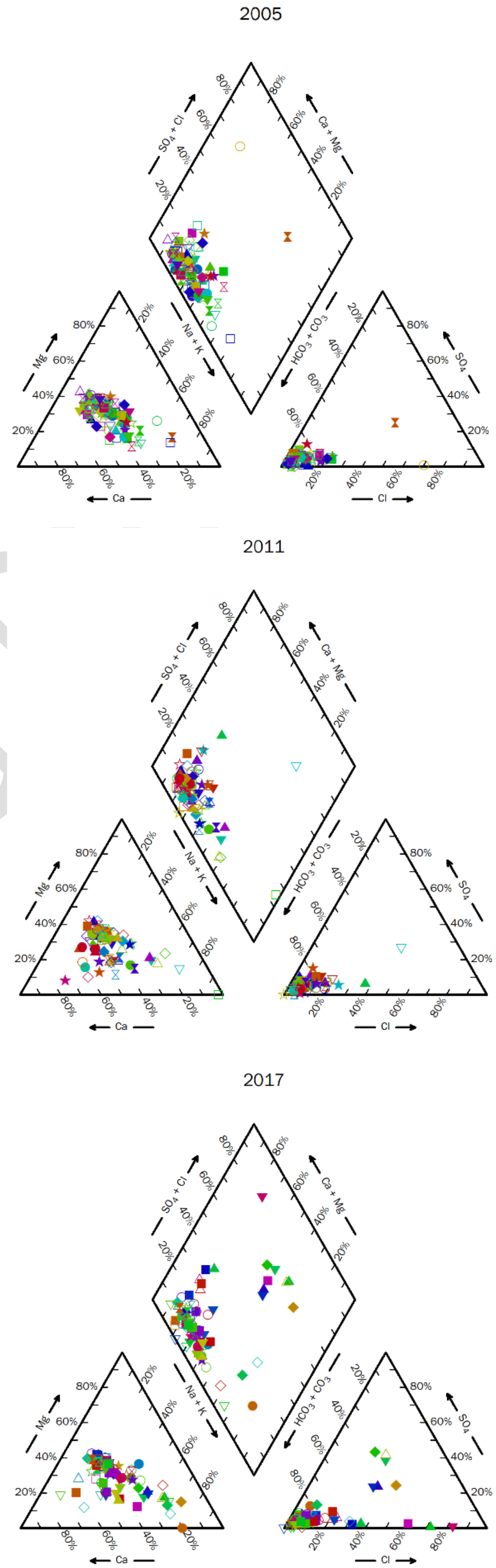


Figure 3-30: Chloride Annual Variation

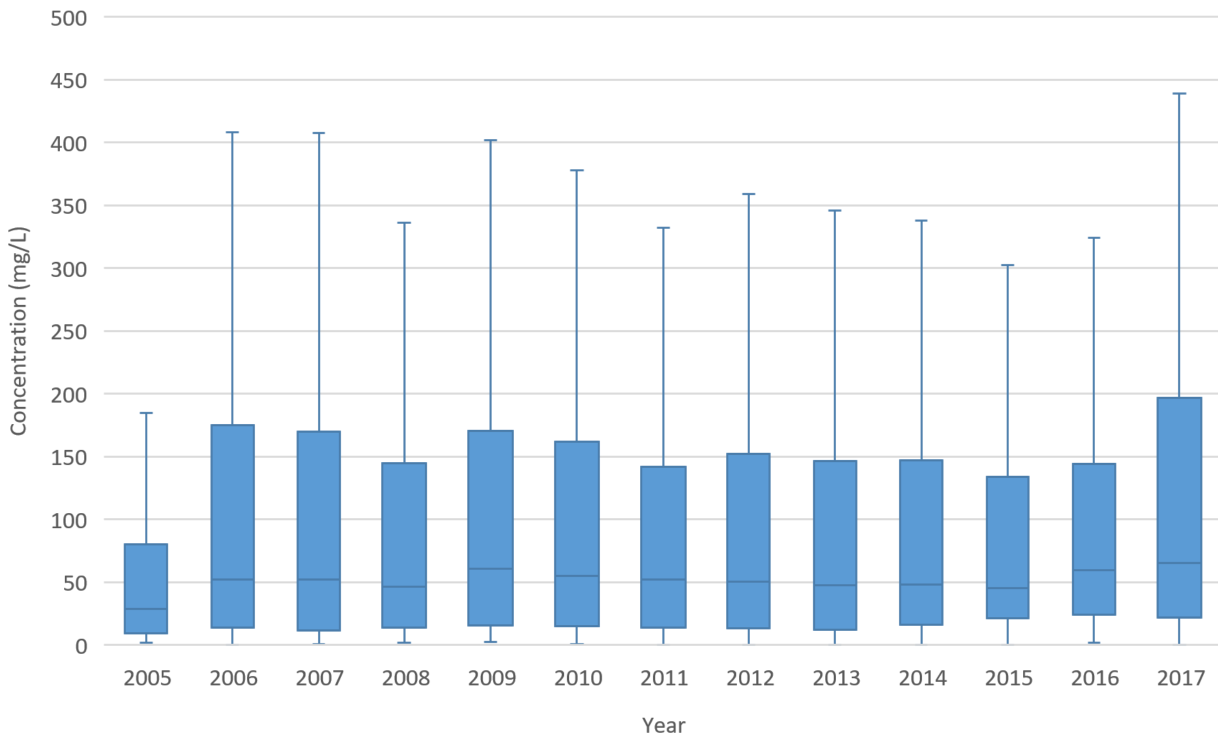


Figure 3-31: Sulfate Annual Variation

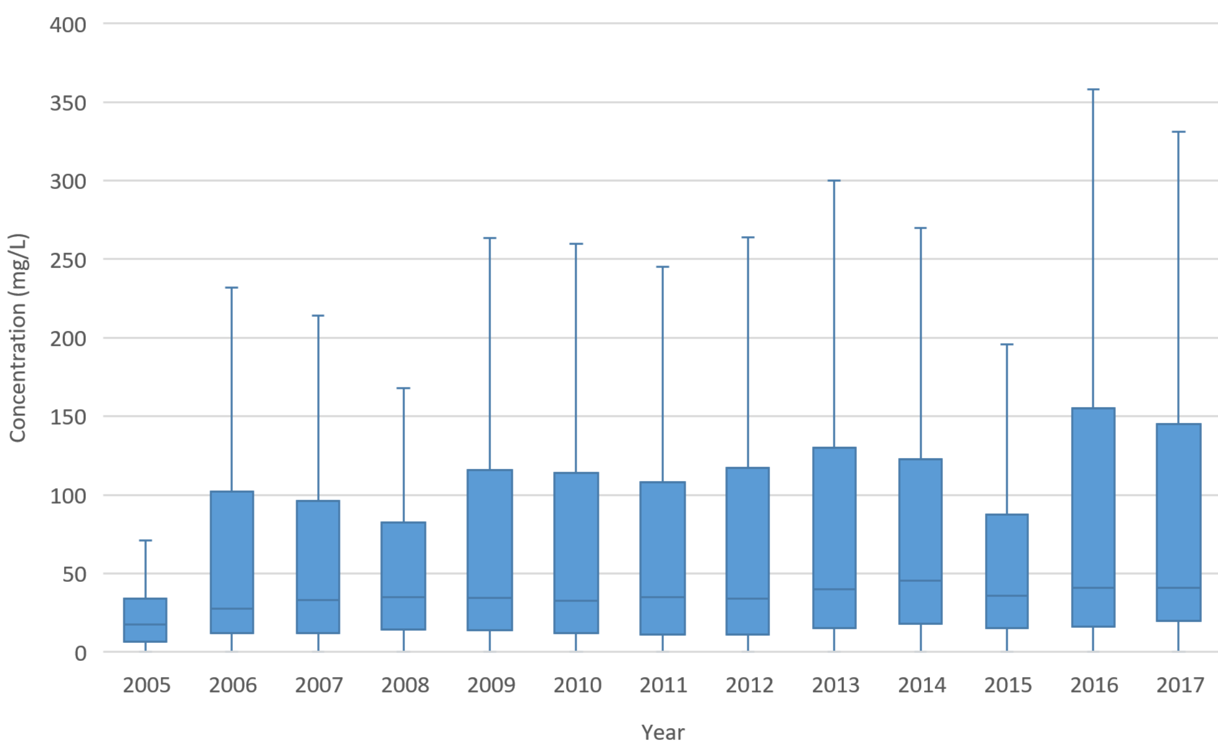


Figure 3-32: Chloride Concentrations in 2017

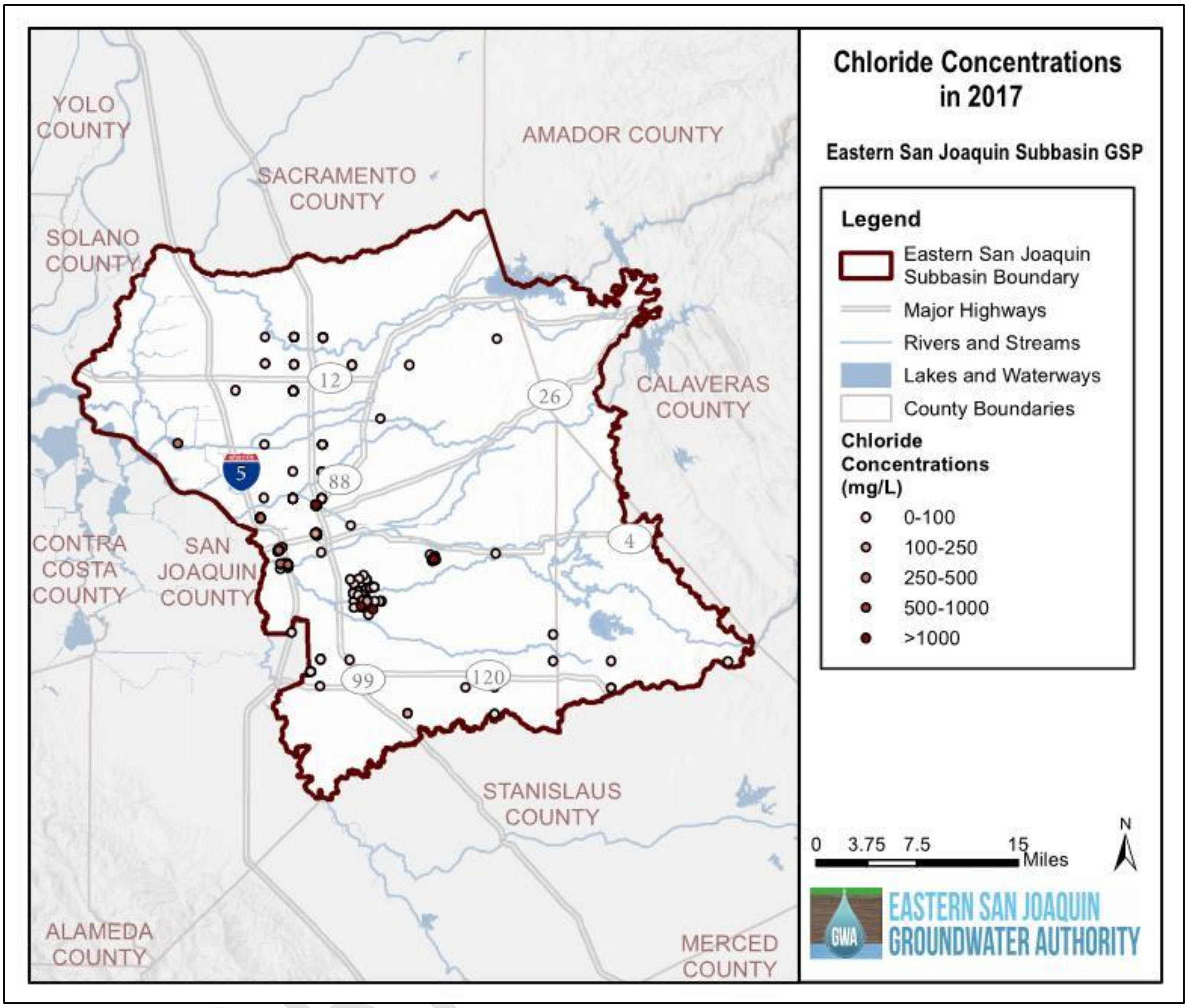
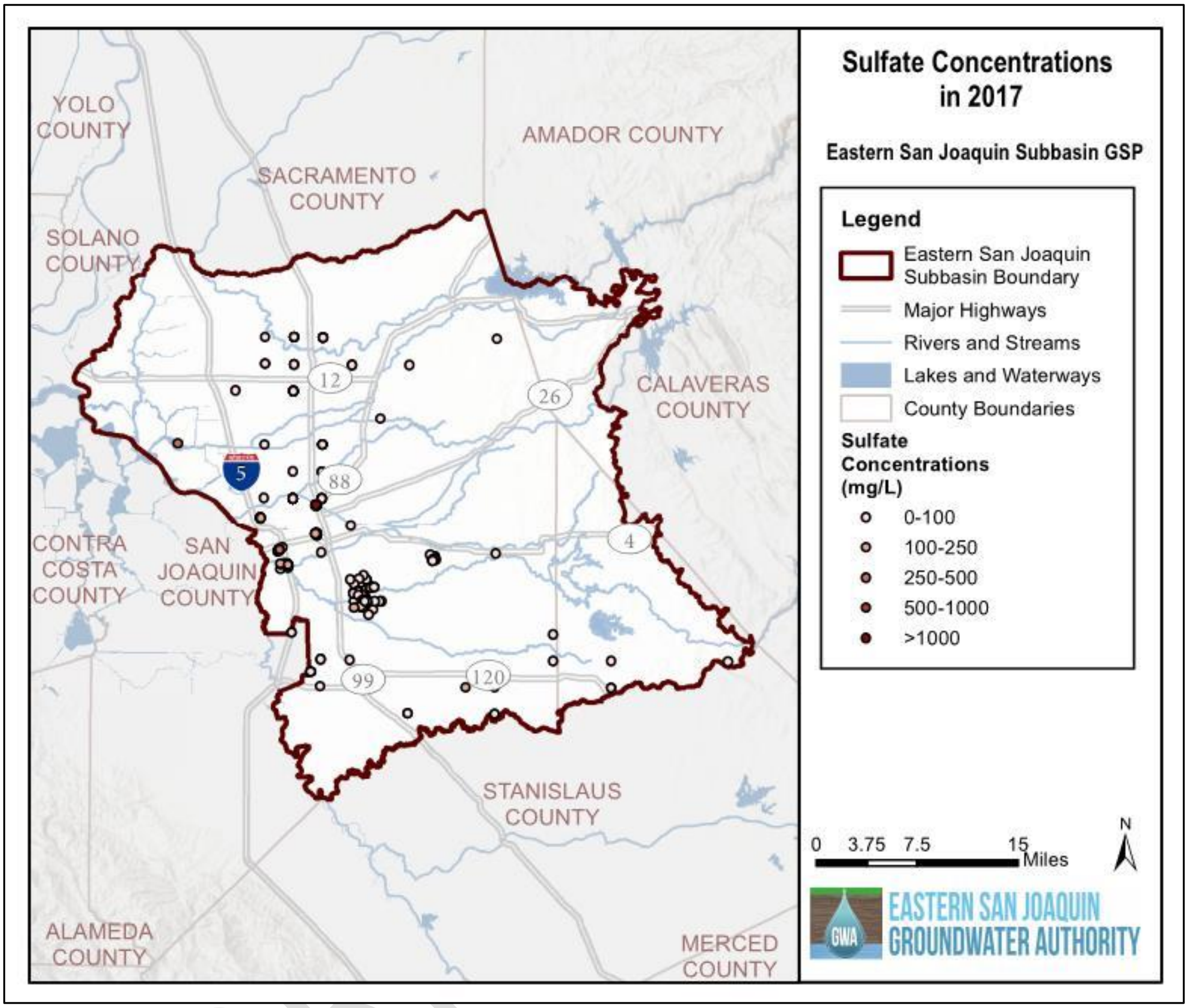


Figure 3-33: Sulfate Concentrations in 2017

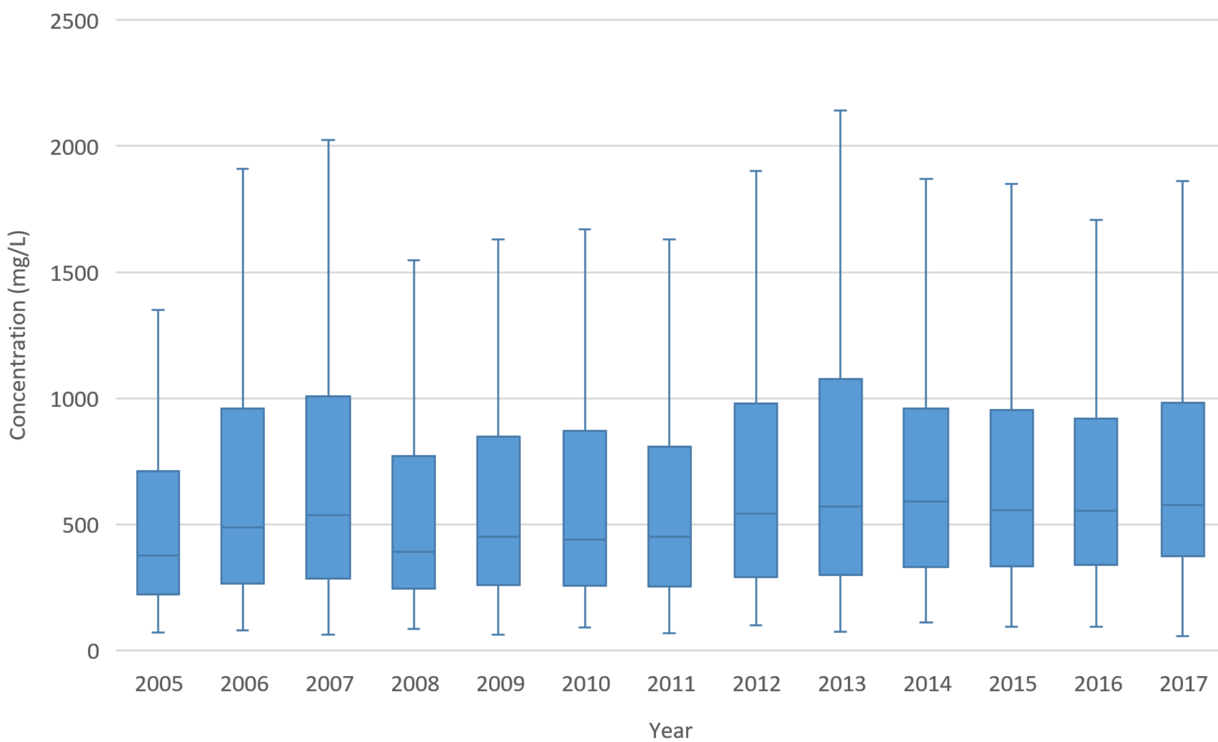


Bennet and others (2006) assessed GAMA groundwater quality data in the Northern San Joaquin Basin. Groundwater samples were compared to thresholds such as the U.S. Environmental Protection Agency secondary maximum contaminant levels (SMCL). None of major cations and anions measured in the Eastern San Joaquin Subbasin resulted in exceedances of the SMCL (Bennet et al., 2005). These measurements took place in December 2004 to February 2005. Additional parameters were sampled in this study and are discussed further in the Current and Historical Groundwater Conditions section.

3.2.8.2.3.3 Total Dissolved Solids

A wide range of TDS values exist in the Eastern San Joaquin Subbasin. Based on data in the GAMA database from 2005 to 2017, TDS values generally varied from 100 to 2,000 milligrams per liter (mg/L) (Figure 3-34). Over the 13-year period shown in Figure 3-34, the median value has remained relatively stable over this time. Sources of TDS in the basin include San Joaquin Delta sediments, deep deposits, and irrigation return water, as discussed in Section 3.4.4.1. Additional details on TDS concentrations is provided in the Current and Historical Groundwater Conditions section of this GSP.

Figure 3-34: TDS Annual Variation



3.2.9 HCM Data Gaps

All hydrogeologic conceptual models contain a certain amount of uncertainty and can be improved with additional data and analysis. The Eastern San Joaquin Subbasin HCM data gaps are present in the understanding of the HCM presented in this GSP. These data gaps are listed below and will be updated with future monitoring, modeling, and data refinement efforts.

- Water quality of principal aquifers
  - Additional depth-specific water quality data will inform minimum thresholds for the degraded water quality sustainability indicator and help monitor and identify potential undesirable results.
  - Additional monitoring at various depths for different constituents will help inform the understanding of water quality. This can be achieved through installation of new monitoring wells or through determination of screened intervals of existing monitoring wells.
- Aquifer characteristics
  - Aquifer characteristics (such as hydraulic conductivity) have a significant impact on how projects and management action in one part of the basin may influence sustainability in other parts of the basin.
  - Aquifer characteristics should be confirmed through additional aquifer testing or additional monitoring wells.

HCM data gaps have been identified to improve the GSP and future monitoring tasks. Considerations are listed below based on the development of the HCM. The following data gap elements require additional information, and are discussed further in Section 4.3:

Groundwater Level Data

- Depth- or zone-specific water levels to assess vertical interconnection, including zones within the Principal Aquifer;
- Additional shallow groundwater data near surface waters and NCCAGs;
- Additional groundwater level data in the east and northwest areas of the Subbasin;
- Additional groundwater level data near the Mokelumne River to improve quantification and understanding of subsurface flows.

Groundwater Quality Data

- Groundwater quality database compilation improvements to improve the linkage between the GAMA and CASGEM databases;
- Aquifer zone-specific groundwater quality data;

Subsurface Conditions

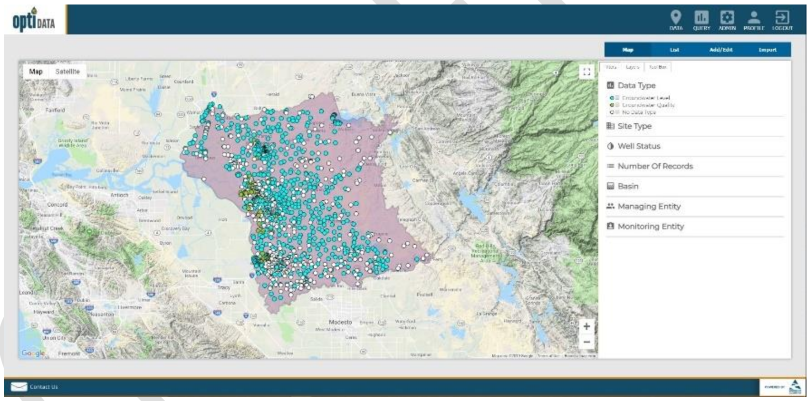
- Stockton Fault extent and impact on the base of fresh water;
- Improved characterization of near-surface conditions as they relate to recharge
- Further definition of aquifer characteristics within and near Subbasin boundary areas to the east, southeast, and northwest, including aquifer tests;

5. DATA MANAGEMENT SYSTEM (DMS)

This chapter includes the Data Management System Section that satisfies § 352.6 of the Sustainable Groundwater Management Act Regulations. This section contains three main subsections:

- Overview of the Eastern San Joaquin Subbasin Data Management System
- Functionality of the Data Management System
- Data Included in the Data Management System

5.1 OVERVIEW OF THE EASTERN SAN JOAQUIN SUBBASIN DATA MANAGEMENT SYSTEM (DMS)



The Eastern San Joaquin Subbasin Data Management System (DMS) is implemented using the Opti platform. The DMS serves as a data sharing portal to enable utilization of the same data and tools for visualization and analysis to support sustainable groundwater management and transparent reporting of data and results.

The DMS is web-based and publicly accessible using common web browsers including Google Chrome, Firefox, and Microsoft Edge. It is a flexible and open software platform that utilizes familiar Google maps and charting tools for analysis and visualization. The site may be accessed here: https://opti.woodardcurran.com/esj

5.2 FUNCTIONALITY OF THE DATA MANAGEMENT SYSTEM

The DMS is a modular system that includes numerous tools to support GSP development and ongoing implementation, including:

- User and Data Access Permissions
- Data Entry and Validation
- Visualization and Analysis
- Query and Reporting

The DMS can be configured for additional tools and functionality as the needs of the GWA change over time. The following sections briefly describe the currently configured tools. For more detailed instructions on the usage of the DMS, please refer to the Opti Public User Guide (the Opti Public User Guide can be accessed online at https://opti.woodardcurran.com/esj/upload/OptiPublicDMS_Guide.pdf.

5.2.1 User and Data Access Permissions

User access permissions are controlled through several user types that have different roles in the DMS as summarized in Table 5-1 below. These user types are broken into three high-level categories:

- System Administrator users manage information at a system-wide level, with access to all user accounts and entity information. System Administrators can set and modify user access permissions when an entity is unable to do so.
- Managing Entity (Administrator, Power User, User) users are responsible for managing their entity's site/monitoring data and can independently control access to this data. Entity users can view and edit their entity's data and view (not edit) shared or published data of other entities. An entity's site information (wells, gages, etc.) and associated data may only be edited by Administrators and Power Users associated with the entity. Note: *San Joaquin County is currently configured as the Managing Entity for all datasets.*
- Public users may view data that is published but may not edit any information. These users may access the DMS using the Guest Login feature on the login screen.

Monitoring sites and their associated datasets are added to the DMS by Managing Entity Administrators or Power Users. In addition to the user permissions, access to the monitoring datasets is controlled through three options:

- Private data is monitoring data that is only available for viewing, depending on user type, by the entity's associated users in the DMS.
- Shared data is monitoring data that is available for viewing by all users in the DMS (excludes Public Users).
- Public data is monitoring data that is available publicly and can be viewed by all user types in the DMS and may be published to other sites or DMSs as needed.

The Managing Entity Administrators have the ability to set and maintain the data access options for each dataset associated with their entity.

Table 5-1: Data Management System User Types

Modules/Submodules	System Administrators	Entity			Public
		Admin	Power User	User	
Data: Map	●	●	●	●	○
Data: List	●	●	●	●	○
Data: Add/Edit	●	●	●		
Data: Import	●	●	●		
Query	●	●	●	●	○
Admin	●				
Profile	●	●	○	○	○

● Indicates access to all functionality, ○ Indicates access to partial functionality (see explanations in following sections)

5.2.2 Data Entry and Validation

To encourage agency and user participation in the DMS, data entry and import tools are easy to use, accessible over the web, and help maintain data consistency and standardization. The DMS allows Entity Administrators and Power Users to enter data either manually via easy-to-use interfaces, or through an import tool utilizing Excel templates, ensuring data may be entered into the DMS as soon as possible after collection. The data is validated by Managing Entity's Administrators or Power Users using a number of quality control checks prior to inclusion in the DMS.

5.2.2.1 Data Collection Sites

Site information is input for groundwater wells, stream gages, and precipitation meters manually either through the Data Entry tool or when prompted in the Import tool. In the Data Entry tool, new sites may be added by clicking on New Site. Existing sites may be updated using the Edit Site tool. During data import, the sites associated with imported data are checked by the system against the existing site list in the DMS. If the site is not in the existing site list, the user is prompted to enter the information via the New Site tool before the data import can proceed.

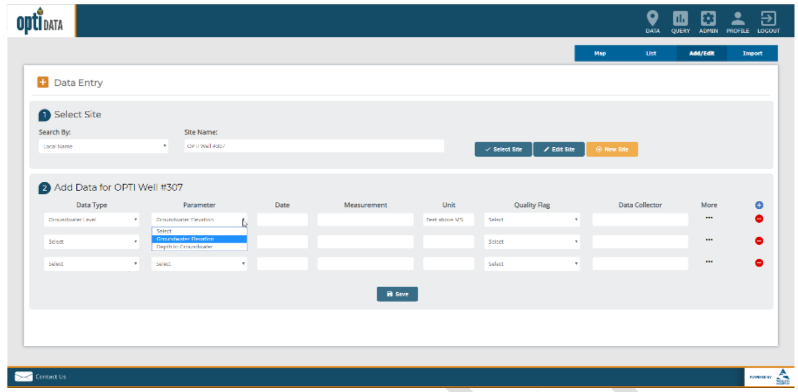
The information that is collected for sites is shown in Table 5-2. Required fields are indicated with an asterisk.

Table 5-2: Data Collection Site Information

Basic Info	Well Info	Construction Info
Site Type*	State Well ID	Total Well Depth
Local Site Name*	CASGEM ID	Borehole Depth
Local Site ID	Ground Surface Elevation	Casing Perforations
Latitude/Longitude*	Reference Point	Casing Diameter
Description	Reference Point Elevation	Casing Modifications
County	Reference Point Location	Well Capacity
Managing Entity*	Reference Point Description	Well Completion Report Number
Monitoring Entity*	Well Use	Comments
Type of Monitoring	Well Status	
Type of Measurement	Well Type	
Monitoring Frequency	Aquifers Monitored	
	Groundwater Basin Name/Code	
	Comments	
	Upload File	

* Required fields; all other fields are optional

5.2.2.2 Monitoring Data Entry



Monitoring data, including but not limited to groundwater elevation, groundwater quality, streamflow, and precipitation, may be input either manually through the Data Entry tool or using templates in the Import tool. The Data Entry tool allows users to select a site and add data for the site using a web-based tool. The following information is collected:

- Data Type (e.g., groundwater elevation, groundwater quality, streamflow, or precipitation)
- Parameter for selected Data Type, units populate based on selection
- Date of Measurement
- Measurement Value
- Quality Flag (e.g., quality assurance description for the measurement such as “Pumping”, “Can’t get tape in casing”, etc., as documented by the Data Collector)
- Data Collector
- Supplemental Information based on Data Type (e.g., Reference Point Elevation, Ground Surface Elevation, etc.)

Data import templates include the same data entry fields and are available for download from the DMS. The Excel-based templates contain drop-down options and field validation similar to the data entry interface.

5.2.2.3 Data Validation

Quality control helps ensure the integrity of the data added to the DMS. The entities that maintain the monitoring data that were loaded into the DMS may have performed previous validation of that data; no effort was made to check or correct that previous validation and it was assumed that all data provided was valid. While it is nearly impossible to determine complete accuracy of the data added to the DMS since the DMS cannot detect incorrect measurements due to human error or mechanical failure, it is possible to verify that the data input into the DMS meets some data quality standards. This helps promote user confidence in the data stored and published for visualization and analysis.

Upon saving the data in the data entry interface or importing the data using the Excel templates, the following data validation checks are performed by the DMS:

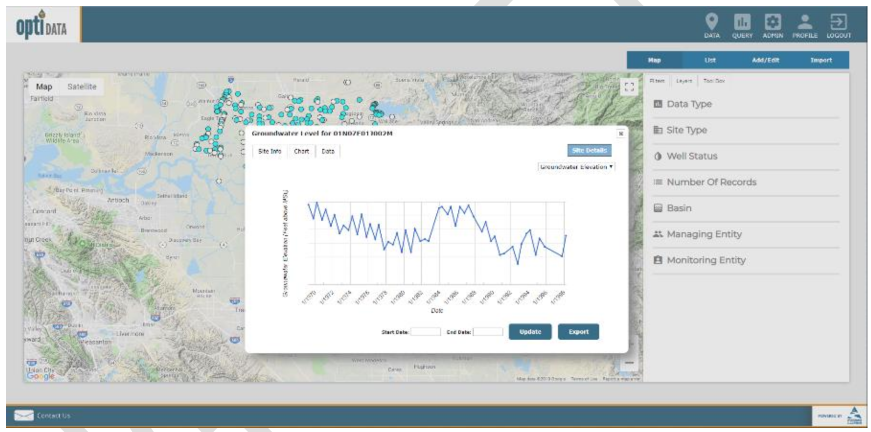
- Duplicate measurements: The database checks for duplicate entries based on the unique combination of site, data type, date, and measurement value.
- Inaccurate measurements: The database compares data measurements against historical data for the site and flags entries that are outside the historical minimum and maximum values.
- Incorrect data entry: Data field entries are checked for correct data type (e.g., number fields do not include text, date fields contain dates, etc.)

Users are alerted to any validation issues and may either update the data entries or accept the values and continue with the entry/import. Users may access partially completed import validation through the import logs that are saved for each data import. The partially imported data are identified in the Import Log with an incomplete icon under the Status field. This allows a second person to also access the imported data and review prior to inclusion in the DMS.

5.2.3 Visualization and Analysis

Transparent visualization and analysis tools enable utilization of the same data and methodologies, allowing stakeholders and neighboring GSAs to use the same data and methods for tracking and analysis. In the Eastern San Joaquin Subbasin DMS, data visualization and analysis are performed in both Map and List views.

5.2.3.1 Map View



The Map view displays all sites (groundwater wells, stream gages, precipitation meters, etc.) in a map-based interface. The sites are color coded based on associated data type and may be filtered by different criteria such as number of records or monitoring entity. Users may click on a site to view the site detail information and associated data. The monitoring data is displayed in both chart and table formats. In these views, the user may select to view different parameters for the data type. The chart and table may be updated to display selected date ranges, and the data may be exported to Excel.

5.2.3.2 List View

The List view displays all sites (groundwater wells, stream gages, precipitation meters, etc.) in a tabular interface. The sites are listed according to site names and associated entities. The list can be sorted and filtered by different criteria such as number of records or monitoring entity. Similar to the Map view, users may click on a site to view the site detail information and associated data. The monitoring data is displayed in both chart and table formats. In these views, the user may select to view different parameters for the data type. The chart and table may be updated to display selected date ranges, and the data may be exported to Excel.

5.2.3.3 Analysis Tools

The Toolbox is available in the Map view and offers Administrative and Entity users access to the Well Tiering tool to support monitoring plan development. The flexibility of the DMS platform allows for future analysis tools, including contouring, total water budget visualization, and management area tracking.

5.2.4 Query and Reporting

The DMS has the ability to format and export data and analysis at different levels of aggregation, and in different formats, to support local decision making and for submission to various statewide and local programs (i.e., SGMA, CASGEM, GAMA, etc.).

5.2.4.1 Ad-hoc Query

The data in the DMS can be queried and reported using the Query Tool. The Query Tool includes the ability to build ad-hoc queries using simple options. The data can be queried by:

- Monitoring or Managing Entity
- Site Name
- Data Type

Once the type of option is selected, the specific criteria may be selected (e.g., groundwater elevation greater than 100 ft.). Additionally, users may include time periods as part of the query. The query options can build upon each other to create reports that meet specific needs. Queries may be saved and will display in the saved query drop-down menu of the user who created the query for future use.

The query results are displayed in a map format and a list format. In both the Map and List views, the user may click on a well to view the associated data. The resulting data of the query may be exported to Excel.

5.2.4.2 Standard Reports

The DMS can be configured to support wide-ranging reporting needs through the Reports tool. Standard report formats may be generated based on a predetermined format and may be created at the click of a button. These report formats may be configured to match state agency requirements for submittals, including annual reporting of monitoring data that must be submitted electronically on forms provided by the DWR.

5.3 DATA INCLUDED IN THE DATA MANAGEMENT SYSTEM

Many monitoring programs exist at both the local and state/federal levels. A cross-sectional analysis was conducted within the Subbasin to document and assess the availability of data within the Subbasin, as well as statewide or federal databases that provide data relevant to Subbasin.

The DMS is configured to include a wide variety of monitoring data types and associated parameters. Based on the analysis of existing datasets within the subbasin and the GSP needs, the data types shown in Table 5-3 below were identified and are currently used in the DMS.

Table 5-3: Data Types and Their Associated Parameters Configured in the DMS

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Level	Depth to Groundwater	feet	Yes
	Groundwater Elevation	feet	Yes
Groundwater Quality	CL	PPM	Yes
	EC	Mmhos	Yes
	TDS	PPM	Yes
	Various Parameters (1,000+)	Various	
Surface Water Quality	Various Parameters (1,000+)	Various	
Streamflow	Streamflow	CFS	
Precipitation	Precipitation	inches	
	Reference Evapotranspiration (ETo)		
	Average Air Temperature		

Additional data types and parameters can be added and modified as the DMS grows over time.

The data were collected from a variety of sources, as shown in Table 5-4 below. Each dataset was reviewed for overall quality and consistency prior to consolidation and inclusion in the database.

The groundwater wells shown in the DMS are those that are included datasets provided by the monitoring data sources shown below for groundwater elevation and quality. These do not include all wells currently used for production and may include wells historically used for monitoring that do not currently exist. Care was taken to minimize duplicative wells in the DMS. As datasets were consolidated, sites were evaluated based on different criteria (e.g., naming conventions, location, etc.) to determine if the well was included in a different dataset. Datasets for the wells were then associated with the same well, where necessary.

After the data was consolidated and reviewed for consistency, it was loaded into the DMS. Using the DMS data viewing capabilities, the data was reviewed for completeness and consistency to ensure the imports were successful.

Table 5-4: Sources of Data Included in the Data Management System

Data Source	Datasets Collected	Date Collected	Activities Performed
CVSALTS	Well Location Well Type (Limited) Well Depth (Limited) Groundwater Quality	8/13/2018	• Removed duplicate records • Matched existing records with other data sources (GAMA, DWR)
Department of Water Resources (DWR) CASGEM)	Groundwater Elevation Well Type (Limited) Well Depth (Limited) Well Location	4/18/2018	• Removed duplicate records
EnviroStor	Groundwater Quality	7/23/2018	• Removed duplicate records
GeoTracker	Groundwater Quality	7/23/2018	• Removed duplicate records
Groundwater Ambient Monitoring and Assessment (GAMA)	Well Type Well Depth (Limited) Well Location Groundwater Quality	8/2/2018	• Removed duplicate records
Local Data	Groundwater Elevation (Limited) Well Type (Limited) Well Depth Well Location Groundwater Quality	2/2017-10/2018	• Removed duplicate records
San Joaquin County	Groundwater Elevation Well Type (Limited) Well Depth (Limited) Well Location	9/19/2017	• Removed duplicate records

6. REFERENCES

Bartow, J. (1985). *Maps showing Tertiary stratigraphy and structure of the Northern San Joaquin Valley, California.* United States Geological Survey (USGS).

Bartow, J. (1992). *Contact Relations of the Ione and Valley Springs Formation in the East-Central Great Valley, California.* USGS.

Bennett, G., Belitz, K., & Milby Dawson, B. (2006). *California GAMA Program - Ground-Water Quality Data in the Northern San Joaquin Basin Study Unit.* USGS.

Bertoldi, G., Johnston, R., & Evenson, K. (1991). *Groundwater in the Central Valley, California - A Summary Report.* USGS.

Burow, K. R., Shelton, J. L., Hevesi, J. A., & Wissman, G. S. (2004). *Hydrogeologic Characterization of the Modesto Area, San Joaquin Valley, California.* USGS.

CA Department of Parks and Recreation (California State Parks). (n.d.). *Caswell Memorial State Park*. Retrieved from: https://www.parks.ca.gov/?page_id=557

CA Department of Water Resources (CA DWR). (1967). *Bulletin 146, San Joaquin County Investigation.*

CA DWR. (2000). *Water Facts, Numbering Water Wells in California, Issue No. 7.*

CA DWR. (2006). *Bulletin 118: San Joaquin Valley Groundwater Basin Eastern San Joaquin Subbasin.*

CA DWR. (2016a). *Groundwater Sustainability Agency Frequently Asked Questions*. Retrieved from: https://www.water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Groundwater-Sustainability-Agencies/Files/GSA-Frequently-Asked-Questions.pdf

CA DWR. (2016b). *Groundwater Sustainability Plan (GSP) Annotated Outline.*

CA DWR. (2016c). *GSP Emergency Regulations.*

CA DWR. (2016d). *Preparation Checklist for GSP Submittal*. Cal Water Library.

CA DWR. (2018). *SGMA Groundwater Management*. Retrieved from: https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management

CA DWR. (2019). *Station OBB August 1994 through April 2019.* California Data Exchange Center (CDEC).

CA DWR. (n.d.). *Mapping Tools.* Retrieved from: https://water.ca.gov/Work-With-Us/Grants-And-Loans/Mappting-Tools

CA DWR. (n.d.). *Water Data Library*. Retrieved from http://wdl.water.ca.gov/waterdatalibrary/

CA Regional Water Quality Control Board (CA RWQCB). (2012). *Waste Discharge Requirements Order No. R5-2012-01016.* Retrieved from: https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/san_joaquin/r5-2012-0106.pdf

CA RWQCB Central Valley Region. (2016). *The Water Quality Control Plan (Basin Plan) - Sacramento River Basin and San Joaquin River Basin*.

CA State Water Resources Control Board (SWRCB). (2017). *Division of Water Quality - GAMA Program: Groundwater Information Sheet, Salinity*. Retrieved from https://www.waterboards.ca.gov/gama/docs/coc_salinity.pdf

CA SWRCB. (2018a). *Maximum Contaminant Levels and Regulatory Dates for Drinking Water U.S. EPA vs California.* Retrieved from: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/ccr/MCLsEPAvsDWP-2018-10-02.pdf

CA SWRCB. (2018b). *Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS)*. Retrieved from: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/PFOA_PFOS.html

CA SWRCB. (2019) *1,2,3, -Trichloropropane (1,2,3-TCP)*. Retrieved from: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/123TCP.html

Calaveras County. (1996). *Calaveras County General Plan.*

Calaveras County Board of Supervisors. (2008). *Calaveras County, California – Code of Ordinances/Chapter 8.20 Well Construction and Destruction.* Municode Library.

Calaveras County Water District (CCWD). (2012). *Calaveras County Monitoring Plan Portions of the Eastern San Joaquin Ground Water Subbasin.*

CCWD. (2015). *2015 Urban Water Management Plan for Calaveras County Water District.*

California Water Service. (2015). *2015 Urban Water Management Plan for California Water Service.*

Chapman, R., & Bishop, C. (1975). *Geophysical Investigation in the Ione Area, Amador, Sacramento, and Calaveras Counties, California.* Sacramento: California Division of Mines and Geology.

City of Elk Grove. (2018). *Elk Grove General Plan (Draft).*

City of Escalon. (2010). *Escalon General Plan.*

City of Lodi. (2010). *Lodi General Plan.*

City of Lodi. (2015). *2015 Urban Water Management Plan for City of Lodi.*

City of Manteca. (2015). *2015 Urban Water Management Plan for City of Manteca.*

City of Manteca. (2017). *Manteca General Plan Update.*

City of Modesto. (2008). *City of Modesto Urban Area General Plan.*

City of Ripon. (2006). *City of Ripon General Plan.*

City of Ripon. (2015). *2015 Urban Water Management Plan Update for City of Ripon.*

City of Stockton. (2015). *2015 Urban Water Management Plan for City of Stockton.*

City of Stockton. (2016). *Envision Stockton 2040 General Plan Update.*

City of Tracy. (2011). *City of Tracy General Plan.*

Clark et al. (2012). *Groundwater Data for Selected Wells within the Eastern San Joaquin Groundwater Subbasin, California, 2003-8*. USGS. Retrieved from: https://pubs.usgs.gov/ds/696/pdf/ds696.pdf

Creely, S., & Force, E. (2007). *Type Region of the Ione Formation (Eocene), Central California: Stratigraphy, Paleogeography and Relation to Auriferous Gravels.* USGS.

Davis, G., Green, J., Olmsted, F., & Brown, D. (1959). *Ground-Water Conditions and Storage Capacity in the San Joaquin Valley California.* USGS.

Davis, S., & Hall, F. (1959). *Water quality of eastern Stanislaus and northern Merced Counties, California.* Stanford University Publications, Geological Science 6(1).

Eastern San Joaquin County Groundwater Basin Authority (Eastern San Joaquin County GBA). (2014). *Eastern San Joaquin Integrated Regional Water Management Plan Update.*

Eastern San Joaquin Groundwater Authority (Eastern San Joaquin GWA). (2017a). *Bylaws of the Eastern San Joaquin Groundwater Authority.*

Eastern San Joaquin GWA. (2017b). *Joint Exercise of Powers Agreement Establishing the Eastern San Joaquin Groundwater Authority.*

Environmental Working Group (EWG). (2019a). *Perfluorooctane sulfonate (PFOS)*. Retrieved from https://www.ewg.org/tapwater/system-contaminant.php?pws=CA3910015&contamcode=E206

EWG. (2019b). *Perfluorooctanoic acid (PFOA)*. Retrieved from https://www.ewg.org/tapwater/system-contaminant.php?pws=CA3910015&contamcode=E207

Faunt, C. (2009). *Groundwater Availability of the Central Valley Aquifer, California.* USGS.

Ferriz, H. (2001). *Groundwater Resources of Northern California: an Overview.*

Freeze, R., & Cherry, J. (1979). *Groundwater.* ~~Prentice Hall.~~

Hoffman, R. (1964). *Geology of the northern San Joaquin Valley: Selected Papers Presented to San Joaquin Geological Society, v. 2. 30-45.*

Holloway, J. M., R. A. Dahlgren, B. Hansen, & W. H. Casey. (1998). *Contribution of Bedrock Nitrogen to High Nitrate Concentrations in Stream Water*. Nature.

Izbicki, J., Metzger, L., McPherson, K., Everett, R., Bennett V, G. (2006). *Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California*. USGS. Retrieved from: https://pubs.usgs.gov/of /2006/1309/pdf/ofr2006-1309.pdf

Izbicki, J., Stamus, C., Metzger, L., Halford, K., Kulp, T., & Benner, G. (2008). *Source, Distribution, and Management of Arsenic in Water from Wells, East San Joaquin Ground-Water Subbasin, California.* USGS.

Loyd, R. (1983). *Mineral Land Classification of the Sutter Creek 15-Minute Quadrangle, El Dorado and Amador Counties, California.*

Luhdorff and Scalmanini; Larry Walker. (2016). *CV-SALTS Region 5: Updated Groundwater Quality Analysis and High Resolution Mapping for Central Valley Salt and Nitrate Management Plan*.

Marchand, D., & Allwardt, A. (1981). *Late Cenozoic Stratigraphic Units, Northeastern San Joaquin Valley.* USGS.

Metzger, L., Izbicki, J., & Nawikas, J. (2012). *Test Drilling and Data Collection in the Calaveras County Portion of the Eastern San Joaquin Groundwater Subbasin, California.* USGS.

Montgomery Watson Harza (MWH). (2001). *Farmington Groundwater Recharge/Seasonal Habitat Study- Final Report.* United States Army Corps of Engineers. Retrieved from: http://sewd.net/wp-content/uploads/2016/11/1a-Farmington-GW-Recharge-Feasibility-2001-Chap-1-to-5.pdf

North Delta Water Agency (NDWA). (2015). *Comments of North Delta Water Agency on the Partially Recirculated Bay-Delta Conservation Plan EIR/EIS with New CA WaterFix Sub-Alternatives.*

Northeastern San Joaquin County Groundwater Banking Authority. (2004). *Eastern San Joaquin Groundwater Basin Management Plan.*

Oakdale Irrigation District (OID). (2015). *2015 Agricultural Water Management Plan.*

O'Leary, D. R., Izbicki, J. A., & Metzger, L. F. (2015). *Sources of high-chloride water and managed aquifer recharge in an alluvial aquifer in California USA*. USGS. Retrieved from: https://pubs.er.usgs.gov/publication/70155190 %

Page, R. (1974). *Base and thickness of the Post-Eocene continental deposits in the Sacramento Valley, California.* USGS.

Pask, J., & Turner, M. (1952). *Geology and Ceramic Properties of the Ione Formation, Buena Vista area, Amador County, California.* California Division of Mines and Geology.

San Joaquin County Flood Control and Water Conservation District (SJCFCWCD). (2006). *San Joaquin County Flood Control and Water Conservation District CASGEM Monitoring Plan*.

San Joaquin County (SJC). (1992). *Linden Planning Area.*

SJC. (2016a). *Lockeford Community Services District Municipal Service Review.*

SJC. (2016b). *San Joaquin County General Plan Policy Document.*

SJC Environmental Health Department. (1993). *San Joaquin County Well Standards*. Retrieved from: https://www.sjgov.org/uploadedfiles/sjc/departments/ehd/forms/well%20standards.pdf

San Joaquin Groundwater Basin Authority (San Joaquin GBA). (2015). *Mokelumne Interregional Sustainability Evaluation (MokeWISE) Program.*

Sneed, Michelle., Brandt, Justin., & Solt, Mike. (2013). *Land subsidence along the Delta-Mendota Canal in the northern part of the San Joaquin Valley, California*. 2003–10: U.S. Geological Survey Scientific Investigations Report 2013–5142. Retrieved from: https://pubs.usgs.gov/sir/2013/5142/

South San Joaquin Irrigation District (SSJID). (2015a). *Agricultural Water Management Plan*.

SSJID. (2015b). *2015 Urban Water Management Plan for South San Joaquin Irrigation District.*

Stanislaus and Tulume Rivers Groundwater Basin Association. (2005). *Integrated Regional Groundwater Management Plan (IRGMP*).

Stanislaus County. (2016). *Stanislaus County General Plan*.

Stanislaus County. (2019). *Stanislaus County Code*, Chapter 9.36 Water Wells. Retrieved from: https://qcode.us/codes/stanislauscounty/

Stanislaus County Department of Environmental Resources (Stanislaus County DER). (2016). *CASGEM Monitoring Plan for the Stanislaus County Portion of Eastern San Joaquin Groundwater Subbasin.*

Stanislaus Local Agency Formation Commission (Stanislaus LAFCO). (2018). *Municipal Service Review and Sphere of Influence Update for the Rock Creek Water District.* Retrieved from: http://www.stanislauslafco.org/info/PDF/MSR/Districts/RockCreekWD.pdf

Stockton East Water District (SEWD). (2015). *2015 Agricultural Water Management Plan.*

Texas A&M AgriLife Extension. (2003). *Irrigation Water Quality Standards and Salinity Management Strategies*. Retrieved from: https://aglifesciences.tamu.edu/baen/wp-content/uploads/sites/24/2017/01/B-1667.-Irrigation-Water-Quality-Standards-and-Salinity-Management-Strategies.pdf

Tonkin, M., & Larson, S. (2002). *Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift.* Groundwater.

United States Department of Agriculture (USDA). (2015). *CropScape - Cropland Data Layer.*

United States Fish and Wildlife (USFW). (2012). *San Joaquin River National Wildlife Refuge*. Retrieved from: https://www.fws.gov/Refuge/San_Joaquin_River/about.html

University of California, Davis. (2018). *Soil Agricultural Groundwater Banking Index.* Retrieved from: https://casoilresource.law.ucdavis.edu/sagbi/

Wagner, D., Bortugno, E., & McJunkin, R. (1991). *Geologic Map of the San Francisco - San Jose Quadrangle, California 1:250,000.* California Division of Mines and Geology.

Wagner, D., Jennings, C., Bedrossian, T., & Bortugno, E. (1981). *Geologic Map of the Sacramento Quadrangle, California 1:250,000.* California Geological Survey.

Williamson, A. (1989). *Ground-Water Flow in the Central Valley, California, Regional Aquifer System Analysis.* USGS.

Woodard & Curran. (2018). *Eastern San Joaquin Water Resources Model (ESJWRM) Final Report.*

Woodbridge Irrigation District (WID). (2016). *Agricultural Water Management Plan*.

APPENDIX A. EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY JPA AGREEMENT AND BYLAWS

APPENDIX B. LEGAL AUTHORITY OF EASTERN SAN JOAQUIN GSAS

APPENDIX C. DWR PREPARATION CHECKLIST

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 3. Technical and Reporting Standards				
352.2		Monitoring Protocols	• Monitoring protocols adopted by the GSA for data collection and management • Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin	TBD
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4		General Information	• Executive Summary • List of references and technical studies	TBD
354.6		Agency Information	• GSA mailing address • Organization and management structure • Contact information of Plan Manager • Legal authority of GSA • Estimate of implementation costs	TBD
354.8(a)	10727.2(a)(4)	Map(s)	• Area covered by GSP • Adjudicated areas, other agencies within the basin, and areas covered by an Alternative • Jurisdictional boundaries of federal or State land • Existing land use designations • Density of wells per square mile	TBD
354.8(b)		Description of the Plan Area	• Summary of jurisdictional areas and other features	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 1. Administrative Information (Continued)				
354.8(f)	10727.2(g)	Land Use Elements or Topic Categories of Applicable General Plans	• Summary of general plans and other land use plans • Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects • Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans • Summary of the process for permitting new or replacement wells in the basin • Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	TBD
354.8(c) 354.8(d) 354.8(e)	10727.2(g)	Water Resource Monitoring and Management Programs	• Description of water resources monitoring and management programs • Description of how the monitoring networks of those plans will be incorporated into the GSP • Description of how those plans may limit operational flexibility in the basin • Description of conjunctive use programs	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 1. Administrative Information (Continued)				
354.8(g)	10727.4	Additional GSP Contents	**Description of Actions related to:** • Control of saline water intrusion • Wellhead protection • Migration of contaminated groundwater • Well abandonment and well destruction program • Replenishment of groundwater extractions • Conjunctive use and underground storage • Well construction policies • Addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects • Efficient water management practices • Relationships with State and federal regulatory agencies • Review of land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity • Impacts on groundwater dependent ecosystems	TBD
354.10		Notice and Communication	• Description of beneficial uses and users • List of public meetings • GSP comments and responses • Decision-making process • Public engagement • Encouraging active involvement • Informing the public on GSP implementation progress	TBD
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14		Hydrogeologic Conceptual Model	• Description of the Hydrogeologic Conceptual Model • Two scaled cross-sections • Map(s) of physical characteristics: topographic information, surficial geology, soil characteristics, surface water bodies, source and point of delivery for imported water supplies	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 2. Basin Setting (Continued)				
354.14(c)(4)	10727.2(a)(5)	Map of Recharge Areas	• Map delineating existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas	TBD
	10727.2(d)(4)	Recharge Areas	• Description of how recharge areas identified in the plan substantially contribute to the replenishment of the basin	TBD
354.16	10727.2(a)(1) 10727.2(a)(2)	Current and Historical Groundwater Conditions	• Groundwater elevation data • Estimate of groundwater storage • Seawater intrusion conditions • Groundwater quality issues • Land subsidence conditions • Identification of interconnected surface water systems • Identification of groundwater-dependent ecosystems	TBD
354.18	10727.2(a)(3)	Water Budget Information	• Description of inflows, outflows, and change in storage • Quantification of overdraft • Estimate of sustainable yield • Quantification of current, historical, and projected water budgets	TBD
	10727.2(d)(5)	Surface Water Supply	• Description of surface water supply used or available for use for groundwater recharge or in-lieu use	TBD
354.20		Management Areas	• Reason for creation of each management area • Minimum thresholds and measurable objectives for each management area • Level of monitoring and analysis • Explanation of how management of management areas will not cause undesirable results outside the management area • Description of management areas	TBD
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24		Sustainability Goal	• Description of the sustainability goal	TBD
354.26		Undesirable Results	• Description of undesirable results • Cause of groundwater conditions that would lead to undesirable results • Criteria used to define undesirable results for each sustainability indicator • Potential effects of undesirable results on beneficial uses and users of groundwater	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria (Continued)				
354.28	10727.2(d)(1) 10727.2(d)(2)	Minimum Thresholds	• Description of each minimum threshold and how they were established for each sustainability indicator • Relationship for each sustainability indicator • Description of how selection of the minimum threshold may affect beneficial uses and users of groundwater • Standards related to sustainability indicators • How each minimum threshold will be quantitatively measured	TBD
354.30	10727.2(b)(1) 10727.2(b)(2) 10727.2(d)(1) 10727.2(d)(2)	Measurable Objectives	• Description of establishment of the measurable objectives for each sustainability indicator • Description of how a reasonable margin of safety was established for each measurable objective • Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 4. Monitoring Networks				
354.34	10727.2(d)(1) 10727.2(d)(2) 10727.2(e) 10727.2(f)	Monitoring Networks	• Description of monitoring network • Description of monitoring network objectives • Description of how the monitoring network is designed to: demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features; estimate the change in annual groundwater in storage; monitor seawater intrusion; determine groundwater quality trends; identify the rate and extent of land subsidence; and calculate depletions of surface water caused by groundwater extractions • Description of how the monitoring network provides adequate coverage of Sustainability Indicators • Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends • Scientific rational (or reason) for site selection • Consistency with data and reporting standards • Corresponding sustainability indicator, minimum threshold, measurable objective, and interim milestone • Location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used • Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	TBD
354.36		Representative Monitoring	• Description of representative sites • Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators • Adequate evidence demonstrating site reflects general conditions in the area	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 4. Monitoring Networks (Continued)				
354.38		Assessment and Improvement of Monitoring Network	• Review and evaluation of the monitoring network • Identification and description of data gaps • Description of steps to fill data gaps • Description of monitoring frequency and density of sites	TBD
Article 5. Plan Contents, Subarticle 5. Projects and Management Actions				
354.44		Projects and Management Actions	• Description of projects and management actions that will help achieve the basin's sustainability goal • Measurable objective that is expected to benefit from each project and management action • Circumstances for implementation • Public noticing • Permitting and regulatory process • Time-table for initiation and completion, and the accrual of expected benefits • Expected benefits and how they will be evaluated • How the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included. • Legal authority required • Estimated costs and plans to meet those costs • Management of groundwater extractions and recharge	TBD
354.44(b)(2)	10727.2(d)(3)		• Overdraft mitigation projects and management actions	TBD

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) or Page Number(s) in the GSP
Article 8. Interagency Agreements				
357.4	10727.6	Coordination Agreements - Shall be submitted to the Department together with the GSPs for the basin and, if approved, shall become part of the GSP for each participating Agency.	**Coordination Agreements shall describe the following:** • A point of contact • Responsibilities of each Agency • Procedures for the timely exchange of information between Agencies • Procedures for resolving conflicts between Agencies • How the Agencies have used the same data and methodologies to coordinate GSPs • How the GSPs implemented together satisfy the requirements of SGMA • Process for submitting all Plans, Plan amendments, supporting information, all monitoring data and other pertinent information, along with annual reports and periodic evaluation • A coordinated data management system for the basin • Coordination agreements shall identify adjudicated areas within the basin, and any local agencies that have adopted an Alternative that has been accepted by the Department	TBD

APPENDIX D. RELEVANT GENERAL PLAN GOALS AND POLICIES

San Joaquin County General Plan

The abbreviations following each policy and program refer to the types of tools or actions the County can use to carry out the policies. There are eight types of tools and actions, listed below.

1. *Regulation and Development Review (RDR)*
2. *Plans, Strategies, and Programs (PSP)*
3. *Financing and Budgeting (FB)*
4. *Planning Studies and Reports (PSR)*
5. *County Services and Operations (SO)*
6. *Inter-governmental Coordination (IGC)*
7. *Joint Partnerships with the Private Sector (JP)*
8. *Public Information (PI)*

The following San Joaquin County General Plan Land Use (LU) Element goals and policies related to groundwater use will potentially influence implementation of the GSP.

- Policy LU-1.1 Compact Growth and Development (RDR): The County shall discourage urban sprawl and promote compact development patterns, mixed-use development, and higher-development intensities that conserve agricultural land resources, protect habitat, support transit, reduce vehicle trips, improve air quality, make efficient use of existing infrastructure, encourage healthful, active living, conserve energy and water, and diversify San Joaquin County's housing stock.

- Policy LU-1.7 Farmland Preservation (RDR): The County shall consider information from the State Farmland Mapping and Monitoring Program when designating future growth areas in order to preserve prime farmland and limit the premature conversion of agricultural lands.

- Policy LU-2.17 Delta Primary Zone Amendments (RDR/PSP): The County shall require proposed General Plan amendment or zoning reclassification for areas in the Primary Zone of the Delta to be consistent with the Land Use and Resource Management Plan for the Primary Zone of the Delta, as required by the State Delta Protection Act of 1992 (Public Resources Code 29700 et seq.).

- Policy LU-8.1 Open Space Preservation (PSP): The County shall limit, to the extent feasible, the conversion of open space and agricultural lands to urban uses and place a high priority on preserving open space lands for recreation, habitat protection and enhancement, flood hazard management, public safety, water resource protection, and overall community benefit.

The following San Joaquin County General Plan County Areas and Communities (C) Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Policy C-1.2 Character and Quality of Life (RDR): The County shall encourage new development in Urban and Rural communities to be designed to strengthen the desirable characteristics and historical character of the communities, be supported by necessary public facilities and services, and be compatible with historical resources and nearby rural or resource uses.

- Policy C-6.18 New Urban Community Water Supply (RDR/PSP): The County shall require new Urban Communities demonstrate access to adequate water supplies to meet the ultimate buildout of the community, consistent with General Plan policies for reducing further groundwater aquifer overdraft and maintaining sufficient water supplies for agriculture. Applicants for new Urban Communities shall be required to study and guarantee, through a development agreement, that existing and future water supply needs can be met and that existing users' water supplies will not be negatively impacted.

The following San Joaquin County General Plan Economic Development (ED) Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Policy ED-3.2 Considerations for New Commercial and Industrial Development (RDR): The County shall consider the following factors when reviewing proposed non-agricultural commercial and industrial development applications, including:
    - Water – New developments must have long-term water supplies to meet the ultimate demand of the development and surrounding area and ensure the continued viability of existing and future development
- Goal ED-4: To support the continued financial growth of the agricultural sector and ag-related businesses.
- Policy ED-4.8 Protect Agricultural Infrastructure (PSP): The County shall recognize and protect agricultural infrastructure, such as farm-to-market routes, water diversion and conveyance structures, airfields, processing facilities, research and development facilities, and farmworker housing.

The following San Joaquin County General Plan Infrastructure and Services (IS) Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal IS-4: To ensure reliable supplies of water for unincorporated areas to meet the needs of existing and future residents and businesses, while promoting water conservation and the use of sustainable water supply sources.
- Policy IS-4.1 Interagency Cooperation (IGC): The County shall support efforts of local water agencies, special district, and water conservation districts to ensure that adequate high-quality water supplies are available to support existing and future residents and businesses.
- Policy IS-4.2 Interagency Cooperation (IGC): The County shall work with local water agencies to address existing and future water needs for the County.
- Policy IS-4.3 Water Supply Availability (RDR/PSP): The County shall consider the availability of a long-term, reliable potable water supply as a primary factor in the planning of areas for new growth and development.
- Policy IS-4.4 Water Rights Protection (IGC): The County shall support local water agencies in their efforts to protect their water rights and water supply contracts, including working with Federal and State water projects to protect local water rights.
- Policy IS-4.5 Drought Response (PSP/IGC): The County shall encourage all local water agencies to develop and maintain drought contingency and emergency services plans, emergency inter-ties, mutual aid agreements, and related measures to ensure adequate water service during drought or other emergency water shortages.
- Policy IS-4.6 Coordinate Efforts for Adequate Water Supply (PSP/IGC): The County shall support coordinated efforts to obtain adequate water supplies and develop water storage facilities to meet expected water demand.
- Policy IS-4.7 Conjunctive Use (PSP/IGC): The County shall support conjunctive use of groundwater and surface water by local water agencies to improve water supply reliability.

- Policy IS-4.8 Water Conservation Measures (RDR): The County shall require existing and new development to incorporate all feasible water conservation measures to reduce the need for water system improvements.

- Policy IS-4.9 Groundwater Management (IGC): The County shall continue to support cooperative, regional groundwater management planning by local water agencies, water users, and other affected parties to ensure a sustainable, adequate, safe, and economically viable groundwater supply for existing and future uses within the County.

- Policy IS-4.10 Groundwater Monitoring Program (PSR/IGC): The County shall continue to evaluate the quantity and quality of groundwater.

- Policy IS-4.12 Water Supply Planning (PSP/IGC): The County shall encourage local water agencies to develop plans for responding to droughts and the effects of global climate change, including contingency plans, water resource sharing to improve overall water supply reliability, and the allocation of water supply to priority users.

- Policy IS-4.13 Water Quality Standards (RDR): The County shall require that water supplies serving new development meet State water quality standards. If necessary, the County shall require that water be treated to meet State standards and that a water quality monitoring program be in place prior to issuance of building permits.

- Policy IS-4.14 Sufficient Water Supply Assessments (RDR): The County shall require new developments over 500 dwelling units in size to prepare a detailed water source sufficiency study and water supply analysis for use in preparing a Water Supply Assessment, consistent with any Integrated Regional Water Management Plan or similar water management plan. This shall include analyzing the effect of new development on the water supply of existing users.

- Policy IS-4.15 Test Wells (RDR/PSR): Prior to issuing building permits for new development that will rely on groundwater, the County shall require confirmation for existing wells or test wells for new wells to ensure that water quality and quantity are adequate to meet the needs of existing, proposed, and planned future development.

- Policy IS-4.16 Permit for Groundwater Export (RDR): The County shall continue to require a permit for the extraction of groundwater that is intended to be exported outside County boundaries.

- Policy IS-4.17 Advocate Against Water Exports (PSP): The County shall advocate that water should not be exported to other areas of the state unless no other areas in San Joaquin County are impacted and the current and future needs of San Joaquin County can still be met.

- Policy IS-4.19 Water Efficient Landscaping (RDR): The County shall encourage water efficient landscaping and use of native, drought-tolerant plants consistent with the Model Landscape Ordinance.

- Policy IS-4.20 Water Efficient Agricultural Practices (PSP): The County shall encourage farmers to implement irrigation practices, where feasible and practical, to conserve water.

- Goal IS-5: To maintain an adequate level of service in the water systems serving unincorporated areas to meet the needs of existing and future residents and businesses, while improving water system efficiency.

- Policy IS-5.1 Adequate Water Treatment and Distribution Facilities (RDR): The County shall ensure, through the development review process, that adequate water, treatment and distribution facilities are sufficient to serve new development and are scalable to meet capacity demands when needed. Such needs shall include capacities necessary to comply with water quality and public safety requirements.

- Policy IS-5.2 Water System Standards (RDR): The County shall require the minimum standards for water system improvements provided in Table IS-1 for the approval of tentative maps and zone reclassifications.

- Policy IS-5.3 Water Service in Antiquated Subdivisions (RDR): The County shall require water service through a public water system prior to issuance of building permits for new residences on parcels less than two acres in antiquated subdivisions. Individual wells may be allowed if public water is not available and all well and sewage requirements can be met.

- Policy IS-5.4 Water Infrastructure Fees (RDR): As a condition of approval for new developments, the County shall require verification of payment of fees imposed for water infrastructure capacity per the fee payment schedule from the appropriate local agency prior to the approval of any final subdivision map.

- Policy IS-5.5 Water System Rehabilitation (PSP): The County shall encourage the rehabilitation of irrigation systems and other water delivery systems to reduce water losses and increase the efficient use and availability of water.

- IS-5.6 Consistent Fire Protection Standards for New Development (RDR/IGC): The County, in coordination with local water agencies and fire protection agencies, shall ensure consistent and adequate standards for fire flows and fire protection for new development.

The following San Joaquin County General Plan Resource Conservation and Sustainability (NCR) goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Policy NCR-3.1 Preserve Groundwater Recharge Areas (PSP): The County shall strive to ensure that substantial groundwater recharge areas are maintained as open space.

- Policy NCR-3.2 Groundwater Recharge Projects (PSP): The County shall encourage the development of groundwater recharge projects of all scales within the County and cities to increase groundwater supplies.

- Policy NCR-3.3 Multi-Jurisdictional Groundwater Management Evaluation (IGC): The County shall support multi-jurisdictional groundwater management that involves adjacent groundwater basins.

- Policy NCR-3.4 Eliminate Pollution (PSP): The County shall support efforts to eliminate sources of pollution and clean up the County's waterways and groundwater.

- Policy NCR-3.7 Septic Tank Regulation (RDR): The County shall enforce its septic tank and onsite system regulations consistent with Central Valley Regional Water Quality Control Board policy that recognizes the County as the responsible agency to protect the water quality of surface water and groundwater.

The following San Joaquin County General Plan Delta Element (D) goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Policy D-2.4 Water Rights (RDR/PSP): The County shall protect existing water rights within the Delta, including the "area of origin" laws and anti-degradation policy of the SWRCB for areas in the Delta, such that there is no deprivation of the water needed for present and future reasonable beneficial use in the areas where the water originates.

- Goal D-4: To regulate development within the Delta to ensure the long-term viability of agricultural operations, success of natural ecosystems, and continuation of Delta heritage.

- Goal D-6: To protect Delta water supplies for agricultural uses and ecosystems enhancement and improve overall Delta water quality.

- D-6.5 Water Storage Options (IGC/PSR): The County shall advocate for the study of above- and below-ground storage options as part of a statewide improved flood management and water supply system.

Calaveras County General Plan

The following Calaveras County General Plan Land Use Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Policy II-25B: Encourage the development of alternative individual waste disposal systems which minimize pollution and water usage.

The following Calaveras County General Plan Conservation Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal IV-9: Preserve the County's current water rights and additional water rights necessary to support the County's full development potential.
- Policy IV-9A: Support the development of water projects in the County for domestic and irrigation purposes.
- Goal IV-1: Preserve and encourage the use of land for agriculture purposes.
- Policy IV-1A: Allow resource production lands to remain available for agriculture and rural use.
- Goal IV-2: Protect legally established agriculture from encroachment by incompatible land uses.
- Goal IV-3: Preserve and encourage the expansion of high capability timber lands for timber protection and harvest.
- Policy IV-3A: Allow lands located within high capability timberlands to remain available for timber production.
- Goal IV-4: Maintain and increase timber land productivity.
- Policy IV-4A: Encourage sustained yield timber production and harvest.
- Goal IV-10: Provide for adequate domestic water supplies.
- Policy IV-10A: Encourage continued cooperation among water suppliers in meeting the water needs for the County as a whole.

The following Calaveras County General Plan Open Space Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal V-2: Protect streams, rivers, and lakes from excessive sedimentation due to development and grading.
- Policy V-2A: Review proposed development projects for potential effects on nearby and adjacent streams, rivers, and lakes.
- Goal V-3: Protect and preserve riparian habitat along streams and rivers in the County.
- Policy V-9A: Balance water resources development with the preservation of streams and rivers in their natural state.

Stanislaus County General Plan

The following Stanislaus County General Plan Land Use Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal 1: Provide for diverse land use needs by designating patterns which are responsive to the physical characteristics of the land as well as to environmental, economic, and social concerns of the residents of Stanislaus County.
- Policy 2: Land designated Agriculture shall be restricted to uses that are compatible with agricultural practices, including natural resources management, open space, outdoor recreation, and enjoyment of scenic beauty.
- Policy 4: Urban development shall be discouraged in areas with growth-limiting factors such as high water table or poor soil percolation, and prohibited in geological fault and hazard areas, flood plains, riparian areas, and airport and private airstrip hazard areas, unless measures to mitigate the problems are included as part of the application.
- Policy 7: Riparian habitat along the rivers and natural waterways of Stanislaus County shall, to the extent possible, be protected.
- Policy 14: Uses shall not be permitted to intrude into or be located adjacent to an agricultural area if they are detrimental to continued agricultural usage of the surrounding area.
- Policy 17: Agriculture, as the primary industry of the County, shall be promoted and protected.
- Policy 24: Future growth shall not exceed the capabilities/capacity of the provider of services such as sewer, water, public safety, solid waste management, road systems, schools, health care facilities, etc.
- Policy 29: Support the development of a built environment that is responsive to decreasing air and water pollution, reducing the consumption of natural resources and energy, increasing the reliability of local water supplies, and reduces vehicle miles traveled by facilitating alternative modes of transportation, and promoting active living (integration of physical activities, such as biking and walking, into everyday routines) opportunities.
- Goal 7: Provide for direct citizen participation in land use decisions involving the expansion of residential uses into agricultural and open-space areas in order to encourage compact urban form and to preserve agricultural land.

The following Stanislaus County General Plan Conservation/Open Space Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal 2: Conserve water resources and protect water quality in the County.
- Policy 5: Protect groundwater aquifers and recharge areas, particularly those critical for the replenishment of reservoirs and aquifers.
- Policy 6: Preserve natural vegetation to protect waterways from bank erosion and siltation.
- Policy 7: New development that does not derive domestic water from pre-existing domestic and public water supply systems shall be required to have a documented water supply that does not adversely impact Stanislaus County water resources.
- Policy 8: The County shall support efforts to develop and implement water management strategies.

- Policy 9: The County will investigate additional sources of water for domestic use.

The following Stanislaus County General Plan Agricultural Element goals and policies related to groundwater use will potentially influence implementation of the GSP:

- Goal 1: Strengthen the agricultural sector of our economy.
- Policy 1.1: Efforts to promote the location of new agriculture-related business and industry in Stanislaus County shall be supported.
- Policy 1.10: The County shall protect agricultural operations from conflicts with non-agricultural uses by requiring buffers between proposed non-agricultural uses and adjacent agricultural operations.
- Goal 2: Conserve our agricultural lands for agricultural uses.
- Goal 3: Protect the natural resources that sustain our agricultural industry.
- Policy 3.4: The County shall encourage the conservation of water for both agricultural, rural domestic, and urban uses.
- Policy 3.5: The County will continue to protect the quality of water necessary for crop production and marketing.
- Policy 3.6: The County will continue to protect local groundwater for agricultural, rural domestic, and urban use in Stanislaus County.

City of Stockton General Plan

- Policy SAF-3.2: Protect the availability of clean potable water from groundwater sources.
- Policy SAF-3.2A (PFS-2.11): Continue to cooperate with San Joaquin County, SEWD, and Cal Water to monitor groundwater withdrawals and ensure that they fall within the target yield for the drinking water aquifer.

City of Lodi General Plan

- Policy C-P7 Agricultural Soil Resources: Adopt an agricultural conservation program (ACP) establishing a mitigation fee to protect and conserve agricultural lands. The ACP shall include the collection of an agricultural mitigation fee for acreage converted from agricultural to urban use, taking into consideration all fees collected for agricultural loss (i.e., AB1600). The mitigation fee collected shall fund agricultural conservation easements, fee title acquisition, and research; the funding of agricultural education and local marketing programs; other capital improvement projects that clearly benefit agriculture (e.g., groundwater recharge projects); and administrative fees through an appropriate entity ("Administrative Entity") pursuant to an administrative agreement. Goal CO-2: Prevent the creation of new groundwater contamination or the spread of existing contamination.
- Policy C-P13 Biological Resources: Support the protection, restoration, expansion, and management of wetland and riparian plant communities along the Mokelumne River for passive recreation, groundwater recharge, and wildlife habitat.
- Policy C-P27 Hydrology and Water Quality: Monitor the water quality of the Mokelumne River and Lodi Lake, in coordination with San Joaquin County, to determine when the coliform bacterial standard for contact recreation and the maximum concentration levels of priority pollutants, established by the California Department of Health Services, are exceeded. Monitor the presence of pollutants and variables that could

cause harm to fish, wildlife, and plant species in the Mokelumne River and Lodi Lake. Post signs at areas used by water recreationists warning users of health risks whenever the coliform bacteria standard for contact recreation is exceeded. Require new industrial development to not adversely affect water quality in the Mokelumne River or in the area's groundwater basin. Control use of potential water contaminants through inventorying hazardous materials used in City and industrial operations.

- Policy C-P34 Hydrology and Water Quality: Protect groundwater resources by working with the county to prevent septic systems in unincorporated portions of the county that are in the General Plan Land Use Diagram on parcels less than two acres.
- Policy GM-P17 Potable Water Supply: Cooperate with Northeastern San Joaquin County Groundwater Banking Authority, other member water agencies, and the WID to retain surface water rights and groundwater supply.

City of Manteca General Plan

- Policy PF-P-5 Public Facilities and Services Element: The City will continue to rely principally on groundwater resources for its municipal water in the near term and will participate in the regional improvements to deliver surface water to augment the City's groundwater supply.
- Policy PF-P-15 Public Facilities and Services Element: The City shall monitor water quality regularly and take necessary measures to prevent contamination.
- Policy PF-P-16 Public Facilities and Services Element: The City shall include a groundwater analysis as a technical analysis of water system capacity in the update of the Public Facilities Implementation Plan (PFIP) and shall prepare an environmental analysis in the PFIP that addresses the quality and availability of groundwater.
- Policy PF-P-17 Public Facilities and Services Element: The City shall consider incremental increases in the demands on groundwater supply and water quality when reviewing development applications.
- Policy RC-P-3 Resource Conservation Element – Water Conservation: The City shall protect the quantity of Manteca's groundwater.
- Policy RC-P-4 Resource Conservation Element – Water Conservation: The City shall require water conservation in both City operations and private development to minimize the need for the development of new water sources.
- Policy RC-P-5 Resource Conservation Element – Water Conservation: Development of private water wells within the city limits shall be allowed only where the City makes a finding that municipal water service is not readily and feasibly available, and such private well systems shall only be allowed to be used until such time as City water service becomes available.
- Policy RC-P-15 Resource Conservation Element – Water Conservation: Encourage participation by the County and surrounding communities in a basin-wide groundwater management study.
- Policy S-P-1 Safety Element: The City shall require preparation of geological reports and/or geological engineering reports for proposed new development located in areas of potentially significant geological hazards, including potential subsidence (collapsible surface soils) due to groundwater extraction.

City of Escalon General Plan

- Objective 3.1 (A) Natural Resources: Protect natural resources including groundwater, soils, and air quality to meet the needs of present and future generations.
- Policy 3.1 (1) Natural Resources: Expand programs that enhance groundwater recharge in order to maintain the groundwater supply, including the installation of retention ponds in new growth areas.
- Policy 3.1 (3) Natural Resources: Policy 3.1 (1) Natural Resources: Expand programs that enhance groundwater recharge in order to maintain the groundwater supply, including the installation of retention ponds in new growth areas.
- Policy 9.1 (12) Public Facility Improvement: To encourage groundwater recharge, ponding basins shall be designed as retention basins. However, pumping facilities shall be included in such facilities to handle peak flows and to provide for disposal of stormwater into irrigation ditches when necessary. Stormwater inflow into irrigation district canals and pipelines shall be subject to existing or future agreements by and between the City and the irrigation districts specifying maximum inflow, maximum service area boundary, and any other limitation thereto.
- Policy 9.1 (14) Public Facility Improvement: New municipal water well sites should be planned which include pump, storage, pressure filtration, and/or treatment equipment. These new wells should be located so that they will not conflict with planned residential neighborhoods. They should have design, screening, landscaping, and architectural improvements which make them compatible with adjacent land uses.

City of Ripon General Plan

- Goal F: Groundwater management pursuant to the City's Urban Water Management Plans to avoid overdraft and maintain drinking water quality.
- Policy F1. Expand City's existing system to regularly monitor and evaluate the physical condition and quality of the groundwater system underlying Ripon, and to identify the need for supplemental water as required.
- Policy F2. Identify and secure available sources of supplemental surface water for replacement or recharge of groundwater as required.
- Policy F3. Manage land use and sewage disposal as required to maintain adequate groundwater quality.
- Goal G: Efficient use of water resources throughout the community pursuant to the City's Groundwater Management and Preservation Plan.
- Policy G1. Promote water conservation through public dissemination of groundwater and municipal water use information.
- Policy G2. Develop a plan, financing mechanism, and target date for installation of water meters on un-metered portions of the water system.
- Policy G3. Promote reclamation and reuse of municipal and industrial wastewaters for irrigation, recharge, or other beneficial uses.
- Policy D5. The City shall implement the Groundwater Management Plan adopted by the City Council. This program includes, but is not necessarily limited to: the ongoing collection and analysis of well quantity and quality data; the identification of recharge areas within the Planning Area; inter-agency coordination and

planning to protect and enhance recharge areas; establishment of a well head protection program to ensure well and aquifer testing for new city wells; and the installation of monitoring wells, as required.

- Policy D6. The City shall review design and operation parameters for stormwater detention facilities and make feasible adjustments to these plans, which would promote recharge of stormwater to the groundwater system. For example, siting detention facilities in areas of maximum infiltration capacity, increasing detention time for where necessary storage capacity is not compromised, and adjustment of area/depth ratios to maximize infiltration.

APPENDIX E. LIST OF PUBLIC MEETINGS

APPENDIX F: EASTERN SAN JOAQUIN WATER RESOURCES MODEL (ESJWRM) REPORT