EASTERN SAN JOAQUIN
GROUNDWATER AUTHORITY

Eastern San Joaquin
Groundwater Subbasin

GROUNDWATER SUSTAINABILITY PLAN

November 2019;
revised June 2022

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Eastern San Joaquin Groundwater Subbasin

Groundwater Sustainability Plan

Prepared by:

EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY

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Acronyms

µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
1,2,3-TCP	1,2,3-Trichloropropane
AB	Assembly Bill
ACS	American Community Survey
AEM	airborne electromagnetic survey
AF	acre-feet
AF/day	acre-feet per day
AF/year	acre-feet per year
AMI	Advanced Metering Infrastructure
AWMP	Agricultural Water Management Plan
AWMPs	Agricultural Water Management Plans
B.P.	before present
Bay-Delta Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
bgs	below ground surface
BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, and xylenes
Cal Water	California Water Service Company Stockton District
California State Parks	California Department of Parks and Recreation
CALSIMETAW	California Simulation of Evapotranspiration of Applied Water
CASGEM	California Statewide Groundwater Elevation Monitoring
CC	climate change
CCR	California Code of Regulations
CCWD	Calaveras County Water District
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDP	census designated place
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CDWA	Central Delta Water Agency
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CGPF	CalSim II Generated Perturbation Factors
CGPS	continuously operating Global Positioning System
CNRA	California Natural Resources Agency
CSJWCD	Central San Joaquin Water Conservation District
CVFPB	Central Valley Flood Protection Board
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWSRF	Clean Water State Revolving Fund
DAC	Disadvantaged Community
DACs	Disadvantaged Communities
DBCP	1,2-dibromo-3-chloropropane
DDW	Division of Drinking Water
Delta	Sacramento-San Joaquin River Delta
DER	Department of Environmental Resources
DFW	Department of Fish and Wildlife
DMS	Data Management System

DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	Department of Pesticide Regulation
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
Eastside GSA	Eastside San Joaquin GSA
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity
EDB	ethylene dibromide
EPA	Environmental Protection Agency
ERTs	Encoder Receiver Transmitters
ESJ	Eastern San Joaquin
ESJGWA	Eastern San Joaquin Groundwater Authority
ESJGWA Board	Eastern San Joaquin Groundwater Authority Board of Directors
ESJWRM	Eastern San Joaquin Water Resources Model
ETo	evapotranspiration
EWMPs	efficient water management practices
ft. bgs	feet below ground surface
GAMA	Groundwater Ambient Monitoring and Assessment
GBA	Groundwater Basin Authority
GCM	global climate model
GDE	Groundwater Dependent Ecosystem
GDEs	Groundwater-Dependent Ecosystems
GICIMA	Groundwater Information Center Interactive Mapping Application
GIS	Geographic Information System
GMP	Groundwater Management Plan
gpm	gallons per minute
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
ICU Program	Integrated Conjunctive Use Program
ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
IWFM	Integrated Water Flow Model
JPA	Joint Powers Agreement
LCSD	Lockeford Community Services District
LCWD	Linden County Water District
LLNL	Lawrence Livermore National Laboratory
LOCA	local analogs
MAC	Mokelumne-Amador-Calaveras
MAF	million acre-feet
MAR	managed aquifer recharge
MCL	maximum contaminant level
mg/L	milligrams per liter
MGD	million gallons per day
MHI	median household income
MOA	memorandum of agreement
MokeWISE	Mokelumne Watershed Interregional Sustainability Evaluation
MSL	mean sea level
MtBE	methyl tertiary-butyl ether

MUD	Municipal Utilities Department
MWH	Montgomery Watson Harza
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NCCAG	Natural Communities Commonly Associated with Groundwater
NDWA	North Delta Water Agency
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NSJWCD	North San Joaquin Water Conservation District
NWIS	National Water Information System
OES	San Joaquin County Office of Emergency Services
OID	Oakdale Irrigation District
OSWCR	Online System for Well Completion Reports
PCE	perchloroethylene
PDA	Protest Dismissal Agreement
PMAs	Projects and Management Actions
pdf	portable document format
PFOA	perfluorooctantoic acid
PFOS	perfluorooctanesulfonic acid
PMAs	Projects and Management Actions
PG&E	Pacific Gas and Electric Company
PRISM	Precipitation-Elevation Regressions on Independent Slopes Model
PS	persistent scatter
RCP	representative climate pathways
RD	Reclamation District
RL	Reporting Limit
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCWSP	South County Water Supply Program
SDACs	Severely Disadvantaged Communities
SDWA	South Delta Water Agency
SEWD	Stockton East Water District
SGM	Sustainable Groundwater Management
SGMA	the Sustainable Groundwater Management Act
SJC	San Joaquin County
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
SRA	State Recreation Area
SS	specific storage
SSJ GSA	South San Joaquin GSA
SSJ	South San Joaquin
SSJID	South San Joaquin Irrigation District
SVRA	State Vehicular Recreation Area
SWRCB	State Water Resources Control Board
SWTF	Surface Water Treatment Facility
SY	specific yield

TCE	trichloroethene
TDS	total dissolved solids
TNC	The Nature Conservancy
TSS	Technical Support Services
UNAVCO	University NAVSTAR Consortium
USACE	U.S. Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UWMP	Urban Water Management Plan
UWMPs	Urban Water Management Plans
VIC	Variable Infiltration Capacity
VOC	volatile organic compound
Water Code	California Water Code
WDL	Water Data Library
WDR	waste discharge requirement
WID	Woodbridge Irrigation District
Workgroup	Groundwater Sustainability Workgroup
WPCF	Water Pollution Control Facility
WRFP	Water Recycling Funding Program
WRIMS	Water Resource Integrated Modeling System

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EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY

EXECUTIVE SUMMARY

ES-1. INTRODUCTION

Critical Dates for the Eastern San Joaquin Subbasin

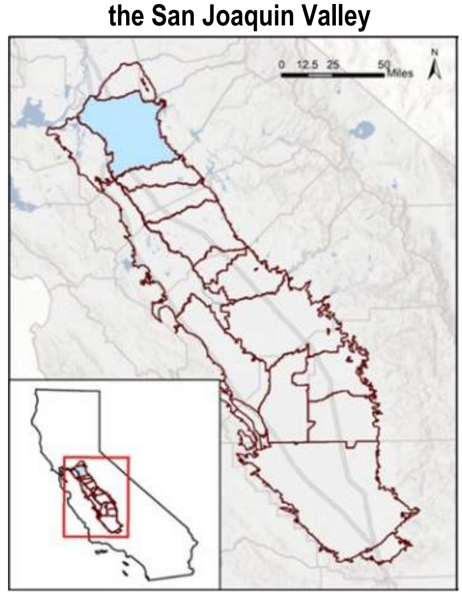
- 2020 By January 31: Submit GSP to DWR
- 2025 Evaluate GSP and update if warranted
- 2030 Evaluate GSP and update if warranted
- 2035 Evaluate GSP and update if warranted
- 2040 Achieve sustainability for the Subbasin

In 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) in response to continued overdraft of California's groundwater resources. The Eastern San Joaquin Groundwater Subbasin (Eastern San Joaquin Subbasin, or Subbasin) is one of 21 basins and subbasins identified by the California Department of Water Resources (DWR) as being in a state of critical overdraft. SGMA requires preparation of a Groundwater Sustainability Plan (GSP) to address measures necessary to attain sustainable conditions in the Subbasin. Within the framework of SGMA, sustainability is generally defined as long-term reliability of the groundwater supply and the absence of undesirable results.

The Eastern San Joaquin Groundwater Authority (ESJGWA) was formed in 2017 in response to SGMA. A Joint Exercise of Powers Agreement establishes the ESJGWA, which is composed of 16 Groundwater Sustainability Agencies (GSAs): Central Delta Water Agency (CDWA), Central San Joaquin Water Conservation District (CSJWCD), City of Lodi, City of Manteca, City of Stockton, Eastside San Joaquin GSA (Eastside GSA) (composed of Calaveras County Water District [CCWD], Stanislaus County, and Rock Creek Water District), Linden County Water District (LCWD), Lockeford Community Services District (LCSD), North San Joaquin Water Conservation District (NSJWCD), Oakdale Irrigation District (OID), San Joaquin County No. 1, San Joaquin County No. 2 (with participation from California Water Service Company Stockton District [Cal Water]), South Delta Water Agency (SDWA), South San Joaquin GSA (composed of South San Joaquin Irrigation District [SSJID] including Woodward Reservoir, City of Ripon, and City of Escalon), Stockton East Water District (SEWD), and Woodbridge Irrigation District (WID). The ESJGWA is governed by a 16-member Board of Directors (ESJGWA Board), with one representative from each GSA. The Board is guided by an Advisory Committee, also with one representative from each GSA, that is tasked with making recommendations to the ESJGWA Board on technical and substantive matters.

SGMA requires development of a GSP that achieves groundwater sustainability in the Subbasin by 2040. The GSP outlines the need to reduce overdraft conditions and has identified 23 projects for potential development that either replace groundwater use (offset) or supplement groundwater supplies (recharge) to meet current and future water demands. Although current analysis indicates that groundwater pumping offsets and/or recharge on the order of 37,000 acre-feet per year (AF/year) may be required to achieve sustainability, additional efforts are needed to confirm the level of pumping offsets and/or recharge required to achieve sustainability. These efforts include collecting additional data and a review of the Subbasin groundwater model, along with other efforts as outlined in the GSP.

Figure ES-1: GSP Plan Area within the San Joaquin Valley



A Public Draft GSP was prepared and made available for public review and comment on July 10, 2019 for a period of 45 days ending on August 25, 2019. The ESJGWA received numerous comments from the public, reviewed and prepared responses to comments, and revised the Draft GSP. This Final GSP includes those edits and revisions. Comment letters and responses are included as appendices to the GSP.

On November 18, 2021, the ESJGWA received a Consultation Initiation Letter (Letter) from DWR. The Letter identified two potential deficiencies in the Subbasin GSPs which may preclude DWR's approval, as well as potential corrective actions to address each potential deficiency. The Letter initiated consultation between DWR, the Plan Manager, the ESJGWA, and the Subbasin's GSAs. In response to DWR's comments, this GSP was revised in June 2022. DWR comments have also been addressed in a series of four technical memoranda appended to this revised GSP and referenced throughout the document.

ES-2. PLAN AREA

The ESJGWA's jurisdictional area is defined by the boundaries of the Eastern San Joaquin Subbasin in DWR's 2003 Bulletin 118 as updated in 2016 and 2018. The Subbasin underlies the San Joaquin Valley, as shown in Figure ES-1.

ES-3. OUTREACH EFFORTS

A stakeholder engagement strategy was developed to enable the interests of beneficial users of groundwater in the Subbasin to be considered. The strategy incorporated monthly Groundwater Sustainability Workgroup (Workgroup) meetings, monthly Advisory Committee meetings, monthly ESJGWA Board meetings, approximately quarterly informational open house events, outreach presentations to community groups, and information distribution to property owners and residents in the Subbasin. Figure ES-2 shows attendees at one of the informational open house events conducted during development of the GSP.

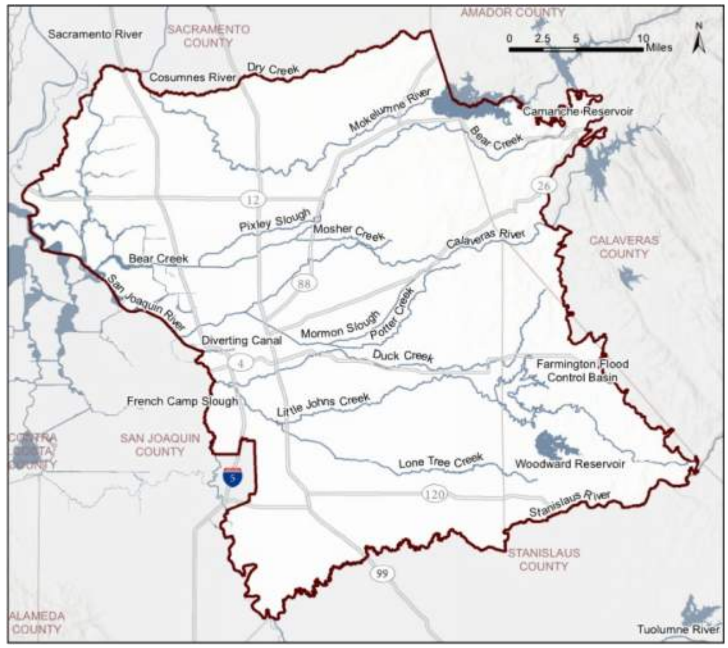
Figure ES-2 - Informational Open House Events

Public Meeting Type	Number of Meetings
ESJGWA Board Meetings	25
Advisory Committee Meetings	17
Groundwater Sustainability Workgroup Meetings	13
Informational Open House Events	4
Outreach Presentations to Community Groups	10

The Workgroup was established to encourage active involvement from diverse social, cultural, and economic elements of the population in the Subbasin. The 23 Workgroup members represent large and small landowners and growers from different geographic locations in the Subbasin, long-time residents, representatives from non-governmental organizations, disadvantaged community policy advocates, and outreach coordinators. Spanish translation was provided at informational open house events, creating an opportunity for local Spanish-speaking individuals to engage in the GSP development process. Input from the Workgroup was presented to the ESJGWA Board and has also been incorporated into the GSP.

ES-4. BASIN SETTING

Figure ES-3: Basin Setting



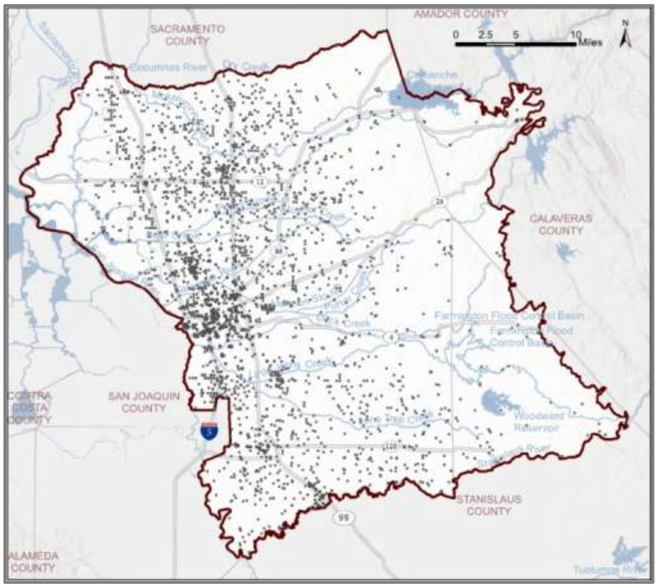
The Subbasin is located to the west of the Sacramento-San Joaquin River Delta (Delta) and is bounded by the Sierra Nevada foothills to the east, the San Joaquin River to the west, Dry Creek to the north, and Stanislaus River to the south. In the eastern portion of the Subbasin, groundwater flows from east to west and generally mirrors the eastward sloping topography of the geologic formations. In the western portion of the Subbasin, groundwater flows eastward toward areas with relatively lower groundwater elevation. Surface water generally flows from east to west, with the major river systems traversing the Subbasin being the Calaveras, Mokelumne, and Stanislaus rivers. Multiple smaller streams flow into the San Joaquin River, which flows from south to north. The location of the Subbasin is shown in Figure ES-3.

ES-5. EXISTING GROUNDWATER CONDITIONS

Groundwater levels in some portions of the Subbasin have been declining for many years, while groundwater levels in other areas of the Subbasin have remained stable or increased in recent years. The change in groundwater levels varies across the Subbasin, with the greatest declines occurring in the central portion of the Subbasin. The western and southern portions of the Subbasin have experienced less change in groundwater levels, in part due to the minimal groundwater pumping in the Delta area to the west and the import of surface water for agricultural and urban uses.

Groundwater quality in the Subbasin varies by location. Areas along the western margin have historically had higher levels of salinity. Salinity may be naturally occurring or the result of human activity. Sources of salinity in the Subbasin include Delta sediments, deep saline groundwater, and irrigation return water. Total dissolved solids (TDS), which is a measure of all inorganic and organic substances present in a liquid in molecular, ionized, or colloidal suspended form, is commonly used to measure salinity. The Groundwater Ambient Monitoring and Assessment (GAMA) Program includes numerous water quality monitoring sites in the Subbasin compiled from different sources, shown in Figure ES-4. Maximum TDS concentrations across the Subbasin have been reported as high as 2,500 milligrams per liter (mg/L) along portions of the Subbasin's western boundary. For drinking water, California has three secondary maximum contaminant level (SMCL) standards for TDS, all based on aesthetic considerations such as taste and odor, not public health concerns. These are 500 mg/L (recommended limit), 1,000 mg/L (upper limit), and 1,500 mg/L (short-term limit). TDS concentrations decrease significantly to the east, to typically less than 500 mg/L (the recommended limit for aesthetic considerations). Elevated concentrations of other constituents, such as nitrate, arsenic, and point-source contaminants, are generally localized and not widespread and are

Figure ES-4: GAMA Water Quality Sampling Locations



generally related to natural sources or land use activities. The GSP establishes ongoing monitoring of salinity, arsenic, nitrate, and a number of other common water quality constituents to fill data gaps and identify potential trends of concern.

While the total volume of groundwater in storage in the Subbasin has declined over time, groundwater storage reduction has not historically been an area of concern in the Subbasin, as there are large volumes of fresh water stored in the aquifer. The total fresh groundwater in storage was estimated at over 50 million-acre-feet (MAF) in 2015. The amount of groundwater in storage has decreased by approximately .01 percent per year between 1995 and 2015. As such, it is highly unlikely the Subbasin will experience conditions under which the volume of stored groundwater poses a concern, although the depth to access that groundwater does pose a concern.

Land subsidence has not historically been an area of concern in the Subbasin, and there are no records of land subsidence caused by groundwater pumping in the Subbasin.

Seawater intrusion is not present in the Subbasin. While the Delta ecosystem evolved with a natural salinity cycle that brought brackish tidal water in from the San Francisco Bay, current management practices endeavor to maintain freshwater flows through a combination of hydraulic and physical barriers and alterations to existing channels.

Surface waters can be hydraulically interconnected with the groundwater system, where the stream baseflow is either derived from the aquifer (gaining stream) or recharged to the aquifer (losing stream). If the water table beneath the stream lowers as a result of groundwater pumping, the stream may disconnect entirely from the underlying aquifer. Major river systems in the Subbasin are highly managed to meet instream flow requirements for fisheries, water quality standards, and water rights of users downstream.

ES-6. SUSTAINABLE MANAGEMENT CRITERIA

SGMA introduces several terms to measure sustainability, including:

Sustainability Indicators – Sustainability indicators refer to any of the effects caused by groundwater conditions occurring throughout the Subbasin that, when significant and unreasonable, cause undesirable results. The six sustainability indicators identified by DWR are the following:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

Sustainability Goal – This goal is the culmination of conditions resulting in a sustainable condition (absence of undesirable results) within 20 years.

Undesirable Results – Undesirable results are the significant and unreasonable occurrence of conditions that adversely affect groundwater use in the Subbasin, including reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses of the Subbasin's groundwater. Categories of undesirable results are defined through the sustainability indicators.

Minimum Thresholds – Minimum thresholds are numeric values for each sustainability indicator and are used to define when undesirable results occur. Undesirable results occur if minimum thresholds are exceeded in an established percentage of sites in the Subbasin's representative monitoring network.

Measurable Objectives – Measurable objectives are a specific set of quantifiable goals for the maintenance or improvement of groundwater conditions.

The method prescribed by SGMA to measure undesirable results involves setting minimum thresholds and measurable objectives for a series of representative wells. Representative wells are identified to provide a basis for measuring groundwater conditions throughout a basin or subbasin without having to measure each well, which would be cost prohibitive. In the Eastern San Joaquin Subbasin, representative wells were selected based on history of recorded groundwater levels and potential to effectively represent the groundwater conditions.

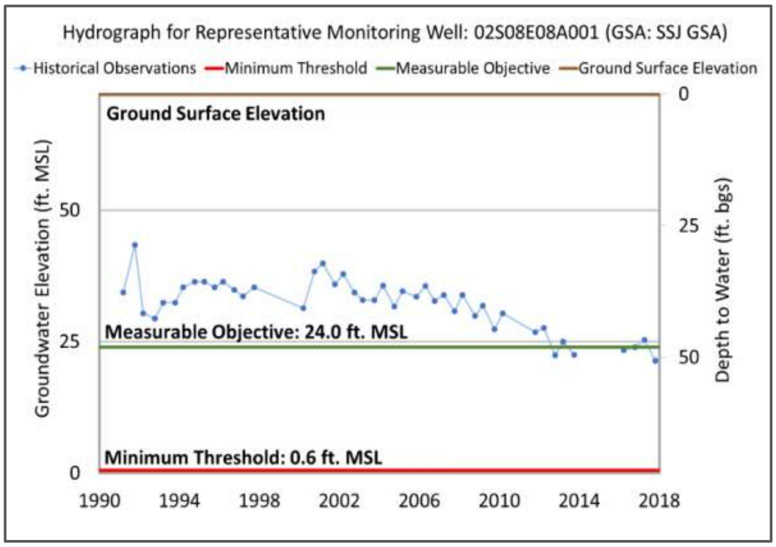
Revisions to Sustainable Management Criteria –This revised GSP reflects changes made to the sustainable management criteria in response to the potential corrective actions recommended by DWR. In their Consultation Initiation Letter, DWR identified the following two deficiencies:

> **Potential Deficiency 1** – The GSP lacks sufficient justification for determining that undesirable results for chronic lowering of groundwater levels, subsidence, and depletion of interconnected surface waters can only occur in consecutive non-dry water year types. The GSP also lacks sufficient explanation for its minimum thresholds and undesirable results for chronic lowering of groundwater levels.
>
> **Potential Deficiency 2** - The GSP does not provide enough information to support the use of the chronic lowering of groundwater level sustainable management criteria and representative monitoring network as a proxy for land subsidence.

Revisions made to sustainable management crieria, as well as additional explanations as to how the Subbasin sustainability indicators and sustainable management criteria were determined, are described in Chapter 3: Sustainable Management Criteria.

A total of 20 representative wells were identified for measurement of groundwater levels in the Subbasin, and 10 representative wells were identified for groundwater quality monitoring. The GSP uses groundwater quality data as the basis for evaluating conditions for seawater intrusion and uses groundwater level data as the basis for evaluating conditions for groundwater storage, depletions of interconnected surface water, and land subsidence. As such, these representative wells provide the basis for measuring the six sustainability indicators across the Subbasin.

Figure ES-5: Sample Relationship Between Minimum Threshold and Measurable Objective



Minimum thresholds and measurable objectives were developed for each of the representative wells. Figure ES-5 shows a typical relationship of the minimum thresholds, measurable objectives, and historical groundwater level data for a sample groundwater level representative monitoring well.

Minimum thresholds for groundwater levels were developed with reference to historical drought low conditions and domestic well depths. Specifically, minimum thresholds were established based on the deeper of the historical drought low plus a buffer of the historical fluctuation *or* the 10th percentile domestic well depth, whichever is shallower – establishing levels that are protective of 90 percent of domestic wells. In municipalities with ordinances requiring the use of City water (water provided by the City's municipal wells), the 10th percentile municipal well depth is used in place of the 10th percentile domestic well depth criteria.

Measurable objectives were established based on the historical drought low and provide a buffer above the minimum threshold. A table summarizing minimum thresholds and measurable objectives is included in the GSP. Graphs showing the minimum threshold and measurable objective for each of the representative wells are contained in an appendix to the GSP.

Minimum thresholds for water quality were defined by considering two primary beneficial uses at risk of undesirable results related to salinity: drinking water and agriculture uses. Minimum thresholds are 1,000 mg/L for each representative monitoring well, consistent with the upper limit SMCL for TDS. Crop tolerances in the Subbasin range by crop type from 900 mg/L TDS for almonds up to 4,000 mg/L TDS for wheat, assuming a 90 percent yield.

The minimum threshold for seawater intrusion is a 2,000 mg/L chloride isocontour line established near the western edge of the Subbasin, between sentinel monitoring locations. 2,000 mg/L chloride is approximately 10 percent of seawater chloride concentrations (19,500 mg/L) and was developed as a minimum threshold based on consideration of existing management practices in other areas of the state.

For depletions of interconnected surface water, the minimum thresholds and measurable objectives for groundwater levels are used. There is significant correlation between groundwater levels and depletions, and the groundwater levels minimum thresholds are found to be protective of depletions.

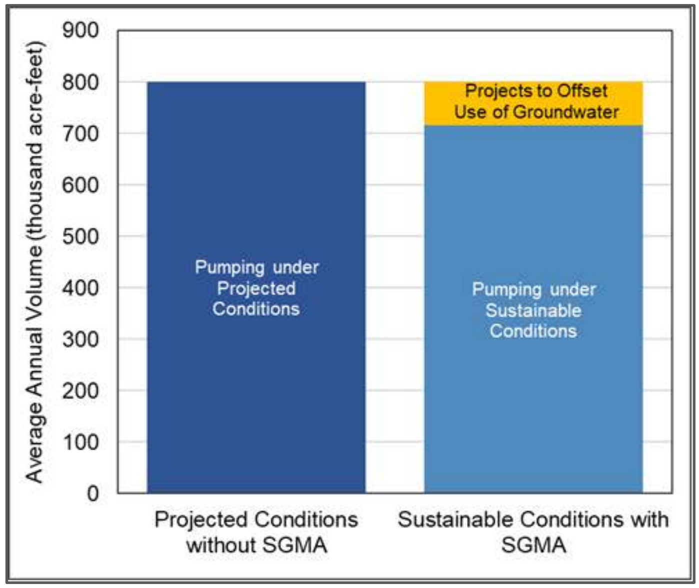
Similarly, the minimum thresholds and measurable objectives for groundwater levels are used for the land subsidence and groundwater storage sustainability indicators, as both are strongly linked to groundwater levels. The groundwater levels minimum thresholds are found to be protective of land subsidence and groundwater storage.

ES-7. WATER BUDGETS

The Eastern San Joaquin Subbasin has been in an overdraft condition for many years. Overdraft occurs when the amount of groundwater extracted exceeds the long-term average groundwater recharged.

The groundwater evaluations conducted as a part of GSP development have provided estimates of the historical, current, and projected groundwater budget conditions. The current analysis was prepared using the best available information and through development of a new groundwater modeling tool, the Eastern San Joaquin Water Resources Model (ESJWRM). It is anticipated that as additional information becomes available, the model can be updated, and more refined estimates of annual pumping and overdraft can be developed.

Figure ES-6: Subbasin-Wide Total Groundwater Pumping and Offsets Required to Achieve Sustainability



Following the submittal of the Eastern San Joaquin Subbasin GSP in January 2020, the ESJWRM was revised to correct data relating to historical surface water deliveries and to include additional data for Water Year (WY) 2016 through WY 2020. The ESJWRM simulation period was extended to simulate Water Years 1995 through 2020 and the model recalibrated for the extended period. As a result of the model update, both the historical and projected water budgets were revised in 2021 to reflect the new data sets used in the model. Additionally, refinements and enhancements were made to the historical data for the updated historical ESJWRM requiring an update to the projected conditions baseline ESJWRM. The updated version of the Projected Conditions Baseline (PCBL) used the extended dataset and calibration results, along with updated data sources and assumptions for projected conditions, representing approximately water year 2040 conditions.

Based on these analyses, at projected groundwater pumping levels, the long-term groundwater pumping offset and/or recharge required for the Subbasin to achieve sustainability is approximately 16,000 AF/year. Groundwater levels are expected to continue to decline based on projections of current land and water uses. Projects that offset groundwater pumping and/or increase recharge will help the Subbasin reach sustainability, as illustrated in Figure ES-6.

The projected Subbasin water budget was also evaluated under climate change conditions, which simulate higher demand requiring increased groundwater pumping despite more precipitation and streamflows. The updated version of the Projected Conditions Baseline with Climate Change (PCBL-CC) largely used the same perturbation factors (2070 Central Tendency climate change conditions) as the original simulation, but the updated PCBL-CC extended the simulation time period by two years. The overdraft modeled under climate change conditions is simulated to increase above projected conditions without climate change, requiring long-term groundwater pumping offset and/or recharge required for the Subbasin to achieve sustainability of approximately 38,000 AF/year.

Finally, as part of the revisions to this GSP to address DWR-identified deficiencies, projects and management actions (PMAs) likely to be implemented over the next five years were simulated in the projected water budget, both with and without climate change. The projected water budget with PMAs demonstrated that with implementation of the identified subset of projects, the Subbasin could achieve and maintain sustainability. However, when climate change impacts are added to the scenario, the Subbasin remains in overdraft conditions, indicating that additional PMAs will be required in the future to address climate change impacts on the groundwater basin.

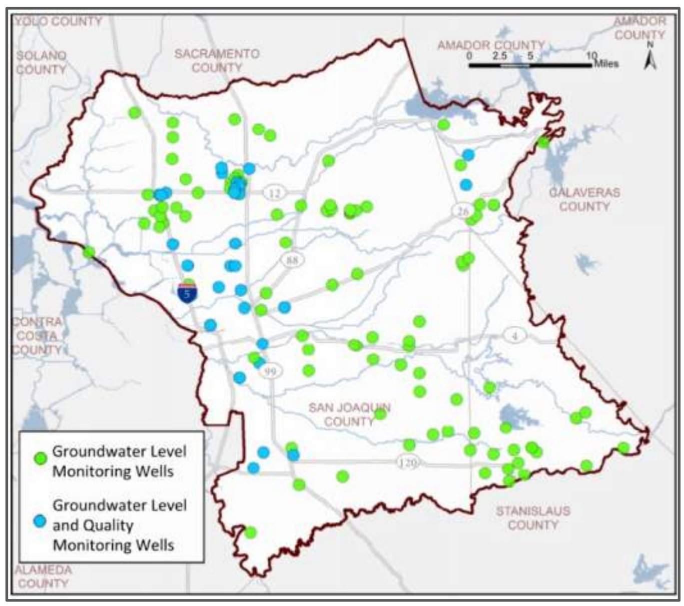
ES-8. MONITORING NETWORKS

The GSP outlines the monitoring networks for the six sustainability indicators. The objective of these monitoring networks is to monitor conditions across the Subbasin and to detect trends toward undesirable results. Specifically, the monitoring network was developed to do the following:

- Monitor impacts to the beneficial uses or users of groundwater
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Demonstrate progress toward achieving measurable objectives described in the GSP

There are four monitoring networks in the Eastern San Joaquin Subbasin: a representative network for water levels, a broad network for water levels, a representative network for water quality, and a broad network for water quality. Representative networks are used to determine compliance with the minimum thresholds, while the broad networks collect data for informational purposes to identify trends and fill data gaps. The two monitoring networks for water quality will additionally be used to develop a chloride isocontour to monitor for potential seawater intrusion and water levels data will inform depletions of interconnected surface water.

Figure ES-7: Groundwater Monitoring Wells



The monitoring networks were designed by evaluating data from the DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) Program, the United States Geological Survey (USGS), and participating GSAs. The monitoring network consists largely of wells that are already being used for monitoring in the Subbasin. Additional wells are being added, including two new deep, multi-completion monitoring wells awarded under DWR's Technical Support Services (TSS) program. Figure ES-7 shows the location of existing groundwater monitoring wells in both the representative and broad monitoring networks.

Wells in the monitoring networks will be measured on a semi-annual schedule. Historical measurements have been entered into the Subbasin Data Management System (DMS), and future data will also be stored in the DMS.

A summary of the wells in the monitoring networks is shown in the table below.

Summary of Monitoring Network Wells	
Representative Networks	**Well Count**
Groundwater Level	20
Groundwater Quality	10
Broad Networks	
CASGEM (Groundwater Levels)	76
Nested or Clustered Wells (Groundwater Levels & Quality)	16
Agency Wells (Groundwater Levels & Quality)	5

ES-9. DATA MANAGEMENT SYSTEM

The Eastern San Joaquin DMS was built on a flexible, open software platform that uses familiar Google maps and charting tools for analysis and visualization. The DMS serves as a data-sharing portal that enables use of the same data and tools for visualization and analysis. These tools support sustainable groundwater management and create transparent reporting about collected data and analysis results.

The DMS is web-based; the public can easily access this portal using common web browsers such as Google Chrome, Firefox, and Microsoft Edge. The DMS is currently populated with available historical data. Future data will also be entered into the system as it is collected.

The DMS portal provides easy access and the ability to query information stored in the system. Groundwater data can be plotted for any of the available data points, providing a pictorial view of historical and current data.

The DMS can be accessed at this link using the Guest Login:
https://opti.woodardcurran.com/esj/

Figure ES-8: Opti DMS Screenshot

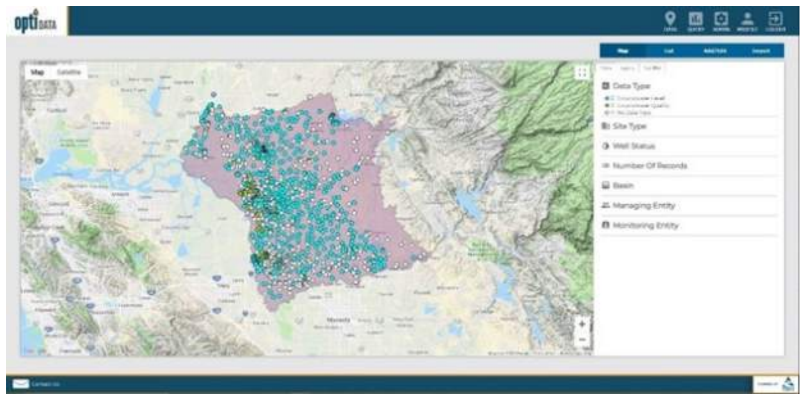
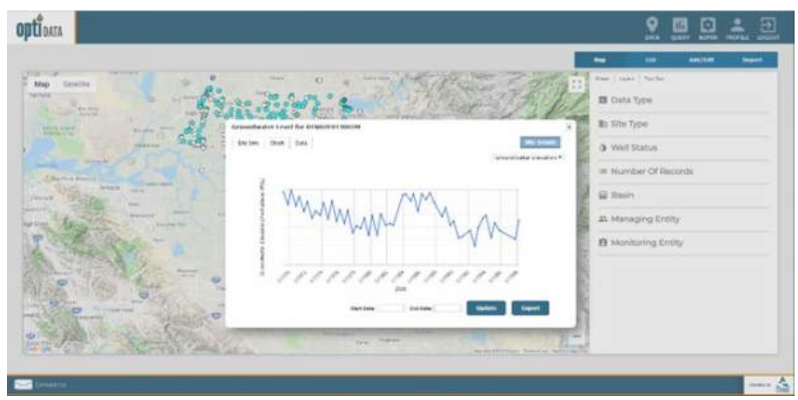


Figure ES-9: Typical DMS Data Display



ES-10. PROJECTS AND MANAGEMENT ACTIONS

Achieving sustainability in the Subbasin requires implementation of projects and management actions. The Subbasin will achieve sustainability by implementing water supply projects that either replace groundwater use or supplement groundwater supplies to attain the current estimated pumping offset and/or recharge need of 16,000 AF/year. It should be noted that this number will be reevaluated in the future after additional data are collected and analyzed. In addition, three projects have been identified that support demand conservation activities, including water use efficiency upgrades. Currently, no pumping restrictions have been proposed for the Subbasin; however, GSAs maintain the flexibility to implement such demand-side management actions in the future if need is determined.

Although the ESJGWA does not have direct authority to require GSAs to implement projects, the ESJGWA will coordinate analysis of GSA-level demands and will compile annual or biannual reports to evaluate progress. If projects do not progress, or if monitoring efforts demonstrate that the projects are not effective in achieving stated recharge and/or offset targets, the GWA will convene a working group to evaluate supply-side and demand-side management actions such as the implementation of groundwater pumping curtailments, land fallowing, etc.

Projects to increase water supply availability in the Subbasin were identified by individual GSAs. The initial set of projects was reviewed with the ESJGWA Board, Advisory Committee, and Workgroup. A final list of 23 potential projects are included in the GSP, representing a variety of project types including direct and in-lieu[1] recharge, intra-basin water transfers, demand conservation, water recycling, and stormwater reuse. Projects are classified into three categories based on project status: Planned, Potential, and Longer-term/Conceptual. Planned projects are anticipated to be completed and implemented prior to 2040. Near-term Planned projects are anticipated to provide enough water to meet the required groundwater pumping offset and/or recharge needed to reach sustainability without climate change; however, additional projects will be required in the future to address climate change impacts. Potential projects provide a menu of options for additional water supply projects that can be implemented in the Subbasin. These projects require further analysis and permitting to determine feasibility and cost effectiveness. Longer-term/Conceptual projects are in the early conceptual planning stages and would require significant additional work to move forward. Additionally, a study has been proposed by NSJWCD to evaluate reaches of the Mokelumne River downstream of Camanche Reservoir to support model refinement and validation and to inform SGMA basin accounting. These projects are summarized below.

1 In-lieu recharge refers to the use of surface water or recycled water supplies for applications where groundwater is currently used. This "in-lieu" use reduces groundwater pumping and allows groundwater to remain in the aquifer.

Project Description	Project Type	Project Proponent	Estimated Demand Reduction (AF/year)
Planned Projects:			
Lake Grupe In-lieu Recharge	In-lieu Recharge	Stockton East Water District	10,000
SEWD Surface Water Implementation Expansion	In-lieu Recharge	Stockton East Water District	19,000
City of Manteca Advanced Metering Infrastructure	Conservation	City of Manteca	272
City of Lodi Surface Water Facility Expansion & Delivery Pipeline	In-lieu Recharge	City of Lodi	4,750
White Slough Water Pollution Control Facility Expansion	Recycling/In-lieu Recharge	City of Lodi	115
CSJWCD Capital Improvement Program	In-lieu Recharge	Central San Joaquin Water Conservation District	5,000
NSJWCD South System Modernization	In-lieu Recharge	North San Joaquin Water Conservation District	4,500
Long-term Water Transfer to SEWD and CSJWCD	Transfers/In-lieu Recharge	South San Joaquin GSA	45,000
Potential Projects			
BNSF Railway Company Intermodal Facility Recharge Pond	Direct Recharge	Central San Joaquin Water Conservation District	1,000
City of Stockton Advanced Metering Infrastructure	Conservation	City of Stockton	2,000
South System Groundwater Banking with EBMUD	In-lieu Recharge	North San Joaquin Water Conservation District	4,000
NSJWCD North System Modernization/Lakso Recharge	In-Lieu Recharge/Direct Recharge	North San Joaquin Water Conservation District	2,600
Manassero Recharge Project	Direct Recharge	North San Joaquin Water Conservation District	8,000
Tecklenburg Recharge Project	Direct Recharge	North San Joaquin Water Conservation District	8,000
City of Escalon Wastewater Reuse	Recycling/In-lieu Recharge/Transfers	South San Joaquin GSA	672
City of Ripon Surface Water Supply	In-lieu Recharge	South San Joaquin GSA	6,000
City of Escalon Connection to Nick DeGroot Water Treatment Plant	In-lieu Recharge	South San Joaquin GSA	2,015
Longer-term/Conceptual Projects			
Farmington Dam Repurpose Project	Direct Recharge	Stockton East Water District	30,000
Recycled Water Transfer to Agriculture	Recycling/Transfers/ In-lieu Recharge	City of Manteca	5,193
Mobilizing Recharge Opportunities	Direct Recharge	San Joaquin County	Not determined
NSJWCD Winery Recycled Water	Recycling/In-Lieu Recharge/Direct Recharge	North San Joaquin Water Conservation District	750
Pressurization of SSJID Facilities	Conservation	South San Joaquin GSA	30,000
SSJID Storm Water Reuse	Stormwater/In-lieu Recharge/Direct Recharge	South San Joaquin GSA	1,100

As previously noted, DWR's Consultation Initiation Letter requested additional detail on how projects and management actions, in conjunction with the proposed chronic lowering of groundwater levels sustainable management criteria, will help the subbasin achieve sustainability and avoid significant and unreasonable impacts. As part of the process to respond to DWR, the ESJGWA worked with each GSA individually to update GSP project descriptions with new information that has become available in the past two years since the GSP was first adopted in 2020. These revised projects were then divided into two categories: Category A projects (projects that are likely to advance in the next five years and have existing water rights or agreements) and Category B projects (projects that are not anticipated to advance in the next five years, but could be leveraged in the future, particularly if Category A projects do not fully achieve stated recharge and/or offset targets). Category A projects were simulated in the projected water budget to evaluate their effectiveness on achieving Subbasin sustainability. Category B projects may be elevated to a Category A project should feasibility studies demonstrate a viable project, if water rights or contracts are firmly identified, if partnerships are formed, and if economic evaluation demonstrate that the projects are cost effective, and remain part of the overall adaptive management strategy that the Subbasin is utilizing in GSP implementation to achieve and maintain Subbasin sustainability.

Category A Projects

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
1. Lake Grupe In-Lieu Recharge	Stockton East Water District	In-Lieu Recharge	The surface water source of this project is from SEWD's existing contract with the U.S. Bureau of Reclamation (USBR) for the New Hogan Reservoir. Surface water is diverted from the Calaveras River. This is an existing surface water right.	Drought	2,000	Range of 0-2,000 AFY in multiple dry years
				Dry	4,900	
				Normal	4,900	
				Wet	4,900	
2. SEWD Surface Water Implementation Expansion	Stockton East Water District	In Lieu Recharge	This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir.	Drought	4,000	Range of 0-4,000 AFY in multiple drought years
				Dry	8,000	
				Normal	19,000	
				Wet	19,000	
3. West Groundwater Recharge Basin	Stockton East Water District	Direct Recharge	This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir. In addition to Calaveras River and Stanislaus River water, stormwater runoff will also contribute to the volume of water available for recharge.	Drought	1,500	
				Dry	4,000	
				Normal	16,000	
				Wet	16,000	
4. CSJWCD Capital Improvement Program	Central San Joaquin Water Conservation District	In-Lieu Recharge	This project relies on water from New Melones Reservoir. This is an existing surface water right. CSJWCD has long-term water supply contracts with USBR for the New Melones Unit Central Valley Project.	Drought	0	
				Dry	12,000	
				Normal	24,000	
				Wet	24,000	

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
5. Long-Term Water Transfer to SEWD and CSJWCD	South San Joaquin GSA	Transfers/In-Lieu Recharge	This project relies on water from New Melones Reservoir (Stanislaus River water). This is an existing surface water right (pre-1914) held by Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID).	Drought	20,000	This project currently only covers the transfer of water from OID and SSJID to SEWD urban customers.
				Dry	5,000	
				Normal	0	
				Wet	0	
6. White Slough Pollution Control Facility Expansion	City of Lodi	Recycled Water/In-Lieu Recharge	Treated wastewater effluent from White Slough Water Pollution Control Facility.	Drought	3,729	
				Dry	3,729	
				Normal	3,729	
				Wet	3,729	
7. NSJWCD South System Modernization	North San Joaquin Water Conservation District	In-Lieu Recharge/Direct Recharge	This project relies on water from the Mokelumne River. This is an existing water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	0	
				Normal	4,800	
				Wet	6,000	
8. NSJWCD Tecklenburg Recharge Project	North San Joaquin Water Conservation District	Direct Recharge	This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	1,000	
				Normal	4,800	
				Wet	6,000	
9. NSJWCD South System Groundwater Banking with EBMUD	North San Joaquin Water Conservation District	In-Lieu Recharge	This project relies on water from the Mokelumne River. This is an existing water right held by East Bay Municipal Utility District (EBMUD) (Permit 10478) as per Protest Dismissal Agreement from 11/25/2014.	Drought	0	
				Dry	1,500	
				Normal	6,400	80% of wet year supply
				Wet	8,000	
10. NSJWCD North System Modernization/Lakso Recharge	North San Joaquin Water Conservation District	In-Lieu Recharge/Direct Recharge	This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	1,000	
				Normal	3,200	
				Wet	4,000	
11. Delta Water Treatment Plant Groundwater Recharge Improvements Project	City of Stockton	Direct Recharge	This project relies on raw water from the Delta Water Treatment Plant.	Drought	5,040	
				Dry	5,040	
				Normal	5,040	

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
Geotechnical Investigation				Wet	5,040	

Category B Projects

Project Name	Project Type	Submitting GSA	Current Status	Time-table (initiation and completion)	Annual Volume (AFY)
Perfecting Mokelumne River Water Right	In-lieu Recharge	San Joaquin County	Planning phase	2022-2025	20,000 to 50,000
City of Manteca Advanced Metering Infrastructure	Conservation	City of Manteca	Currently underway	2019-2021	272
City of Lodi Surface Water Facility Expansion & Delivery Pipeline	In-lieu Recharge	City of Lodi	Planning phase	2030-2033	4,750
BNSF Railway Company Intermodal Facility Recharge Pond	Direct Recharge	CSJWCD	Planning phase	2020-2023	1,000
City of Stockton Advanced Metering Infrastructure	Conservation	City of Stockton	Initial study completed in 2011	2020/25-2025/28	2,000
Manaserro Recharge Project	Direct Recharge	NSJWCD	Planning phase	2019-2022*	8,000
City of Escalon Wastewater Reuse	Recycling/ In-lieu Recharge/ Transfers	SSJ GSA	Planning phase	2020-2028	672
City of Ripon Surface Water Supply	In-lieu Recharge	SSJ GSA	Design complete; environmental permitting underway	2020-2024	6,000
City of Escalon Connection to Nick DeGroot Water Treatment Plant	In-lieu Recharge	SSJ GSA	Conceptual design phase; environmental review complete	2020-2023	2,015
Farmington Dam Repurpose Project	Direct Recharge	SEWD	Preplanning phase with reconnaissance study complete	2030-2050	30,000
Recycled Water Transfer to Agriculture	Recycling/Transfers/ In-lieu Recharge	City of Manteca	Planning phase with evaluation completed in Draft Reclaimed Water Facilities Master Plan	Not determined	5,193
Mobilizing Recharge Opportunities	Direct Recharge	San Joaquin County	Early conceptual planning phase	Not determined	Not determined
NSJWCD Winery Recycled Water	Recycling/ In-Lieu Recharge/ Direct Recharge	NSJWCD	Conceptual planning and discussion	2025-2027	750

Project Name	Project Type	Submitting GSA	Current Status	Time-table (initiation and completion)	Annual Volume (AFY)
Pressurization of SSJID Facilities	Conservation	SSJ GSA	Feasibility study complete	2019-2030	30,000
SSJID Storm Water Reuse	Storm Water/ In-lieu Recharge/ Direct Recharge	SSJ GSA	Planning phase	2027-2030	1,100

ES-11. GSP IMPLEMENTATION

The overdraft condition in the Subbasin requires projects to offset groundwater pumping and/or increase recharge. The exact amount of required offset/recharge will be reevaluated after additional data are collected and analyzed.

Projects will be administered by the GSA project proponents. GSAs may elect to implement projects individually or jointly with one or more GSAs or with the ESJGWA.

Implementing the GSP will require numerous management activities that will be undertaken by the ESJGWA, including the following:

- Monitoring and recording of groundwater levels and groundwater quality data
- Maintaining and updating the Subbasin DMS with newly collected data
- Annual monitoring of progress toward sustainability
- Annual reporting of Subbasin conditions to DWR as required by SGMA
- Refining Subbasin model and water budget planning estimates
- Evaluating the GSP once every 5 years and updating if warranted

The ESJGWA Board adopted a preliminary schedule for project implementation. Project implementation is scheduled to begin in 2020, with full implementation by 2040. This approach provides adequate time to put in place methods necessary to refine model estimates and verify project cost effectiveness.

Implementation of the eight identified Planned Projects will begin prior to 2030 and will continue through 2040. Evaluation and possible implementation of the nine Potential Projects and six Longer-term/Conceptual Projects will be based on long-term management or changing needs of the GSA or Subbasin. Further evaluation is necessary to determine technical, economic, and institutional feasibility.

ES-12. FUNDING

Implementation of the GSP requires funding sources. To the degree they become available, outside grants will be sought to assist in reducing cost of implementation to participating agencies, residents, and landowners of the Subbasin. However, there will be a need to collect funds to support implementation.

The areas associated with ESJGWA-wide management and GSP implementation will be borne by the ESJGWA through contributions from the member GSAs, under a cost-sharing arrangement to be developed following GSP adoption. These costs include:

- ESJGWA administration
- Groundwater level monitoring and reporting
- Groundwater quality monitoring and reporting

- Water use estimation
- Data management
- Stakeholder engagement
- Annual report preparation and submittal to DWR
- Developing and implementing a funding mechanism
- Grant applications
- GSP evaluation and updates, if warranted (every 5 years)

For budgetary purposes, the estimated initial cost of these activities is on the order of $600,000 to $1 million per year excluding projects and management actions costs and costs associated with the installation of new monitoring wells and grant writing. Additional one-time costs, such as model refinement, are estimated to be on the order of $315,000.

GSAs will individually fund implementation of projects in their respective areas. Options for GSA funding include fees based on groundwater pumping, acreage, or combinations of these, and pursuit of any available grant funds. The GSAs will evaluate options for securing the needed funding on an individual basis.

The estimated initial costs of projects range from on the order of $50,000 to $328 million, depending on the project. Annual project costs range from $3,000 to $9 million per year to provide funds for operations and maintenance.

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1. AGENCY INFORMATION, PLAN AREA, AND COMMUNICATION

1.1 INTRODUCTION AND AGENCY INFORMATION

1.1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this Groundwater Sustainability Plan (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 if continued over the planning and implementation horizon
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- 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 the Department of Water Resources (DWR) as critically overdrafted. The Eastern San Joaquin Groundwater Sustainability Plan (Eastern San Joaquin GSP, 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 have occurred previously or are concurrently proceeding. The following figure (Figure 1-1) shows flagship reports from these efforts, which include integrated regional water management, urban water management, agricultural water management, watershed management, habitat conservation, and general planning. 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 1.2.2.7 of this document.

Figure 1-1: Interconnected Planning and Modeling Efforts for Water Resource Protection

1.1.2 Sustainability Goal

A sustainability goal is the culmination of conditions resulting in a sustainable condition (absence of undesirable results) within 20 years. The sustainability goal reflects this requirement and succinctly states the GSP's objectives and desired conditions of the Subbasin.

The sustainability goal description for the Eastern San Joaquin Subbasin is *to maintain an economically-viable groundwater resource for the beneficial use of the people of the Eastern San Joaquin Subbasin by operating the Subbasin within its sustainable yield or by modification of existing management to address future conditions. This goal will be achieved through the implementation of a mix of supply and demand type projects consistent with the GSP implementation plan* (see Chapter 6: Projects and Management Actions).

Additional discussion of the sustainability goal can be found in Chapter 3: Sustainable Management Criteria.

1.1.3 Contact Information

The San Joaquin County Department of Public Works Director has been designated as Plan Manager and record keeper. As Plan Manager, the Public Works Director is tasked with submitting a single, jointly-composed GSP to DWR on behalf of the entire Subbasin. Contact information for the submitting agency and Plan Manager is provided in Figure 1-2.

Figure 1-2: Plan Manager 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

Fritz Buchman, C.E., T.E., CFM
Director
San Joaquin County Department of Public Works
1810 E. Hazelton Ave.,
Stockton, CA 95205
(209) 468-3101

fbuchman@sjgov.org

1.1.4 Agency Information

The Eastern San Joaquin GSP was developed jointly by the Eastern San Joaquin Groundwater Authority (ESJGWA), which is a joint powers authority formed by the 16 groundwater sustainability agencies (GSAs) within the Eastern San Joaquin Subbasin. The ESJGWA includes the Central Delta Water Agency (CDWA), Central San Joaquin Water Conservation District (CSJWCD), City of Lodi, City of Manteca, City of Stockton, Eastside San Joaquin GSA (Eastside GSA) (composed of Calaveras County Water District [CCWD], Stanislaus County, and Rock Creek Water District), Linden County Water District (LCWD), Lockeford Community Services District (LCSD), North San Joaquin Water Conservation District (NSJWCD), Oakdale Irrigation District (OID), San Joaquin County No. 1, San Joaquin County No. 2, South Delta Water Agency (SDWA), South San Joaquin GSA (composed of South San Joaquin Irrigation District [SSJID] including Woodward Reservoir, City of Ripon, and City of Escalon), Stockton East Water District (SEWD), and Woodbridge Irrigation District (WID). Collectively, these 16 GSAs will be referred to as “GSAs”. Figure 1-3 below indicates the jurisdictional boundaries of the individual GSAs.

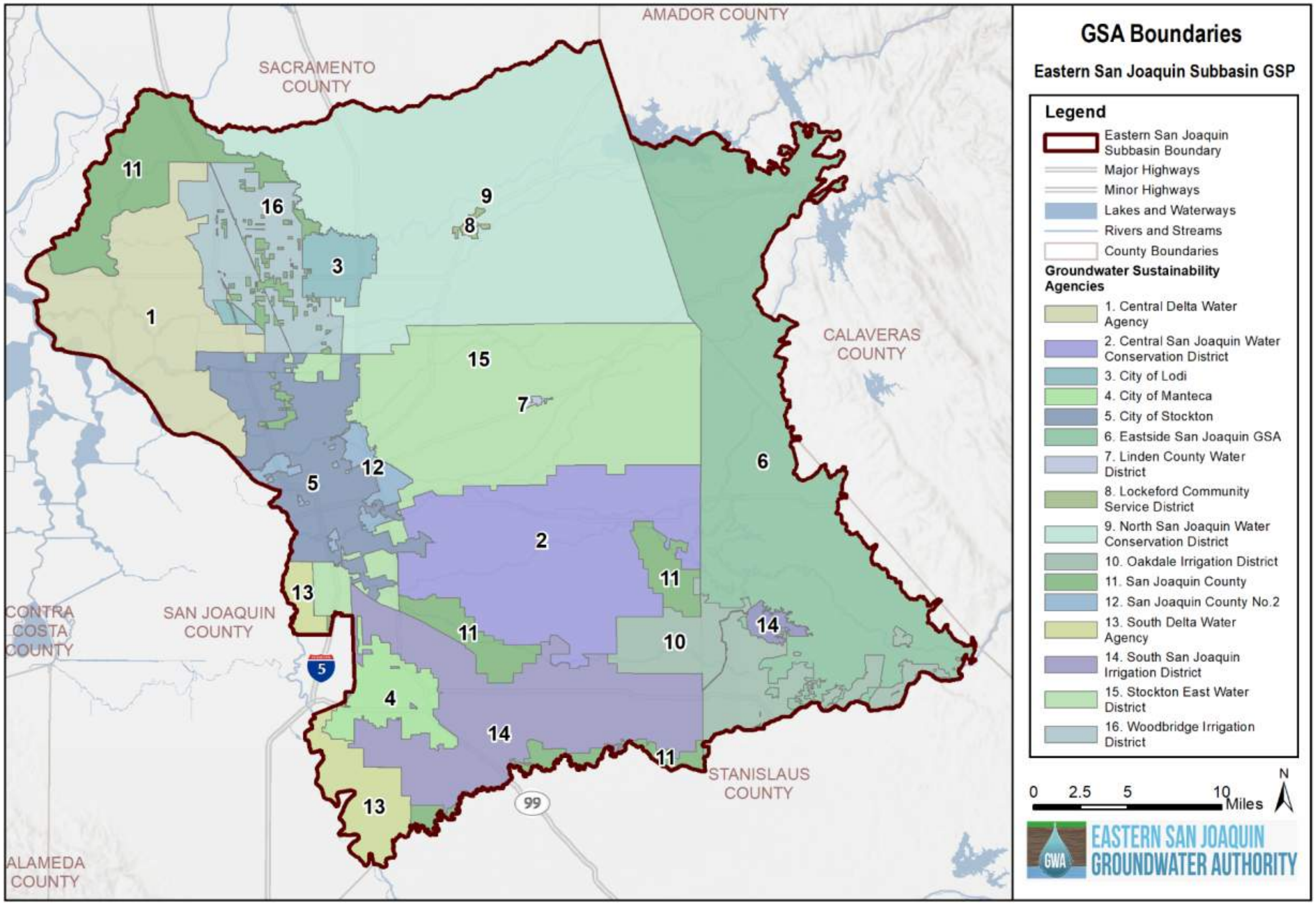
The GSAs represent a diverse range of water management organizations. The agencies include water agencies, irrigation districts, water conservation districts, and local governments at the city and county level. The GSAs will work through the ESJGWA to implement this GSP to cover the entire geographic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

California Water Service 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 prohibited it from forming its own GSA under SGMA regulations until later amendments under SB 13 (Pavley). 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.

The portion of the City of Lathrop located east of the San Joaquin River was initially involved in the Eastern San Joaquin Subbasin GSP development process as a 17th GSA (City of Lathrop GSA) and was part of the ESJGWA. The City of Lathrop GSA voluntarily withdrew its status from the ESJGWA in March 2019 following DWR’s approval of their request for a basin boundary modification between the Eastern San Joaquin Subbasin and the neighboring Tracy Subbasin, which moved the City of Lathrop entirely within the Tracy Subbasin.

Additionally, WID voluntarily withdrew its status as a GSA and its membership in the ESJGWA in December 2018; WID reinstated its status as a GSA and its membership in the ESJGWA in October 2019.

Figure 1-3: Eastern San Joaquin Groundwater Sustainability Agencies



1.1.4.1 Eastern San Joaquin Groundwater Authority Joint Powers Agreement

The Joint Powers Agreement (JPA) provides the basis for forming the ESJGWA. The ESJGWA 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 1-A.

The purpose of the ESJGWA is to act as the coordinating agency and cooperatively carry out the purposes of SGMA in the Eastern San Joaquin Subbasin. The ESJGWA 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 ESJGWA 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 Subbasin. Collaboration among the ESJGWA 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).

1.1.4.2 Organization and Management Structure of the GSAs

The governing body of the ESJGWA, the ESJGWA Board of Directors (ESJGWA 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 16 GSAs has a voice on the ESJGWA Board and has appointed two representatives to serve: one Board member and one Alternate member to attend in the Board member's absence.

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

- Approving budget(s) and appropriate cost sharing for any project or program that requires funding from the ESJGWA
- Proposing guidance and options for obtaining grant funding
- Adopting rules, regulations, policies, and procedures related to the JPA
- Approving 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
- Approving and implementing a GSP

The ESJGWA 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 matters. The Advisory Committee is tasked with developing actions including, but not limited to, the following:

- Recommending 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
- Recommending the action and/or approval of a GSP

The ESJGWA 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 Subbasin. 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 1.3.4.2.

Decisions of the ESJGWA 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 ESJGWA 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 ESJGWA beyond expenditures approved in the annual budget; adoption of rules, regulations, policies, bylaws, and procedures related to the function of the ESJGWA; decisions related to the establishment of the members' percentage obligations for payment of the ESJGWA'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 ESJGWA 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 ESJGWA Bylaws in Appendix 1-A.

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

1.1.4.3 Description of Participating Agencies

A brief description of each of the GSAs that make up the ESJGWA is provided in the sections below.

Central Delta Water Agency – The Central Delta Water Agency (CDWA) 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, fruit and nut trees, row crops, and field crops. CDWA protects water supply within its service area (which extends outside of the Subbasin), assists landowners and reclamation districts with water issues, and represents landowners in flood control matters. CDWA does not own any facilities, and surface water from the Delta is the area's only utilized 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 – The 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 United States 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 ESJGWA 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 of Lodi relies on both groundwater and surface water to satisfy customer needs. In 2003, Lodi entered into a 40-year agreement with 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 covers 9,000 acres and includes the White Slough Water Pollution Control Facility area (City of Lodi, 2015).

City of Manteca – The approximately 13,000 acres of 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 of treated surface water 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 (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 of Stockton grows. The City of Stockton GSA (approximately 39,000 acres) overlaps with the extent of the Cal Water service area (City of Stockton, 2015).

Eastside San Joaquin GSA – Eastside San Joaquin GSA (Eastside GSA) is 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 (CCWD) serves a population of 20,700 people through 17,000 service connections and shares the same boundaries as Calaveras County. Supply for CCWD 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. CCWD 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 the 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 973,000 acres and nine incorporated cities and extends beyond Eastern San Joaquin Subbasin. 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. These incorporated cities are outside of the Subbasin. The portions of Stanislaus County that fall within the Eastern San Joaquin Subbasin not already included in a GSA have partnered with the CCWD and Rock Creek Water District as the Eastside 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 1,800 acres in northeastern Stanislaus County. Through the Salt Spring Valley Reservoir in Calaveras County, Rock Creek Water District delivers agricultural water for irrigation (Stanislaus LAFCO, 2018).

Linden County Water District – Linden County Water District (LCWD) provides water and wastewater services to the 300 acres of the unincorporated community of Linden, located approximately 12 miles northeast of the City of Stockton along State Route 26. LCWD 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. LCWD relies on groundwater to meet residential demands in Linden (SJC, 1992).

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

North San Joaquin Water Conservation District GSA – North San Joaquin Water Conservation District (NSJWCD), organized in 1948 under provisions of the Water Conservation District Act of 1931, includes approximately 149,000 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, NSJWCD was located in both the Cosumnes and the Eastern San Joaquin Subbasins. NSJWCD 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 ESJGWA that focused on groundwater management (Eastern San Joaquin County GBA, 2014).

Oakdale Irrigation District – 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 (over 31,000 acres), 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 consists of 51,000 acres of areas within the Eastern San Joaquin Subbasin not covered by the other GSAs. Overlapping agencies include North Delta Water Agency (NDWA), unincorporated county, riparian land along Stanislaus River, and areas in the City of Stockton served by the City of Stockton MUD. 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. San Joaquin County has also 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.

- North Delta Water Agency – The NDWA was formed by a special act of the Legislature in 1973 to protect the water supply against seawater 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). The reclamations districts within the NDWA and the Eastern San Joaquin Subbasin include Reclamation District (RD) 38 – Staten Island, RD 2086 – Canal Ranch, and RD 348 – New Hope Tract.

San Joaquin County No. 2 (Cal Water) – San Joaquin County No. 2 GSA includes approximately 7,000 acres of the unincorporated San Joaquin County portion of the Cal Water Service Area. 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 South Delta Water Agency (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 SDWA 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 highly saline (Eastern San Joaquin County GBA, 2014).

South San Joaquin GSA – South San Joaquin GSA's 64,000 acres encompass most of the South San Joaquin Irrigation District (SSJID), including Woodward Reservoir and canals leading to SSJID; the City of Ripon; and the City of Escalon. The portion of SSJID within the incorporated City of Manteca is included in the City of Manteca GSA.

- South San Joaquin Irrigation District – 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 account for approximately 20,000 acres of the SSJID 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 Manteca, Lathrop, and Tracy for the SCWSP, with Escalon to receive water in the future (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 people and is expected to grow to about 30,800 people 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 of Escalon (SSJID, 2015b).

Stockton East Water District – Stockton East Water District (SEWD) was formed in 1948, includes a total of 143,300 acres, overlaps with portions of WID, and includes the entire City of Stockton and the entire Cal Water service area. The SEWD GSA covers 101,000 acres of the district, with the remaining SEWD areas covered by the City of Stockton, San Joaquin County, and San Joaquin County No. 2 GSAs. SEWD is guaranteed 56.5 percent of New Hogan Reservoir's yield and is provided a total amount of 75,000 AF/year from New Melones Reservoir through agreements with USBR. SEWD delivers wholesale drinking water to the City of Stockton, Cal Water, San Joaquin County, and Woodbridge Irrigation District (WID) 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 efforts preceding the current ESJGWA that focused on groundwater management (Eastern San Joaquin County GBA, 2014).

Woodbridge Irrigation District – WID, organized in 1924 under the California Irrigation District Act, encompasses a gross area of approximately 42,900 acres with over 29,000 acres covered by the WID GSA. WID is discontinuous, resulting in patches of non-district lands within its boundary, and overlaps with portions of NSJWCD, SEWD, and the City of Lodi. WID owns and operates the Woodbridge Diversion Dam, located on the Lower Mokelumne River northeast of the City of Lodi, as well as an extensive canal system serving approximately 13,000 acres west of Lodi and north of Stockton. Recent improvements made to the new Woodbridge Diversion Dam include state-of-the-art fish and diversion works which enable WID to keep Lodi Lake full year-round. At the regional level, WID has participated as a member agency in regional groundwater management efforts, including the GBA.

1.1.4.4 Legal Authority

Any local public agency that has water supply, water management, or land use responsibilities in a basin can decide to become a GSA under SGMA. 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 ESJGWA has legal authority to jointly prepare, adopt, and implement a GSP consistent with the terms of the JPA Agreement and the ESJGWA Bylaws (Eastern San Joaquin GWA, 2017a).

The ESJGWA's JPA calls out the following powers granted to GSAs by SGMA:

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

Each GSA that is a member of the ESJGWA has its own legal authorities. For example, NSJWCD has the legal authorities granted to a GSA under the California Water Code (Water Code) as well as the legal authorities granted to a Water Conservation District pursuant to Water Code § 74000 et seq. The legal authorities of each GSA are listed in Appendix 1-B. Agency resolutions to become GSAs are provided in Appendix 1-C.

1.1.4.5 Estimated Costs and Approach to Meeting Costs

Implementation of the GSP requires funding sources. To the degree they become available, outside grants will be sought to assist in reducing cost of implementation to participating agencies, residents, and landowners of the Subbasin. However, there will be a need to collect funds to support implementation.

For budgetary purposes, the estimated initial cost of these activities is on the order of $600,000 to $1 million per year excluding projects and management actions costs and costs associated with the installation of new monitoring wells and grant writing. Additional one-time costs, such as model refinement, are estimated to be on the order of $315,000. The ESJGWA Board will evaluate options for securing the needed funding. Additional detail on GSP implementation costs and funding sources are detailed in Chapter 7: Plan Implementation.

1.1.5 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 1-D (CA DWR, 2016d).

1.2 PLAN AREA

1.2.1 Description of Plan Area

This section 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.

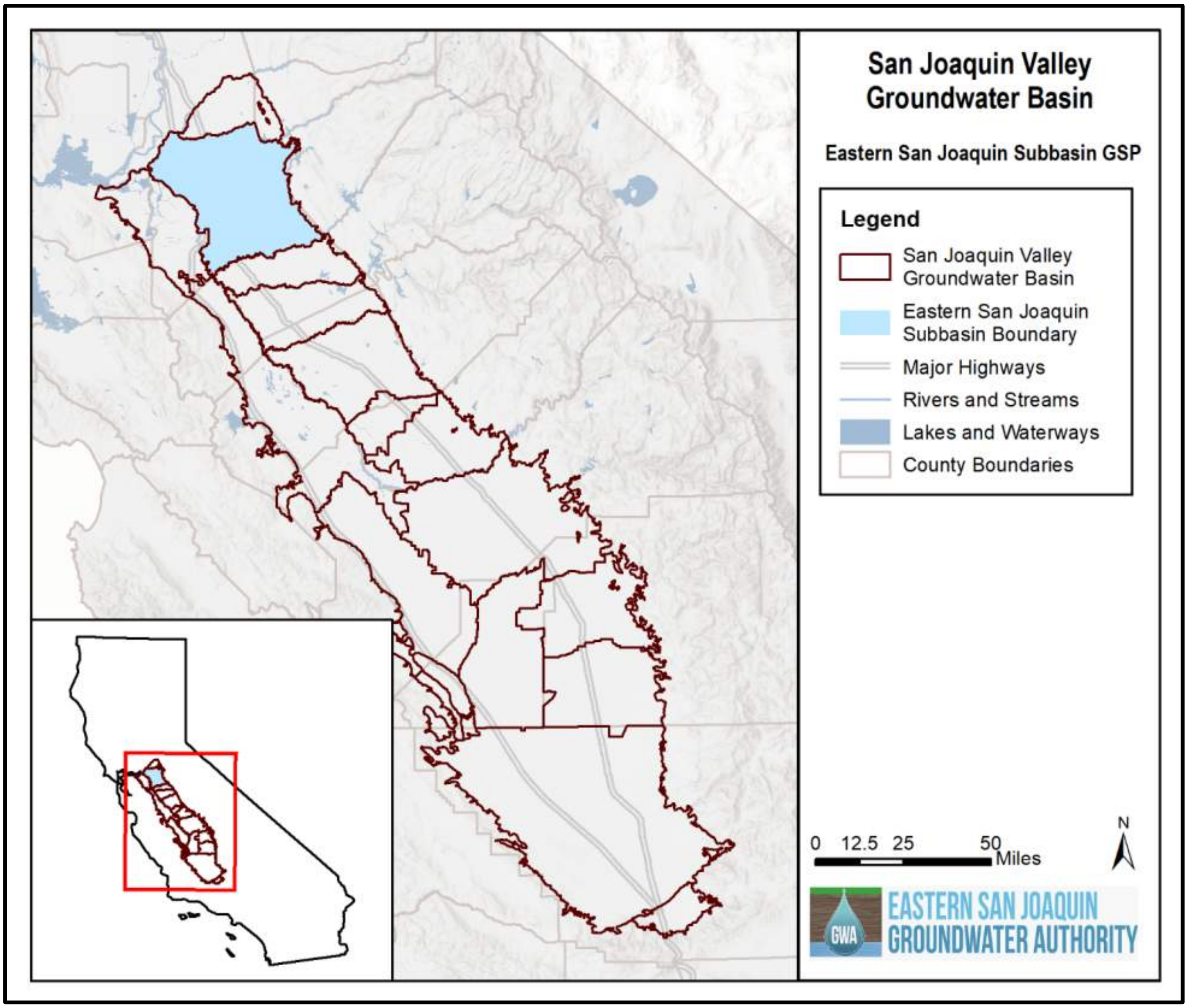
1.2.1.1 Summary of Jurisdictional Areas and Other Features

The Eastern San Joaquin Subbasin falls within the larger San Joaquin Valley Groundwater Basin (see Figure 1-4). Basin designations by DWR were first published in 1952 in Water Quality Investigations Report No. 3, *Ground Water Basins in California*, and subsequently updated in Bulletin 118 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 Solano 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) and East Contra Costa Subbasin (Bulletin 118 Basin Number 5-022.19) (see Figure 1-5).

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).

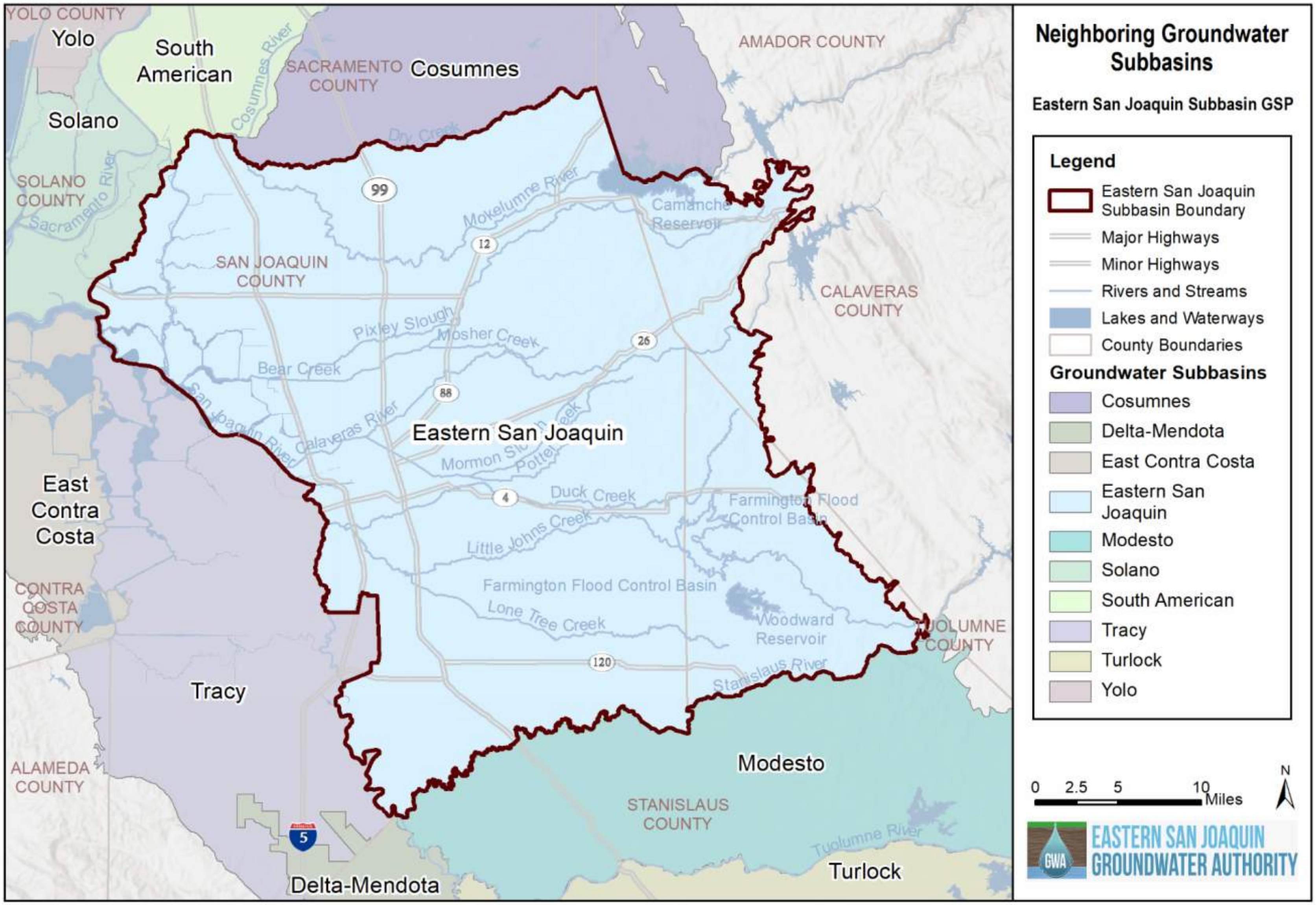
No adjudicated areas or areas covered by an alternative to a GSP exist within the Eastern San Joaquin Subbasin.

Figure 1-4: Placement within the San Joaquin Valley Groundwater Basin



EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY

Figure 1-5: Neighboring Groundwater Subbasins



The Eastern San Joaquin Subbasin underlies areas of San Joaquin, Stanislaus, and Calaveras Counties. Figure 1-6 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 1-6: Underlying and Surrounding Counties

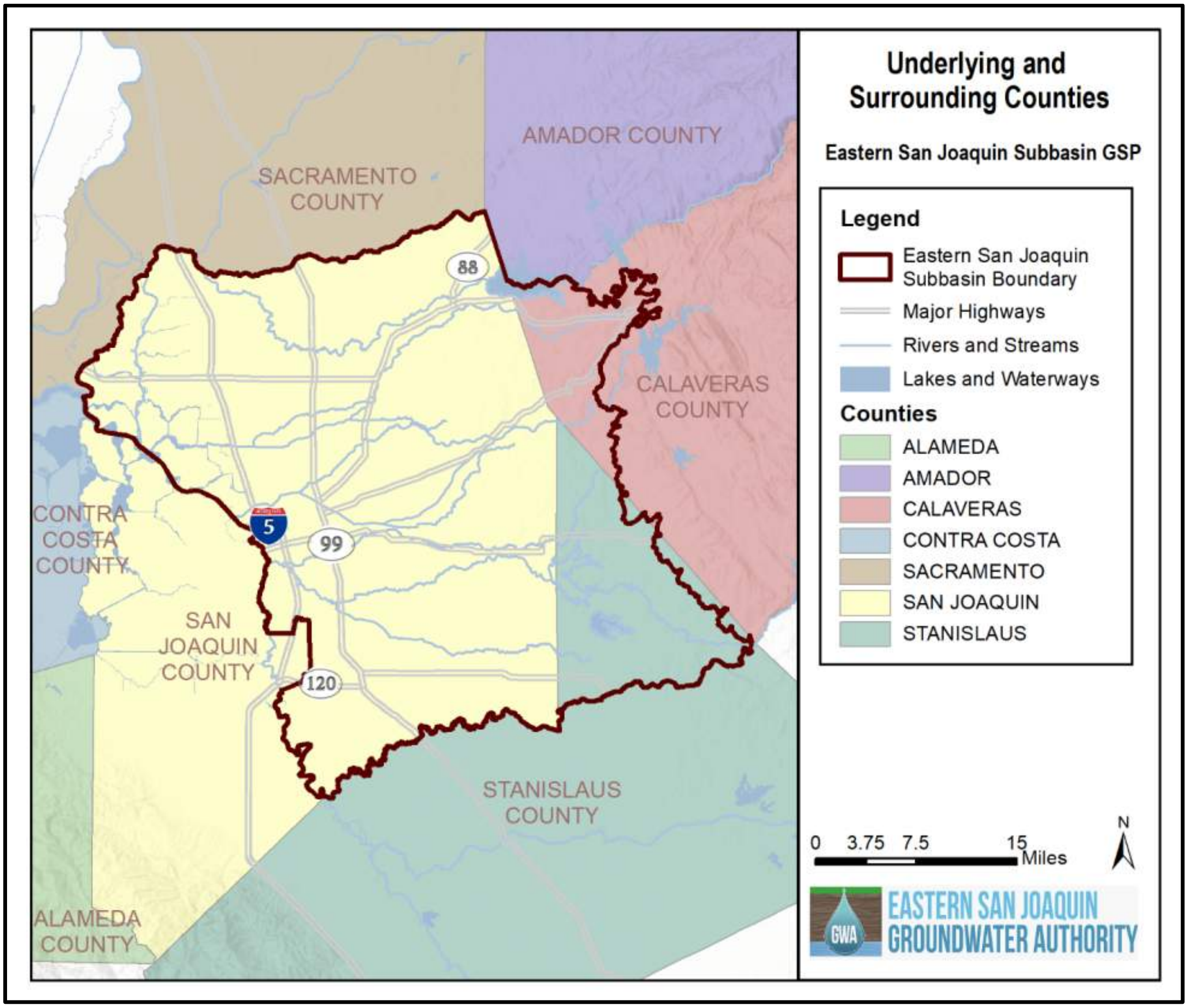


Figure 1-7 shows the Eastern San Joaquin Subbasin and the Subbasin's key geographic features. The Subbasin encompasses an area of about 1,195 square miles. There are eight entities within the region with land use jurisdiction: the County of San Joaquin, the County of Calaveras, the County of Stanislaus, 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 western portions of San Joaquin County and the City of Stockton, and eastern portions of Calaveras and Stanislaus counties, lie in neighboring subbasins or outside of groundwater subbasins altogether. The Eastern San Joaquin Subbasin encompasses the following unincorporated communities: Acampo, Adela, Atlanta, August, Bear Creek, Burson, Clements, Collierville, Country Club, Dogtown, East Oakdale, Eugene, Farmington, French Camp, Garden Acres, Goodmans Corner, Jenny Lind, Kennedy, Knights Ferry, Lake Camanche Ranches, Lincoln Village, Linden, Lockeford, Milton, Morada, Mormon, Oak Grove, Peters, South Camanche Shore, Taft Mosswood, Terminous, Thornton, Valley Home, Valley Springs, Victor, Wallace, Waterloo, Woodbridge, and Youngstown.

Figure 1-7: City Boundaries

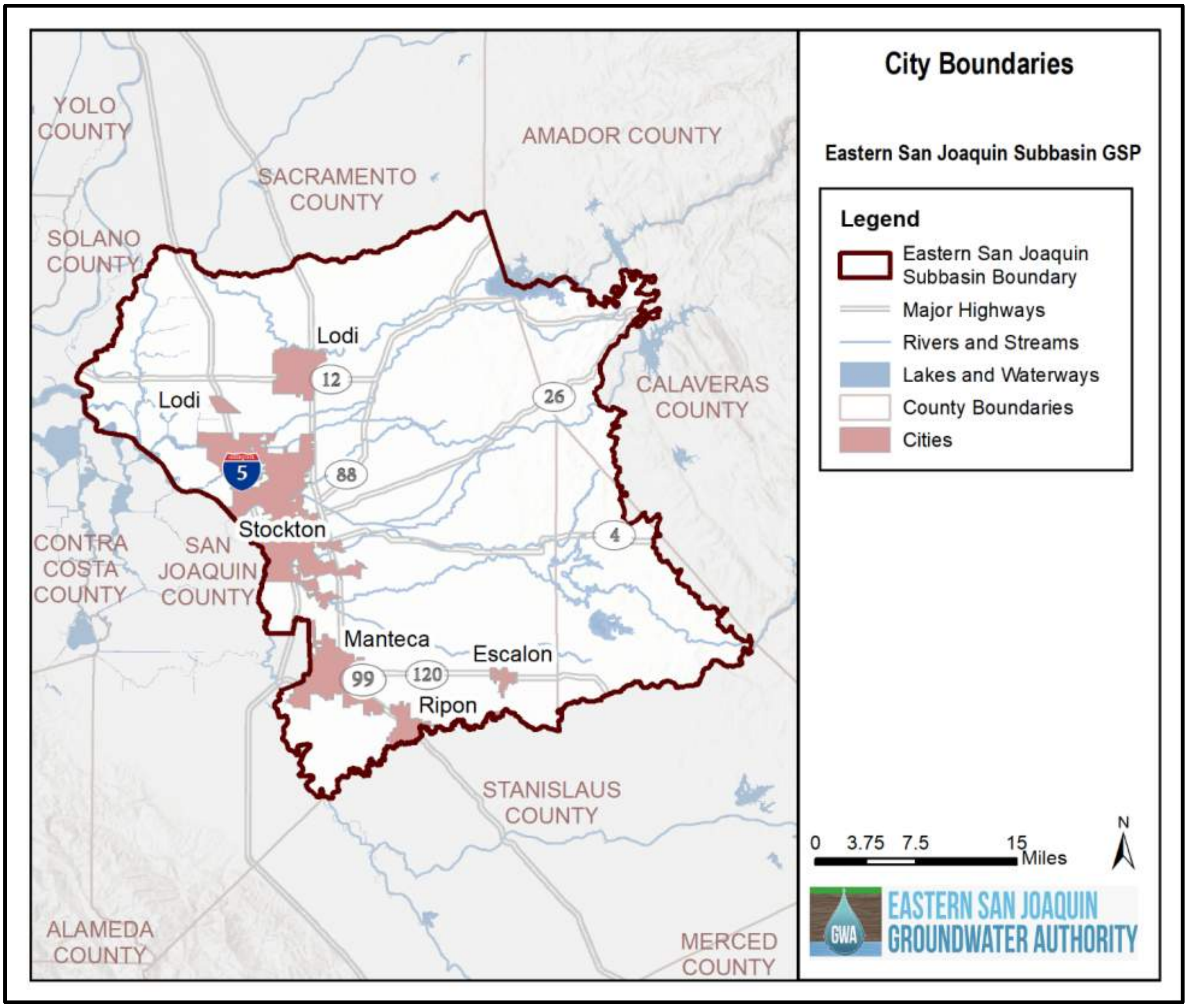


Figure 1-8 shows the spatial extent of Disadvantaged Communities (DACs) and Severely Disadvantaged Communities (SDACs) in the Eastern San Joaquin Subbasin. DWR defines DACs as census geographies (census tracts, census block groups, and census-designated places) with an annual median household income (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 1-8: Disadvantaged Communities (DACs)

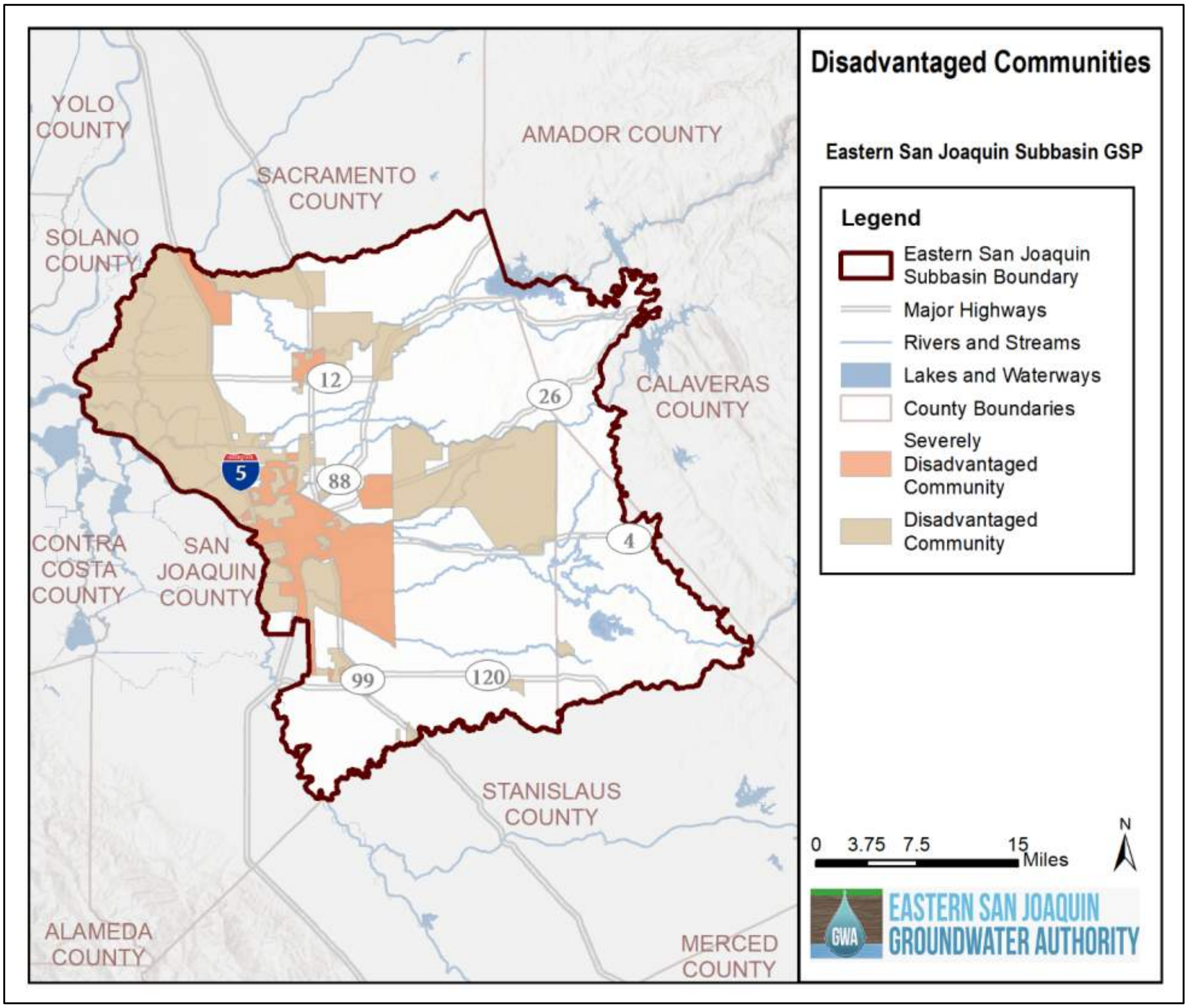
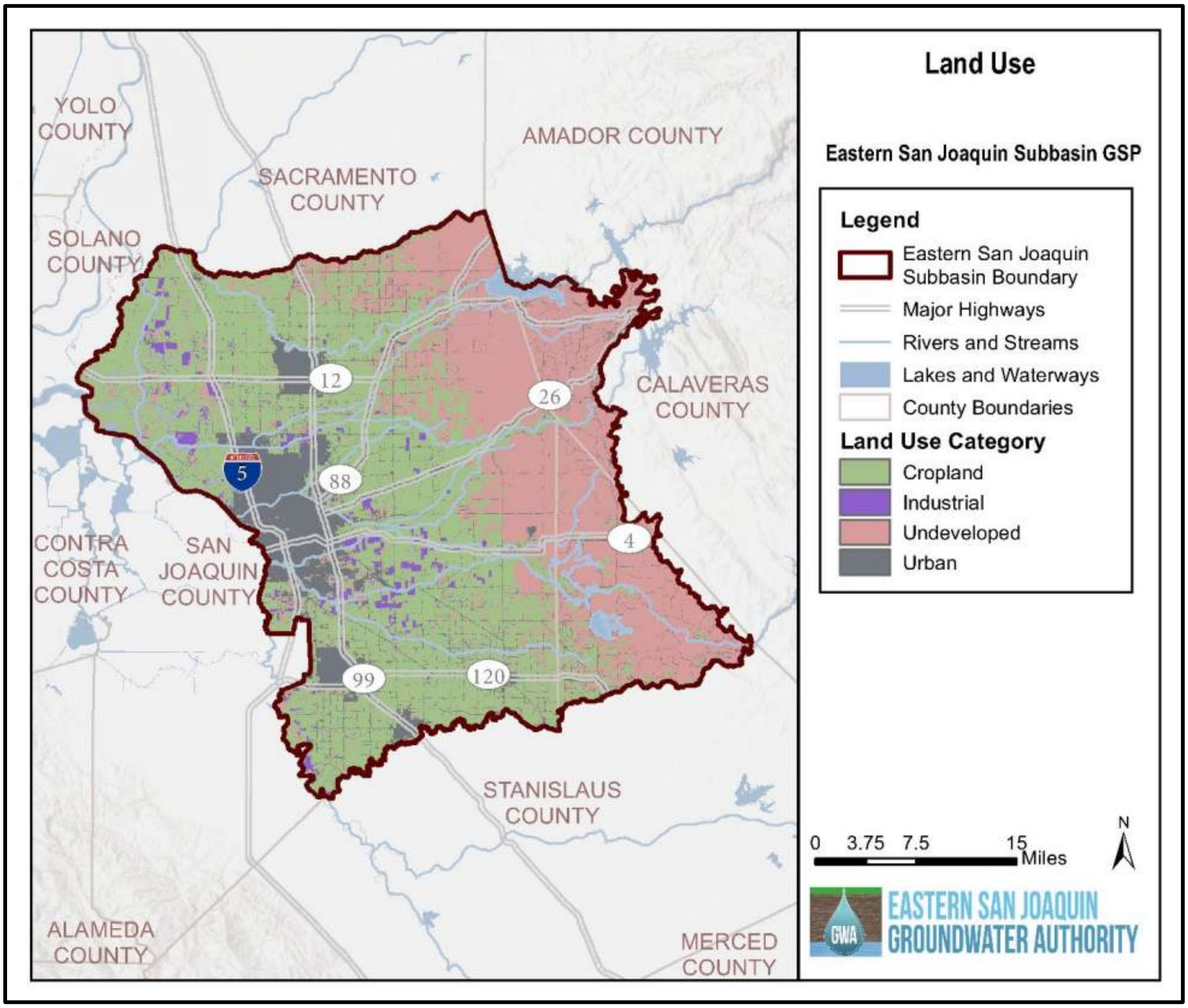


Figure 1-9 shows a map of land use in the Eastern San Joaquin Subbasin across four general categories: cropland, industrial, undeveloped, and urban. These categories were mapped based on categories provided by 2015 land use from the United States Department of Agriculture's (USDA) CropScape 2015 dataset.

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. Both agricultural and urban land use rely on a combination of surface water and groundwater, with some agricultural lands using recycled or reusing water. Land use is primarily controlled by local agencies. Land use patterns in the low foothills to the east are dominated by native vegetation and unirrigated pasture lands (USDA, 2015).

Figure 1-9: Land Use



Crop type varies by region, with fruit and nut trees 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 1-10). Irrigated crop acreage in the Subbasin are 37 percent fruit and nut trees, 24 percent vineyards, and 11 percent alfalfa and irrigated pasture, according to the 2015 CropScape dataset (USDA, 2015).

Figure 1-10: Land Use by Crop Type

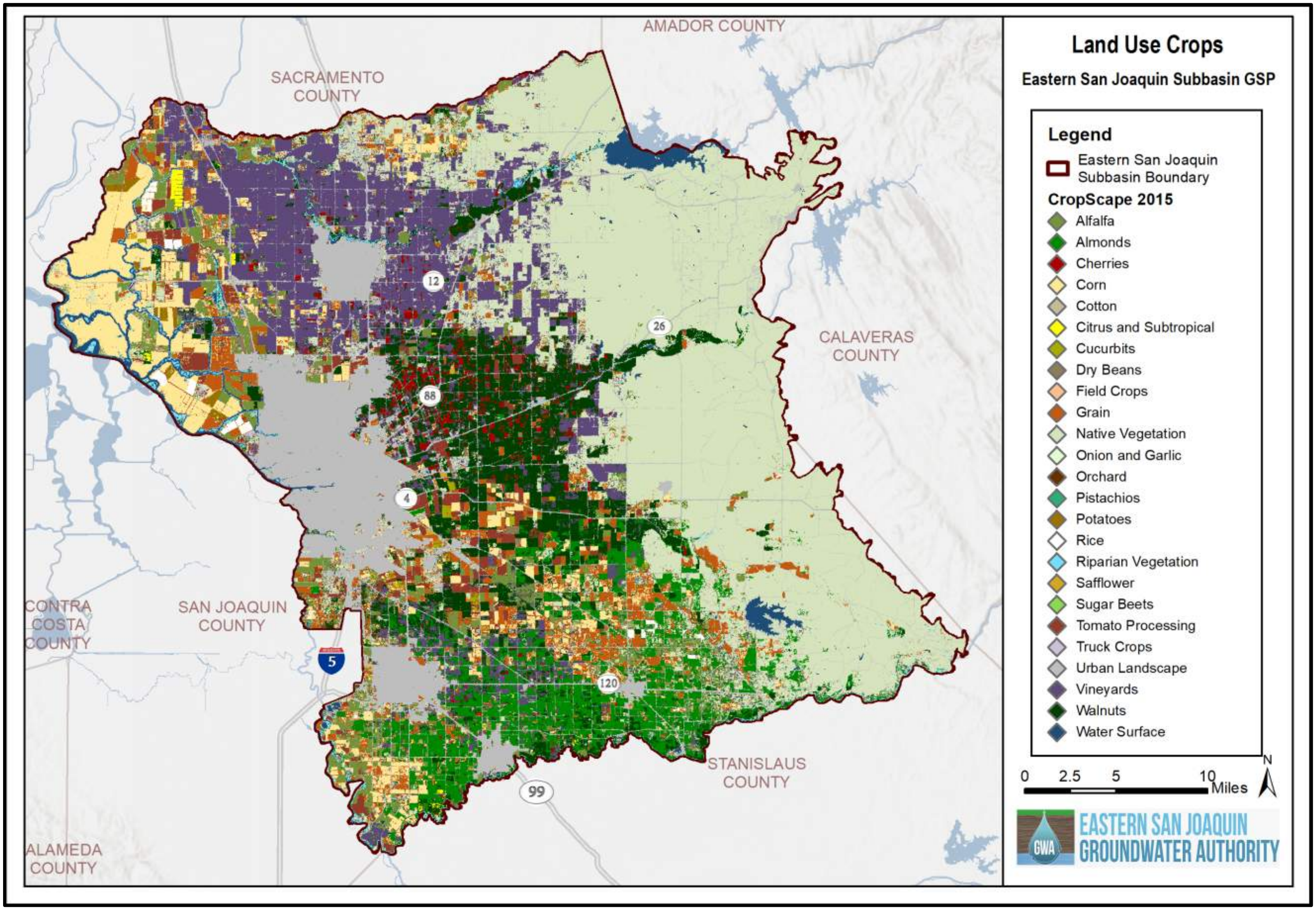


Figure 1-11 shows a map with boundaries of federal and state public lands within the region that includes the Eastern San Joaquin Subbasin. The United States Fish and Wildlife Service (USFWS) manages the San Joaquin River National Wildlife Refuge situated in Stanislaus County where the Tuolumne, Stanislaus, 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 (USFWS, 2012).

The California Department of Parks and Recreation (California State Parks, 2019) 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, 2019). 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.

The California Department of Fish and Wildlife (CDFW) owns 880 acres of man-made ditches, canals, and marshes with both grassland and riparian habitat, recognized as the White Slough Wildlife Area. The property was designated by the Fish and Game Commission in 1980 and provides recreational opportunities such as fishing, hunting, and hiking (CDFW, 2019a). CDFW also maintains the 353-acre Woodbridge Ecological Reserve to protect primarily the sandhill crane population, but also other migratory waterfowl. The sandhill crane was listed as a threatened species in 1983. Woodbridge Ecological Reserve and the greater Stockton Delta wetlands make up the largest freshwater marsh in California (CDFW, 2019b). Lastly, Vernalis Ecological Reserve is also shown in Figure 1-11. It serves as a public access area owned by CDFW for hunting and wildlife viewing (CDFW, 2019c).

Figure 1-11: US Fish and Wildlife Service, California State Parks, and California Department of Fish and Wildlife Boundaries

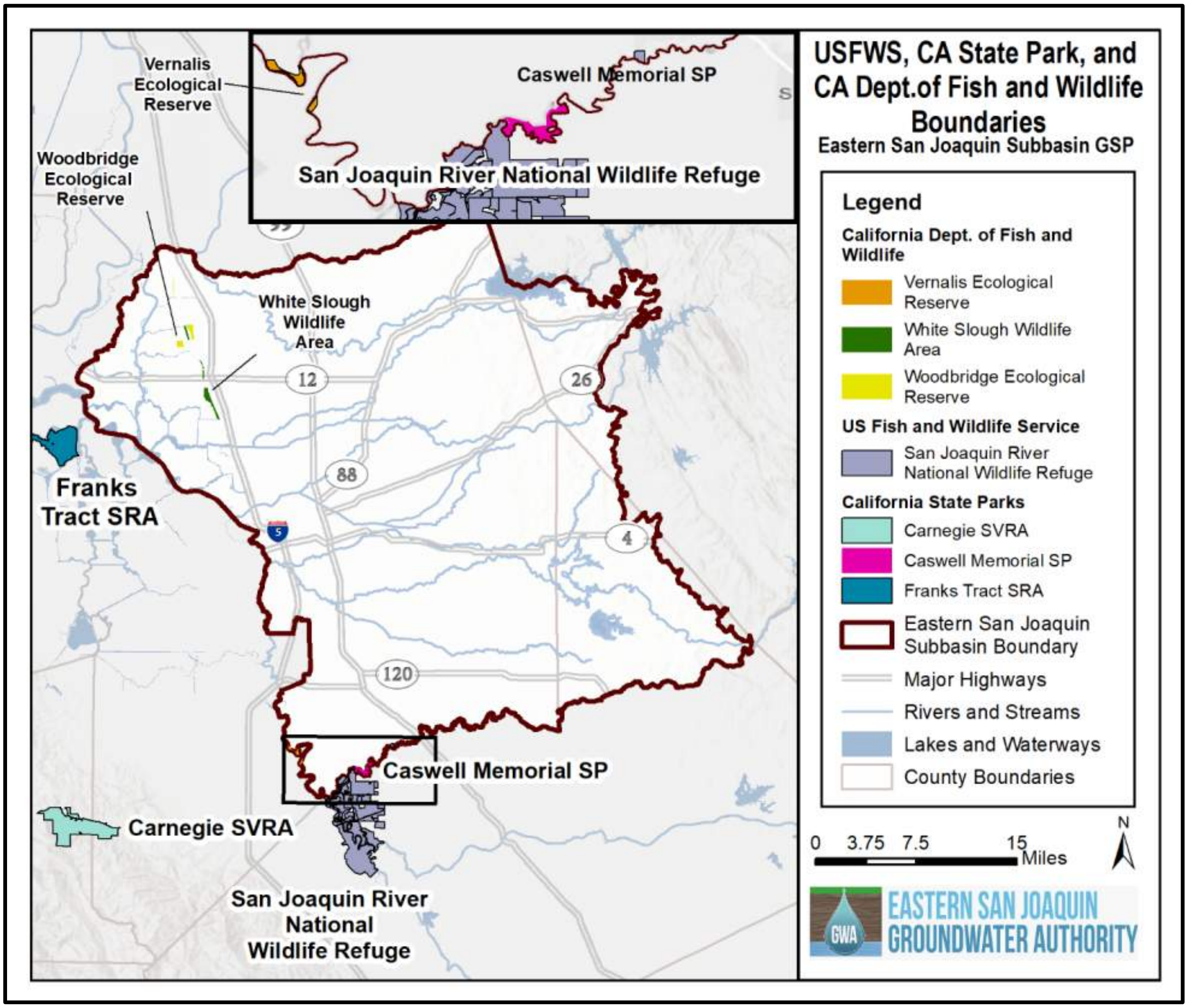


Figure 1-12 to Figure 1-14 shows the density of domestic, public, and production wells per square mile in the Eastern San Joaquin Subbasin, as classified by the DWR Online System for Well Completion Reports (OSWCR), which is discussed in Section 1.2.2.1. This includes approximately 1,000 unique wells collected primarily from DWR's Water Data Library (WDL), but also other state, regional, and local monitoring entities. Though there are overlaps and discrepancies in the designation of wells, domestic wells are largely private residential wells, public wells are municipal-operated wells, and production wells are for irrigation, municipal, public, and industrial purposes (CA DWR, 2019). Areas with few wells exist in the Subbasin, particularly in the northwestern corner of the Subbasin and to the east. Wells containing groundwater level data are described further in Section 1.2.2.1. Community water systems, defined by the State Water Resources Control Board (SWRCB) as wells serving 15 or more connections or more than 25 people per day, are identified in Appendix 1-F.

Figure 1-12: Density of Domestic Wells per Square Mile

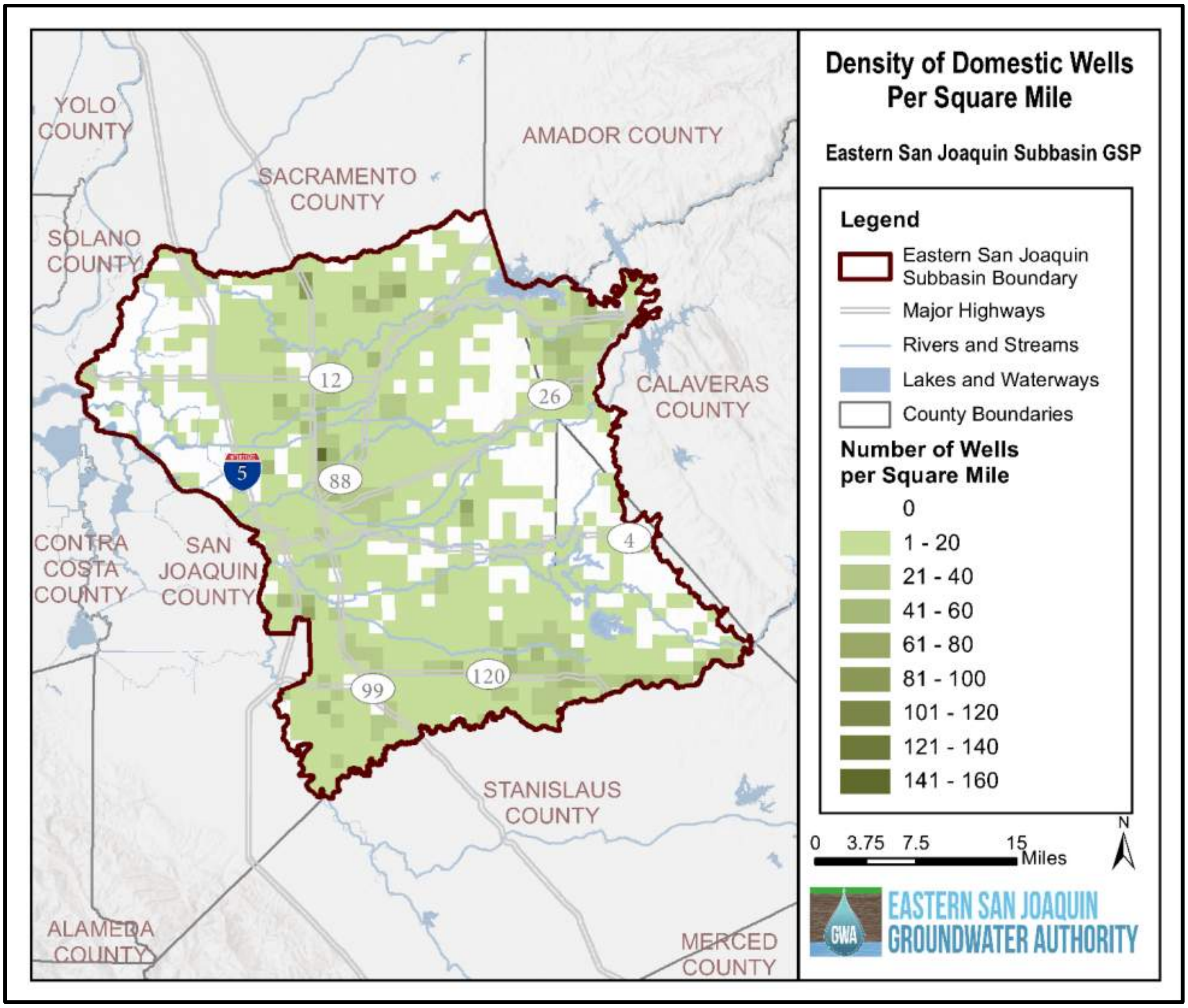


Figure 1-13: Density of Public Wells per Square Mile

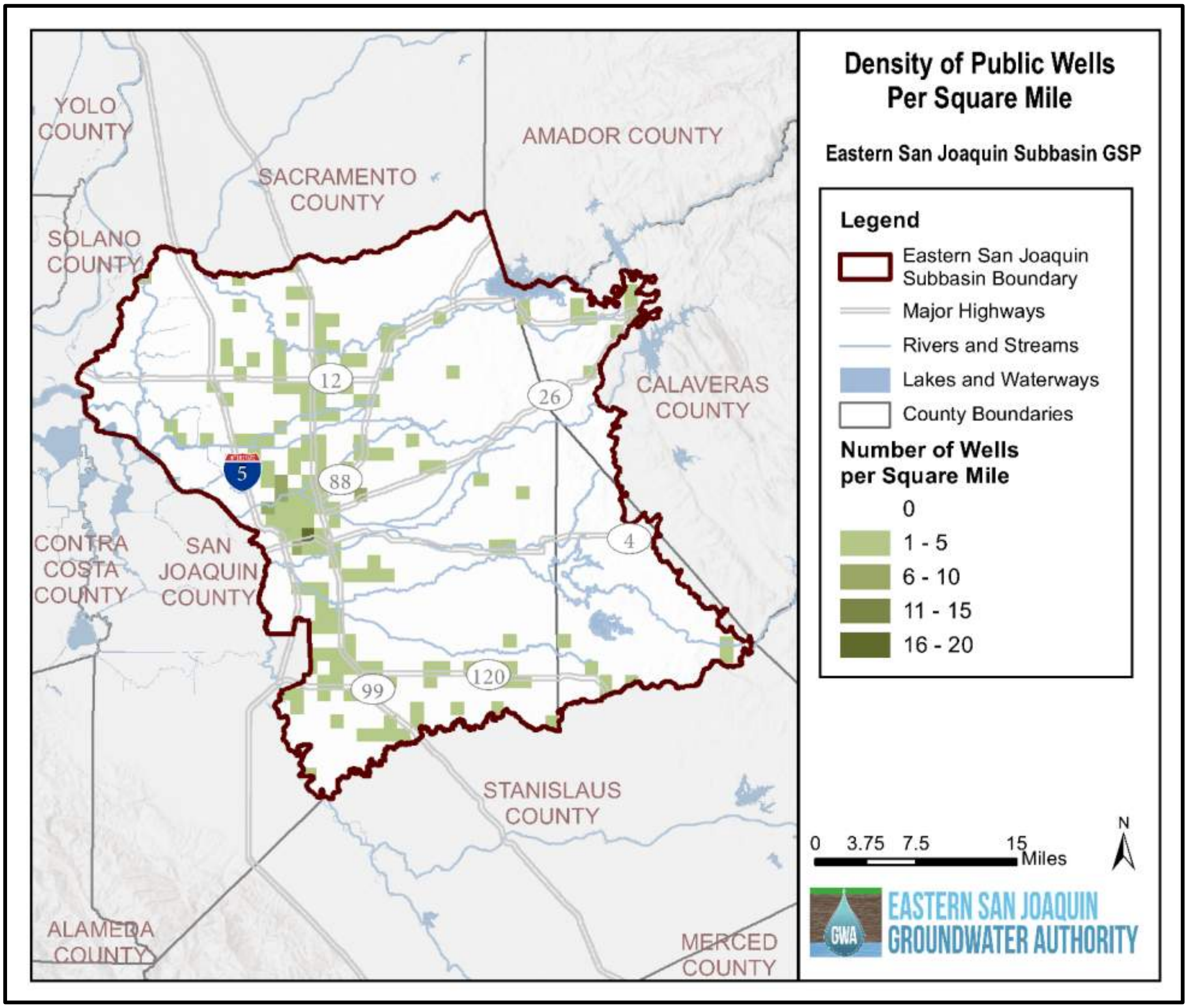
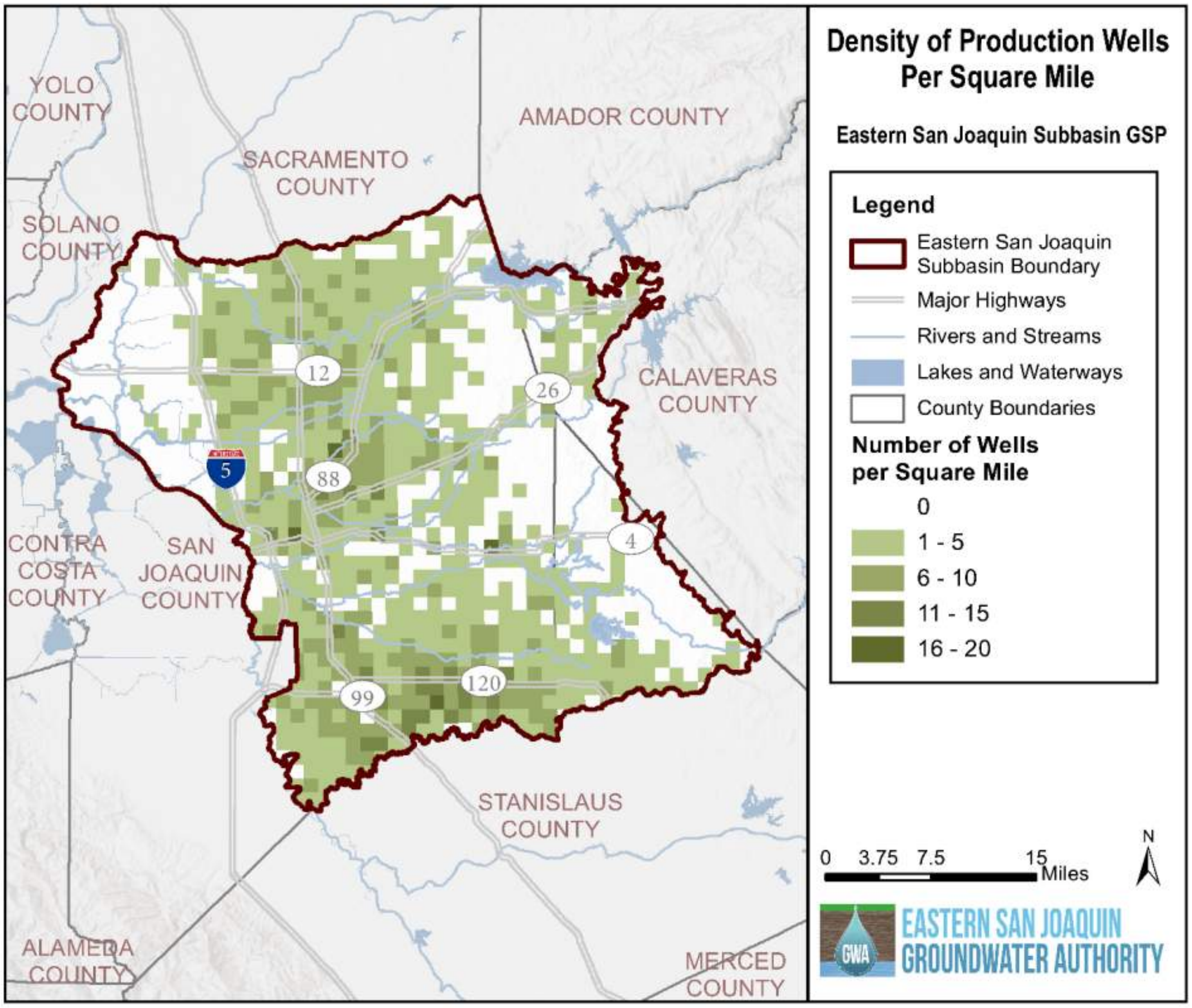


Figure 1-14: Density of Production Wells per Square Mile



1.2.2 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 have 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 may be improved during SGMA implementation.

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. Programs and agencies are listed by the jurisdiction they operate across: statewide, regional, or local. The sections that follow describe in detail the programs most heavily relied upon in the development of the GSP and are organized by data type. Section 1.2.2.3 addresses the interconnection between databases.

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 (DWR):
  - California Statewide Groundwater Elevation Monitoring (CASGEM)
  - California Statewide Groundwater Elevation Monitoring Groundwater Information Center Interactive Mapping Application (GICIMA)
  - Online System for Well Completion Reports (OSWCR)
  - Water Data Library (WDL)
- Groundwater Ambient Monitoring and Assessment (GAMA) Program
- GeoTracker
- University NAVSTAR Consortium (UNAVCO)
- United States Bureau of Reclamation (USBR)
- United States Geological Survey (USGS)

Regional Monitoring Programs:

- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)
- California Department of Public Health (CDPH)
- 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
- Stockton East Water District

A description of the monitoring programs that will be used in GSP implementation is provided in Chapter 4: Monitoring Networks.

1.2.2.1 Groundwater Level Monitoring and Data Sources

1.2.2.1.1 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 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" (Water Code §10927). Three CASGEM monitoring entities exist in the Eastern San Joaquin Subbasin: 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 taken 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 semi-annual 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). SJCFCWCD sent out consent forms to these private well owners to release well information to CASGEM; about 40 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, and depth of screened interval.
- **Stanislaus County CASGEM Monitoring Plan:** The Stanislaus County Department of Environmental Resources (DER) 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 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 to be measured semi-annually, consisting of one domestic and ten irrigation wells, plus six wells that are of unknown type. Well information such as depth and screened interval was uploaded to CASGEM for these wells (Stanislaus County DER, 2016).

1.2.2.1.2 San Joaquin County Flood Control and Water Conservation District

The SJCFCWCD 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 district include the data mentioned in the CASGEM section, above, and additional data that are not incorporated into CASGEM. The data are maintained by the SJCFCWCD.

1.2.2.1.3 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 monthly or semi-annual 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.

1.2.2.1.4 USGS – National Water Information System

The NWIS is a USGS program comprising several water datasets, including groundwater level measurements, river flow, and river stage data. Like the WDL, NWIS contains continuous and periodic water measurements for recent and historical conditions. Within the Eastern San Joaquin Subbasin, there are only a few active NWIS sites and many inactive sites with historical records. For stream measurements, active sites are largely along major streams, such as the Mokelumne River, the Stanislaus River, and the San Joaquin River; along Delta waterways; or in the Sierra Nevada foothills, upstream of reservoirs.

1.2.2.1.5 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 Eastern San Joaquin Water Resources Model (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 through the Eastern San Joaquin County GBA, the organizational structure for agency coordination that proceeded SGMA regulations and the formation of the ESJGWA. Through this effort, many of the staff and consultants representing GSAs forming the ESJGWA, participated in a prior group through the GBA, which acted as a forum to review model input data and assumptions. The group 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 in meetings related to the development of the ESJWRM 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.

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 as a data source for wells identified for monitoring. In this GSP, the OSWCR database was used to describe the Plan area and identify sustainable management criteria.

1.2.2.2 Groundwater Quality Monitoring and Data Sources

1.2.2.2.1 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 2-3 in Chapter 2: Basin Setting shows the GAMA well locations throughout the Eastern San Joaquin Subbasin, roughly 6,800 monitoring points.

1.2.2.2.2 Water Data Library

DWR's WDL contains groundwater quality data in addition to the groundwater level records described previously. This information includes data from discrete groundwater quality samples collected by DWR and other cooperating entities. These water quality data 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. WDL water quality measurements in this GSP are utilized for basin characterization but are acquired from the other programs.

1.2.2.2.3 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 create 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.

1.2.2.2.4 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 are used for regulatory compliance by water purveyors and become part of Consumer Confidence Reports (CCR) and GAMA.

1.2.2.2.5 GeoTracker

GeoTracker, operated by the SWRCB, 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.

1.2.2.2.6 Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program (ILRP) 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. Agricultural users biannually sample and submit data for irrigation and domestic wells. As part of the ILRP, the San Joaquin County & Delta Water Quality Coalition members monitor drinking water wells on enrolled parcels for nitrates. This requirement began January 1, 2019, based on the February 7, 2018 revision of ILRP WDR (Order) for the Eastern San Joaquin River Watershed by the SWRCB. 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 & Delta Water Quality Coalition members also monitor domestic wells for nitrate in high vulnerability areas.

1.2.2.2.7 Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS)

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 Nitrate Management Plan (SNMP). The 2017 SNMP was developed based on 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.

1.2.2.3 Interconnection of Databases

Several of the databases discussed above 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 are 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 are 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.

1.2.2.4 Land Subsidence Monitoring

Subsidence monitoring is performed using continuous global positioning system (CGPS) stations.

UNAVCO's Plate Boundary Observatory Program – Reporting since 2004, the UNAVCO (formerly University Navigation Satellite Timing and Ranging or NAVSTAR Consortium) Plate Boundary Observatory network consists of a network of about 1,100 continuous global positioning system (CGPS) and meteorology stations in the western United States to measure deformation resulting from the constant motion of the Pacific and North American tectonic plates in the western United States. Stations located within the Subbasin contain data from at least 2006 to current and include station P309 located east of Linden and station P273 located west of Lodi. Other stations are also available in nearby Subbasins.

Subsidence analyses have also been conducted using satellite-based methods over limited time periods, as described below.

United States Geological Survey – 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 scatter (PS) InSAR. Both sources of data were collected from the Japanese Aerospace Exploration Agency's Advanced Land Observing Satellite.

Other – DWR has made two InSAR datasets available for SGMA application: TRE Altamira InSAR point and raster data and NASA JPL raster data. Vertical displacement approximations in both datasets are collected by the European Space Agency's Sentinel-1A satellite. The two different datasets represent two different processing results, one by TRE Altamira Inc. and one by NASA JPL. The TRE Altamira data have coverage between January 2015 and June 2018. Both annual and total raster datasets from TRE Altamira are available and represent interpolations of the vertical displacement point features. The NASA JPL processed dataset spans Spring of 2015 to Summer of 2017 (CA DWR, 2019). The TRE Altamira dataset is mapped in Figure 2-64 and discussed in Section 2.2.5.

1.2.2.5 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.

1.2.2.6 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 Chapter 4: Monitoring Networks. Sources of groundwater level data are described in Section 1.2.2.1. Surface water data on stream flows and levels from stream gages are available from the USGS, CDEC, and local agencies.

1.2.2.7 Existing Water Management Programs and Plans

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

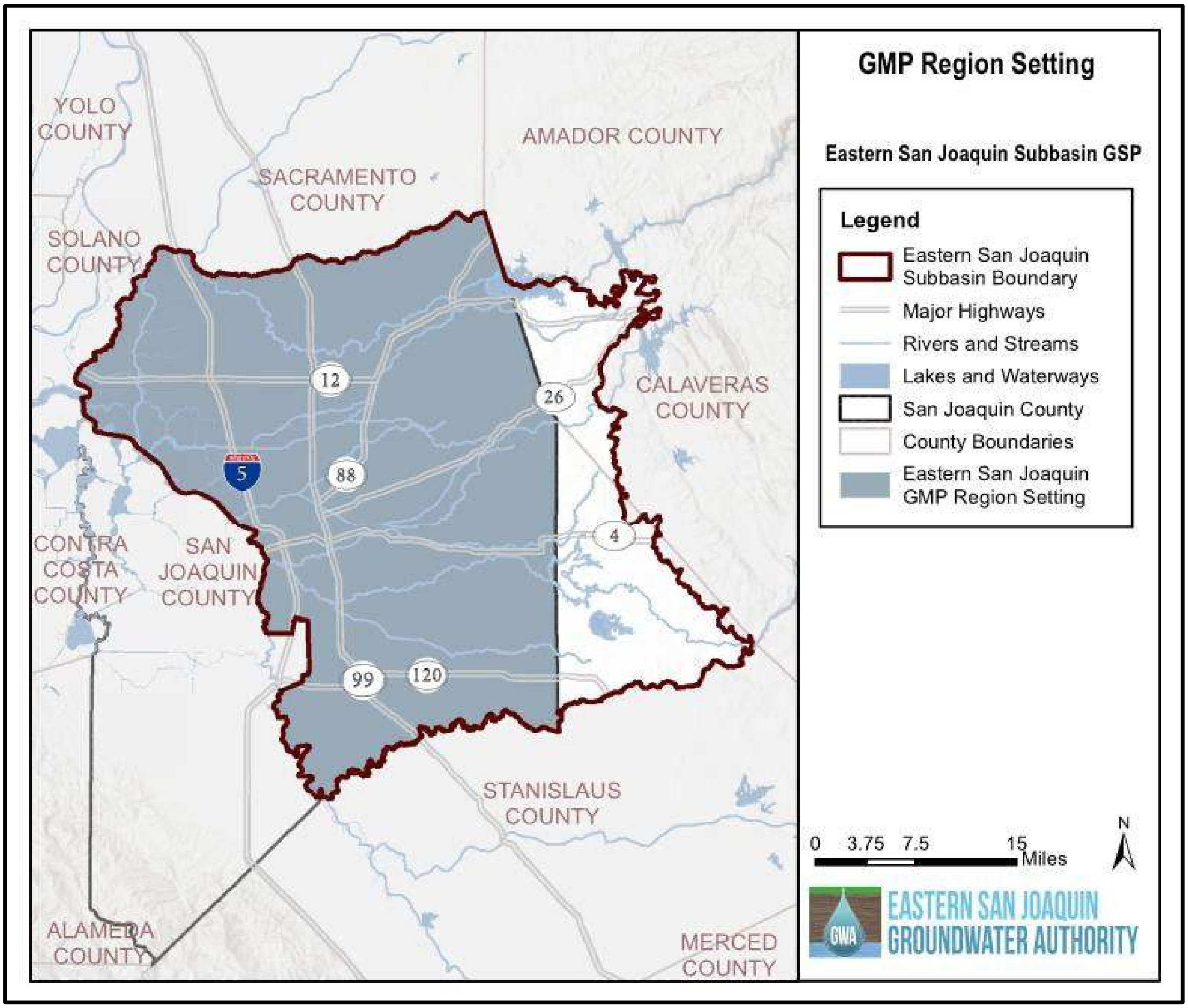
1.2.2.7.1 Groundwater Management Plan

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 entire 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. A map of the Eastern San Joaquin GMP Region is shown in Figure 1-15.

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 will 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 1-15: Eastern San Joaquin GMP Region Setting



1.2.2.7.2 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 IRWMP is currently underway.

1.2.2.7.3 Mokelumne Interregional Sustainability 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 in Amador and Calaveras counties due to low yield, unreliability, age of groundwater, and limited storage options, although conjunctive use and recharge opportunities may be available

1.2.2.7.4 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 to comply with requirements of the Water Code
- 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 Water Code
- 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 reports
- 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.

1.2.2.7.5 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 Water Code.

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

1.2.2.8 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 a combination of natural watercourses, canals, and pipelines 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 the entire lateral system historically consisted of open, unlined ditches, 100 miles of the laterals have been converted to pipelines; 105 miles are 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 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 buried pipelines. By 2015, SSJID 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 the 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 estimated 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 distribution, as well as natural watercourses within its boundaries. SEWD estimates that 26,000 AF overall is recharged through canal and natural watercourse seepage within district boundaries for an average year (SEWD, 2015).

Historically, 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 WID. To address 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, provides groundwater recharge and has played and will continue to play a crucial role in the long-term sustainability of groundwater resources in the Eastern San Joaquin Subbasin.

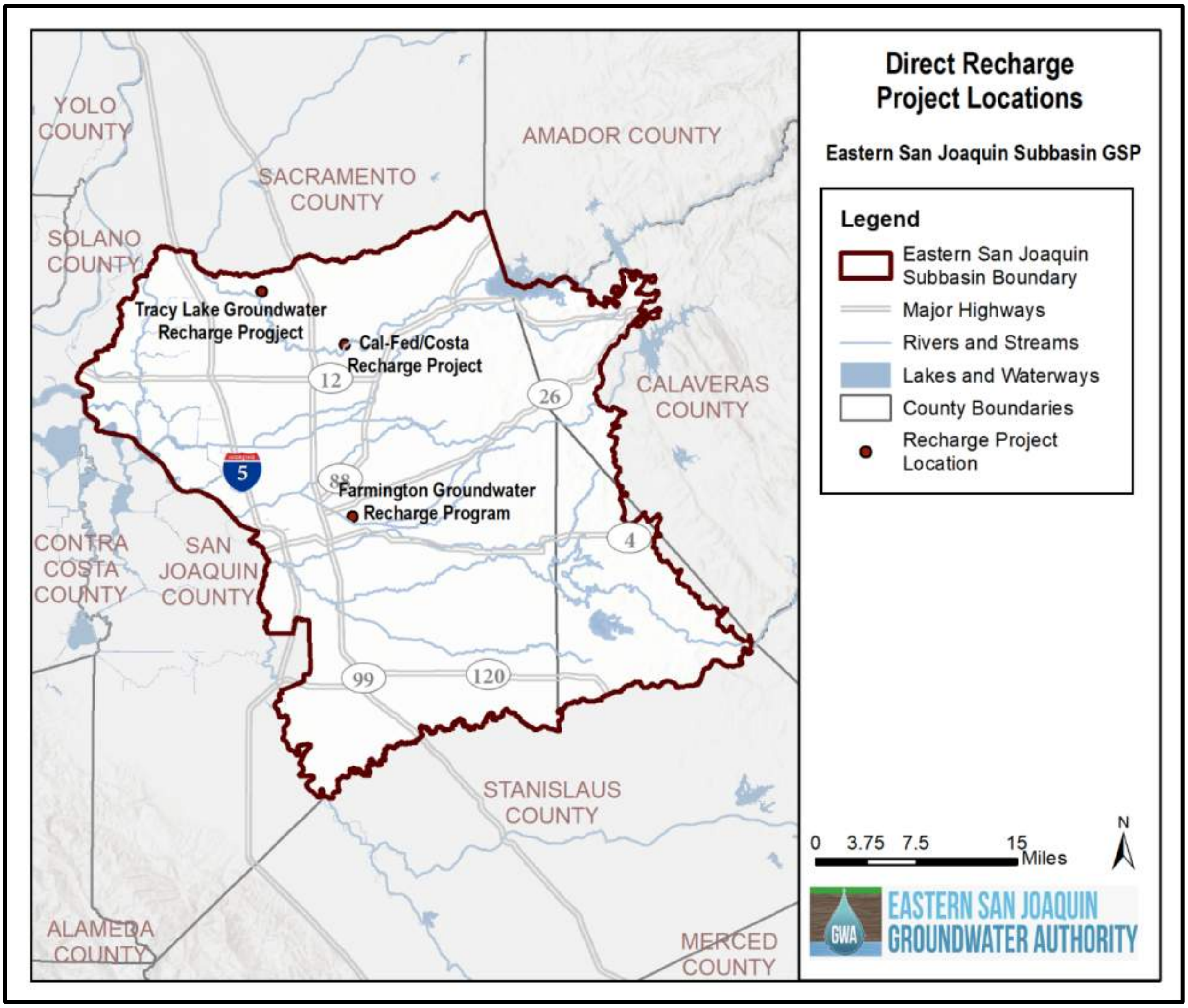
1.2.2.9 Conjunctive Use Programs

Conjunctive use is the use of surface water to allow the Subbasin to recharge and store additional water supply, either through 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, as shown below in Figure 1-16. NSJWCD's Tracy Lake Groundwater Recharge Project includes direct recharge of 500 to 1,000 AF/year 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 AF/year 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. SEWD has operated a 60-acre recharge site since 2003 as a result of the Farmington Program with additional 73 acres coming online in 2019. The observed recharge amount ranges from 2,800 AF/year to 5,800 AF/year with an average of 4,400 AF/year for a total recharge volume of about 65,000 AF since the inception of the project. SEWD also has several wells to pump some of this recharged water for municipal supply during especially dry years.

Figure 1-16: Locations of Existing Groundwater Recharge Projects



1.2.3 Land Use Elements or Topic Categories of Applicable General Plans

1.2.3.1 General Plans in the Plan Area

San Joaquin County has jurisdiction over land use planning for the majority of the surface area of the Subbasin. Stanislaus County, Calaveras County, and 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 counties and respective cities.

This section describes how implementation of the various General Plans may change water demands in the Subbasin, 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 1-E.

1.2.3.1.1 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. Stakeholder input 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. The General Plan encourages preservation of the San Joaquin County's groundwater resources and states that future urban and agricultural growth should occur within the sustainable capacity of these resources (SJC, 2016b).

1.2.3.1.2 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).

1.2.3.1.3 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).

1.2.3.1.4 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).

1.2.3.1.5 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 input from 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).

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).

1.2.3.1.6 City of Manteca General Plan

The City of Manteca adopted the current 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 2020 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 justice policies and laws (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.

1.2.3.1.7 City of Escalon General Plan

The Escalon General Plan was developed by 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 (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).

1.2.3.1.8 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 localized 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).

1.2.3.2 Effect of GSP Implementation on Applicable General Plans

The General Plans in the Subbasin provide guidelines to facilitate anticipated growth within the sustainable capacity of existing resources. Successful land use planning also promotes sustainable water supply and use within the region. 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. The potential for future management actions, which could impact water supplies and development, is discussed in Section 6.5. 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.

1.2.3.3 Land Use Plans Outside the Plan Area

Land use decisions in neighboring areas experiencing overdraft are likely to affect groundwater conditions in the Eastern San Joaquin Subbasin. Ongoing coordination with neighboring groundwater subbasins will include updates on major land use planning that may impact the groundwater system. The cities of Tracy, Lathrop, Modesto, Galt, and Elk Grove are the largest urban areas neighboring 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 1.2.3.1.1.

The City of Tracy, located within San Joaquin County and the Tracy Subbasin, 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. 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 and the Tracy Subbasin, 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 Galt, located in Sacramento County, is on the southern edge of the Cosumnes Subbasin and last updated its General Plan in 2009. Groundwater from the Cosumnes Subbasin is the sole source of water supply for the city. The General Plan outlines policies to ensure groundwater availability and protection (City of Galt, 2009).

The City of Elk Grove, located in Sacramento County, relies heavily on groundwater from the South American Subbasin. 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).

1.2.3.4 Well Permitting

1.2.3.4.1 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 Water Code §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 §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 for new wells that define property line setbacks (at least 10 feet depending on well type), 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. Other setbacks for potential sources of contamination or pollution require at least 50 feet depending on the contamination source and well type.

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 depth for wells in San Joaquin County is summarized in Table 1-1 (San Joaquin County, 1993).

Table 1-1: 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

1.2.3.4.2 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 as well as minimum horizontal setback requirements. Horizontal setbacks from property lines range from 10 feet (for small parcels) to 150 feet (for underground storage with nearby wells at least 25 feet away). The minimum annular seal depths for wells in Calaveras County are summarized in Table 1-2 (Calaveras County Board of Supervisors, 2008).

Table 1-2: 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

1.2.3.4.3 Stanislaus County

Pursuant to Chapter 9.36 of the Stanislaus County Code, well owners must first receive a valid permit from Stanislaus County to construct, install, repair, or destroy any well or well seal within the county. Stanislaus County 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 (Stanislaus County, 2019a).

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, 2019b). If the permit applicant is not exempt, a non-exempt wells supplemental application must be submitted and show that the groundwater pumped from the well is being sustainably extracted and will not cause any of the "Undesirable Results" listed in § 97.030 (9) of the groundwater ordinance. Additional permit application fees may be required, and the application review is conducted at the expense of the applicant (Stanislaus County, 2019c).

The minimum annular seal depths for wells in Calaveras County are summarized in Table 1-3, and are consistent with the state well standards (CA DWR, 1991).

Table 1-3: 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

1.2.3.4.4 Sacramento County

Sacramento County, which borders the northern boundary of the Eastern San Joaquin Subbasin (see Figure 1-6), oversees well permitting within their jurisdiction and requires property owners to obtain a permit for work including well construction, modification, repair, inactivation, destruction, installation, and replacement. Each well or pump requires its own permit application and fee, but waivers can be considered for multiple wells or exploratory borings of similar construction (Sacramento County, 2019).

The Sacramento County Code water well standards are designed to meet or exceed the water well standards in DWR's Bulletin 74-81 and 74-90. These standards apply to all types of monitoring wells, vapor extraction wells where applicable, and any other well installed in an area where special precautions are necessary to protect groundwater quality. The Sacramento County Environmental Management Department has the power under special circumstances to grant a variance from provisions in Chapter 6.28 of the Sacramento County Code and to prescribe alternative requirements in their place (Sacramento County, 2019).

The minimum annular seal depth for wells in Sacramento County is 50 feet for all well types, except for in cases of special approval (Sacramento County, 2019).

1.2.4 Additional GSP Elements

The Additional GSP Elements section of the GSP provides GSAs with the opportunity to discuss "any additional Plan elements included in Water Code §10727.4 that the Agency determined to be appropriate". These additional elements include:

- Control of saline water intrusion
- Wellhead protection areas and recharge areas
- Migration of contaminated groundwater
- A well abandonment and well destruction program
- Replenishment of groundwater extractions
- Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage
- Well construction policies
- Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects
- Efficient water management practices, as defined in Water Code §10902, for the delivery of water and water conservation methods to improve the efficiency of water use
- Efforts to develop relationships with state and federal regulatory agencies
- Processes to review 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

Each of the Additional Elements listed are relevant and important to the Eastern San Joaquin Subbasin, and are discussed throughout this GSP, as identified below.

Control of saline water intrusion – Section 2.2.3 describes the current status of saline water intrusion in the Subbasin. Section 3.2.4 addresses seawater intrusion as a sustainability indicator and identifies minimum thresholds, measurable objectives, and interim milestones. Actions to identify and monitor for saline water intrusion early is described in Section 3.2.4.4.

Wellhead protection areas and recharge areas – Section 1.2.3.4 addresses wellhead protection programs in San Joaquin County, Calaveras County, and Stanislaus County.

Migration of contaminated groundwater – The migration of contaminated groundwater that may impair water supplies is addressed in Section 3.2.3.

A well abandonment and well destruction program – Requirements and procedures for well destruction and abandonment are discussed in Section 1.2.3.4.

Replenishment of groundwater extractions – Proposed projects and management actions that will facilitate replenishment of groundwater extraction are discussed in Chapter 6: Projects and Management Actions. Areas where potential groundwater replenishment could occur through direct recharge are described in Section 2.1.4.5.

Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage – Existing conjunctive use projects are identified in Section 1.2.2.9. The proposed projects and management actions that will address implementing, opportunities for, and removing impediments to, conjunctive use or underground storage projects in the Subbasin are discussed in Chapter 6: Projects and Management Actions.

Well construction policies – Section 1.2.3.4 addresses well construction policies in San Joaquin County, Calaveras County, and Stanislaus County. Annular well seal depth requirements are tabulated in Tables 1-1, 1-2, and 1-3.

Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects – Proposed projects and management actions that address groundwater recharge, in-lieu use, diversions to storage, conservation, and water recycling are discussed in Chapter 6: Projects and Management Actions.

Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use – Ongoing efforts to implement efficient water management practices are described in Section 1.2.2.7. Conservation methods and efficiency of water use are also noted in many local or regional general plans, detailed in Section 1.2.3. Projects relevant to this topic are discussed in Chapter 6: Projects and Management Actions.

Efforts to develop relationships with state and federal regulatory agencies – A strong relationship between the GSAs and existing regulatory agencies is valuable to the success of this GSP. Efforts to develop this relationship are described in Chapter 7: Plan Implementation.

Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity – Summaries of land use plans both inside the Subbasin and in nearby Subbasins can be found in Section 1.2.3. Efforts are being made at the local level to develop a formal opportunity for GSAs to provide input on the land use and water-related elements of future General Plans and CEQA documentation to promote consistency with the GSP.

Impacts on groundwater dependent ecosystems – Groundwater dependent ecosystems (GDEs) are defined in Section 2.2.7. The methodology for identifying GDEs can be found in Section 2.2.7.1. A map of identified GDEs in the Subbasin is shown in Section 2.2.7.2. Adverse impacts to GDEs are described under Depletions of Interconnected Surface Water, Section 3.2.6, as part of the undesirable results discussion.

1.3 NOTICE AND COMMUNICATION

1.3.1 Beneficial Uses and Users in the Basin

The CVRWQCB 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).

As listed in Water Code §10723.2, beneficial uses and users of groundwater in the region include the following interests:

- Agricultural users and domestic well owners that hold overlying groundwater rights.
- Public water systems/municipal well operators in the Subbasin.
- Community water systems (wells serving 15 or more connections or more than 25 people per day). 433 community water systems were identified in the Eastern San Joaquin Subbasin and are presented in Appendix 1-F Of these 433 community water systems, 182 are located in DAC or SDAC areas, shown also in Appendix 1-F.
- Local agencies that have land use planning jurisdiction. These include counties of San Joaquin, Calaveras, and Stanislaus, and cities of Stockton, Lodi, Manteca, Escalon, and Ripon.
- Environmental users of groundwater, including species and habitat reliant on instream flows, as well as wetlands and GDEs. Identified GDEs are mapped in Figure 2-69 in Section 2.2.7.2. Freshwater species in the Eastern San Joaquin Subbasin are listed in Appendix 1-G.

- Irrigation districts in the Subbasin that divert surface water to deliver to their customers.
- Lands managed by the federal government. The San Joaquin River National Wildlife Refuge lies just outside of the Subbasin boundary. While managed by the State of California, Caswell Memorial SP is in the Subbasin and Carnegie SVRA and Franks Tract SRA are situated just outside of the Subbasin.
- DACs and SDACs. DACs and SDACs are mapped in Figure 1-8 and are primarily in the western portions of the Subbasin. Approximately 33 percent of the Subbasin area is considered disadvantaged and 7 percent is considered severely disadvantaged. 55 percent of the Subbasin population is considered either DAC or SDAC; within that, 25 percent of the population is SDAC. DACs include the following census designated places (CDPs)[1]: Stockton City CDP, Collierville CDP, Lockeford CDP, Terminous CDP, and Valley Home CDP. Severely disadvantaged communities include: Kennedy CDP, August CDP, French Camp CDP, Taft Mosswood CDP, and Thornton CDP.
- Entities that monitor and report groundwater elevations. Monitoring in the Subbasin is extensive. A list of monitoring agencies can be found in Section 1.2.2.
- California Native American tribes

1.3.2 List of Public Meetings Where the GSP was Discussed

During the development of this GSP, meetings of the ESJGWA Board, Advisory Committee, and Workgroup were open to the public, with meeting information noticed, as appropriate, and posted to the ESJGWA website (discussed below in Section 1.3.4.1). In addition, informational open house events were held throughout GSP development (see Section 1.3.2.4).

Below is a list of the public meetings where the GSP was discussed. The following includes the public meetings held from June 2017 through July 2019.

1.3.2.1 ESJGWA Board Meetings

In 2017, ESJGWA Board meetings were held on June 14, July 12, August 9, September 13, October 11, and November 8.

In 2018, ESJGWA Board meetings were held on February 14, March 14, April 11, May 9, June 13, July 11, August 8, September 12, October 10, and November 14.

In 2019, ESJGWA Board meetings were held on February 13, March 13, April 10, May 8, June 12, July 10, August 14, September 11, and October 17.

ESJGWA Board meetings are anticipated for November 13, 2019; December 11, 2019; and January 8, 2020 prior to GSP submittal.

1.3.2.2 ESJGWA Advisory Committee Meetings

In 2018, Advisory Committee meetings were held on May 9, June 13, July 11, August 8, September 12, October 10, and November 14.

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[1] A census designated place is a concentration of population identified by the United States Census Bureau for statistical purposes. CDPs are delineated for each decennial census as the statistical counterparts of incorporated places, such as cities, towns, and villages.

In 2019, Advisory Committee meetings were held on January 9, February 13, March 13, April 10, April 24, May 8, June 12, July 10, September 11, and October 17.

ESJGWA Advisory Committee meetings are anticipated for November 13, 2019; December 11, 2019; and January 8, 2020 prior to GSP submittal.

1.3.2.3 Groundwater Sustainability Workgroup Meetings

In 2018, Workgroup meetings were held on June 12, July 10, August 15, September 11, October 9, and November 13.

In 2019, Workgroup meetings were held on January 9, February 13, March 13, April 10, May 8, June 12, and September 11.

1.3.2.4 Informational Open House Events

In 2018, informational open house events were held on August 29 and November 7.

In 2019, informational open house events were held on February 12 and July 18.

1.3.2.5 Outreach Presentations to Community Groups

In 2018, presentations to community groups were conducted for targeted outreach on May 10 (Manteca Kiwanis Sunrise Club), August 8 (San Joaquin County Farm Bureau Federation), August 27 (NSJWCD Board of Directors), September 24 (Delta-Sierra Group), and November 14 (San Joaquin County Hispanic Chamber of Commerce).

In 2019, presentations to community groups were conducted for targeted outreach on February 20 (Manufacturers Council of the Central Valley), and September 25 (Stanislaus County Board of Supervisors).

In 2019, GSAs conducted informational community meetings, which included outreach presentations, on March 26 (City of Lodi), August 7 (French Community), August 8 (Thornton Community), and August 16 (Mokelumne River Association).

1.3.3 Decision-Making Process

The ESJGWA Board is tasked with the vote and approval of policy decisions for the development and implementation of this GSP. The ESJGWA Board receives input from an Advisory Committee, the Workgroup, and the public, as described in Section 1.1.4.2.

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. Projects will be administered by the GSA project proponents. Although the ESJGWA does not provide direct authority to require GSAs to implement projects, the GWA will be working on GSA-level water budgets and will be requesting annual or biannual progress reports to evaluate progress. A description of the agencies that comprise the GSAs can be found in Section 1.1.4.3.

1.3.4 Opportunities for Public Engagement and How Public Input was Used

Throughout the process of GSP development, the ESJGWA 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's Facilitation Support Services Program. This included a Situation Assessment to determine stakeholder concerns related to the GSP development process. The Situation Assessment is discussed in more detail in Section 1.3.4.6.

1.3.4.1 ESJGWA Website

The ESJGWA website has been online since 2018 and continues to be maintained on a regular basis at **www.esjgroundwater.org**. It contains an introduction to SGMA, details on member agencies, and ESJGWA Board updates with meeting information and materials posted regularly. There are detailed sections for GSP resources, technical reports and data, educational materials, and meeting notices with the accompanying presentation materials and minutes. A section of the website is devoted to press releases, newsletters, public notices, and other major events and accomplishments. Contact information is readily available for interested parties to communicate with ESJGWA members and staff, and members of the public can subscribe to the ESJ GWA mailing list to receive updates on GSP development and outreach events.

1.3.4.2 Groundwater Sustainability Workgroup

The ESJGWA developed a Workgroup in order to promote stakeholder input and relied upon the Workgroup 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 who represent one or more of the interested parties' groups. Table 1-4 lists the organizations and interests represented on the Workgroup.

Table 1-4: 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 County 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 groundwater 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 Sacramento-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 and is interested in groundwater rights and contributing to the stakeholder Workgroup.

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

1.3.4.3 Stakeholder Outreach and Engagement Plan

With the support of the Workgroup, the ESJGWA developed an initial Stakeholder Outreach and Engagement Plan (see Appendix 1-H) for the San Joaquin Subbasin detailing a 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 mode of communication
- Engage DWR for facilitated support to aid in the development of the GSP
- Open ESJGWA planning efforts to the public with agendas and meeting minutes published on the ESJGWA 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 ESJGWA 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

1.3.4.4 Stakeholder Database

The ESJGWA 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 Eastern San Joaquin Subbasin engagement efforts, conducting new research, and obtaining referrals from key stakeholders and stakeholder groups.

During the initial development of the stakeholder database, the ESJGWA worked with those responsible for implementing the GSP to obtain contact lists of interested parties within the Subbasin 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 at public meetings and through website signups. Contacts were updated or removed as needed. The database served as the foundation for targeted outreach and communication throughout the project and was also used to:

- Provide a single repository to collect, store, and organize information on Subbasin 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 1-5 provides a summary breakdown of the number of parties and interests represented in the Stakeholder Database.

Table 1-5: 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**

Outreach materials promoting informational open house events were distributed via email to the stakeholder database, and hard copies were distributed to the 433 community water systems, in August 2018, October 2018, January 2019, and July 2019.

1.3.4.5 Stakeholder Education and Outreach

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

- The ESJGWA held four 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 (51 attendees)
  - **November 2018 –** Manteca Transit Center, Manteca (25 attendees)
  - **February 2019 –** Lockeford Community Center, Lockeford (61 attendees)
  - **July 2019 –** Robert J. Cabral Agricultural Center, Stockton (38 attendees)
- Targeted outreach presentations were given at community meetings to the following groups:
  - Delta-Sierra Group (September 2018)
  - Manteca Kiwanis Sunrise Club (May 2018)
  - Manufacturers Council of the Central Valley (February 2019)

- North San Joaquin Water Conservation District Board of Directors (August 2018)
- San Joaquin County Hispanic Chamber of Commerce (November 2014)
- San Joaquin Farm Bureau Federation (August 2018)
- Stanislaus County Board of Supervisors (September 2019)

- Additionally, GSA member agencies hosted local informational community meetings related to the SGMA process and to publicize the release of the Public Draft GSP for public comment.
  - City of Lodi – City of Lodi Public Outreach Event (Hutchins Street Square, Lodi) (March 2019)
  - San Joaquin Public Works Department – French Community SGMA Outreach Event (Robert J. Cabral Agricultural Center, Stockton) (August 2019)
  - San Joaquin Public Works Department – Thornton Community SGMA Outreach Event (Thornton Community Center, Thornton) (August 2019)
  - Stanislaus County – Mokelumne River Association Meeting SGMA Outreach Opportunity (Hotel Leger, Mokelumne Hill) (August 2019)
- Individually, member GSAs provided targeted outreach materials to their constituencies through the distribution of outreach and informational materials.
- The ESJGWA distributed SGMA outreach materials 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 email announcements 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 Facebook page for the ESJGWA was developed, and social media templates were distributed to members of the ESJGWA 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 ESJGWA events such as workgroup and public meetings.

1.3.4.6 Situation Assessment

The ESJGWA applied for and received facilitation support through DWR's Facilitation Support Services Program to conduct a Situation Assessment, the purpose of which was to facilitate the stakeholder engagement process by determining stakeholder concerns related to the GSP development process. The facilitation services supported third-party interviews conducted with the members of the Workgroup in the winter of 2018 as part of the Situation Assessment. 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 ESJGWA 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

Situation Assessment findings were presented to the Workgroup, the Advisory Committee, and the ESJGWA Board. Changes, including those to the Workgroup process, meeting presentations and discussions, and draft GSP development and review schedule were made based on feedback from the Workgroup members.

1.3.4.7 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 ESJGWA 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 ESJGWA Board meetings. Input was captured in monthly meeting summaries, which were reviewed by Workgroup members prior to being presented to the ESJGWA Board in meeting agenda packets and posted to the ESJGWA 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 ESJGWA 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 1.3.4.5 above) were added based on feedback to further spread the word about SGMA and local GSP development efforts. Changes to the Workgroup meeting structure and process were also made based on findings of the Situation Assessment.

1.3.4.8 Draft GSP Public Comment Review Period

The Public Draft GSP was posted on the ESJGWA website for a 45-day public comment period from July 10 through August 25, 2019. Notices and press releases were provided in English and Spanish publicizing the public comment period and inviting members of the public to attend the July 2019 informational open house event for more information. This event was scheduled to align with the release of the Draft GSP to provide a forum for the public to receive information, ask questions, and provide input. Hard copies of the Draft Plan were placed in libraries and at GSA main offices for public viewing and were available by request.

The following libraries received hard copies of the Public Draft GSP:

- Lodi Public Library
- Cesar Chavez Central Library
- Margaret Troke Library
- Maya Angelou Library
- Fair Oaks Branch Library
- Weston Ranch Library

The ESJGWA received 19 public comment submissions from a range of interested parties, including non-government organizations, neighboring subbasins, ESJGWA GSAs, state and federal agencies, and others. These individuals and organizations are listed below, and comments are provided in Appendix 1-I.

- California Department of Fish and Wildlife, North Central Region
- California Poultry Federation
- California Sportfishing Protection Alliance, including comments by Greg Kamman (Kamman Hydrology & Engineering, Inc.)
- Collective comments by The Nature Conservancy, Audubon California, Clean Water Action, Clean Water Fund, American Rivers, and Union of Concerned Scientists
- Collective comments by The League of Women Voters of San Joaquin County; Environmental Justice Coalition for Water; Sierra Club, Delta Sierra Group; Puentes; and Restore the Delta
- Cosumnes Subbasin
- East Bay Municipal Utility District (EBMUD)
- Jane Wagner-Tyack (Communication Consultant)
- Larry Walker Associates, on behalf of agricultural interests
- North San Joaquin Water Conservation District
- Restore the Delta
- Sierra Club, Delta-Sierra Group
- South San Joaquin GSA
- Stockton East Water District
- Terra Land Group, LLC

- The Freshwater Trust, on behalf of Northern Delta GSA and associate member Staten Island-Conservation farms and ranches
- The Nature Conservancy
- The Wine Group
- Tracy Subbasin

The ESJGWA appointed an Ad-Hoc Committee to review and summarize public comments, and to draft proposed response to comment recommendations for approval by the ESJGWA Board. The Comment Review Ad-Hoc Committee convened for three workshops on September 19, September 24, and October 4, 2019. The ESJGWA reviewed the Ad-Hoc Committee's recommendation and took action to approve functional changes to the Public Draft GSP on October 17, 2019. The ESJGWA's responses to comments are provided in Appendix 1-J.

1.3.5 Inter-basin Coordination

As part of the SGMA process, stakeholder outreach includes inter-basin coordination efforts. To date, there have been initial meetings between representatives of the ESJGWA and the neighboring subbasins to initiate this process. The purpose of these coordination meetings was to share and discuss elements included in the Eastern San Joaquin Draft GSP, including water budget estimates, boundary flow assumptions, and minimum thresholds. Participants discussed next steps for data sharing and ongoing coordination.

A summary of the initial inter-basin coordination meetings with neighboring subbasins is below.

- Cosumnes Subbasin – April 15, 2019
- Tracy Subbasin – June 20, 2019
- Modesto Subbasin – July 10, 2019
- South American, Solano, and East Contra Costa Subbasins – July 19, 2019

The ESJGWA plans to reach out to neighboring subbasins as part of GSP implementation to increase coordination as neighboring subbasins further GSP development.

1.3.6 Notice of Intent to Adopt the GSP

A notice of intent (NOI) to adopt a GSP was signed by the GSAs and distributed on August 16, 2019. The NOI was posted to the ESJGWA website homepage and hard copies were mailed cities and counties within the Subbasin, including the following:

- County of Calaveras
- County of Stanislaus
- County of San Joaquin
- City of Escalon
- City of Ripon
- City of Manteca
- City of Oakdale

- City of Ripon
- City of Stockton
- Linden County Water District
- Lockeford Community Services District

The signed NOI is provided in Appendix 1-K.

This revised GSP was accepted by the ESJGWA on July 13, 2022 and subsequently adopted by each of the individual GSAs. The NOI to adopt the revised GSP was distributed by ESJGWA on behalf of the GSAs on April 15, 2022. The signed NOI to adopt the revised GSP is provided in Appendix 1-L.

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2. BASIN SETTING

This Basin Setting chapter contains three main sections as follows:

- **Hydrogeologic Conceptual Model –** Section 2.1 (Hydrogeologic Conceptual Model) provides the geologic information needed to understand the framework under which water moves through the Subbasin. It focuses on geologic formations, aquifers, structural features, and topography.
- **Current and Historical Groundwater Conditions –** Section 2.2 (Current and Historical Groundwater Conditions) describes and presents groundwater trends, levels, hydrographs and level contour maps, estimates changes in groundwater storage, identifies groundwater quality issues, addresses land subsidence, and addresses surface water interconnection.
- **Water Budgets –** Section 2.3 (Water Budgets) describes the data used to develop the water budget. This section also discusses how the budget was calculated and provides water budget estimates for historical conditions, current conditions, and projected conditions.

2.1 HYDROGEOLOGIC CONCEPTUAL MODEL

2.1.1 Data Compilation

This section describes the HCM for the Eastern San Joaquin Subbasin. The regulatory framework is based on the California Code of Regulations (CCR) Title 23 § 354.14. The HCM presents the physical characteristics used to define water movement throughout the Eastern San Joaquin Subbasin.

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 were 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 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 were sourced and provides insight on the unique obstacles within each.

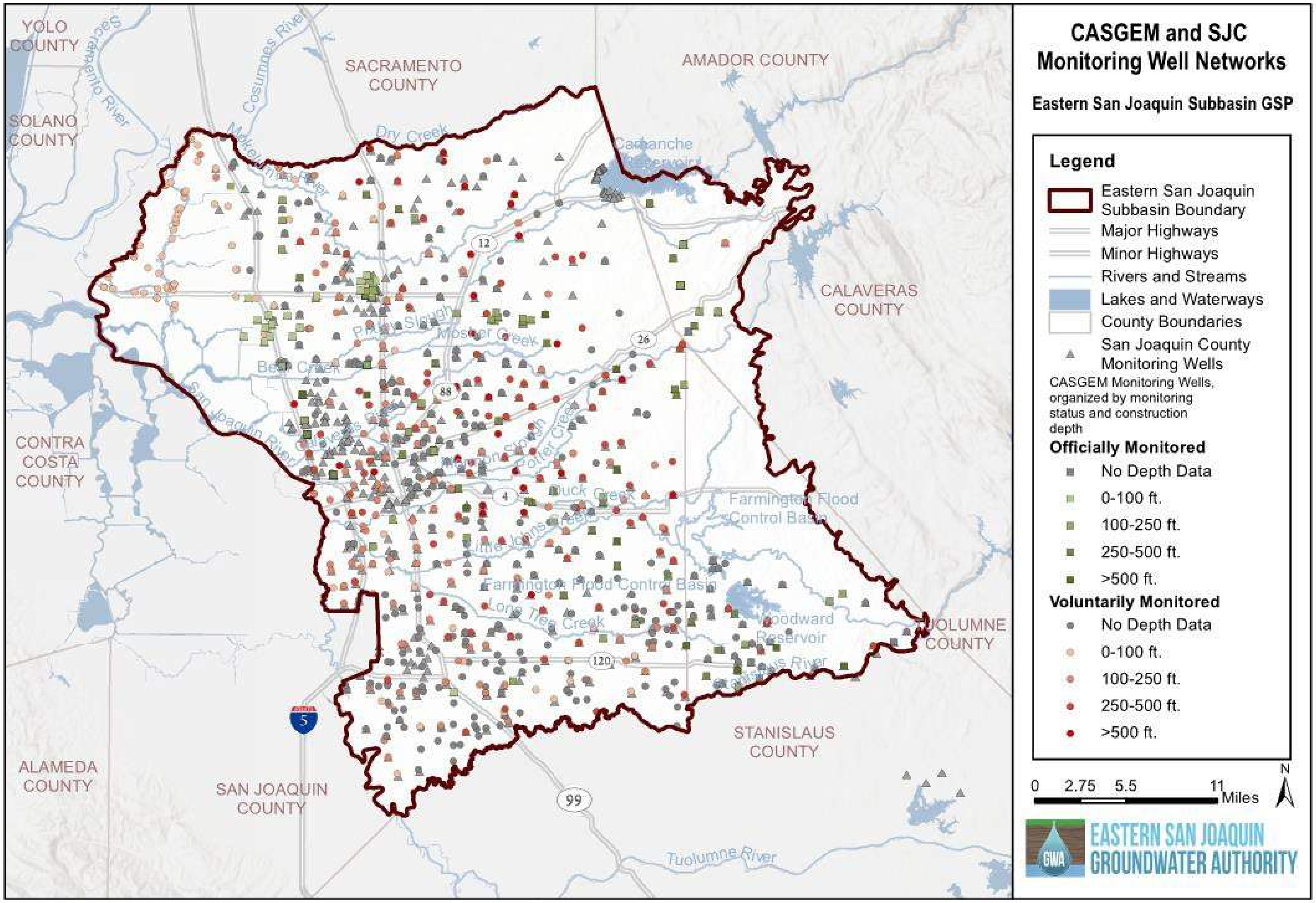
2.1.1.1 Groundwater Level Data

The California Statewide Groundwater Elevation Monitoring (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 groundwater level information. San Joaquin County's monitoring well data comes from the San Joaquin County Flood Control and Water Conservation District (SJCFCWCD).

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.

The CASGEM and San Joaquin County monitoring well networks together include approximately 1,000 unique wells across the Eastern San Joaquin Subbasin. Despite the large number of wells, horizontal and vertical data gaps still exist. Large areas of the Subbasin contain very few wells, particularly in the northwest and southeast portions of the Subbasin (see Figure 2-1).

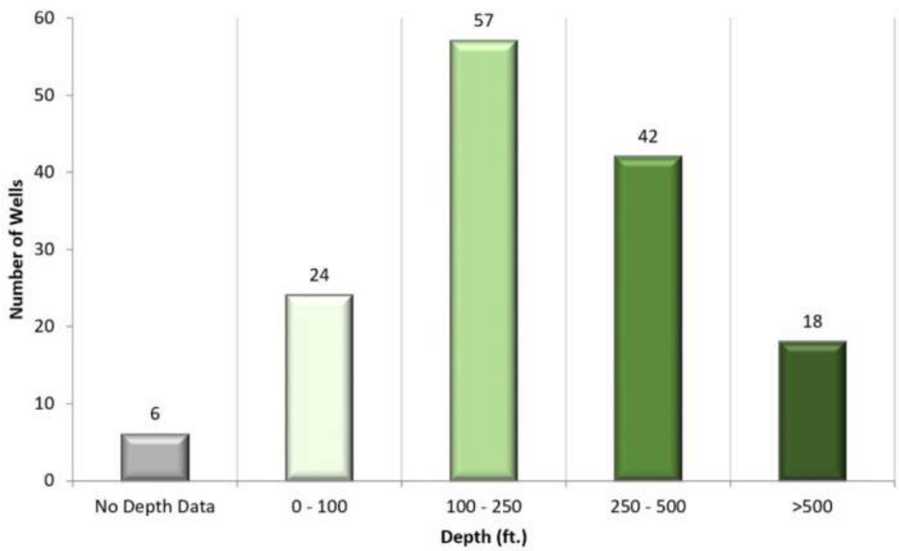
Figure 2-1: CASGEM and San Joaquin County Monitoring Well Networks



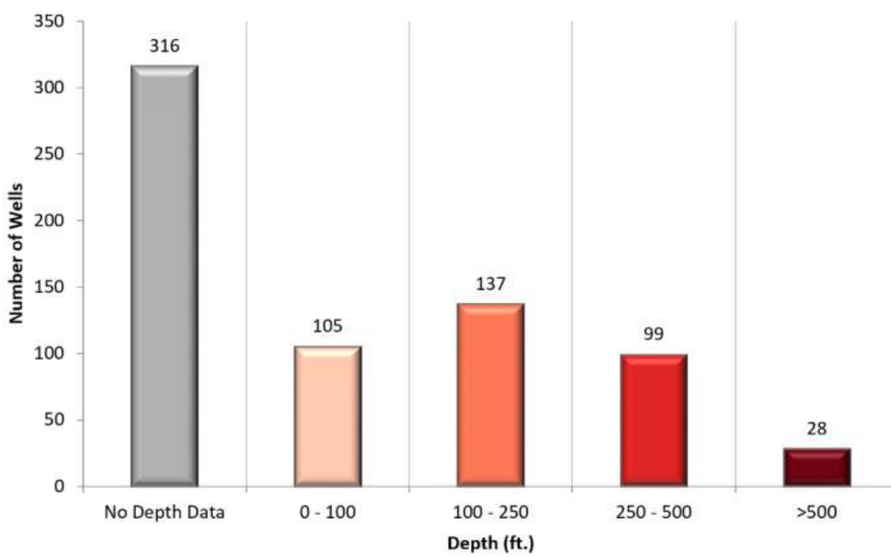
Vertical data gaps are even more pronounced, as lack of construction data is an obstacle. Figure 2-2 shows the distribution of well depths of officially and voluntarily monitored CASGEM wells, a large number of which do not have construction depth or screen interval information. This makes determining groundwater levels for depth-discrete aquifer intervals impossible. Groundwater elevation contour maps were prepared for the single principal aquifer, consistent with CCR Title 23 § 354.16 Groundwater Conditions requirements. Despite uncertainties due to limited construction information, this Groundwater Sustainability Plan (GSP) presents maps that provide a useful description of groundwater conditions.

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

Officially Monitored CASGEM Wells



Voluntarily Monitored CASGEM Wells



2.1.1.2 Groundwater Quality Data

This GSP relies on groundwater quality data from the Groundwater Ambient Monitoring and Assessment (GAMA) Program. GAMA includes water quality data from numerous sources, such as United States Geological Survey (USGS) and Department of Water Resources (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 2-3).

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 timeframe. 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 2-4, 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 2-3: GAMA Monitoring Well Network

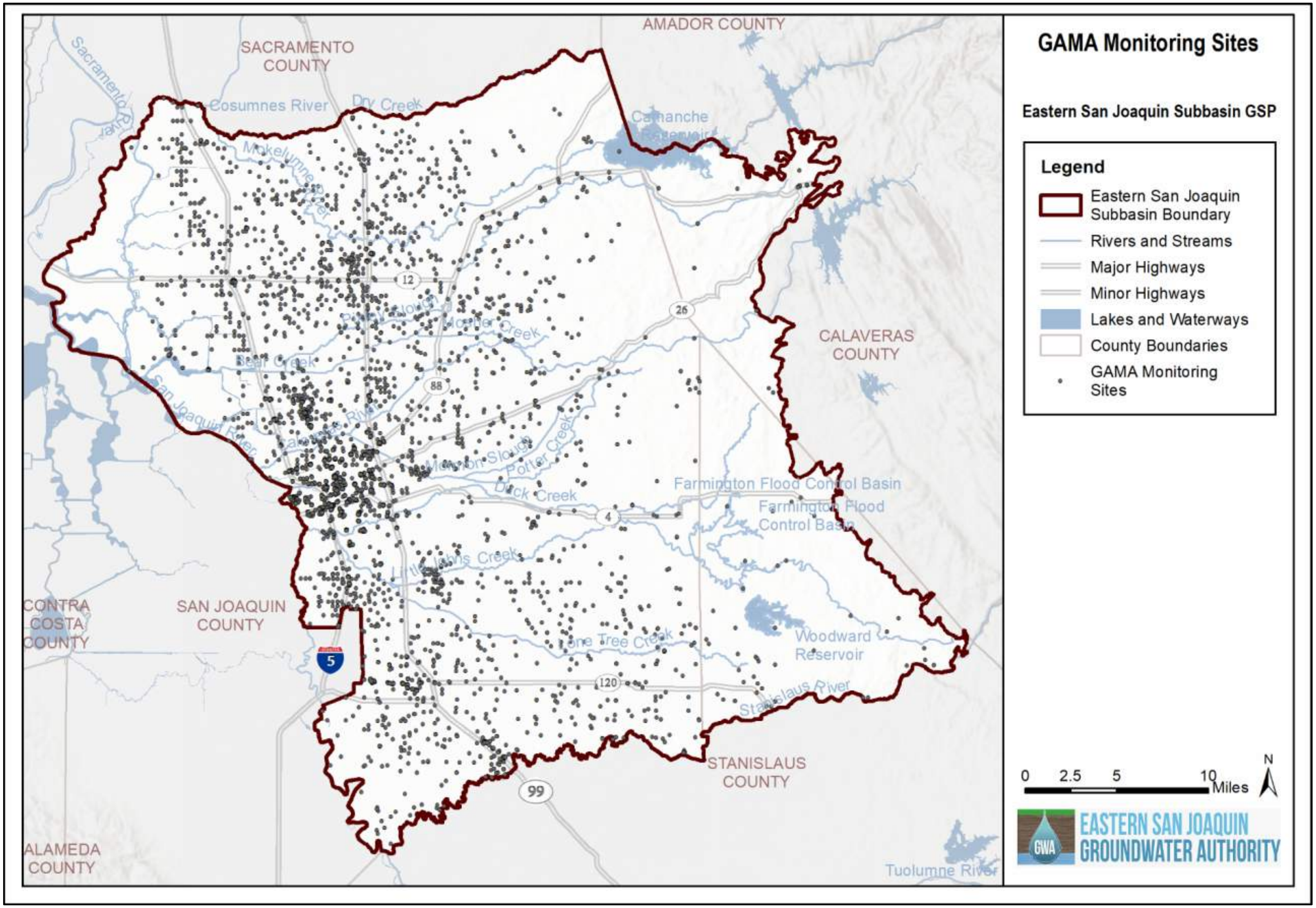
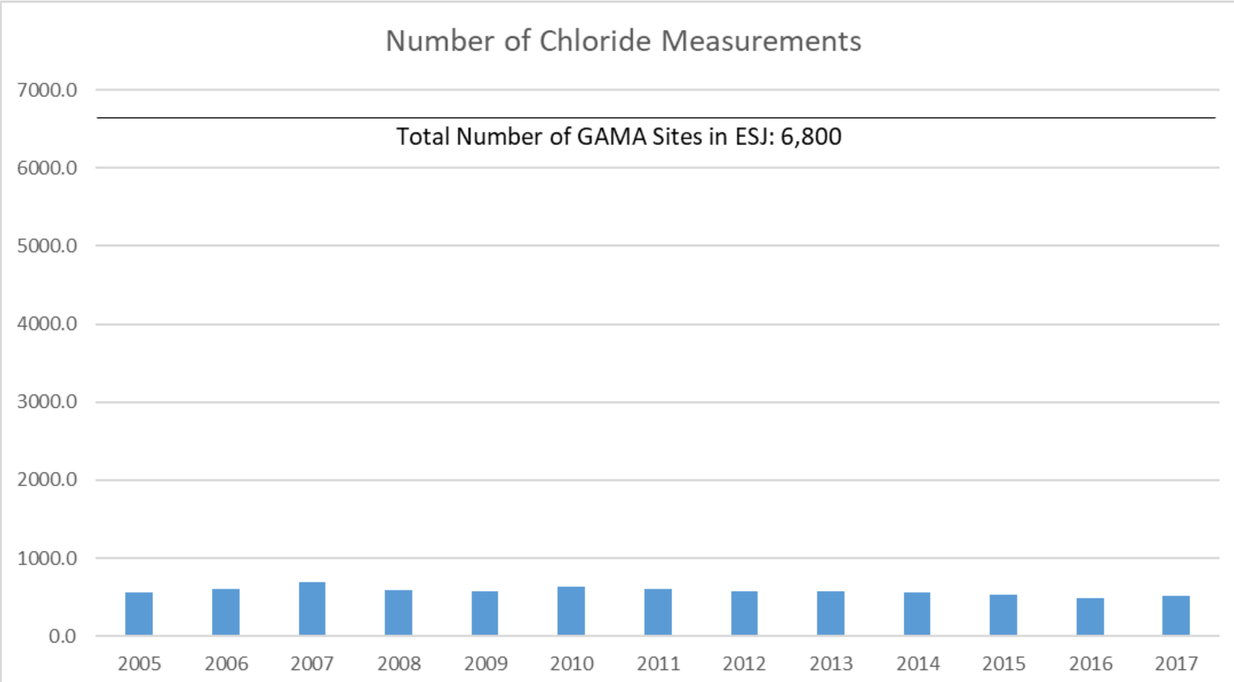


Figure 2-4: Number of Chloride Measurements Taken at GAMA Monitoring Sites (2005-2017)



Below is a list of attributes for each groundwater quality result 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, promote 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.

2.1.1.3 Stratigraphic Data

The Online System for Well Completion Reports (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 were 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 (CA 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 municipal 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 are mostly 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. Data from the Division of Oil, Gas, and Geothermal Resources (DOGGR) 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 2.1.5), surficial geologic maps (Section 2.1.5), location and depth of borehole (Section 2.1.7), and professional judgement.

2.1.1.4 GIS Data

In accordance with CCR Title 23 § 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 Title 23 § 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.

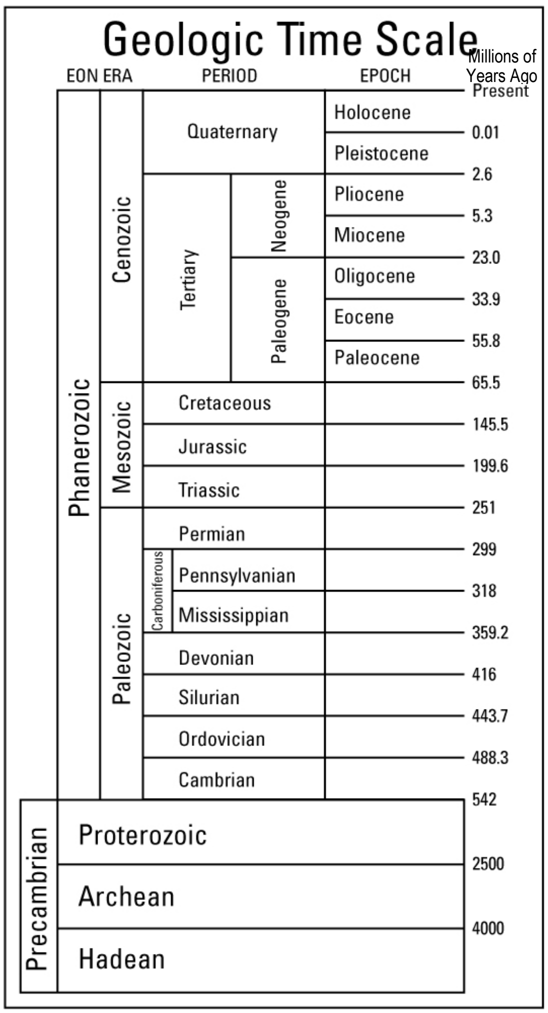
Certain GIS software programs, including QGIS and ArcGIS, were relied on heavily. QGIS is a powerful open-source program, whereas ArcGIS is the industry standard. Both are capable of completing the required elements for the GSP.

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 2.1.7. 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.

2.1.2 Regional Geologic and Structural Setting

The Eastern San Joaquin Subbasin lies within the San Joaquin Valley, which is 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 2-2 (Section 2.1.5) for the generalized stratigraphic column and Figure 2-5 below for the geologic time scale. The Sierra Nevada Mountain Range, east of the Central Valley, consists of pre-Tertiary igneous and metamorphic continental rocks. The Coast Range, to the west, consists of pre-Tertiary and Tertiary semi-consolidated to consolidated marine sedimentary and continental rocks. The material sources for the Central Valley continental deposits are the Coast Range and the 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 2-5: Geologic Time Scale



2.1.3 Geologic History

The origin of geologic formations within the Eastern San Joaquin Subbasin varies 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 (~3-30 million years ago) after which time sedimentation changed from marine to continental deposits due to the retreat of the sea and the regional rising of land mass previously inundated by the ocean. Intermittent volcanism dominated with the deposition of rhyolites and andesites (CA DWR, 1967).

2.1.4 Near-Surface Conditions

2.1.4.1 Topography

Ground surface elevations vary extensively across the Eastern San Joaquin Subbasin from almost 1,000 feet above mean sea level (MSL) in the upland areas in the east to around sea level in the flat lying valley floor to the west. The Eastern San Joaquin Subbasin topographic map is provided as Figure 2-6.

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.

2.1.4.2 Major Hydraulic Features

The major hydrologic features within the Eastern San Joaquin Subbasin are shown in Figure 2-7. The Subbasin is bounded on all sides except to the east by streams. Adjacent groundwater subbasins also share an interest in the impacts of the Sustainable Groundwater Management Act (SGMA) on these boundary streams.

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 2-7). 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.

Figure 2-6: Topography

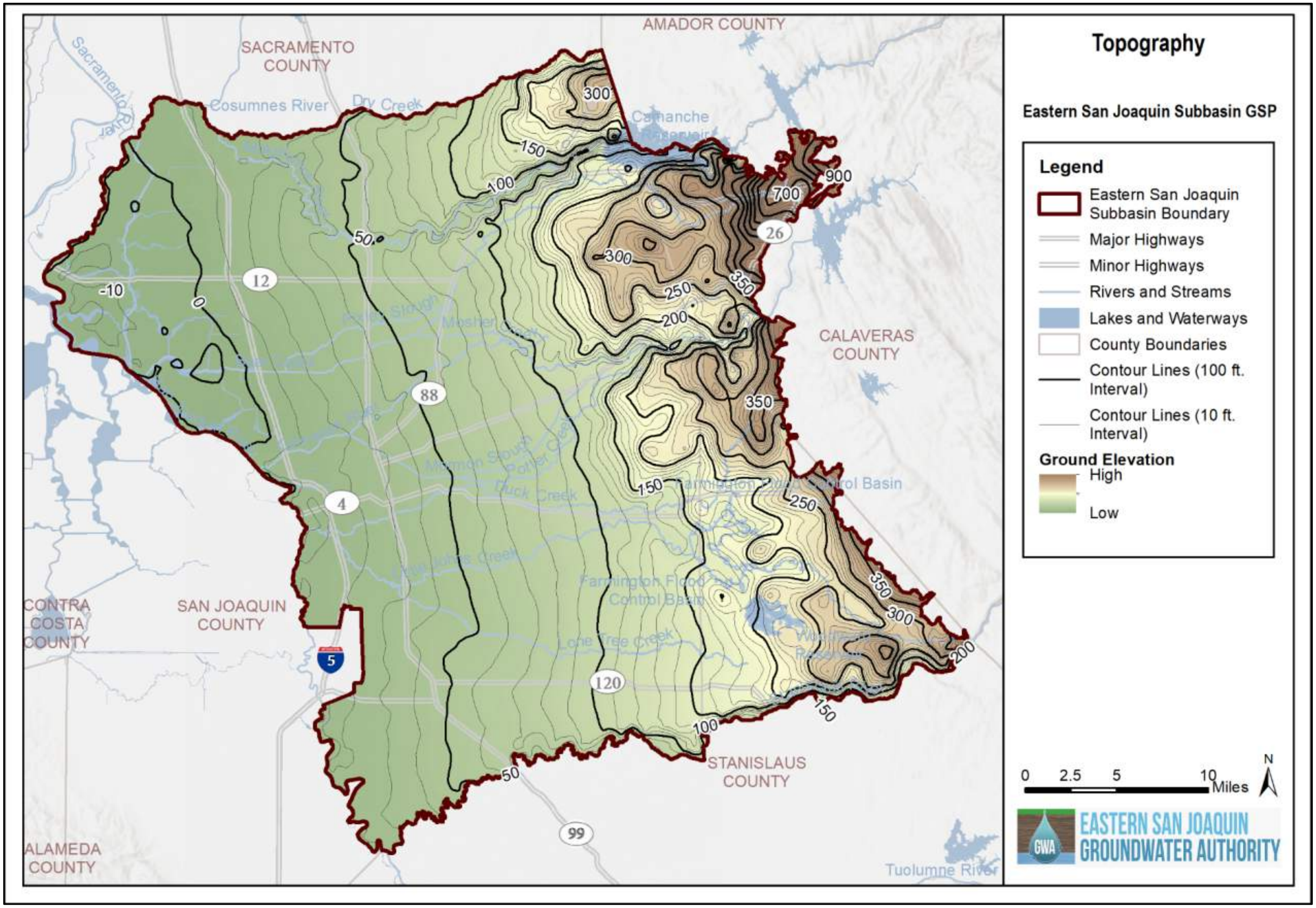
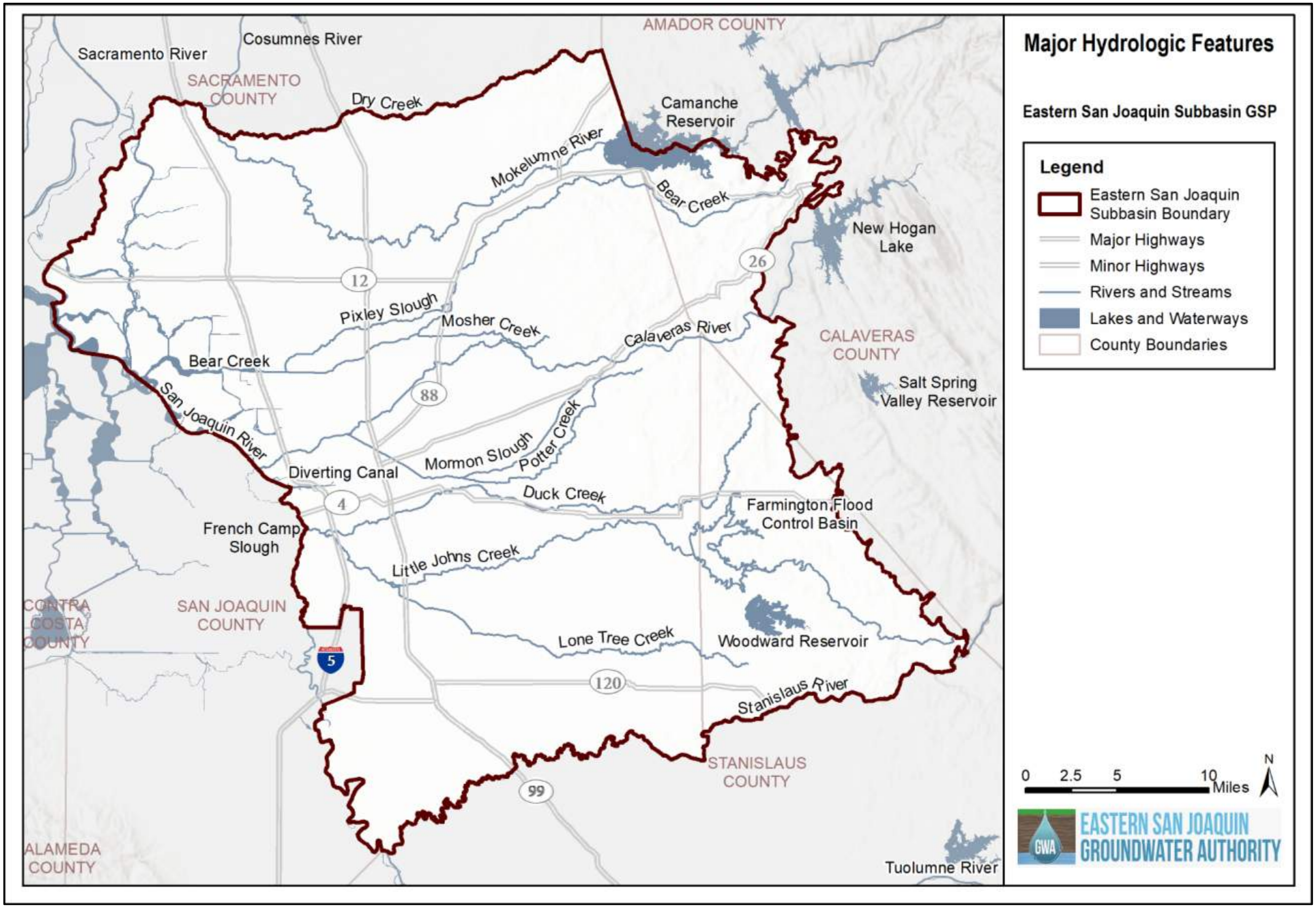


Figure 2-7: Major Hydrologic Features



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 Sacramento-San Joaquin River Delta (Delta) (Burow et al., 2004). Two major westerly flowing tributaries to the San Joaquin River within or adjacent to the Eastern San Joaquin Subbasin are the Stanislaus River (Subbasin south boundary), the Mokelumne River (north portion of Subbasin), and the Calaveras River (central portion of Subbasin).

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 (see Figure 2-8). Most of the watershed area falls within Modesto Subbasin. The flow in the Stanislaus River varies seasonally from less than 134 acre-feet per day (AF/day) during the dry season in early fall to over 16,400 AF/day during wet season in winter. These flows correlate to discharges from 68 to over 8,270 cubic feet per second (cfs) recorded at the Orange Blossom Bridge gauging station approximately one mile east of Oakdale and eight miles west of the Subbasin boundary along the river (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, the majority of which is within Cosumnes Subbasin. 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 less than 200 AF/day during the dry season to 9,900 AF/day during the wet season. These flows correlate to discharges from as low as 100 to no more than 5,000 cfs reported by the USGS below the Camanche Dam. Major watersheds of the river are the Upper Mokelumne River (most of which is outside of the Subbasin to the east with a small portion overlapping with Cosumnes Subbasin) and the Lower Mokelumne River (mostly contained in the Subbasin with a small portion intersecting the South American and Solano Subbasins).

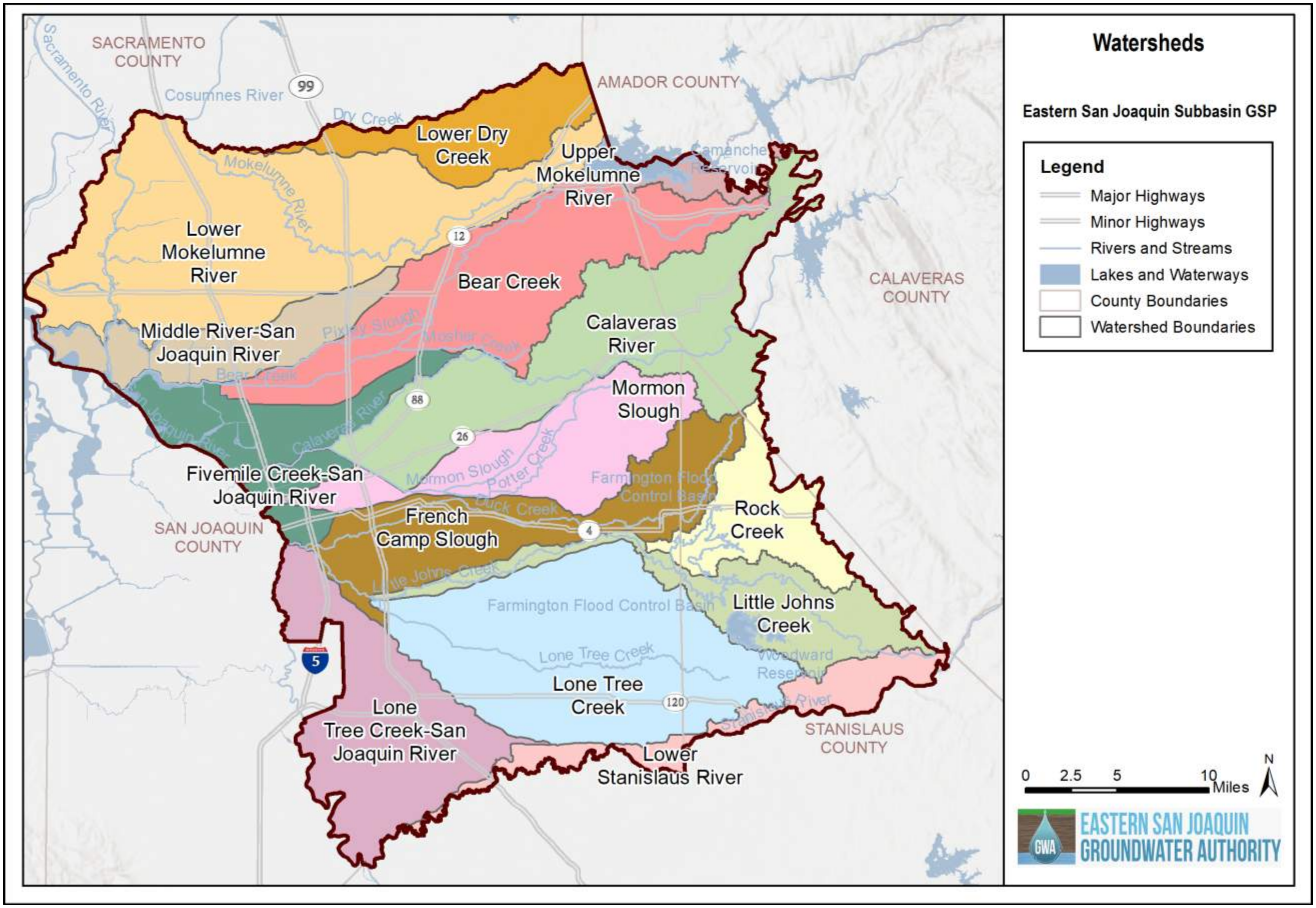
The Calaveras River, also with headwaters in the Sierra Nevada, drains a watershed of about 1,370 km^2 (530 mi^2) and flows into and across the Subbasin to its confluence with the San Joaquin River on the northwest side of Stockton. Flow in the Calaveras River below the New Hogan Reservoir varies seasonally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

In addition to the Stanislaus, Mokelumne, and Calaveras Rivers, 10 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 East Contra Costa or Tracy Subbasins: 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 2-8 depicts the Eastern San Joaquin Subbasin and the watersheds that overlie the Subbasin. Table 2-1 is a list of watersheds that overlie the Subbasin.

Table 2-1: 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	98	58
Five Mile Creek-San Joaquin River	154	62	40
Bear Creek	127	127	100

Figure 2-8: Eastern San Joaquin Subbasin Watersheds



2.1.4.3 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:

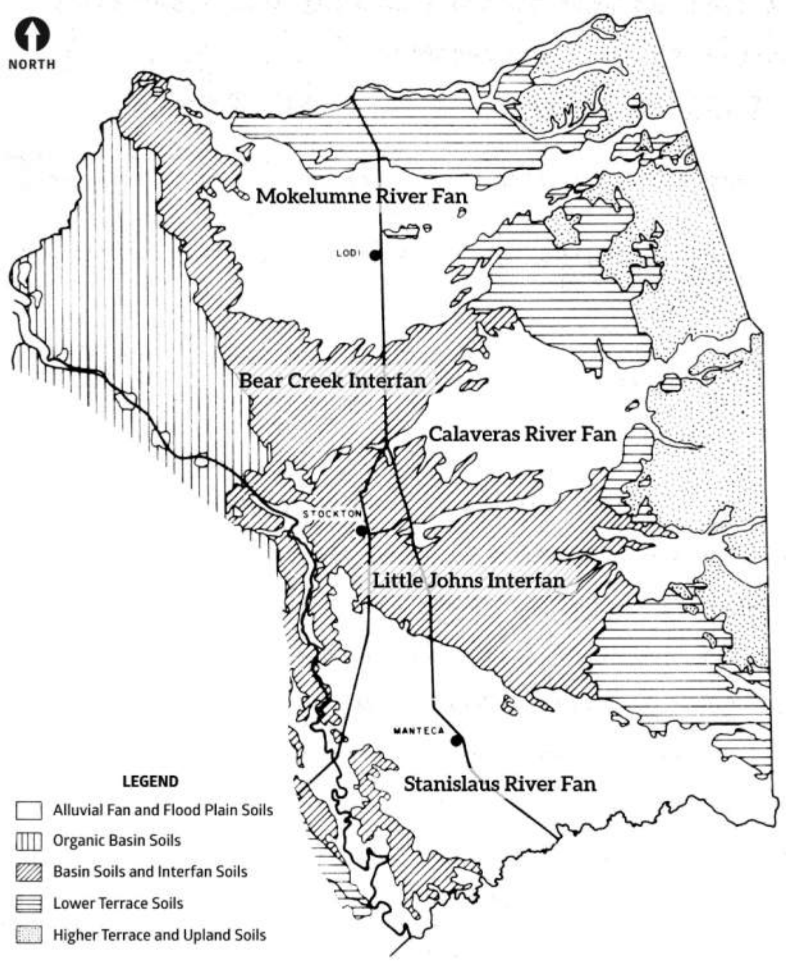
1. Alluvial fan and flood plain soils
2. Organic basin soils
3. Basin soils
4. Lower terrace soils
5. Higher terrace and upland soils

These groupings coincide in part 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 2-2-9 shows the areal distribution of the five soil types in San Joaquin County (CA DWR, 1967).

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 2-9 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.

Figure 2-9: Soil Depositional Areas



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 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 2-10 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 2-10).

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 (MWH, 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 2-11 in dark blue cross hatching.

Figure 2-10: Hydrologic Soil Groups

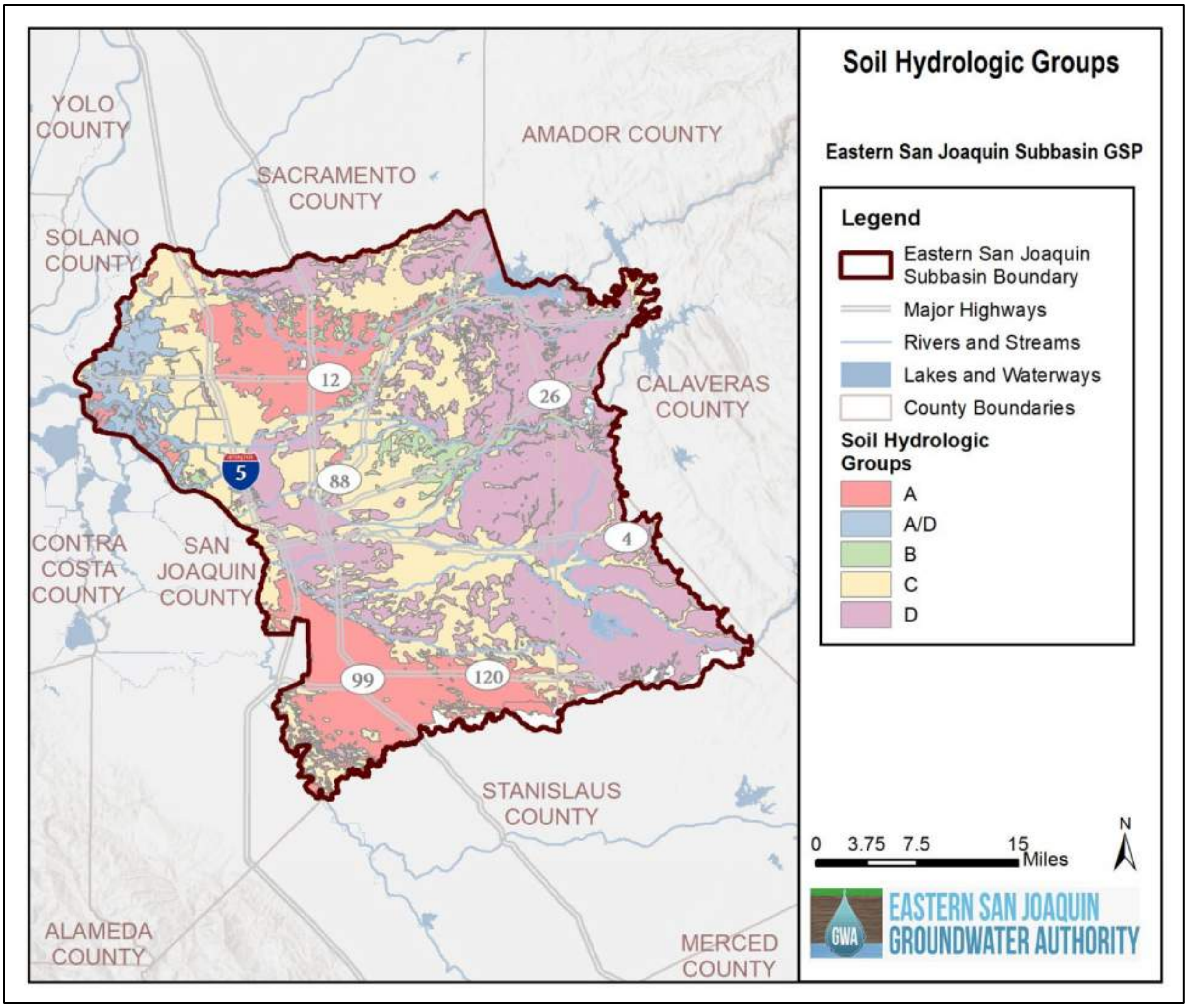
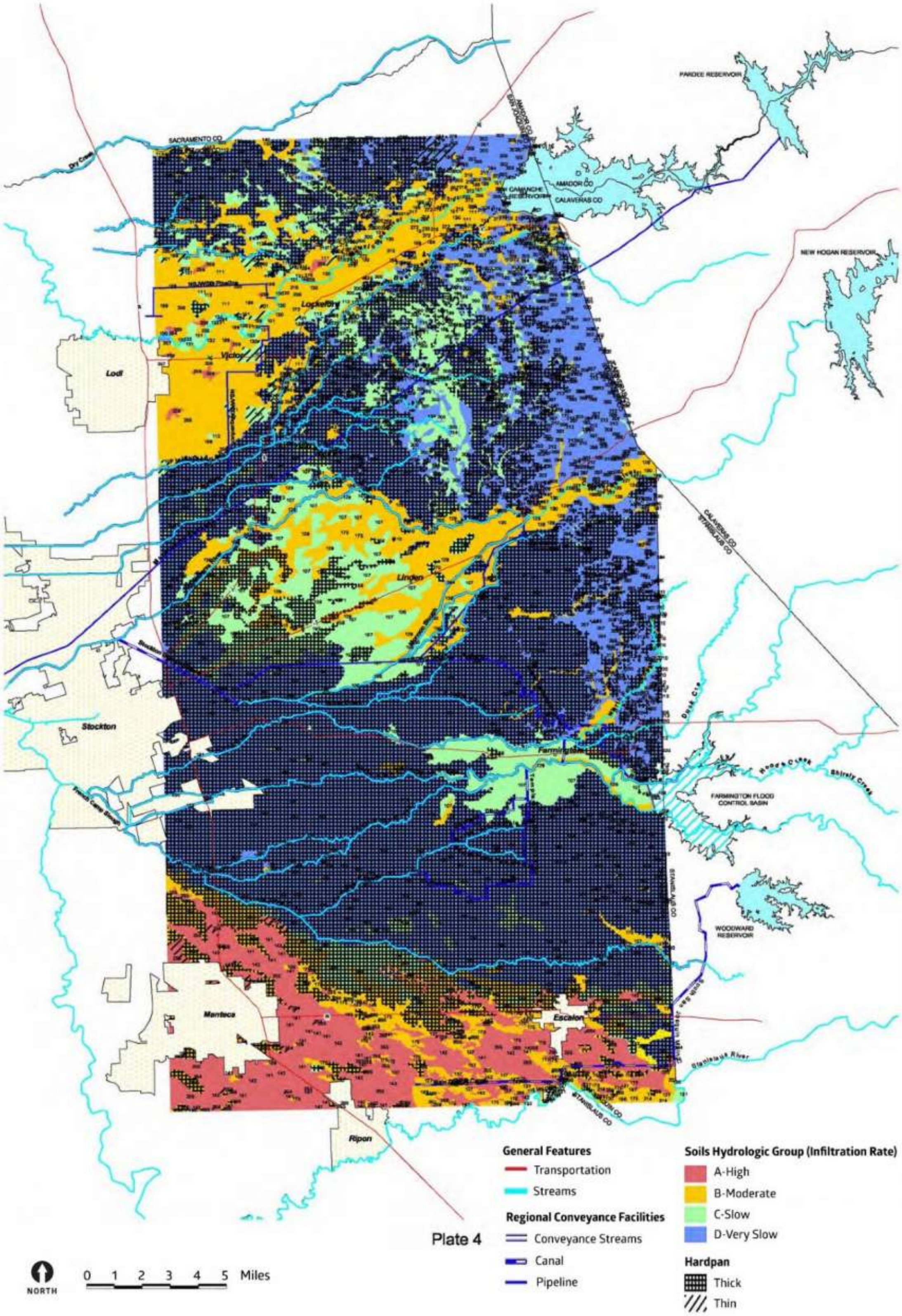


Figure 2-11: Occurrence of Hardpan within the Eastern San Joaquin Subbasin



2.1.4.4 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 the 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.

2.1.4.5 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 Section 2.3.

2.1.4.5.1 Description of Recharge Areas

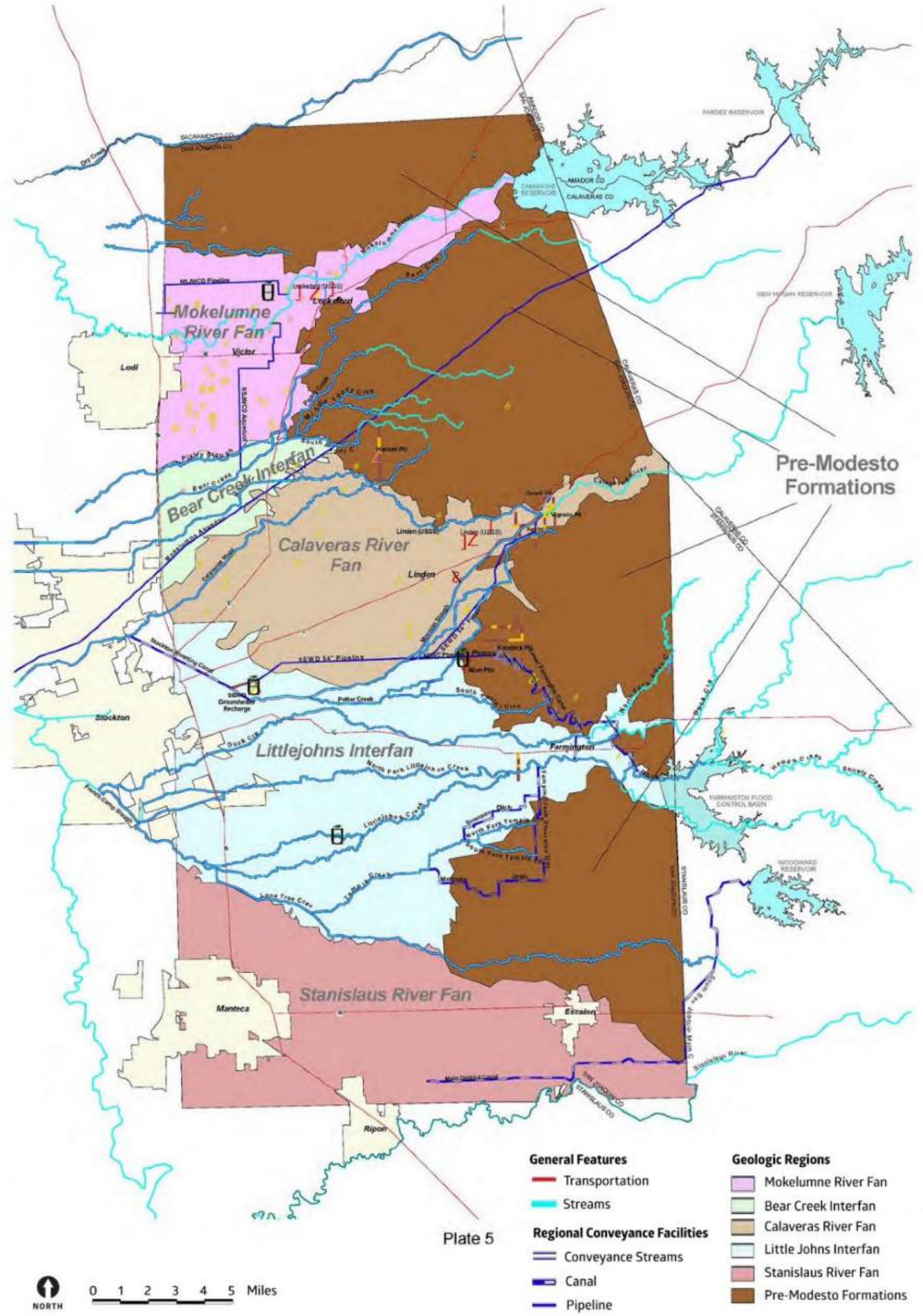
The recharge potential of soils and formations encountered in the Eastern San Joaquin Subbasin varies considerably and is dependent on primary and secondary geologic effects. Primary geologic patterns that influence permeability relate to grain size and sorting as a result of depositional characteristics. 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). Additional information on geologic formations is provided in Section 2.1.5.

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 2-12 depicts the aerial extents of the alluvial fans, interfan areas, and pre-Modesto formations.

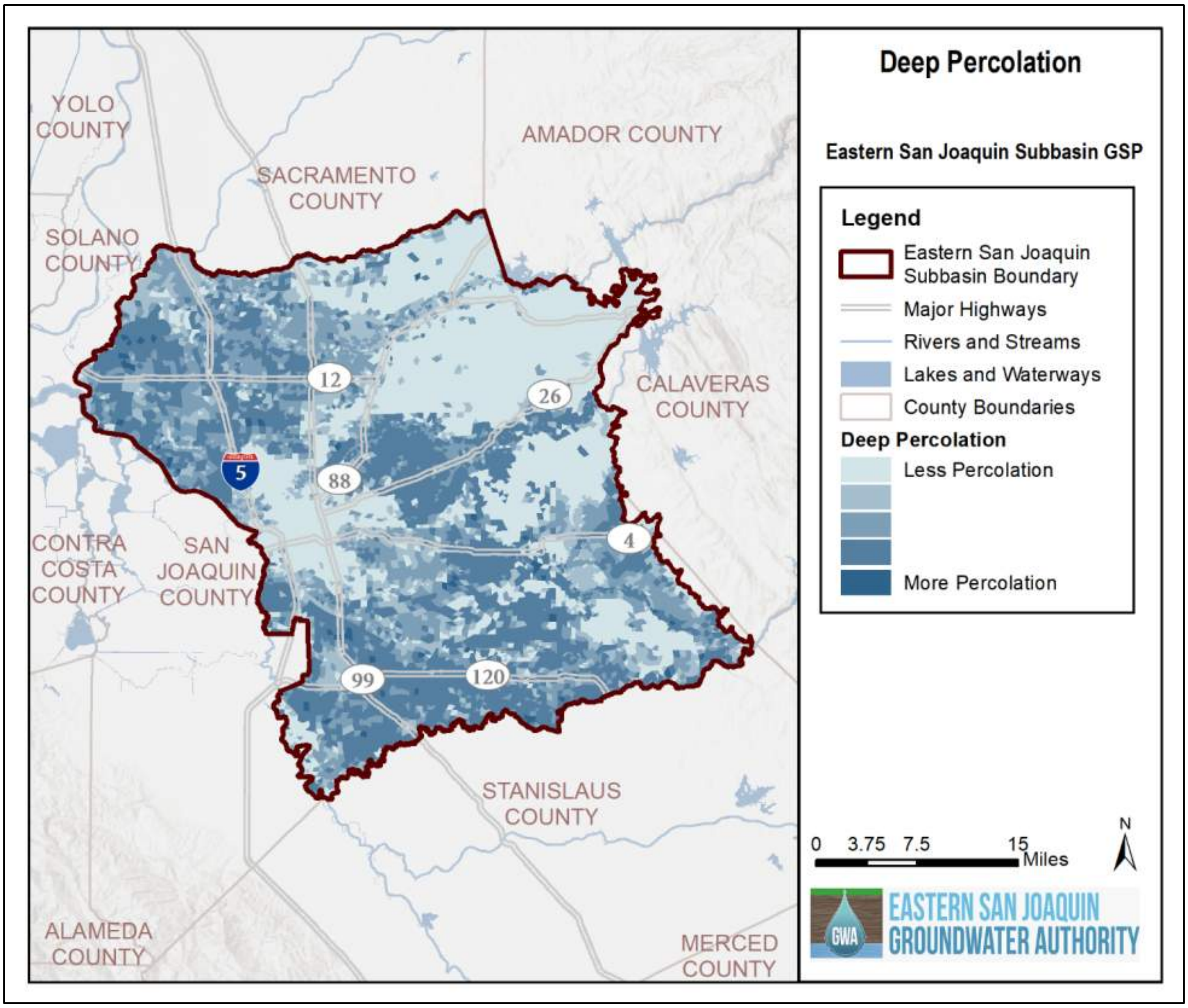
Figure 2-12: Areal Extents of Alluvial Fans, Interfans and Pre-Modesto Formations



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. Stream channels migrate and abruptly jump to new locations over time in this depositional environment, 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 historical alluvial depositional factors are useful 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; and 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 2-13 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). The higher percolation areas are those that substantially contribute to the replenishment and recharge in the Subbasin. Section 1.2.2.9 describes existing conjunctive use programs, and Figure 1-16, shown previously in Chapter 1: Agency Information, Plan Area, and Communication, maps direct recharge areas in the Subbasin.

Figure 2-13: Existing Areas of Groundwater Recharge



Note: Figure shows the distribution of deep percolation of precipitation and applied water based on ESJWRM model outputs. It does not include recharge from rivers and streams, boundary flows, or recharge projects.

2.1.4.5.2 Description of Discharge Areas

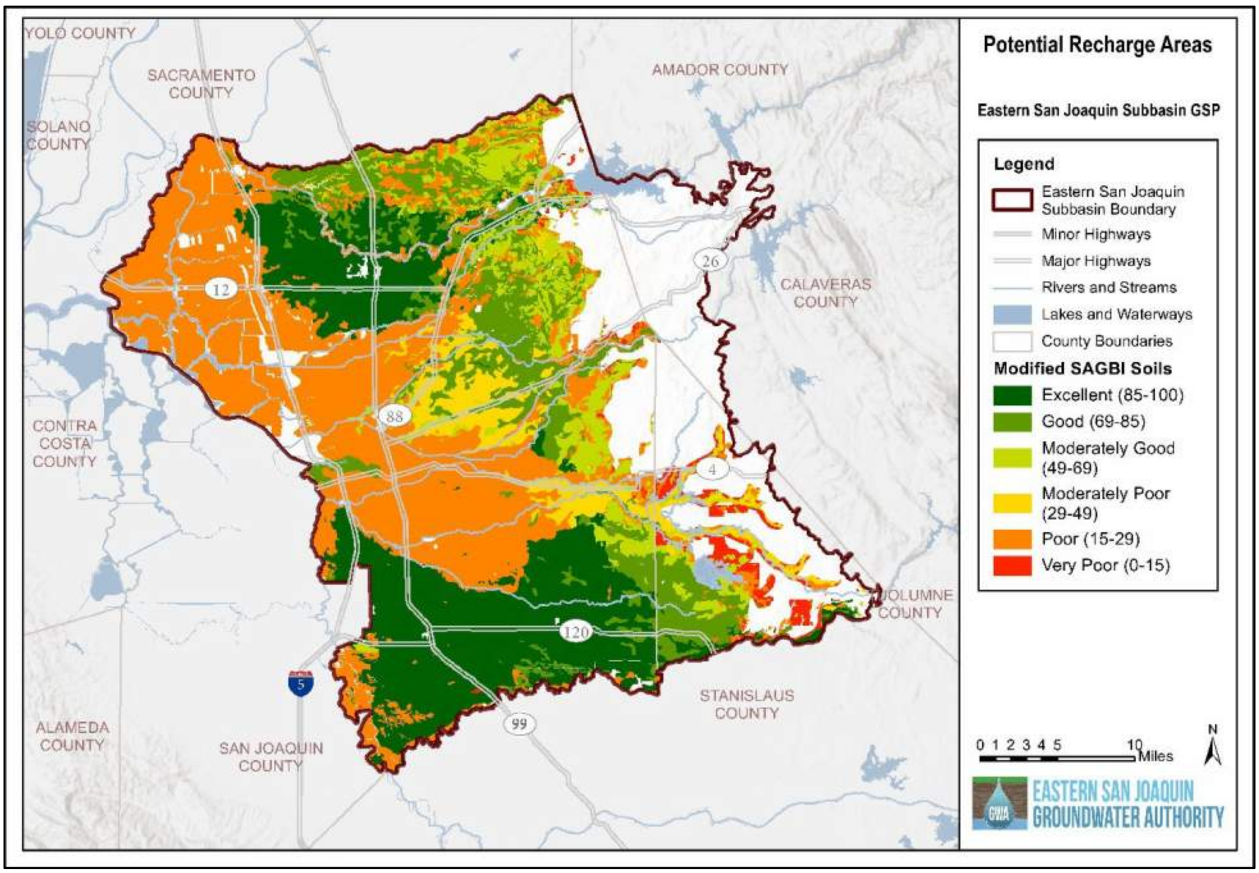
Groundwater discharge primarily occurs through groundwater production wells. Groundwater production in Eastern San Joaquin Subbasin is discussed further in Section 2.2. Groundwater also discharges to rivers and streams where groundwater elevations are higher than river stage. Other sources of groundwater discharge are evapotranspiration from riparian areas, phreatophyte woodlands, and other groundwater dependent ecosystem (GDE) communities. Groundwater discharge to streams is described more in Section 2.2.6 and discusses analysis based on modeling results from the ESJWRM for approximately 900 stream nodes (locations along simulated streams where calculations are made related to stream flows and interaction with groundwater) in the Eastern San Joaquin Subbasin.

2.1.4.5.3 Description of Potential Recharge Areas

Figure 2-14 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 are 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 categorize 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).

Figure 2-14: Potential Recharge Areas



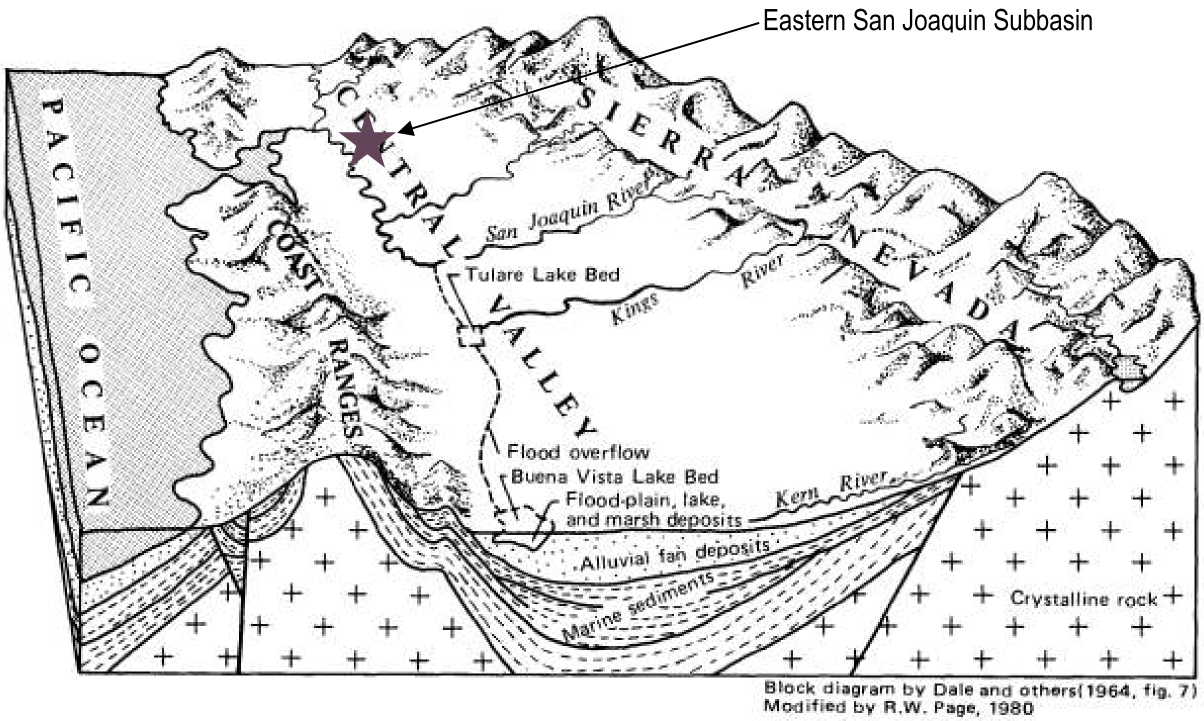
2.1.5 Geologic Formations and Stratigraphy

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. The Eastern San Joaquin Subbasin is located to the east of the San Joaquin River. Eastside continental formation material generally originates from deposits from the Sierra Nevada and westside continental formation material generally originates from the deposits of the Coast Range. 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 2-15) 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, labeled "Central Valley" in Figure 2-15, and the granitic Sierra Nevada geomorphic province, labeled "Sierra Nevada" in Figure 2-15.

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 2-15: 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 2-16 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 2-2.

Figure 2-16: Geologic Map

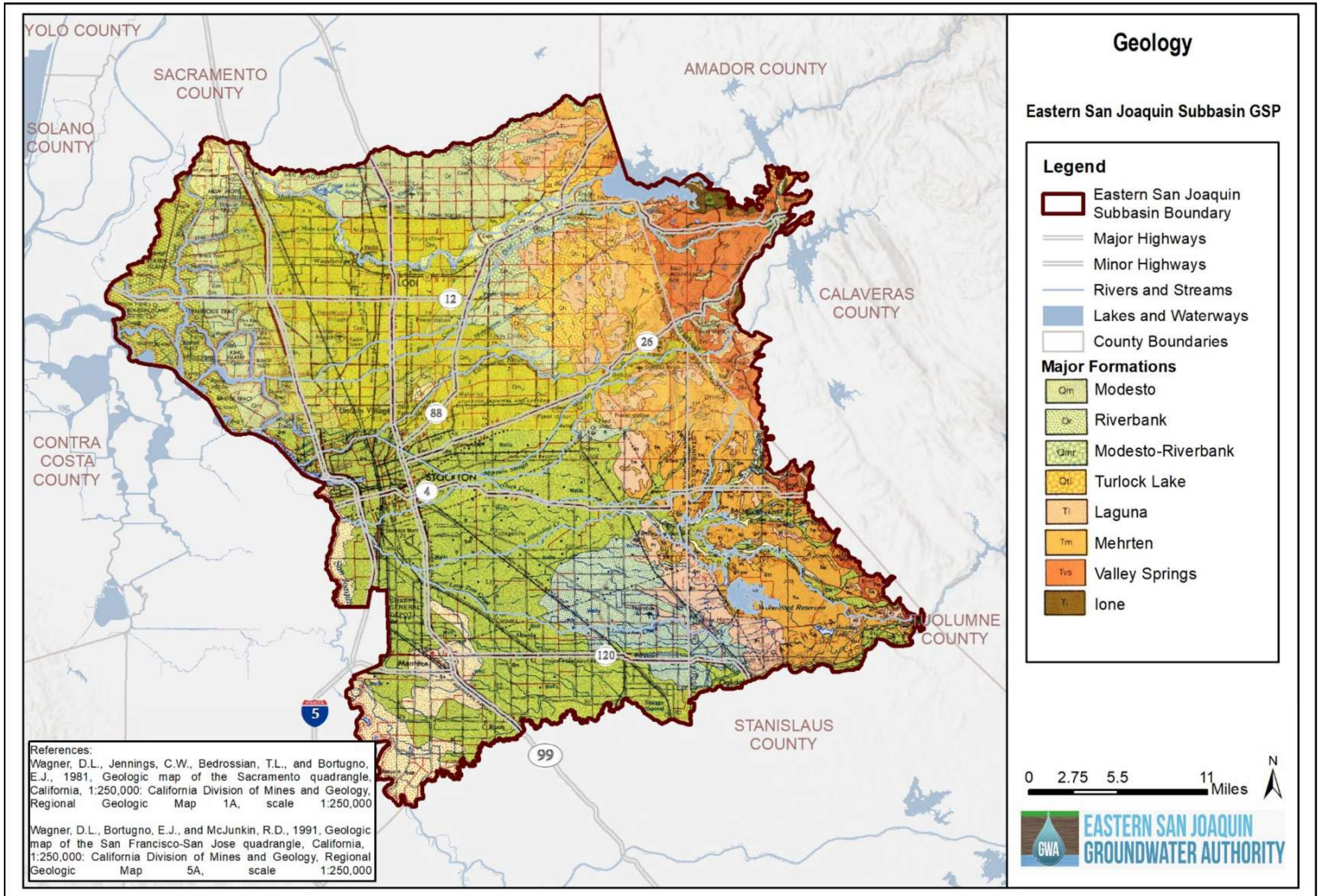


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Table 2-2: Generalized Stratigraphic Column, Formation Descriptions, and Water-Bearing Properties

Era*	Period*	Epoch*	Formation & Map Symbol	Thickness Maximum (feet)	Rock Characteristics and Environment	Water-Bearing Properties
CENOZOIC	*Quaternary*	Holocene	Stream Channel Deposits	50±	Continental unconsolidated gravel and coarse to medium sand deposited along present stream channels.	High permeability, significant avenue for percolation to underlying formations.
		Late Pliocene	Modesto (Qm)	65-130±	Continental fan and interfan material, locally some basin types, lenticular gravel, sand, silt, clay.	Moderate permeabilities. Unconfined aquifer.
		Pliocene	Riverbank (Qr)	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 Formation (Qtl)	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 (Tl)	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.
		Miocene	Valley Springs (Tvs)	0-500±	Continental rhyolitic ash, clay, sand & gravel and their indurated equivalent.	Low permeability. Not considered as significant in groundwater studies.
		Eocene	Ione (Tl)	0-500±	Light colored clay and sand. Marine shale, siltstone and sandstone	Contains saline waters except where flushed in outcrop areas.
MESOZOIC	*Creta-ceous* / *Pre-Cretace-ous*	Cretaceous Jurassic	Undifferentiated Bedrock		Igneous, metamorphics and ultramafics.	Contains saline waters. Not relevant to fresh water basin except as possible contaminant source.

Sources: CA DWR, 1967; Burow et al., 2004
* Figure 2-5 contains time scales corresponding to formations

2.1.5.1 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.

2.1.5.1.1 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 2-2. 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).

2.1.5.1.2 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).

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).

2.1.5.1.3 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.

2.1.5.1.4 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 a non-distinct 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 are produced from the relatively permeable "black sands" commonly described as hard sandstones (CA DWR, 1967).

2.1.5.1.5 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 San Joaquin 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.

2.1.5.1.6 Turlock Lake Formation

The Turlock Lake Formation consists 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 east. 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 Turlock Lake 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.

2.1.5.1.7 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.

2.1.5.1.8 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 Formation 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 differ substantially from exposures near the foothills and from exposures along the westward draining rivers.

2.1.5.1.9 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).

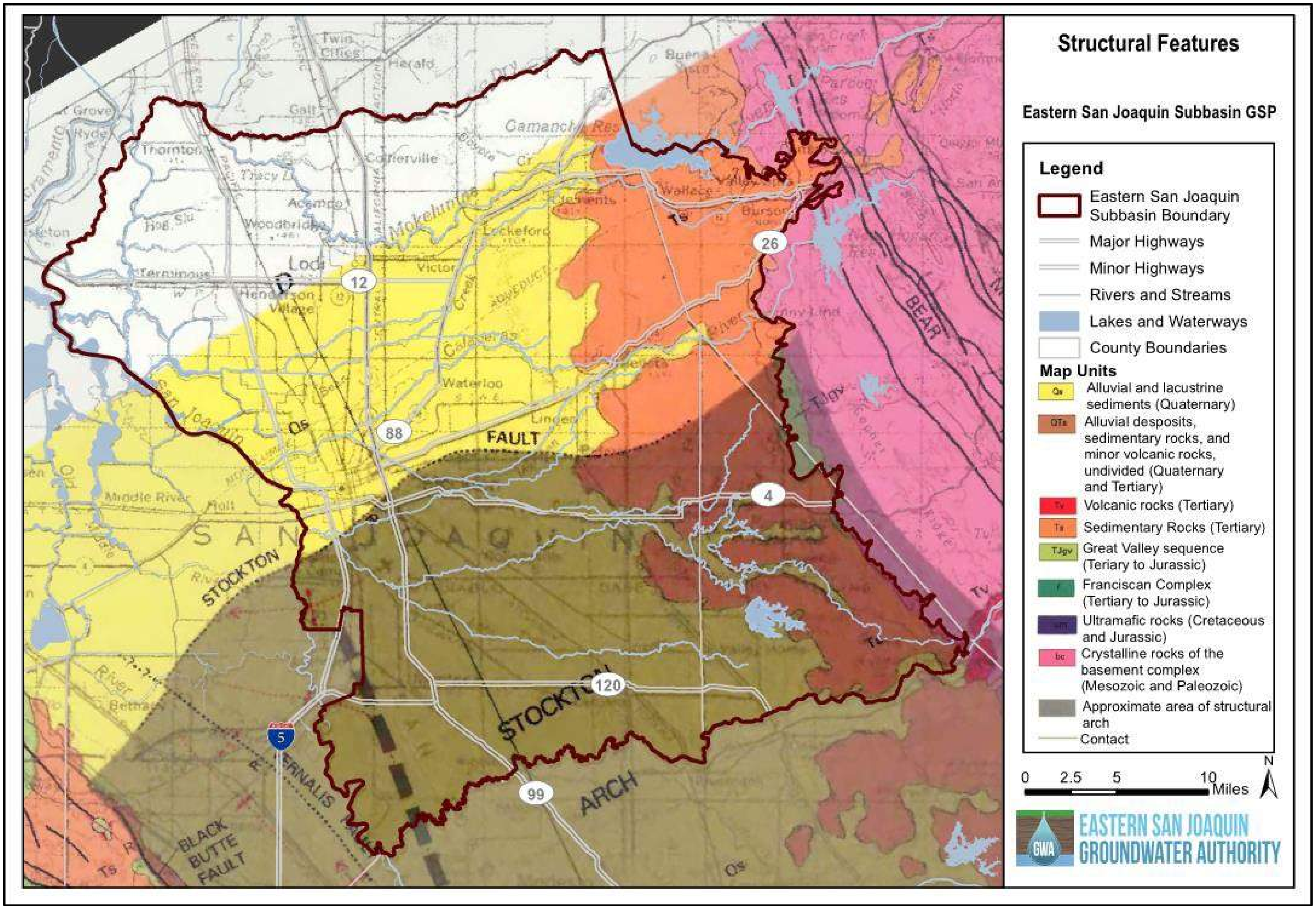
2.1.6 Faults and Structural Features

The Stockton Fault – The Stockton Fault is the largest fault in the Eastern San Joaquin Subbasin, shown in Figure 2-17. 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.

The Vernalis Fault – The Vernalis Fault is a 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 2-5. 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.

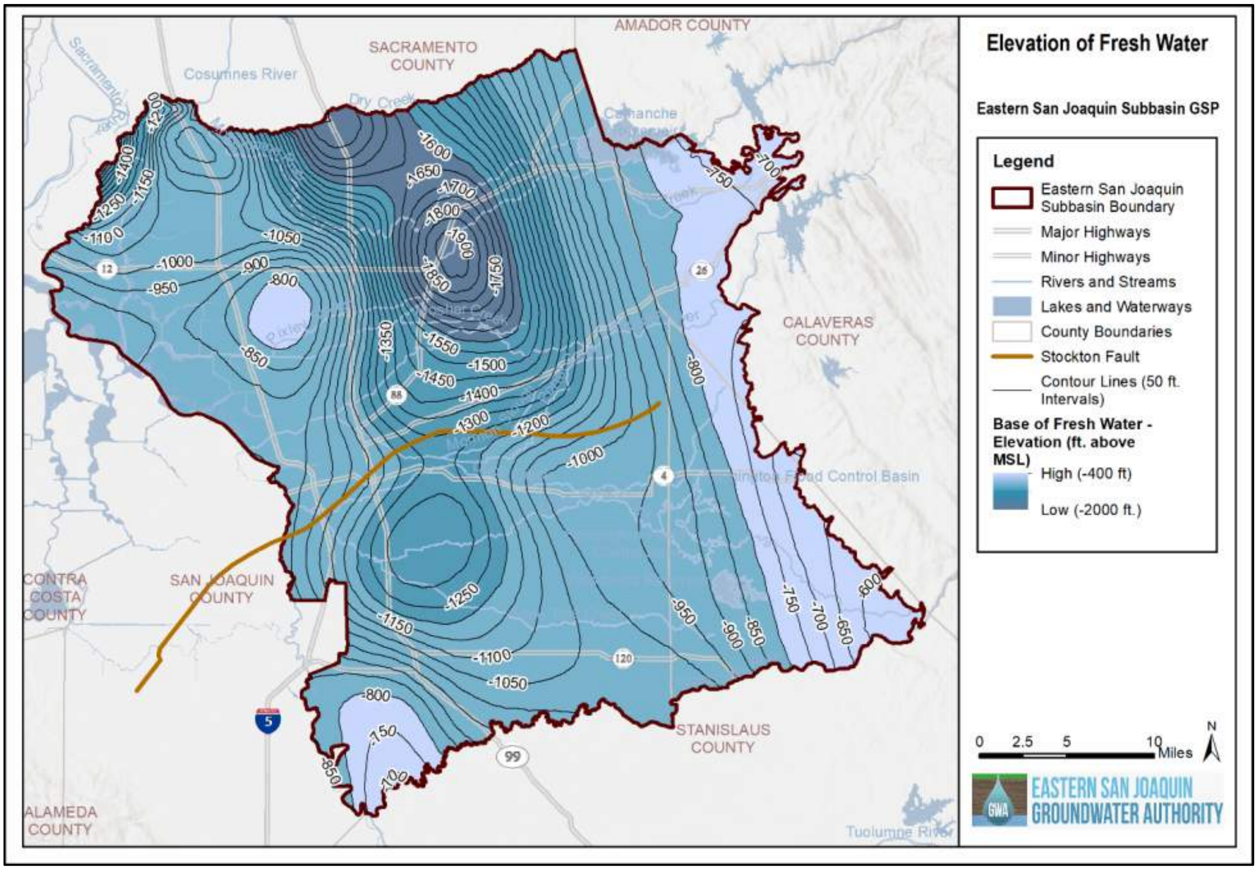
Stockton Arch – The Stockton Arch is a broad transverse structure that underlies the southern half of the Eastern San Joaquin Subbasin. The arch is bounded on the north by the Stockton Fault, and the southern limit is the line of truncation of Paleogene strata south of Modesto (Bartow, 1985). Indications 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 2-17: 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", as shown below in Figure 2-18. The base of fresh water is discussed further in Sections 2.1.7 and 2.1.8.2.

Figure 2-18: Base of Fresh Water Elevation and Stockton Fault



Angular unconformities – 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 million years ago (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.

2.1.7 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 2-19. 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 2-20, Figure 2-21, and Figure 2-22.

Figure 2-19: Cross-Section Location Map

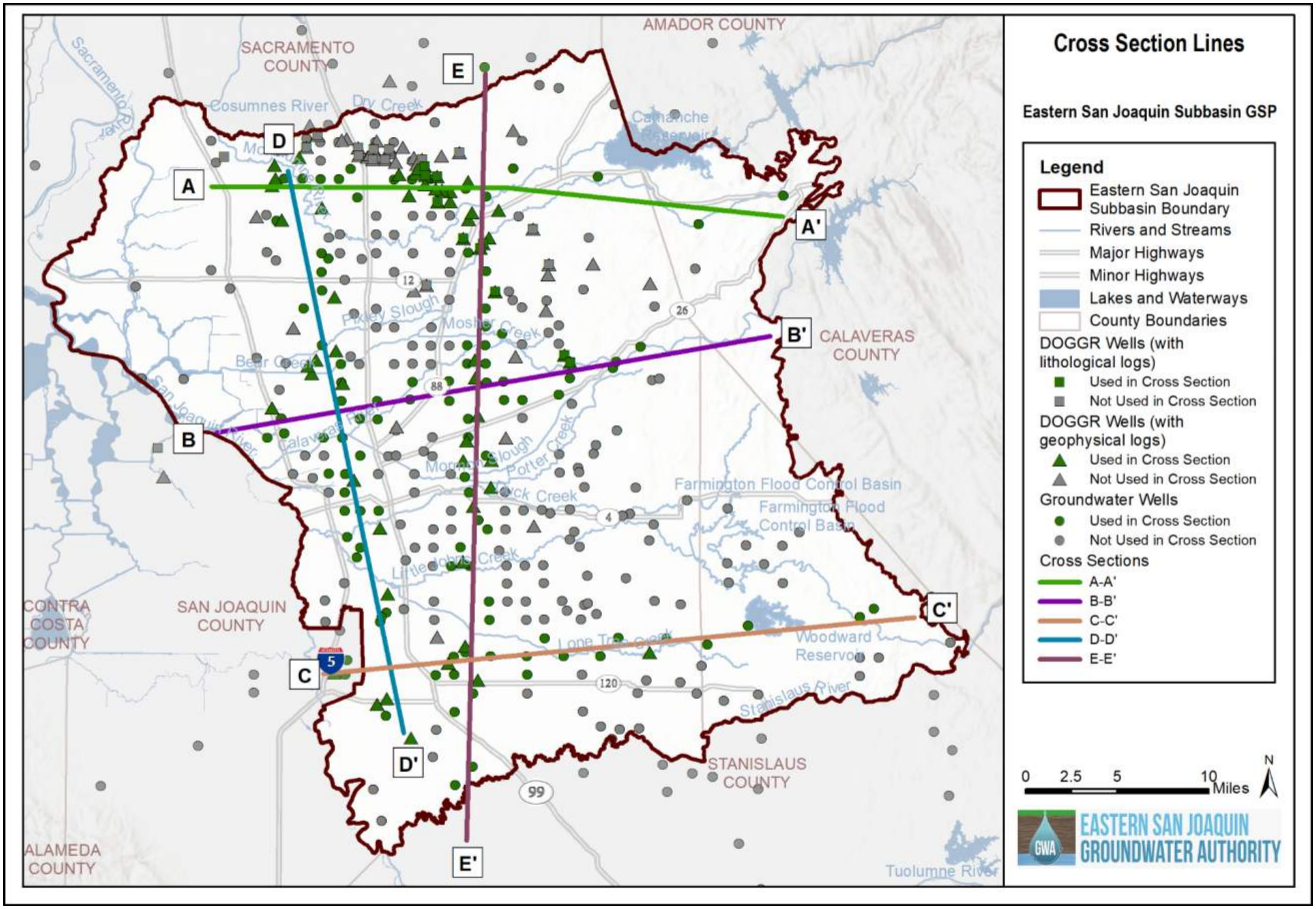


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Figure 2-20: Hydrogeologic Cross-sections A-A' and B-B'

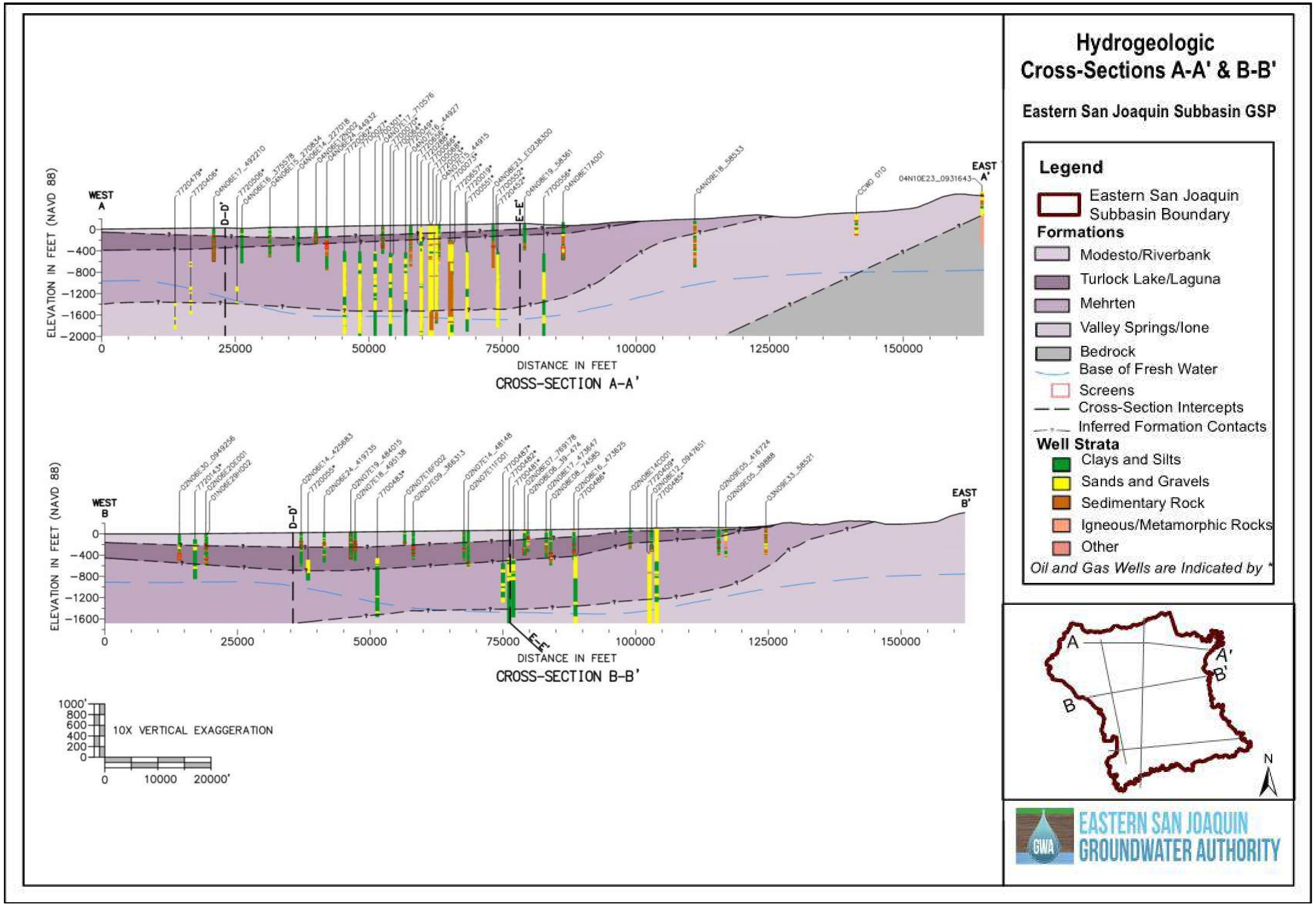


Figure 2-21: Hydrogeologic Cross-sections C-C' and D-D'

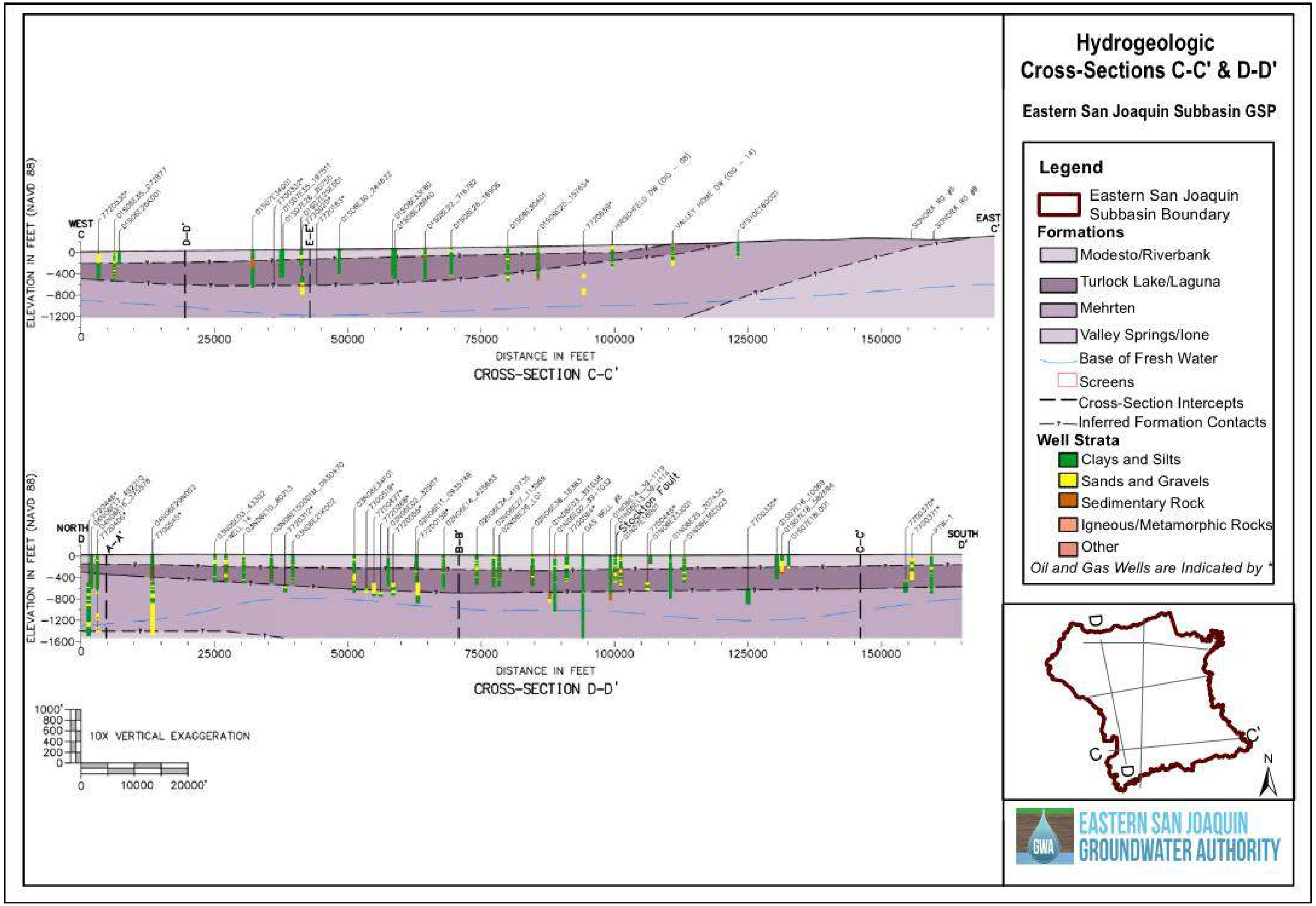
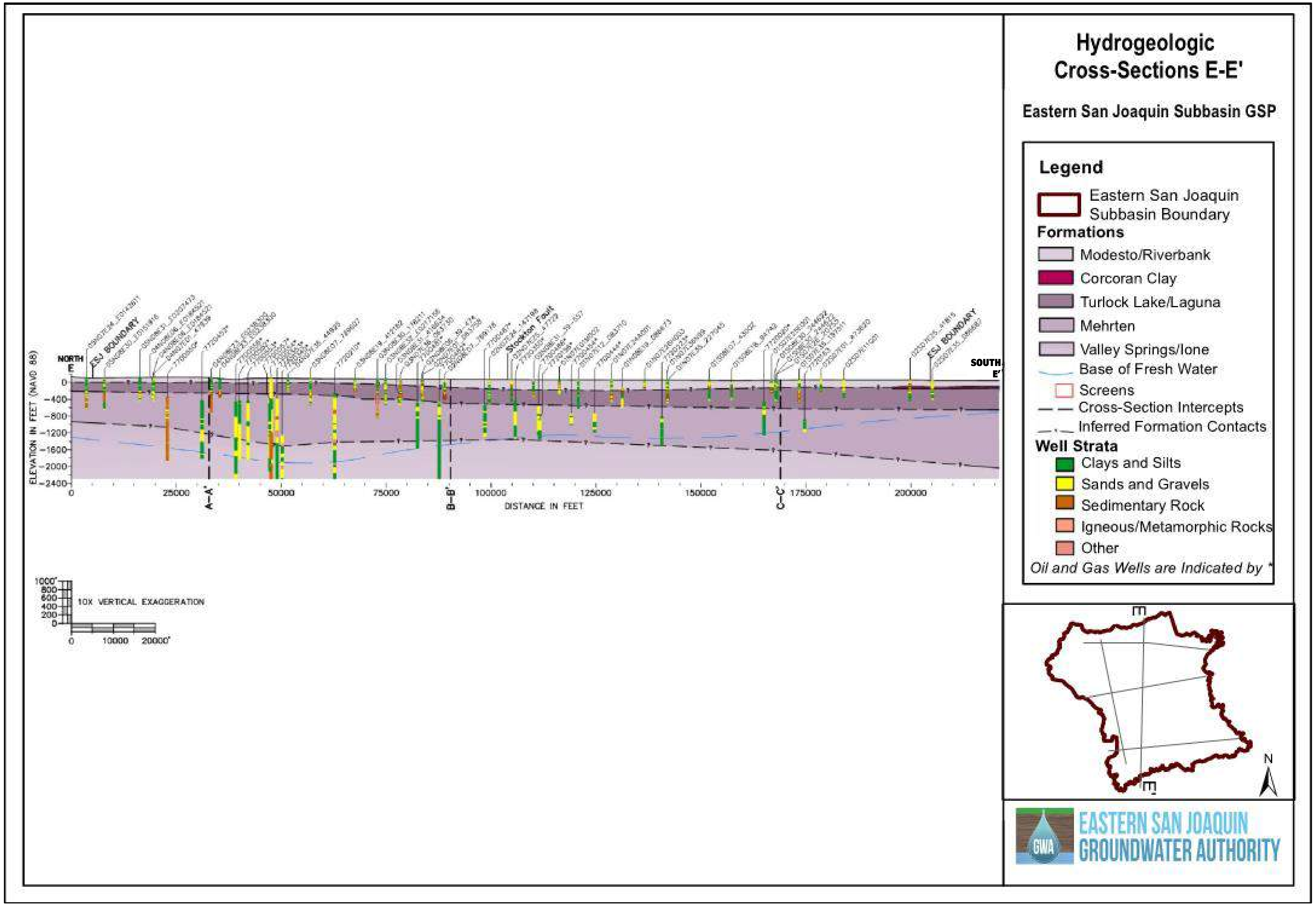


Figure 2-22: Hydrogeologic Cross- section E-E'



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Stratigraphic data from well completion reports of hundreds of water wells and oil and gas wells (indicated by an asterisk on the cross-sections) were used to develop the geologic cross-sections. Stratigraphy (e.g., clays and silts, sands and gravels, sedimentary rock, metamorphic and igneous rock) 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 surficial geology, location, and depth of the borehole to determine geologic formations. The analysis inferred formation contacts in places where data were 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 is superimposed on the cross-sections as supported by works from Page (1974) and Williamson (1989), as represented in Figure 2-18. The base of the fresh water represents the vertical extent of fresh non-saline groundwater within the Eastern San Joaquin Subbasin principal aquifer. 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, as shown on cross-sections A-A' and B-B'. 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 2.1.9.

Well depths generally decrease in total 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.

2.1.8 Basin Boundaries

2.1.8.1 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 are shown in Figure 1-6 and include:

- Cosumnes Subbasin to the north of Dry Creek
- Modesto Subbasin to the south of the Stanislaus River
- South American Subbasin to the northwest of the Mokelumne River
- Solano Subbasin to the northwest of the Mokelumne River

- East Contra Costa Subbasin to the west of the San Joaquin River
- Tracy Subbasin to the west of the San Joaquin River

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

2.1.8.2 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 shown in Figure 2-18, 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 below ground surface (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 (1989).

2.1.9 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 consists of the alluvial sands and gravels of the Modesto, Riverbank, and Upper Turlock Lake Formations
- Intermediate Zone that consists 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 2.1.5.

2.1.9.1 Zones within Principal Aquifer

Zones within the principal aquifer are based on the compilation of five hydrogeologic cross-sections (see Figure 2-20 through Figure 2-22). Cross-sections were based on over 330 well logs in the Subbasin. From this data, well depths for municipal and irrigation wells range from 75 to over 800 feet bgs, with an average depth of 350 feet bgs. Well logs were reviewed for the following information used in putting together the cross-sections:

- Depth of water table
- Depth and thickness of saturated fine to coarse grained sand and gravel layers
- Depth and thickness of discrete layers of sands
- Depth and thickness of discrete clay or silt layers that locally confine groundwater
- Depth of water-bearing 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 2-23 and Figure 2-24 depict the wells 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 2-23: Bottom Elevation of Water-Bearing Zones (Shallow)

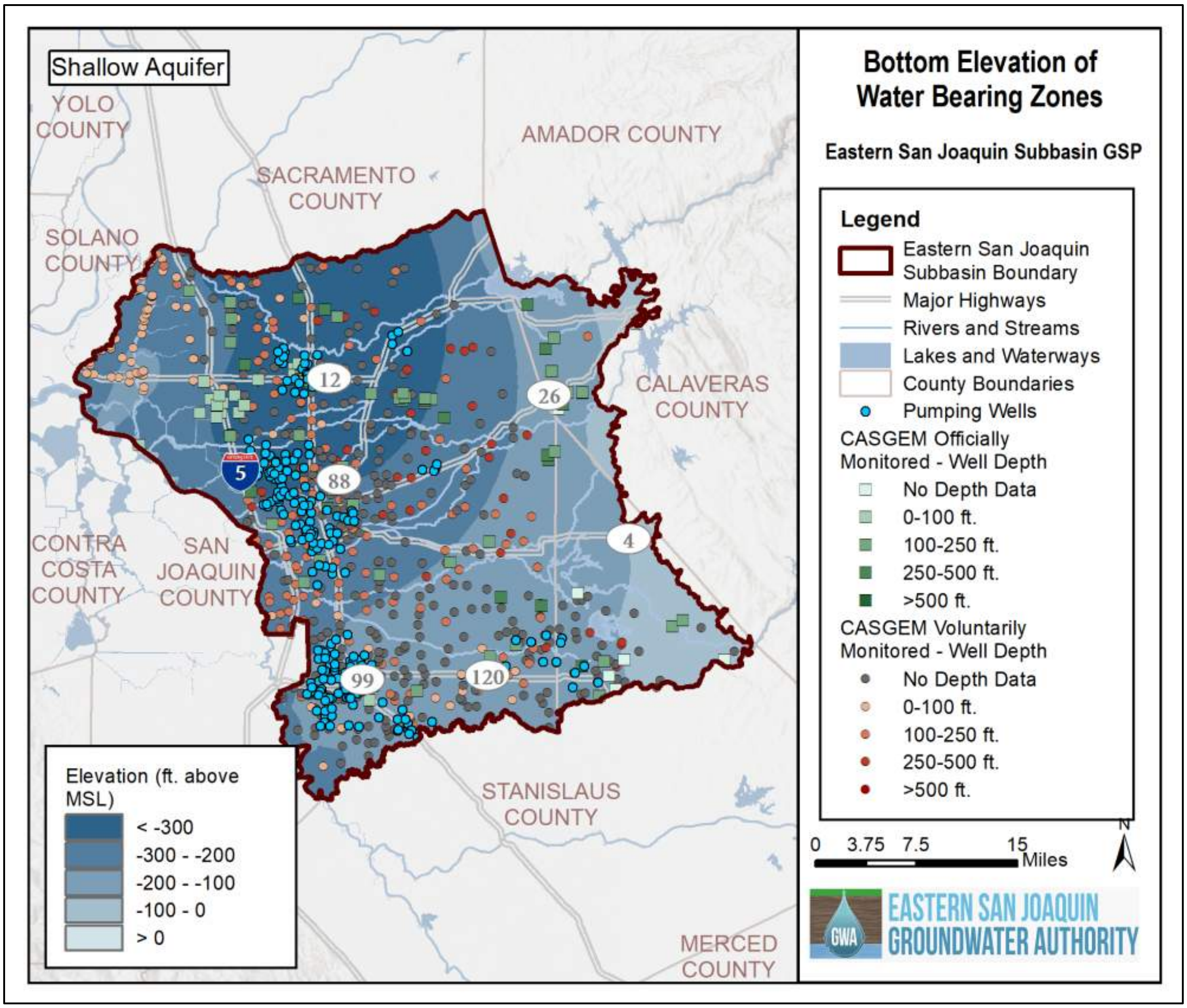
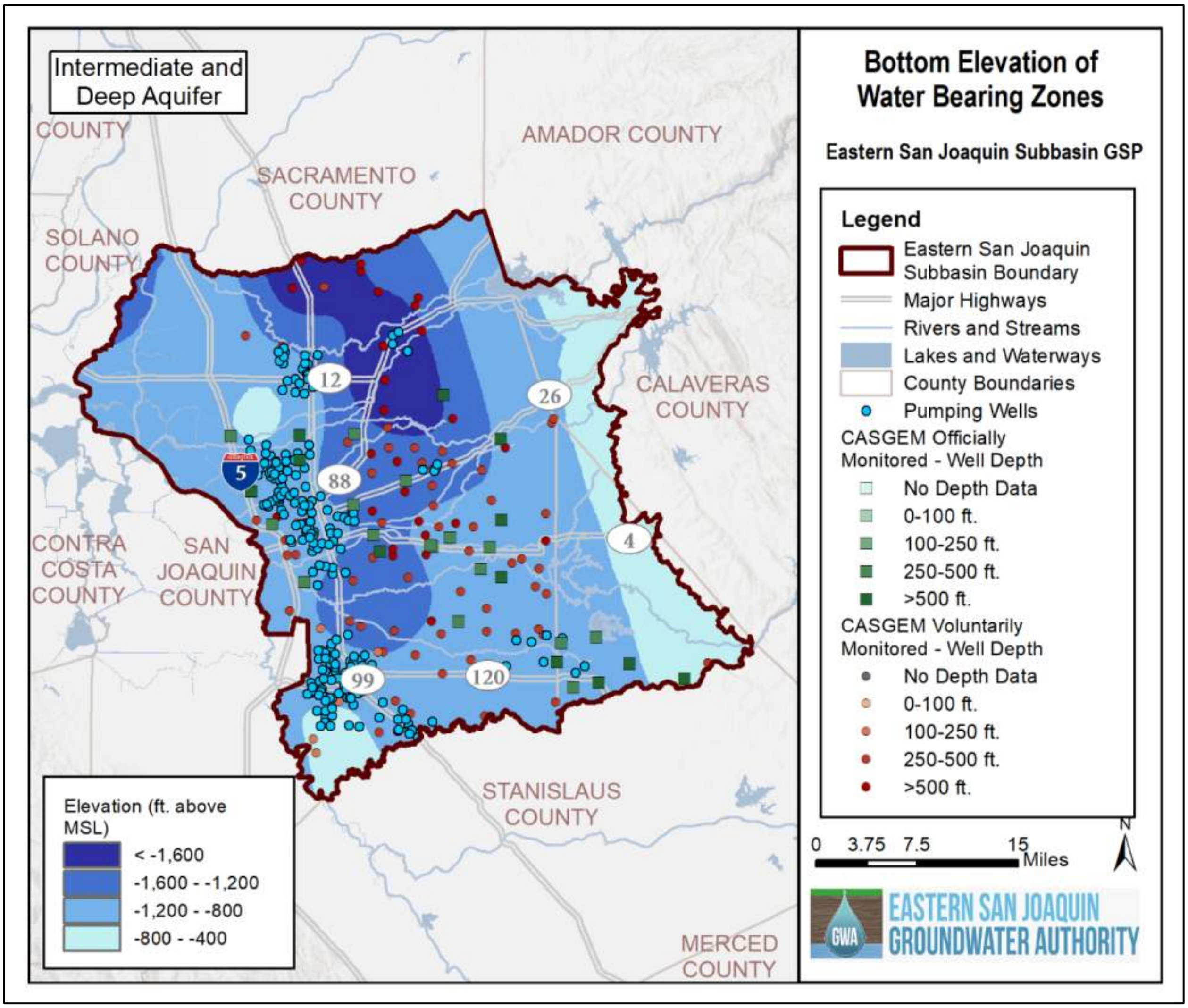


Figure 2-24: Bottom Elevation of Water-Bearing Zones (Deep and Intermediate)



2.1.9.1.1 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 and extend across the majority of the Eastern San Joaquin Subbasin. This zone is generally unconfined above the aquitards (clays/silts, including Corcoran clay, 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' (see Figure 2-20, Figure 2-21, and Figure 2-22). 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. Aquifer characteristic values range as follows (CA DWR, 2967; Burow et al., 2004):

- Transmissivities up to 90,000 gpd/ft

- Specific yields up to 17 percent
- Vertical permeability estimates up to 0.1 ft/day

2.1.9.1.2 Intermediate Zone

As depicted on the hydrogeologic cross-sections A-A' through E-E' (see Figure 2-20, Figure 2-21, and Figure 2-22), 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 the 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

2.1.9.1.3 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' (see Figure 2-20, Figure 2-21, and Figure 2-22). 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' (see Figure 2-20, Figure 2-21, and Figure 2-22), 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 permeability 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

2.1.9.1.4 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. The Corcoran Clay has a limited distribution in the extreme southwestern extent of the Subbasin, southwest of the City of Manteca (Figure 2-22). The clay is typically 20 to over 100 feet thick and is locally eroded and interfingered with coarser materials at its margin. Groundwater below the Corcoran Clay is confined. The Corcoran Clay is found more significantly in subbasins to the south where it 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 (Burow et al., 2004). Significant clay and paleosols divide the water-bearing zones at the base of each sequence. The cross-sections (Figure 2-20, Figure 2-21, and Figure 2-22) 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 have been observed. The general thickness and depth are supported by a southeast to northwest movement of river channels to the existing channel location.

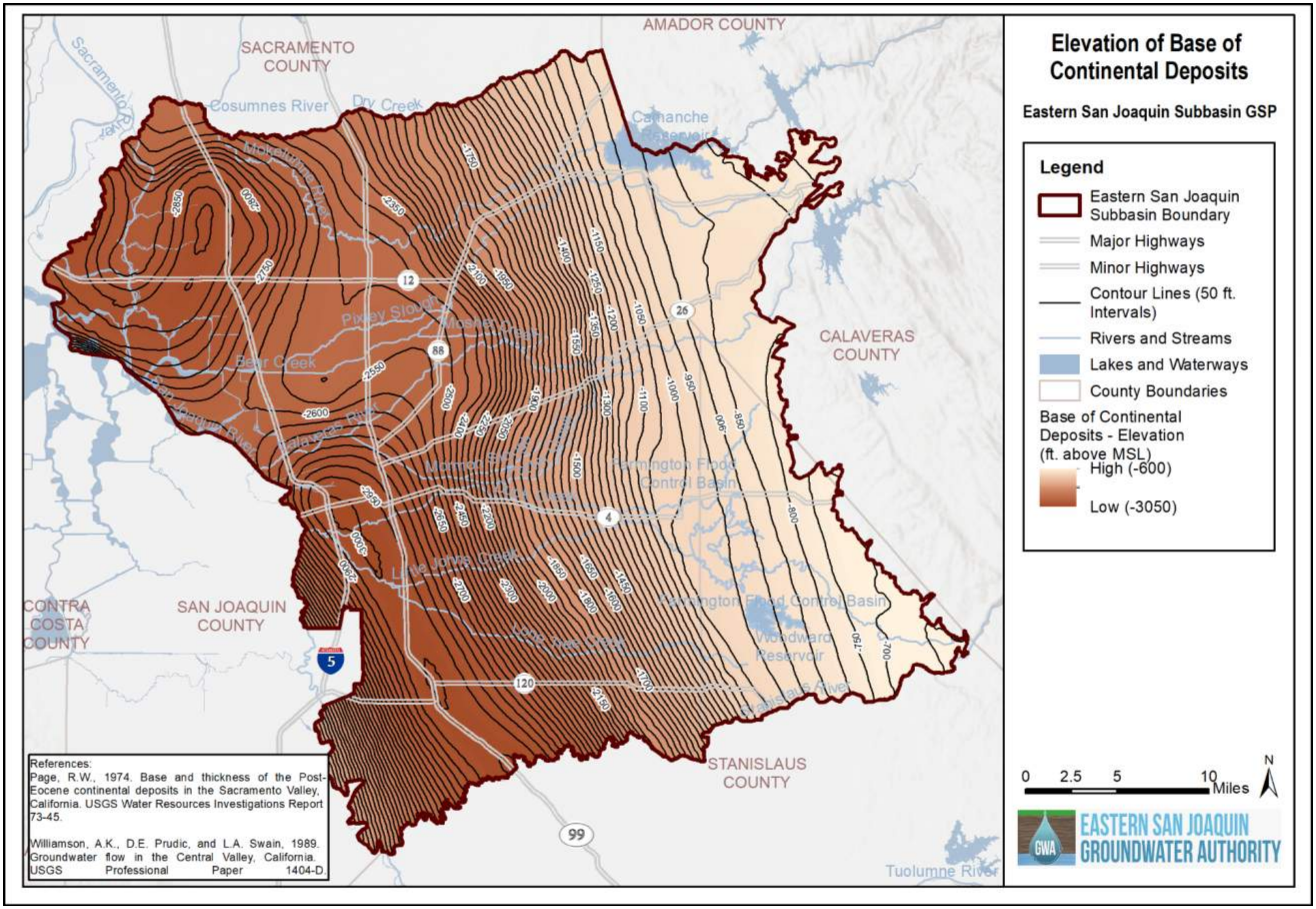
Hydraulic connection for the entire depth of the principal aquifer is supported by cross-section depictions that indicate the laterally extensive interbeds of high and low permeable layered deposits. The historical erosional and depositional history supports the referenced hydraulic interconnection. 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.

2.1.9.1.5 Deep Saline Groundwater

Connate or saline water occurs from the base of fresh water (shown in Figure 2-18 or Figure 2-24) to the base of continental deposits (shown in Figure 2-25), 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 2-25: Elevation of Base of Continental Deposits



2.1.9.2 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 2-26. 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 near the Stanislaus River, south of Woodward 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 historical drainage
- Recognizing 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 as detailed in Section 2.1.9.2.1.

As discussed in Section 2.1.4.3, soils facilitate rainfall and applied water 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 and potentially from flow between subbasins from the north, south, and west. 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.

2.1.9.2.1 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 2-3 includes four investigation areas encompassing the entire Subbasin: 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 2-26: Sand and Gravel Isopach Map

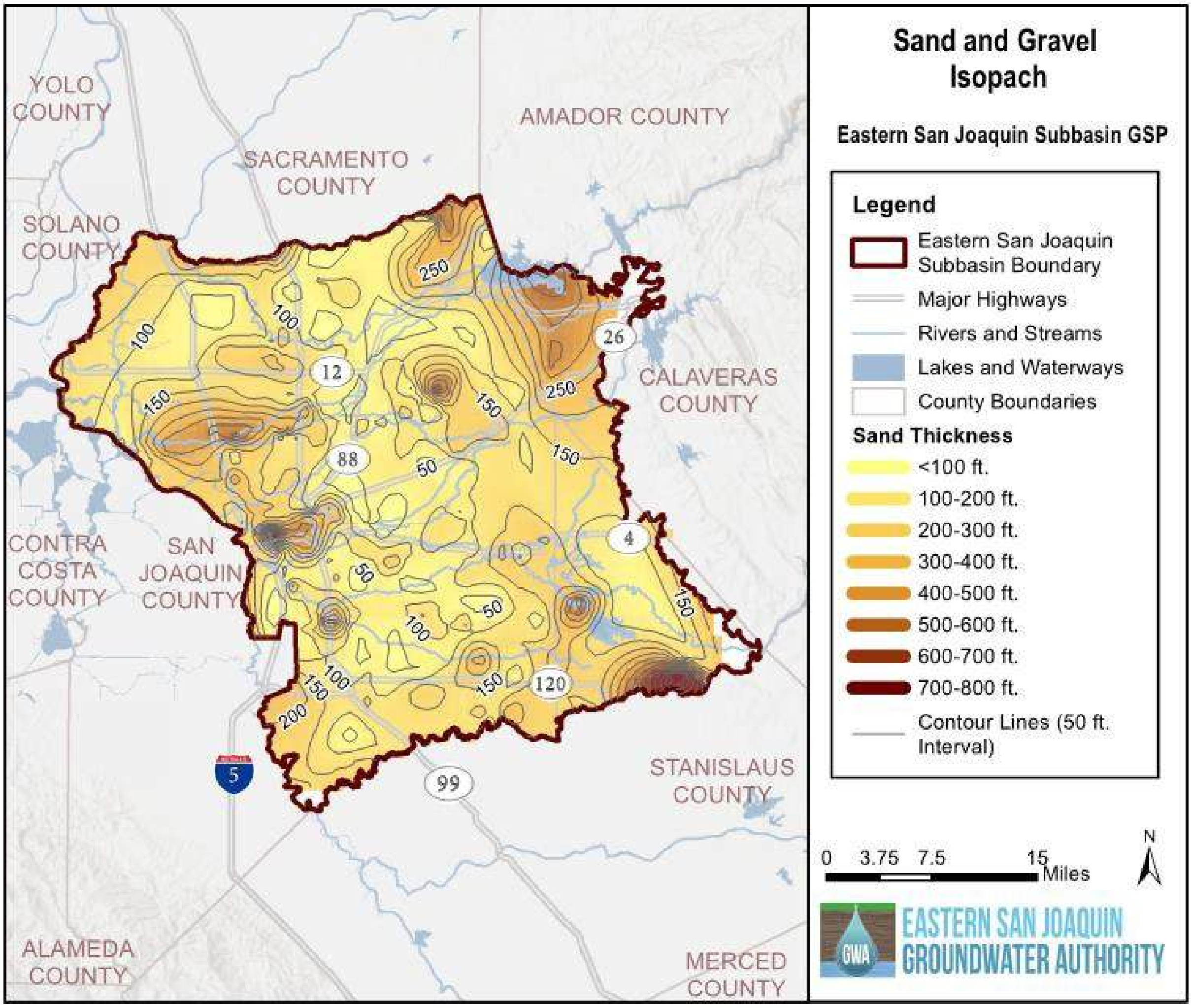


Table 2-3: Production Zone Capacities

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, 2006)	1,500	n/a	n/a	7.3 %		>150	400-600
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 %	0.0001	>130	350
Stanislaus Triangle (Bookman-Edmonston, 2005)	>2,800	>40 (DE, 2007)	35,000	17 %	0.001	>150	Dip to the West

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

$$T = Kb$$

Where: T is transmissivity
K is the hydraulic conductivity (rate of flow under a unit hydraulic gradient through a unit cross-sectional area)
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, data for the four layers of the ESJWRM were provided in the ESJWRM Model Report (see Appendix 2-A)

The distribution of production wells and monitoring wells is provided on Figure 2-23 and Figure 2-24. Table 2-4 provides descriptors for the three water-bearing zones:

- Number of wells for each zone
- Well depths
- Wells used on the cross-sections

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.
- Specific Storage and Yield – SS and 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 2-4: Wells within Water-Bearing Zones

CASGEM Wells				
Water-Bearing Zone	Well Type	Number of Wells	Average Construction Depth (ft. bgs)	Average Construction Bottom Elevation (ft. MSL)
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

2.1.9.2.2 Regional Historic Groundwater Flow and Surface Water Interaction

The horizontal groundwater flow direction for the Eastern San Joaquin Subbasin is typically towards areas of lower groundwater near the center of the Subbasin. The flow generally mirrors topography and is relatively consistent over time. The flow direction follows the overall east dipping gradient of the geologic formations in the eastern portions of the Subbasin. 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 east toward areas with relatively lower groundwater elevation. Horizontal groundwater flow is further discussed in Section 2.2.

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, suggesting downward flow of groundwater. 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 Subbasin is provided in Section 2.2.

Historical groundwater-surface water interaction in the context of the twenty years of the historical model (ESJWRM) is discussed in Section 2.2.6.

2.1.9.2.3 General Groundwater Quality

2.1.9.2.3.1 Geologic Formation Groundwater Quality

The USGS and other government agencies completed several major studies concerning groundwater quality in the Central Valley of California, which includes 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 is 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.

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 typically 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 Range 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 2.1.5.

Groundwater quality of wells in Calaveras County is characterized by Metzger and others in a 2012 study, *Test Drilling and Data Collection in the Calaveras County Portion of the Eastern San Joaquin Groundwater Subbasin, California, December 2009 – June 2011* (Metzger et al., 2012). 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 is 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 2-16, Figure 2-20, Figure 2-21, and Figure 2-22). 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. Elevated levels of nitrate can typically occur as a result of fertilizer application, manure and septic waste, and natural sources. 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).

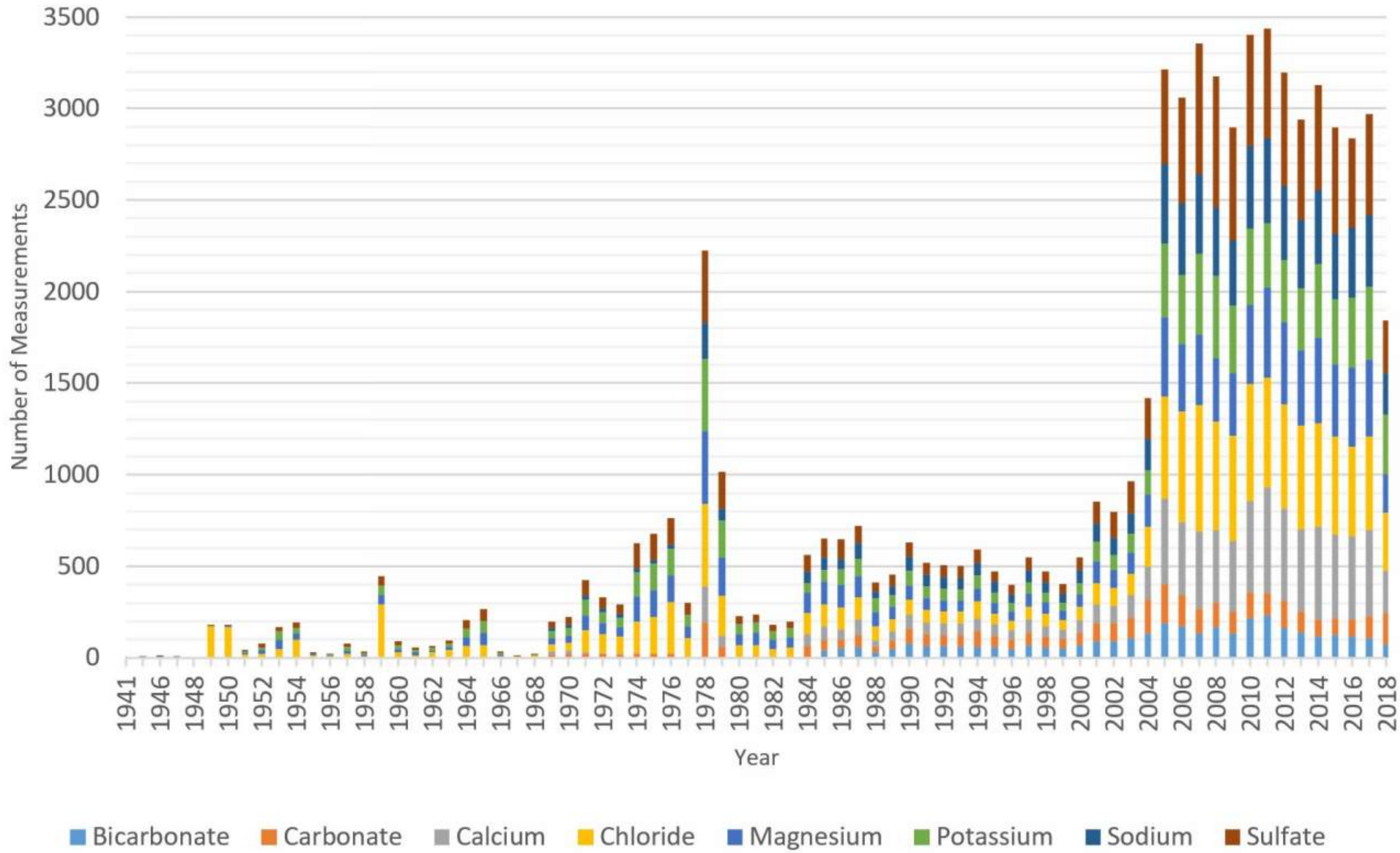
General water quality of principal aquifers is summarized in the following sections, as required by CCR Title 23 § 354.14. General water quality can be determined by assessing commonly measured inorganic parameters as indicators of change. Evaluating these inorganic parameters involves looking at historical 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

2.1.9.2.3.2 Ion Composition

Evaluating the historical trends of these parameters is not straightforward. GAMA records include some groundwater quality results for the Eastern San Joaquin Subbasin going back to the 1940s. However, a thorough analysis requires a large amount of data on all the major cations and anions mentioned above. A large number of measurements of this kind were taken from 2005 to 2017, as shown in Figure 2-27. Data from 2018 are not included because at the time of this writing, the data were incomplete.

Figure 2-27: 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 an idea of possible water type trends. Trilinear diagrams for each of these years show relative concentrations of the major cations and anions (see Figure 2-28). Each symbol in the diagram represents a water sample collected. Water samples, represented by the same symbol, are plotted in the two lower triangle diagrams for each year based on their relative cation (left) and anion (right) concentrations. The top diagram represents a projection of the two ternary diagrams for easier comparison.

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 milligrams per liter (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 the 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 2-29). 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 2-30).

Higher chloride and sulfate concentrations during 2017 are apparent near the cities of Manteca and Stockton (Figure 2-31 and Figure 2-32). A further discussion and assessment of chloride measurements in the Eastern San Joaquin Subbasin is included in Section 2.2.

Figure 2-28: Trilinear Diagrams

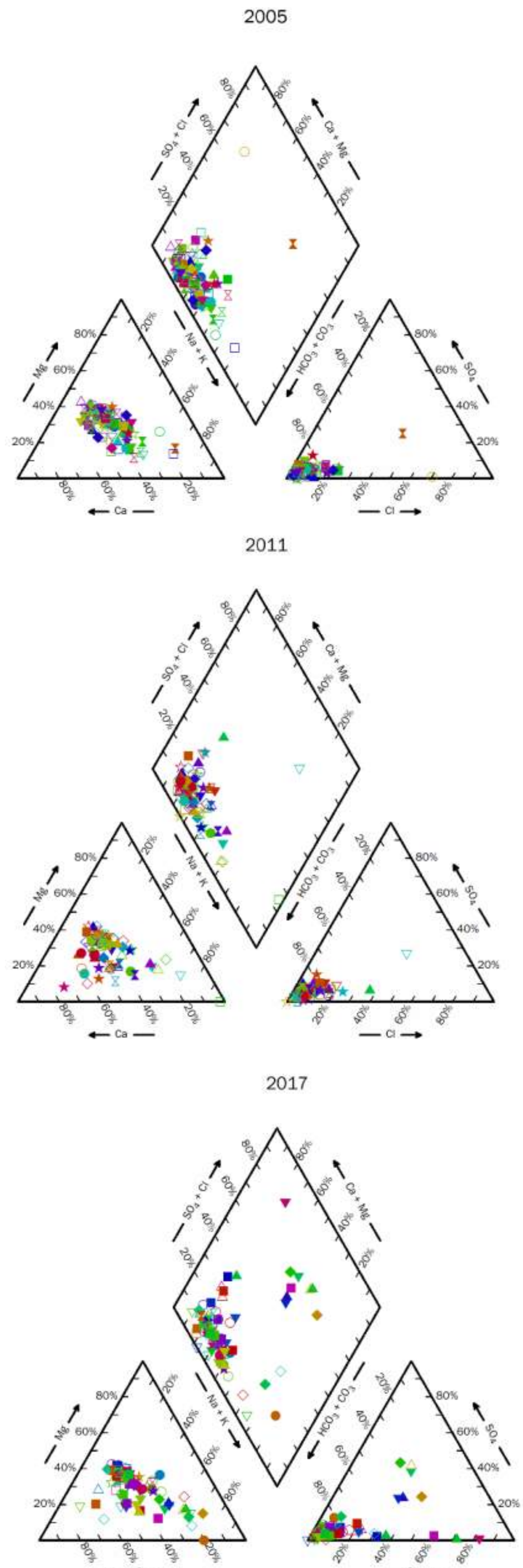


Figure 2-29: Chloride Annual Variation

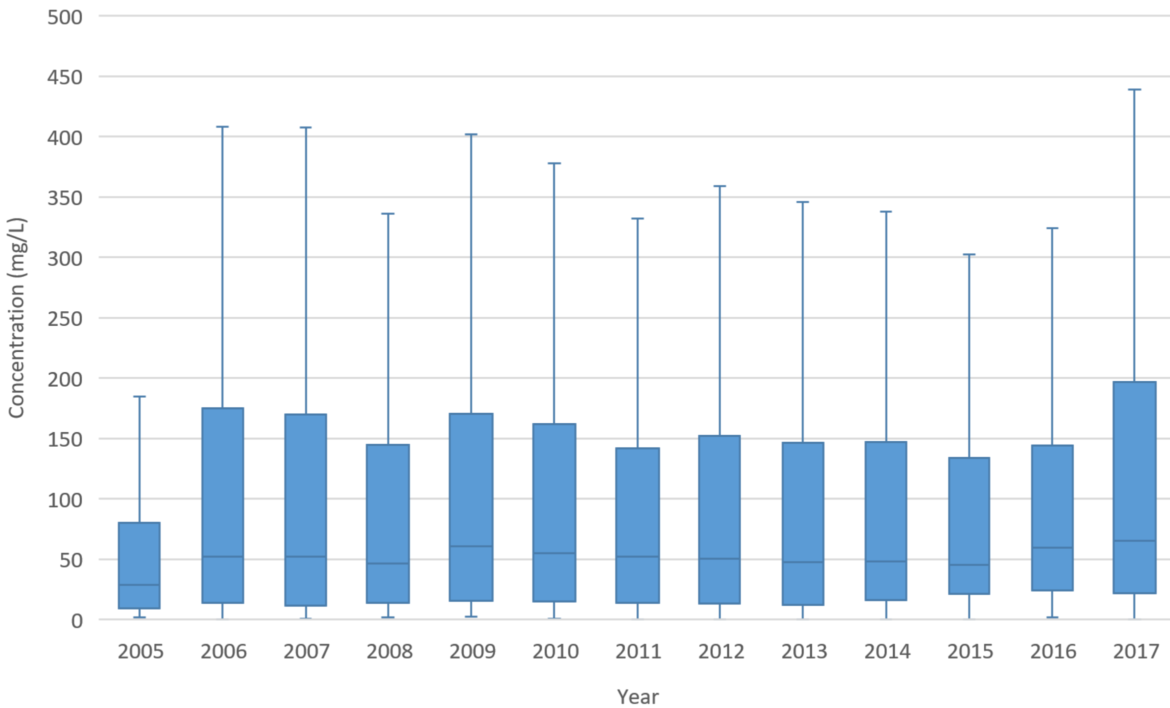
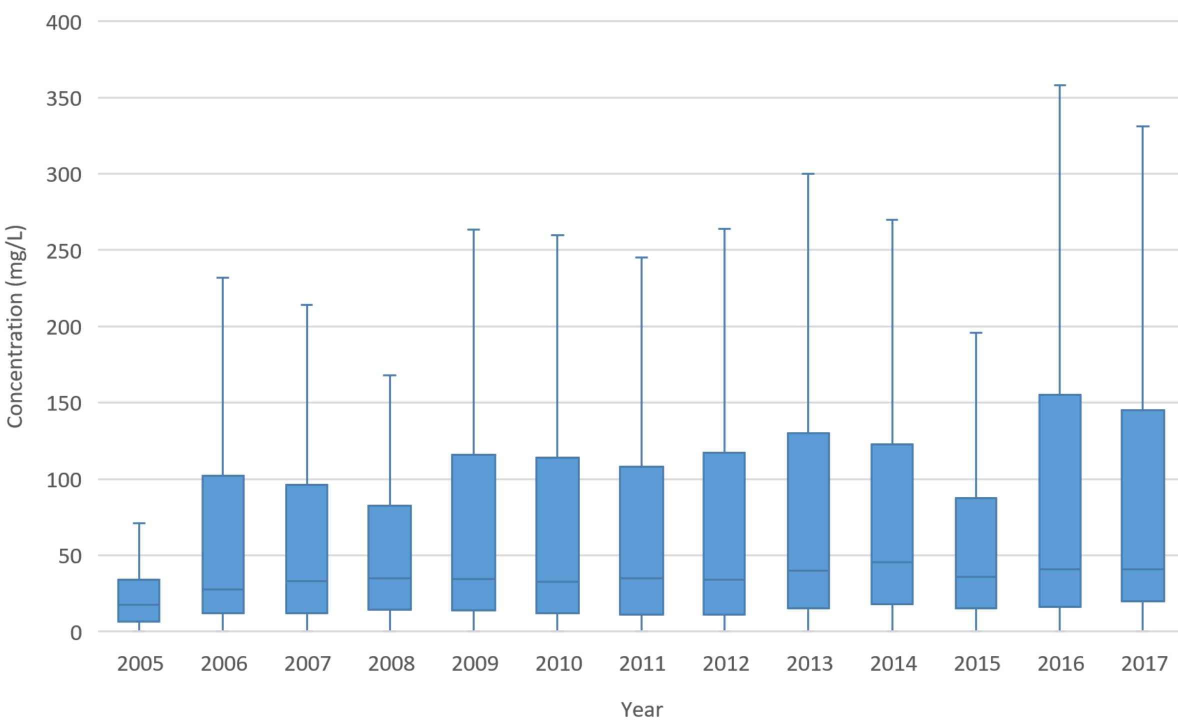


Figure 2-30: Sulfate Annual Variation



Note: This Box-and-Whisker plot represents a summary of five different statistic values of the distribution. Minimum and maximum values are represented by the end points of the extended lines. The center line indicates the median. The top and bottom of the rectangle indicate the first quartile (25th percentile) and third quartile (75th percentile) of the distribution, respectively.

Figure 2-31: Chloride Concentrations in 2017

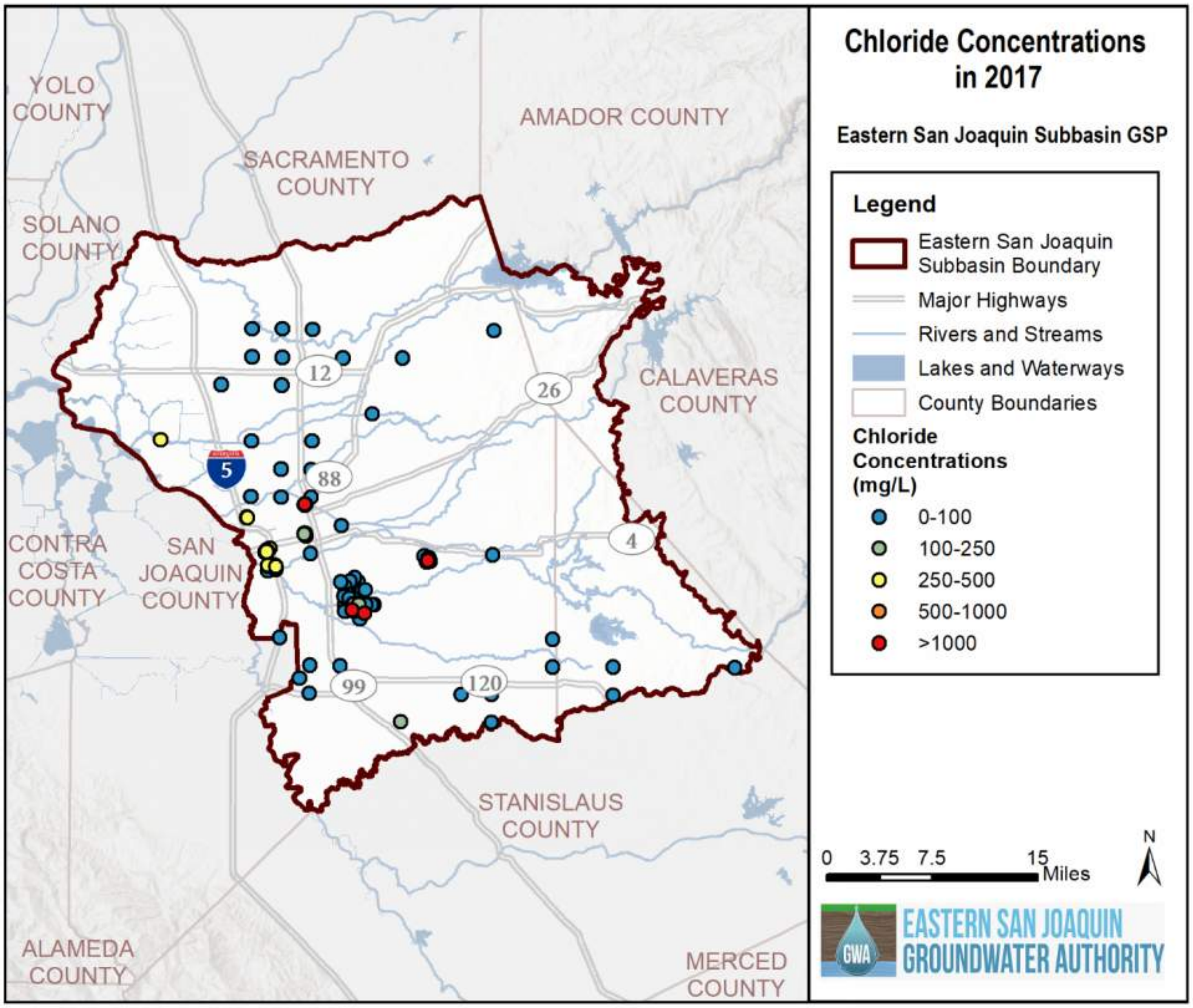
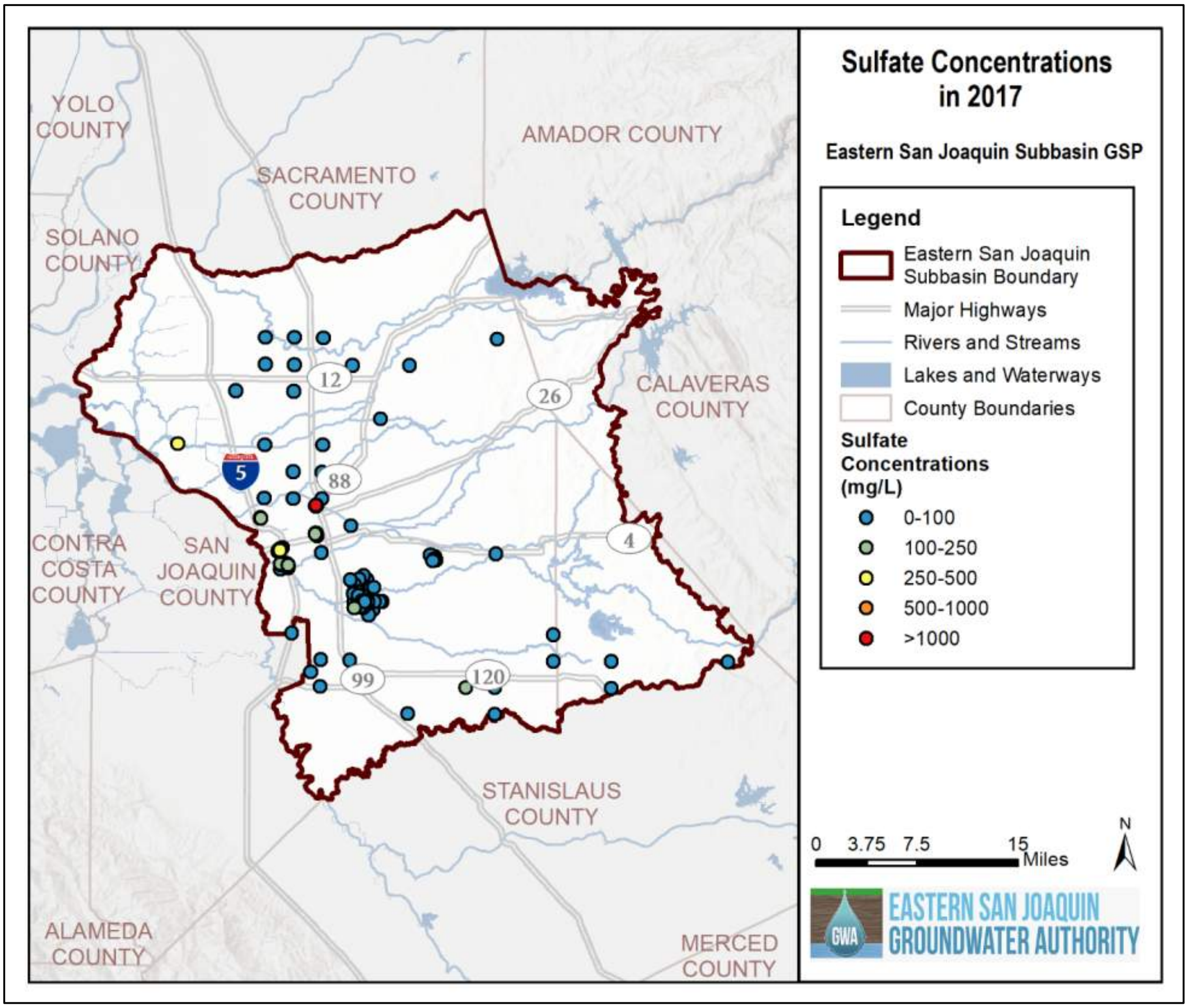


Figure 2-32: Sulfate Concentrations in 2017

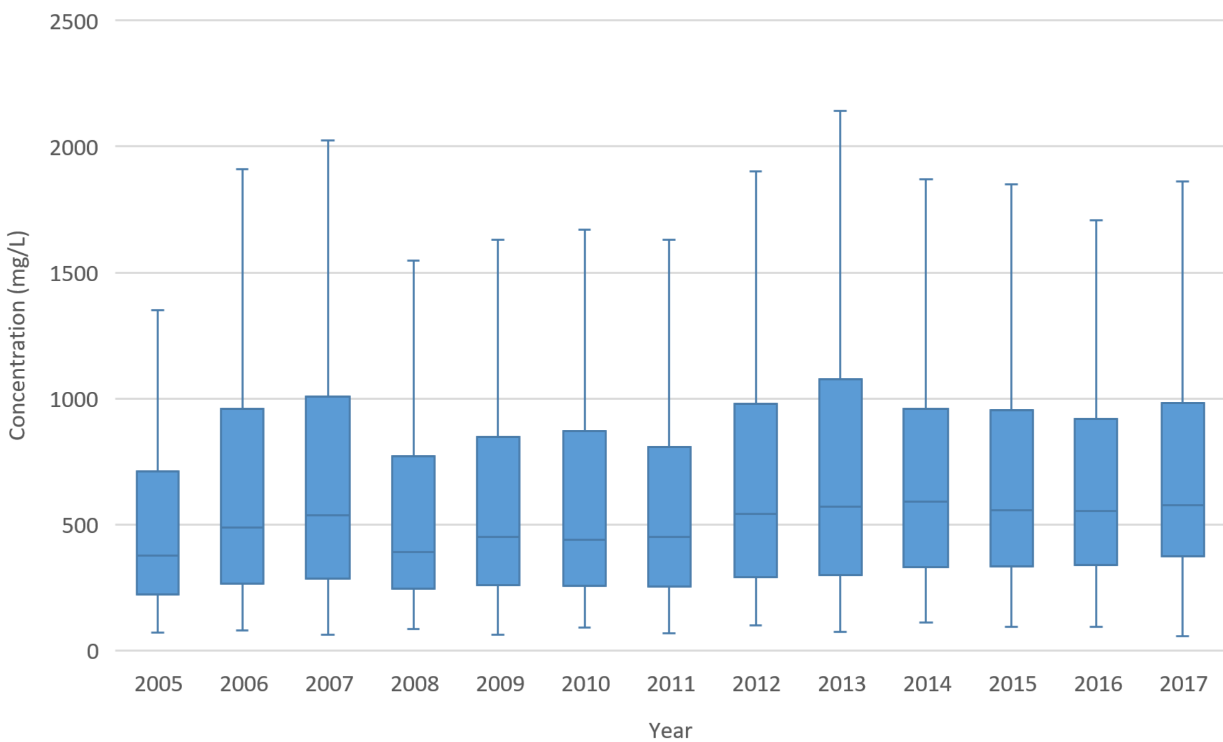


GAMA groundwater quality data in the northern portion of the San Joaquin Valley Groundwater Basin were assessed by Bennett et al. in 2006. Groundwater samples were compared to thresholds such as the U.S. Environmental Protection Agency (USEPA) secondary maximum contaminant levels (SMCL). None of the major cations and anions measured in the Eastern San Joaquin Subbasin resulted in exceedances of the SMCLs (Bennett et al., 2006). These measurements took place in December 2004 to February 2005. Additional parameters were sampled in this study and are discussed further in Section 2.2 (Current and Historical Groundwater Conditions).

2.1.9.2.3.3 Total Dissolved Solids

A wide range of total dissolved solids (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 mg/L (Figure 2-33), with a median value of 520 mg/L. Over the 13-year period shown in Figure 2-33, the median value has steadily increased from approximately 400 mg/L in 2005 to approximately 600 mg/L in 2017. Sources of TDS in the Subbasin include Delta sediments, deep deposits, and irrigation return water, as discussed in Section 2.2.4.1. Additional details on TDS concentrations is provided in Section 2.2 (Current and Historical Groundwater Conditions).

Figure 2-33: TDS Annual Variation



2.1.10 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. The following data gap elements require additional information and will be updated with future monitoring, modeling, and data refinement efforts.

Aquifer Characteristics

- Aquifer characteristics (such as hydraulic conductivity) have a significant impact on how projects and management actions in one part of the Subbasin may influence sustainability in other parts of the Subbasin. Aquifer characteristics should be confirmed through additional aquifer testing or additional monitoring wells.

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 natural communities commonly associated with groundwater (NCCAGs)
- Additional groundwater level data in the east and northwest areas of the Subbasin
- Additional groundwater level data near major creeks and rivers to improve quantification and understanding of subsurface flows between groundwater subbasins and surface water-groundwater interaction

Groundwater Quality Data

- Water quality of the three zones within the principal aquifer
  - 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.
  - 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.
- Groundwater quality database compilation improvements to improve the linkage between the GAMA and CASGEM databases

Subsurface Conditions

- Stockton Fault extent and impact on the base of fresh water
- Improved characterization of near-surface soil conditions as they relate to recharge
- Further definition of aquifer characteristics (e.g., hydraulic conductivity, transmissivity, and storage parameters) within and near Subbasin boundary areas to the east, southeast, north, and northwest, including aquifer tests

2.2 CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

This section describes the current and historical groundwater conditions in the Eastern San Joaquin Subbasin. As required by the GSP regulations, the groundwater conditions section includes:

- Definition of current groundwater conditions in the Subbasin
- Description of historical groundwater conditions in the Subbasin
- Description of the distribution, availability (storage), and quality of groundwater
- Identification of interactions between groundwater, surface water, groundwater dependent ecosystems, and subsidence

The groundwater conditions described in this section present the historical availability, quality, and distribution of groundwater which are the basis of this Plan's sustainable management criteria and monitoring network. The current and historical conditions discussed are further expanded upon in Chapter 3: Sustainable Management Criteria and are used to define undesirable results and to establish measurable objectives, interim milestones, and minimum thresholds.

Historically, the two aspects of greatest focus for groundwater management in the Eastern San Joaquin Subbasin have been groundwater elevation and, in some areas of the Subbasin, groundwater quality. As discussed herein, a groundwater depression exists in the central portion of the Subbasin, while higher groundwater levels characterize the west portion of the Subbasin. Additionally, there are elevated levels of salinity and nitrate in some areas, along with naturally occurring constituents commonly seen throughout the Central Valley. Detailed descriptions of these conditions are provided in the following sections as part of a discussion of the historical and current conditions for each of the six sustainability indicators:

- Groundwater Elevation (Section 2.2.1)
- Groundwater Storage (Section 2.2.2)
- Seawater Intrusion (Section 2.2.3)
- Groundwater Quality (Section 2.2.4)
- Land Subsidence (Section 2.2.5)
- Interconnected Surface Water (Section 2.2.6)

Details of GDEs are provided in Section 2.2.7 to support the sustainability indicator discussions.

2.2.1 Groundwater Elevation

2.2.1.1 Historical Groundwater Elevations

Data sources for groundwater elevation are abundant in the Eastern San Joaquin Subbasin. As discussed in Section 2.1, the CASGEM and San Joaquin County databases constitute the groundwater level data used for this analysis. These sources provide a robust dataset of groundwater levels going back to 1940.

To visually show long-term trends in groundwater elevations in the Eastern San Joaquin Subbasin, 10 wells that have periods-of-record greater than 40 years and that are relatively evenly distributed across the Subbasin were selected from available data (see Figure 2-34). Long-term hydrographs prepared for these wells show that, throughout most of the Eastern San Joaquin Subbasin, groundwater elevations have declined over time.

Average groundwater level decline was quantified for 1996-2015. In Section 0 (Water Budgets), the Historical Water Budget uses 1996-2015 as a representative hydrologic period which includes an average annual precipitation of 14.7 inches, very close to the long-term average of 15.4 inches. The 1996-2015 period also includes the recent 2012-2015 drought, the wet years of 2010-2011, and periods of normal precipitation. Based on data from the 10 selected wells in Figure 2-34, the average groundwater level decline was -0.5 ft/year from 1996-2015. Hydrographs for wells numbered #2, #5, and #6 show the largest decrease in groundwater elevation. These wells are located to the east of the City of Stockton. Hydrograph #9, which corresponds to a well located on the north edge of the Subbasin, shows the least decrease in groundwater elevation from 1996-2015. Hydrograph #4 corresponds with a well located in the western side of the Subbasin and is the only well to show an increasing trend in groundwater elevations. The northeast corner of the Subbasin is an area without a nearby representative hydrograph and was identified as a data gap in Section 2.1.10 (HCM Data Gaps).

Figure 2-34: Hydrographs of Selected Wells

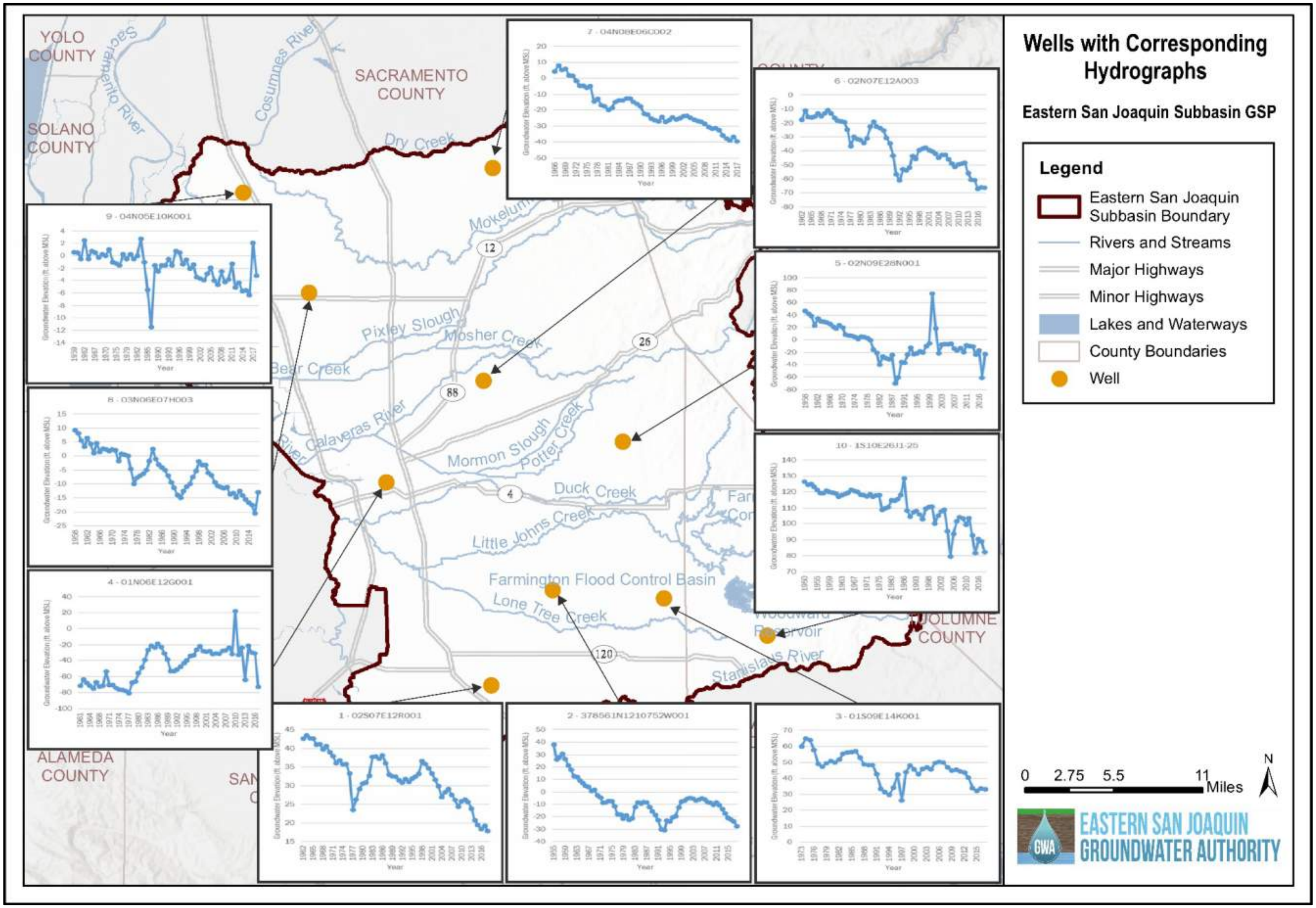
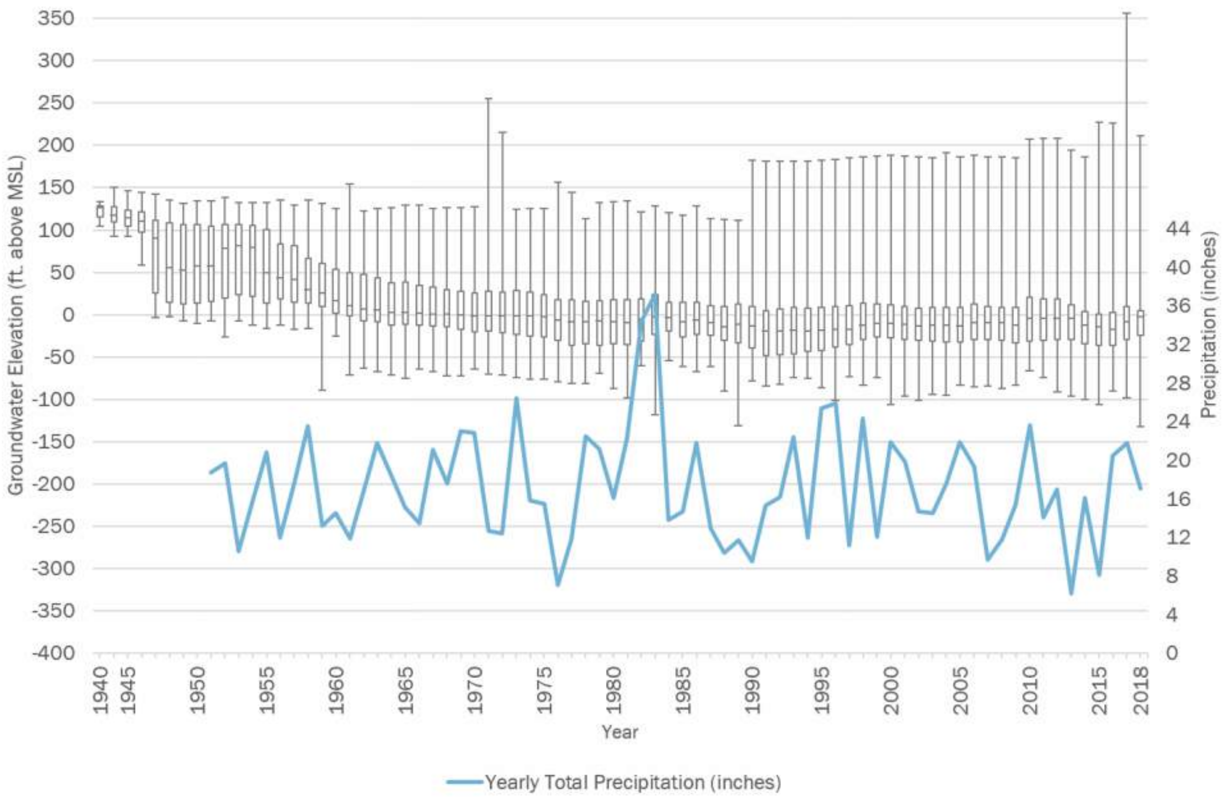


Figure 2-35 shows the distribution of the groundwater elevations from the CASGEM and San Joaquin County databases compared to average precipitation in and near the Subbasin. Figure 2-35 shows an overall decreasing trend in groundwater elevation levels with larger variability over time. The increasing variability comes partly due to a larger number of wells being sampled through time in more varied topography, but also reflects the long-term changes in groundwater levels described above and in Figure 2-34.

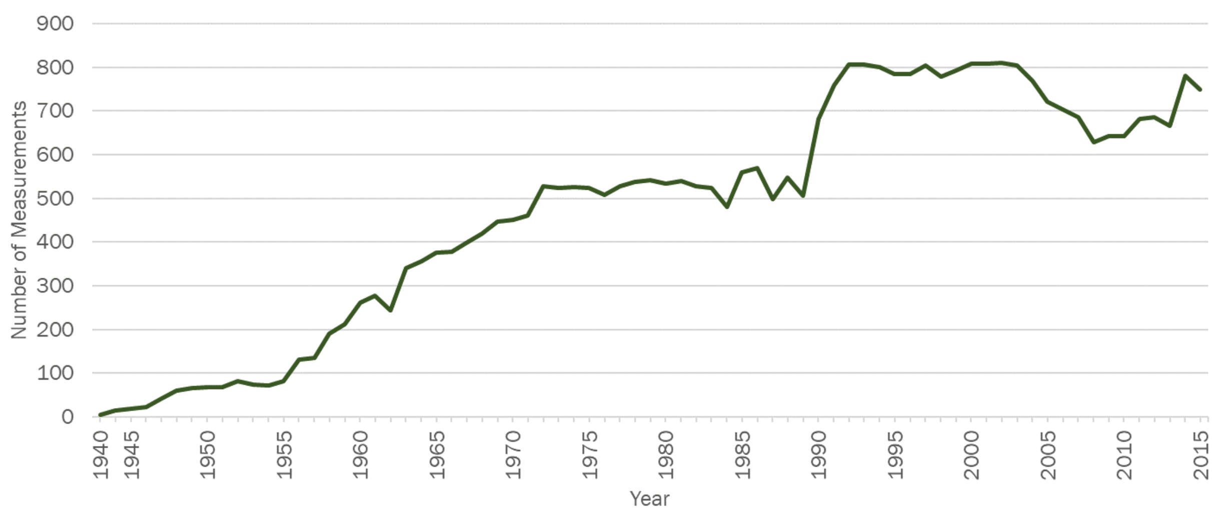
Periods of increases in groundwater elevation moderately correspond to the amount of precipitation in the Eastern San Joaquin Subbasin. A correlating trend can be seen with groundwater elevation increases in several hydrographs in the early 1980s and late 1990s, associated with periods of high precipitation.

Figure 2-35: Summary of Groundwater Elevation Data, 1940-2018

(a) Box-and-Whisker Plot with Precipitation

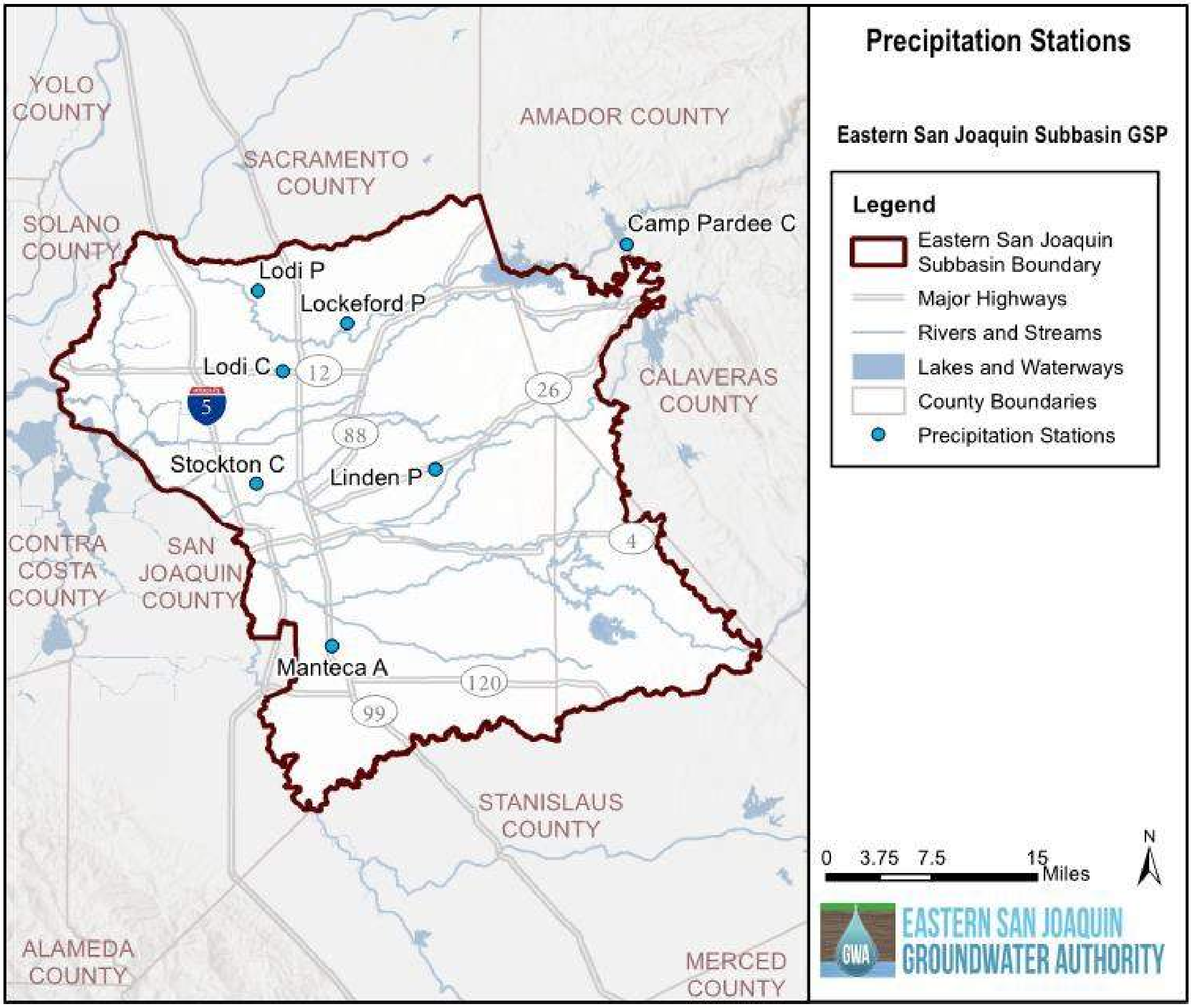


(b) Number of Groundwater Level Measurements



1. Each vertical bar in Figure 2-35 (a) represents the full range of groundwater level measurements recorded in a given year. The central gray box represents the middle 50% of measurements (ranging from the 25th percentile to the 75th percentile), with the horizontal line showing the median. The capped lines below and above the central box represent the minimum and maximum, respectively.
2. Precipitation monitoring depicted in Figure 2-35 (a) began in 1951.
3. The average annual precipitation line presented in Figure 2-35 (b) is based on an average of data collected at 7 stations which are mapped in Figure 2-36.

Figure 2-36: Precipitation Stations



1. These stations are operated by California Irrigation Management Information System (CIMIS) (“A”), National Oceanic and Atmospheric Administration (NOAA) (“C”), and PestCast (University of California Statewide Integrated Pest Management Program [UC IPM] and Department of Pesticide Regulation [DPR]) (“P”).

Additionally, extensive reports and research examining the groundwater conditions of the Central Valley are available from a variety of sources, including the USGS and DWR. These documents supplement the water level data provided by the CASGEM and San Joaquin County databases and were used to assess current and historical groundwater elevations.

USGS Water Supply Paper 780 – One of the earliest discussions of measured groundwater levels in the Eastern San Joaquin Subbasin is the USGS Water Supply Paper 780. The report details river stage of the Mokelumne River and the surrounding groundwater table from roughly 1900 to 1930. Groundwater levels in wells around the Mokelumne River varied, but mostly declined due to an increase in groundwater pumping. Even between years of minimal groundwater pumping, from 1927 to 1933, the water table decreased in elevation, most drastically in areas northeast and southeast of the City of Lodi (Piper et al., 1939).

DWR Bulletin 146 – DWR’s Bulletin 146 (1967) discusses water levels and flow directions in the 1960s and earlier, which provides added historical context to current groundwater conditions. Figures 4 and 5 of Bulletin 146 show groundwater elevation in most of the Eastern San Joaquin Subbasin in fall of 1950 and 1964, respectively. Both maps show groundwater levels at the lowest elevation underneath the City of Stockton, which is attributed to heavy groundwater pumping. This groundwater depression is attributed as causing groundwater from the Delta to flow toward the City of Stockton and is described as having relatively worse water quality due to natural mineral salts. Barriers between the poorer quality water from the Delta and higher quality water from the Sierra Nevada Mountains noted in previous studies around the City of Stockton are not apparent (CA DWR, 1967).

Williamson, 1989 – Groundwater conditions provided in the groundwater model report by Williamson (1989) included horizontal and vertical flows. A westerly groundwater flow direction that roughly parallels the ground surface in the Eastern San Joaquin Subbasin was confirmed, as depicted on Figure 14 of that report. Estimates of groundwater elevations for before-human-development were provided. Vertical flow characteristics before considerable human development were characterized and mapped; areas of wells that flowed without pumps are shown throughout the valley and in the western portion of the Eastern San Joaquin Subbasin. This is in contrast to current conditions, where wells flowing without pumps have not been currently observed in the Subbasin. At present, USGS nested monitoring wells confirm downward vertical flows (Williamson, 1989).

2.2.1.2 Current Groundwater Elevations

Current groundwater elevation conditions, for the purposes of this Plan, have been characterized as first quarter 2017 (recent seasonal high, measured in spring 2017) and fourth quarter 2017 (recent seasonal low, measured in fall 2017) groundwater elevation measurements. At the time of this report, these records constitute the most complete dataset. Groundwater elevations are mapped using the CASGEM dataset (including voluntarily monitored wells) and the San Joaquin County dataset.

Figure 2-37 and Figure 2-38 show the groundwater elevations for these periods. A pumping depression at the center of the Subbasin, east of the City of Stockton, exists during both of these periods. A localized pumping depression is shown expanding from the Cosumnes Subbasin across Dry Creek to the Eastern San Joaquin Subbasin in fourth quarter 2017. However, from the perspective of the entire Eastern San Joaquin Subbasin, the central pumping depression to the east of the City of Stockton is most significant to achieving sustainability in the Subbasin. Groundwater generally flows from the outer edges of the Subbasin towards the depression in the middle of the Subbasin. Along the eastern side of the Subbasin, the lateral gradient of groundwater levels ranges from approximately 21 ft/mi during the seasonal high to 16 ft/mi during the seasonal low. Along the western side of the Subbasin, the lateral gradient ranges from approximately 7 ft/mi during the seasonal high to 6 ft/mi during the seasonal low. The steeper gradients on the east side of the Subbasin compared to the west side is primarly due to the steeper topography in that area.

Figure 2-37: First Quarter 2017 Groundwater Elevation

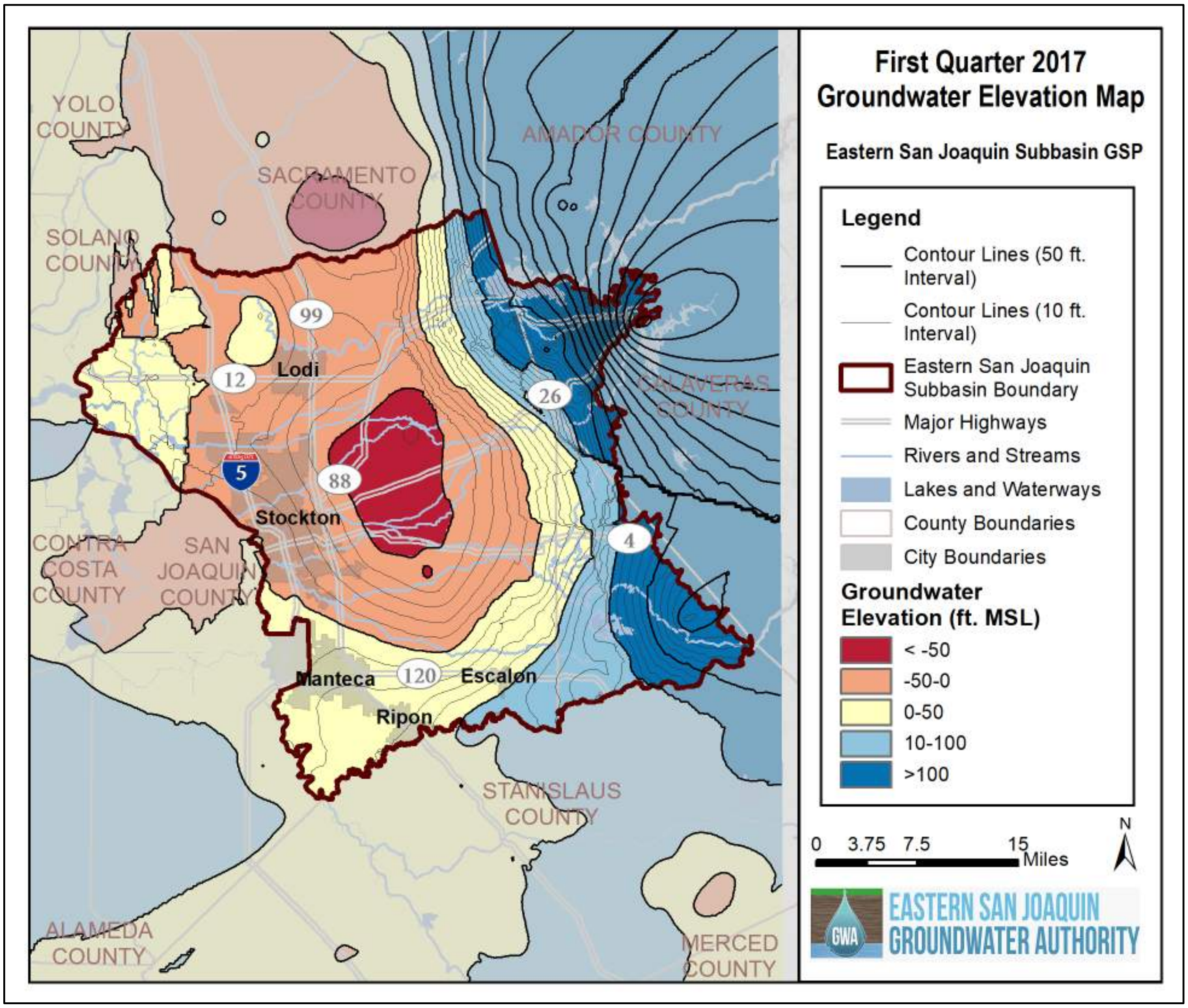
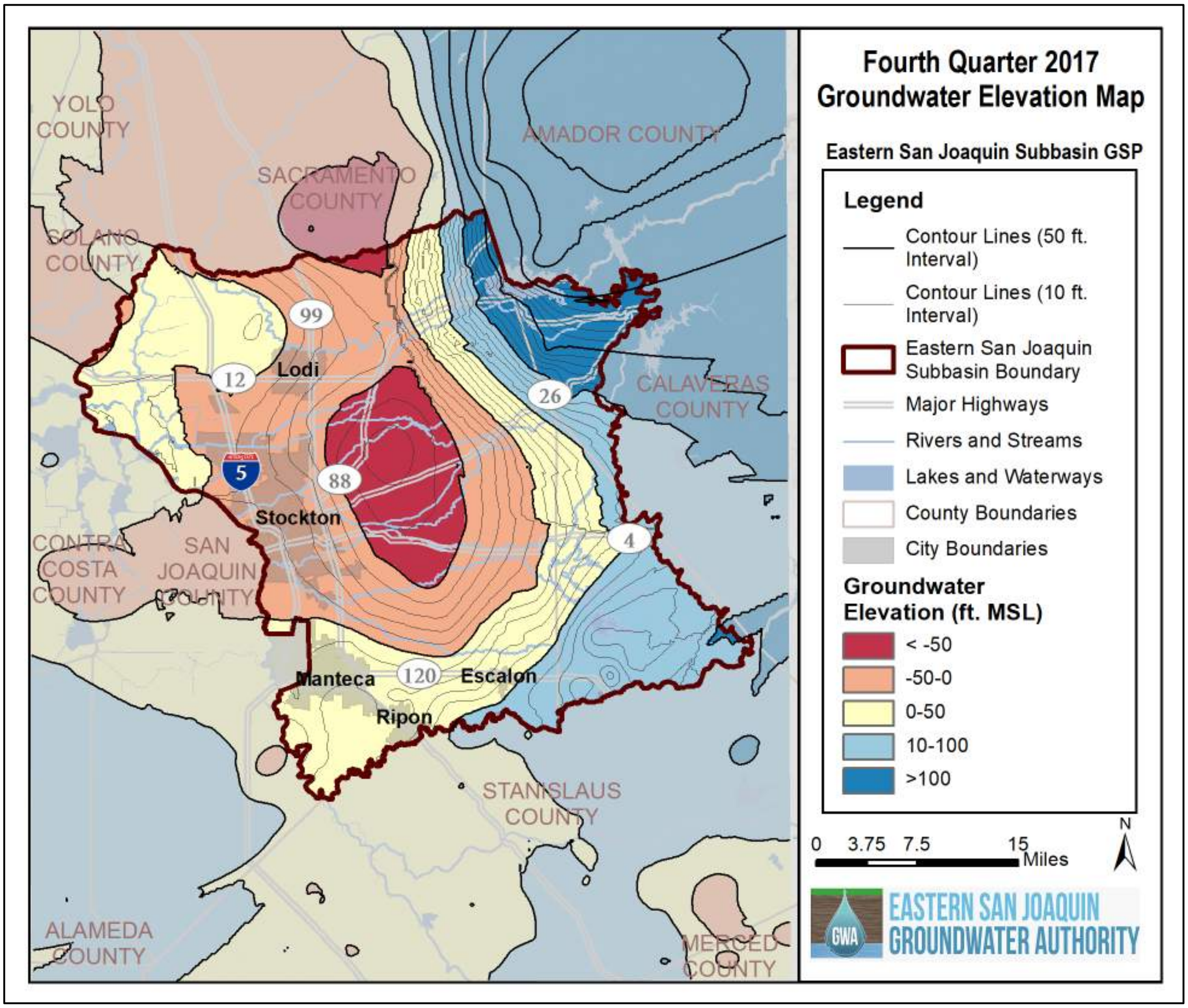


Figure 2-38: Fourth Quarter 2017 Groundwater Levels



2.2.1.2.1 Vertical Gradients

A vertical gradient drives the movement of groundwater perpendicular to the ground surface and is typically measured by comparing the elevations of groundwater in nested and/or clustered wells, wells with multiple completions at different depths. If groundwater elevations in the shallower completions are higher than in the deeper completions, the gradient is identified as a downward gradient. A downward gradient is one where groundwater is moving downward through the subsurface. If groundwater elevations in the shallower completions are lower than in the deeper completions, the gradient is identified as an upward gradient. An upward gradient is one where groundwater is moving upward through the subsurface. If groundwater elevations are the same throughout the completions, there is no vertical gradient. Knowledge about vertical gradients is required by regulation and is useful for understanding how groundwater moves in the Subbasin.

Vertical flow characteristics before considerable human development are characterized and mapped by Williamson (1989), showing that wells flowing without pumps existed in the western portion of the Eastern San Joaquin Subbasin, also corresponding with areas of upward vertical gradients. This contrasts with current conditions, where wells flowing without pumps have not been currently observed in the Subbasin. At present, USGS nested monitoring wells confirm downward vertical gradients (Williamson, 1989).

There are 16 nested and/or clustered well sites located in the Eastern San Joaquin Subbasin. The locations of the wells are shown in Figure 2-39. The majority of these wells are located in the northwest portion of the Subbasin near the cities of Stockton and Lodi. Hydrographs with groundwater elevations for each respective set of nested wells are shown in Figure 2-40 through Figure 2-49. 10 out of 16 sets of wells consistently show elevations in shallower completions that are higher than in the deeper completions which indicates a downward gradient. The remaining six wells are located in the City of Lodi. Four of these wells exhibit a minimal downward gradient and two show no downward gradient.

Figure 2-39: Map of Nested and/or Clustered Well Sites

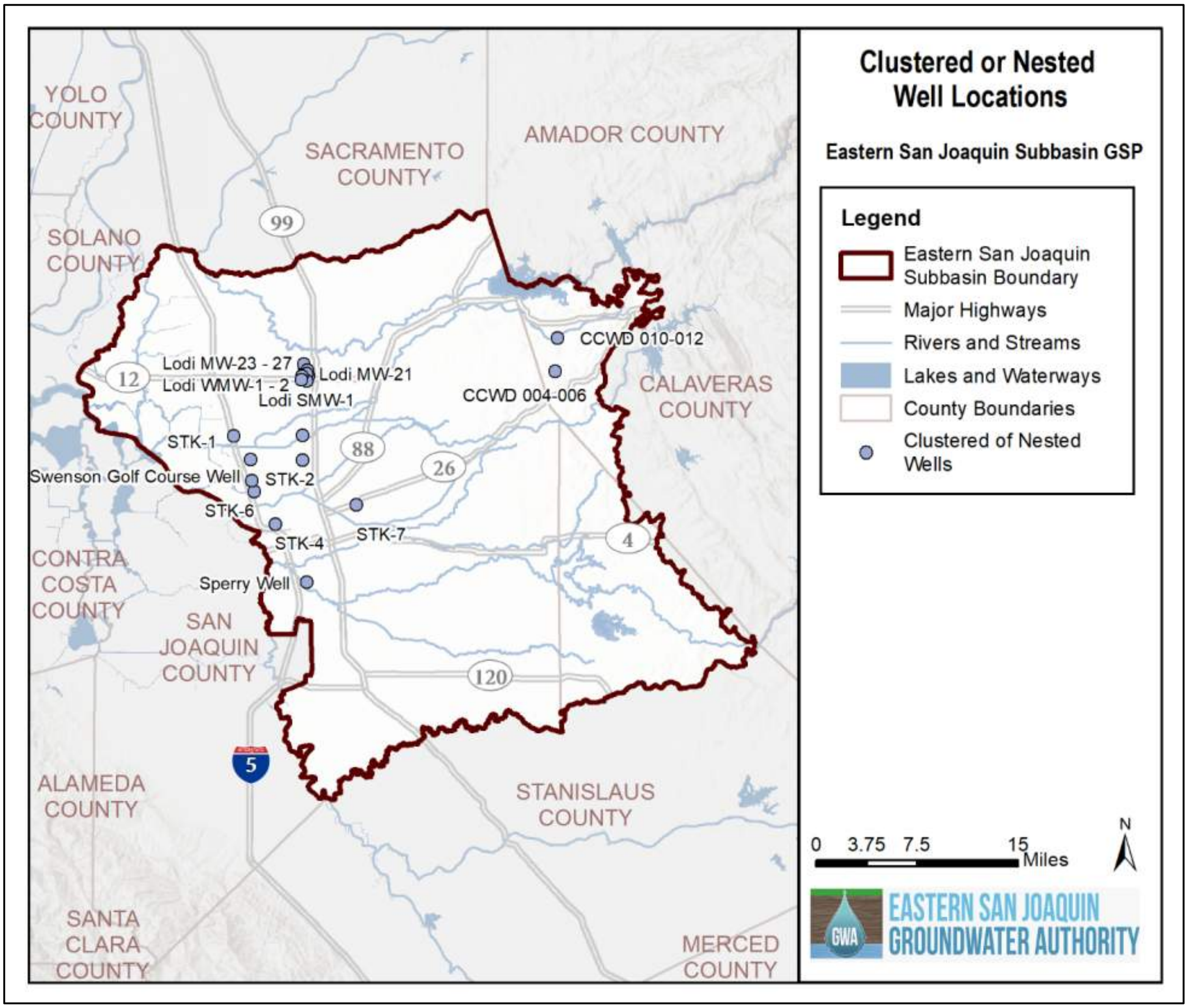


Figure 2-40: Nested Well Hydrographs: CCWD 004-006

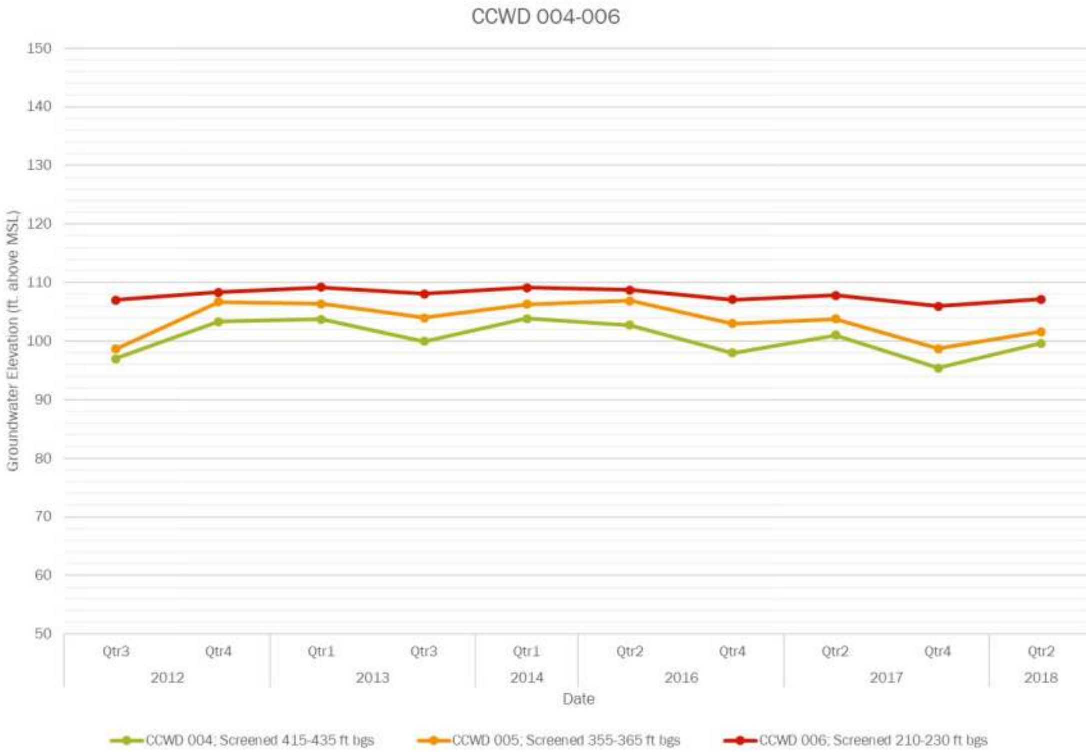


Figure 2-41: Nested Well Hydrographs: CCWD 010-012

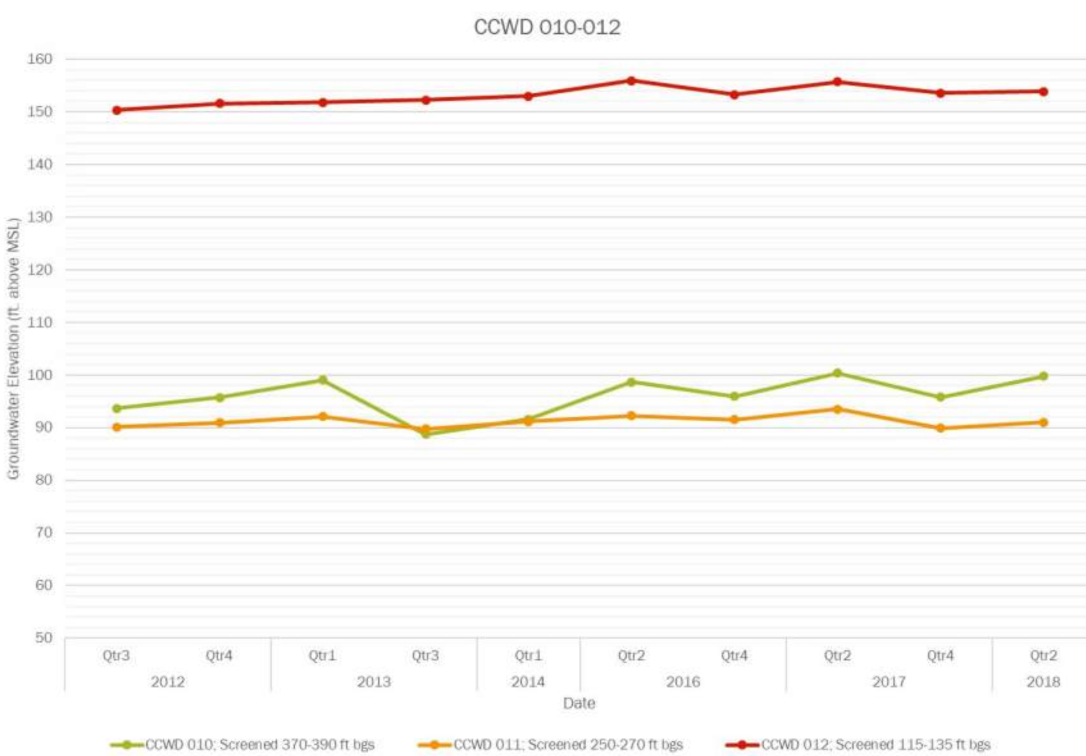


Figure 2-42: Nested Well Hydrographs: Sperry Well

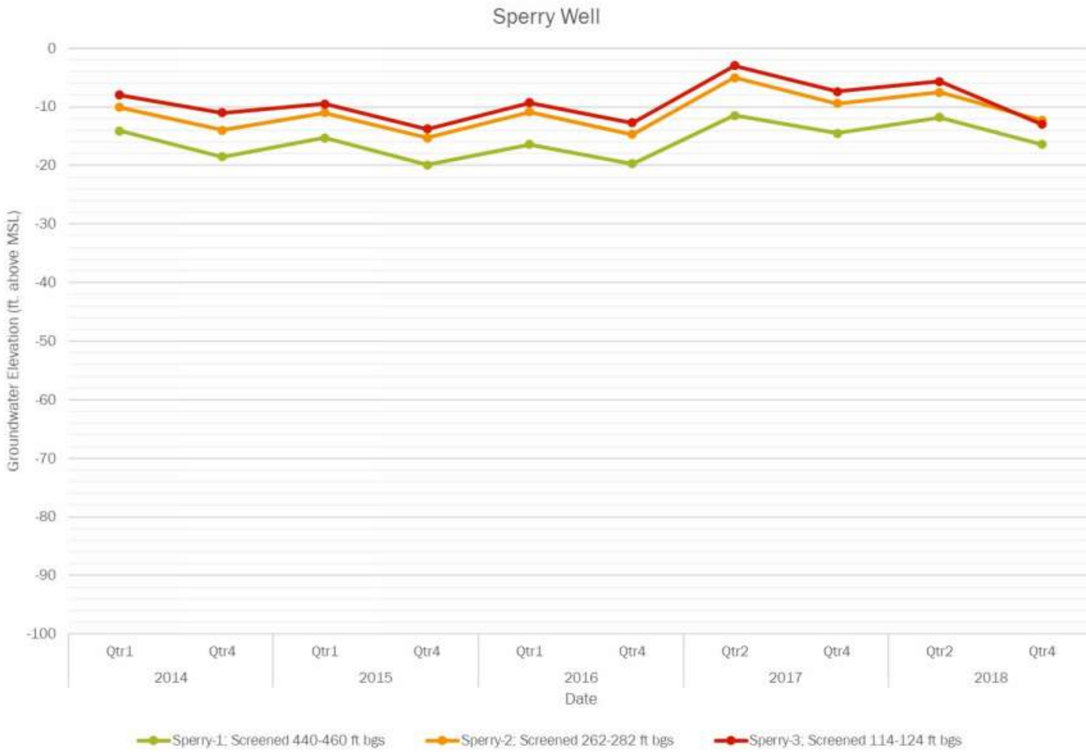


Figure 2-43: Nested Well Hydrographs: Swenson Golf Course

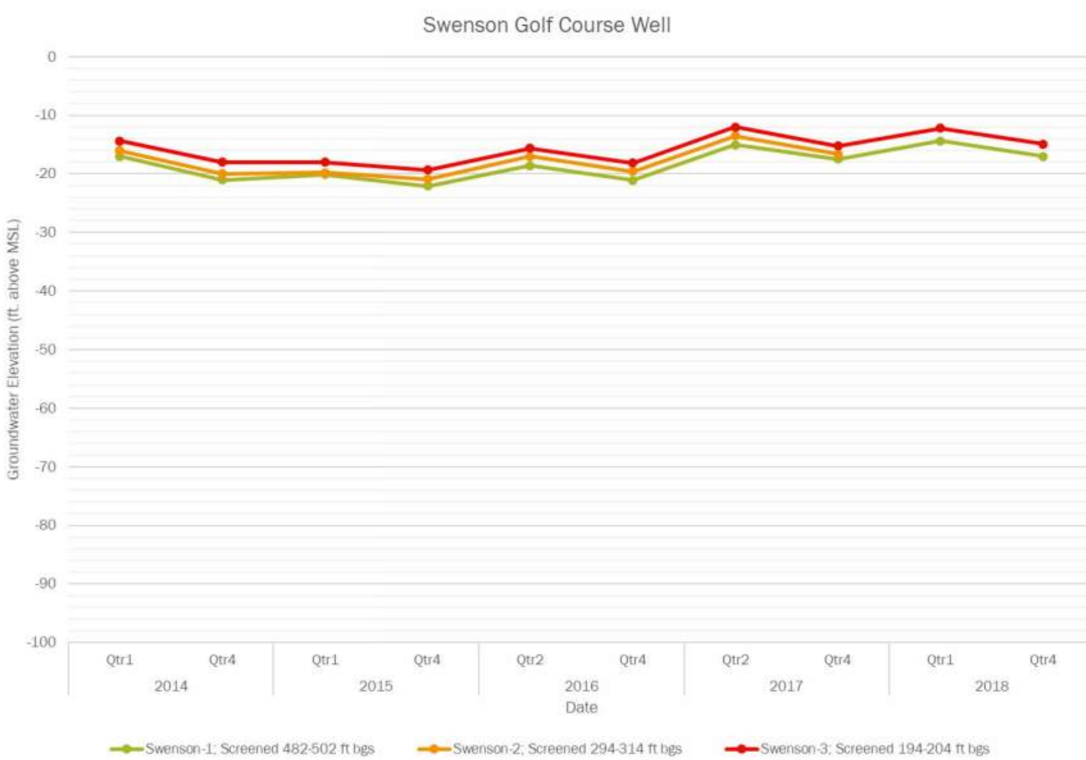


Figure 2-44: Nested Well Hydrographs: STK-1

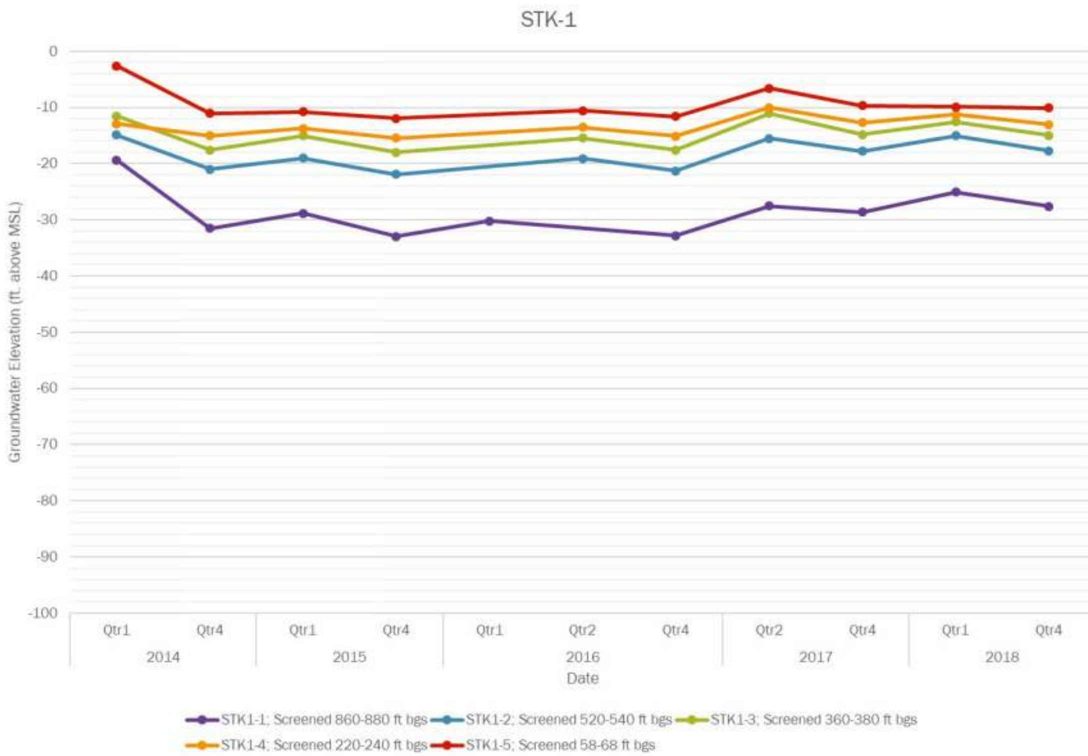


Figure 2-45: Nested Well Hydrographs: STK-2

Figure 2-46: Nested Well Hydrographs: STK-4

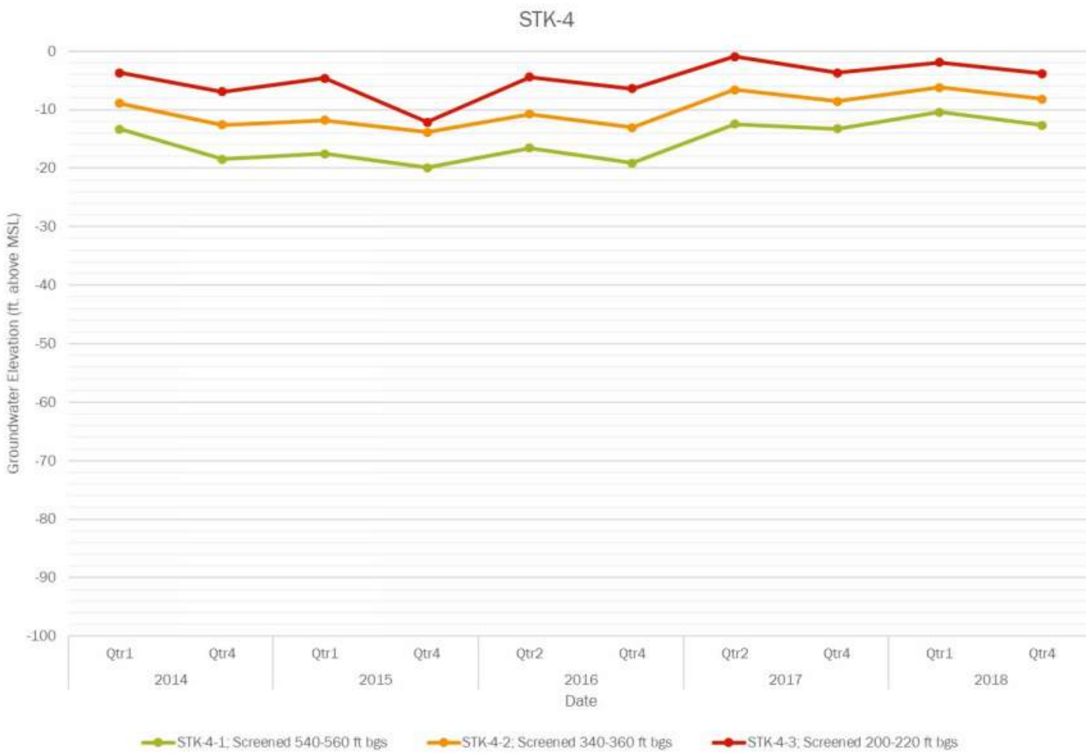


Figure 2-47: Nested Well Hydrographs: STK-5

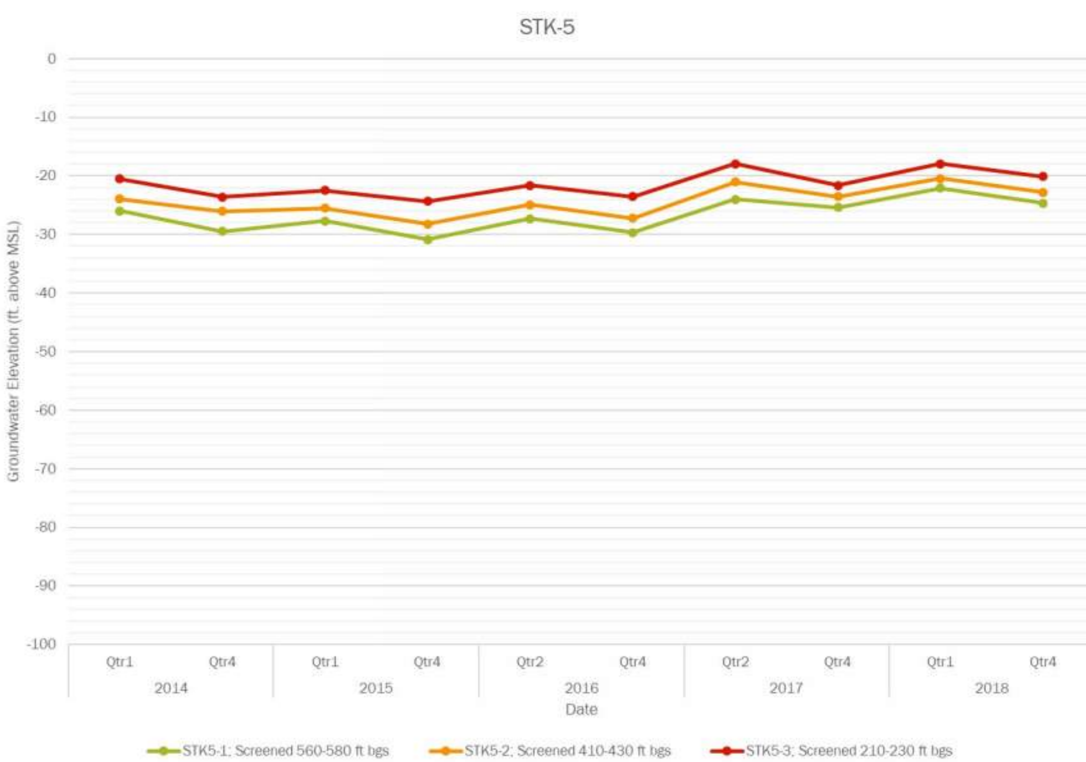


Figure 2-48: Nested Well Hydrographs: STK-6

Figure 2-49: Nested Well Hydrographs: STK-7

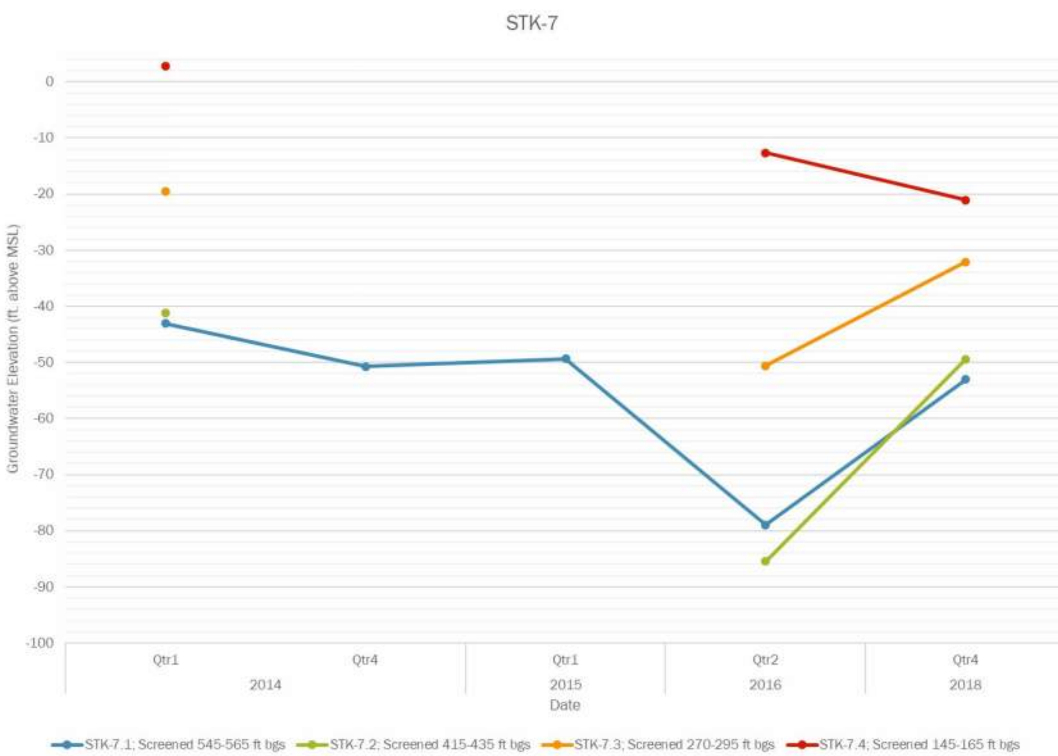


Figure 2-50: Nested Well Hydrographs: Lodi MW-21

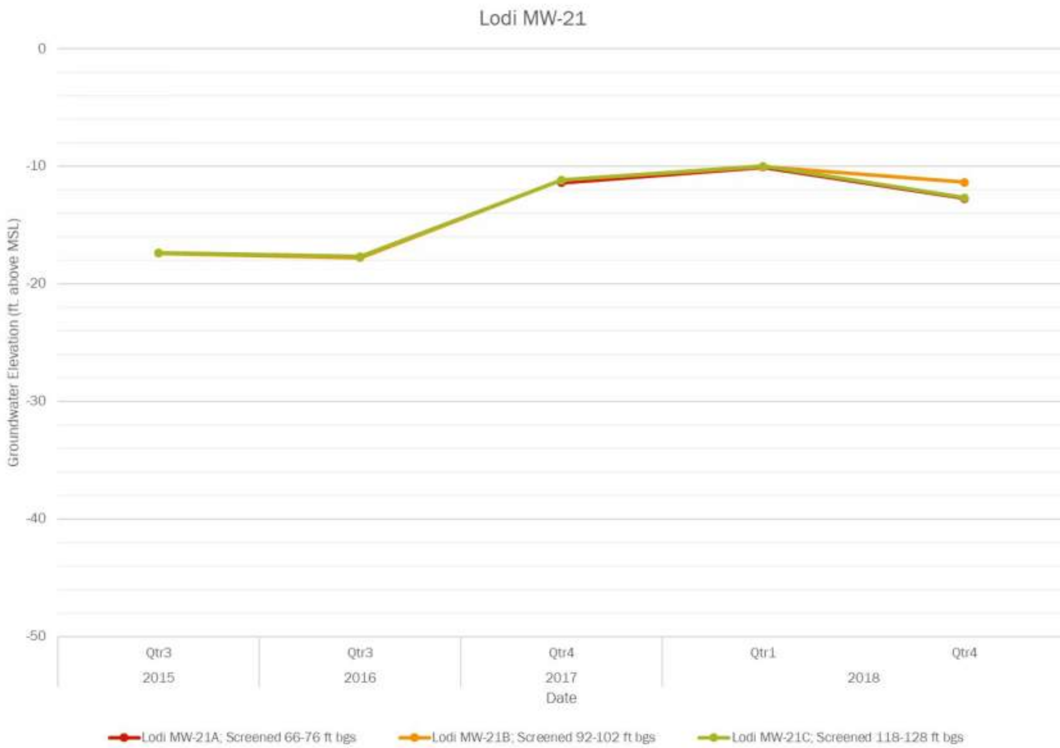


Figure 2-51: Nested Well Hydrographs: Lodi MW-24

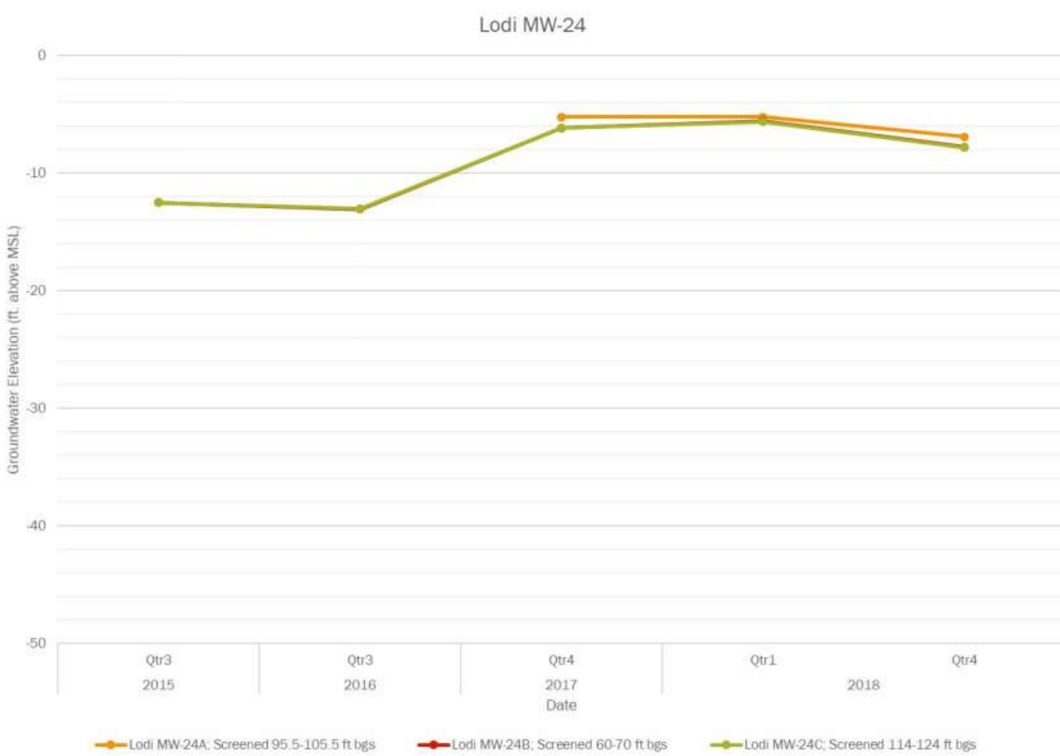


Figure 2-52: Nested Well Hydrographs: Lodi MW-25

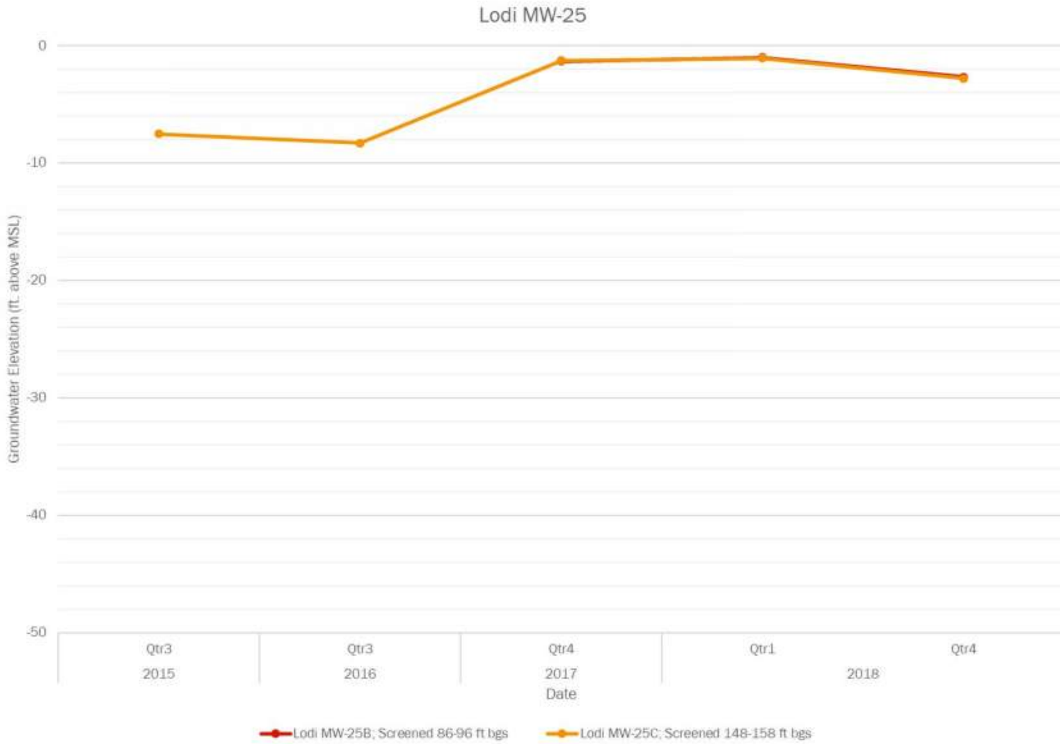


Figure 2-53: Nested Well Hydrographs: Lodi SMW-1

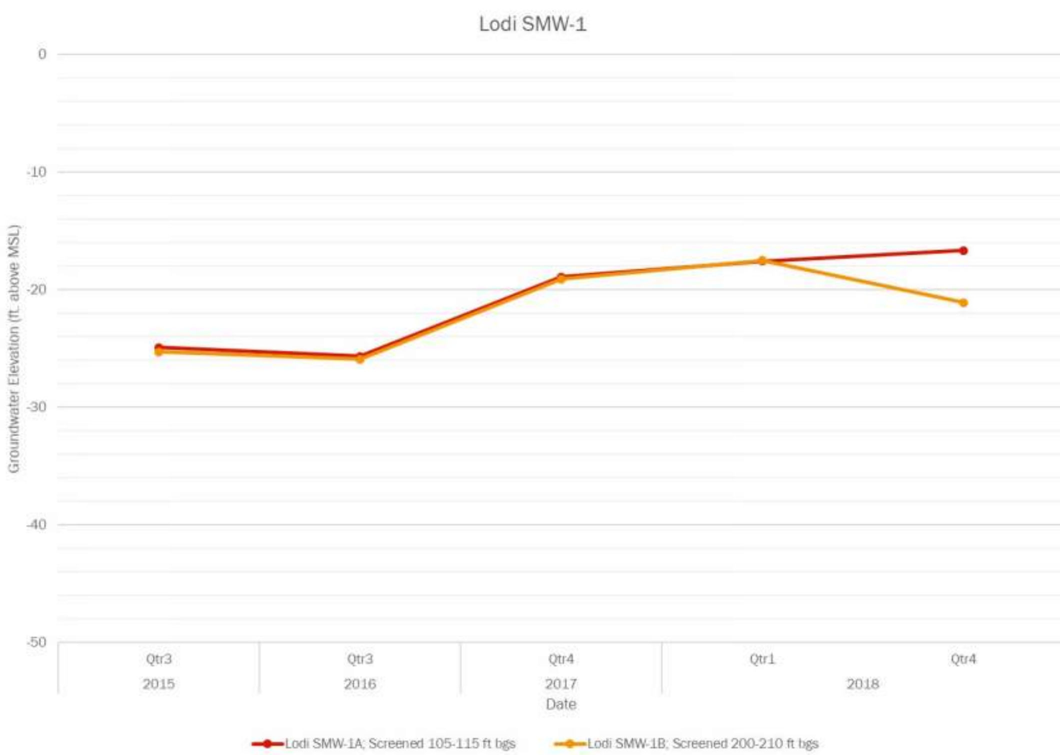


Figure 2-54: Nested Well Hydrographs: Lodi WMW-1

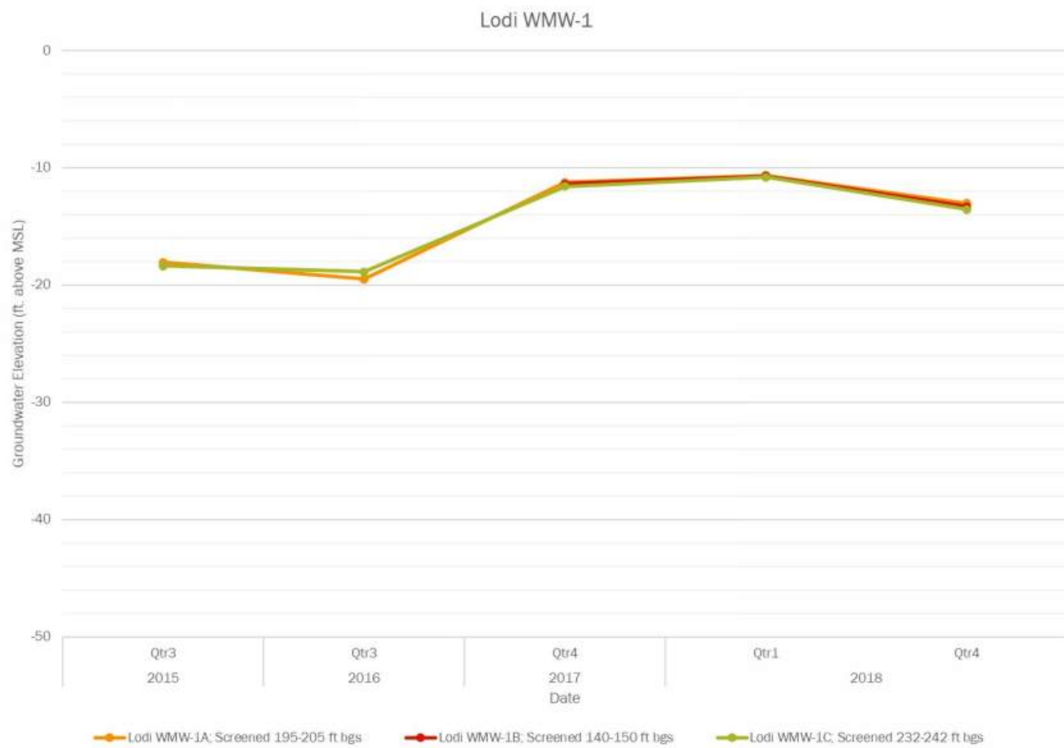


Figure 2-55: Nested Well Hydrographs: Lodi WMW-2

2.2.2 Groundwater Storage

The ESJWRM was used to estimate historical change in storage of the Eastern San Joaquin Subbasin from 1995-2015.

Figure 2-56 shows annual total storage for the combined ESJWRM fresh groundwater layers (not including the deep saline layer). Figure 2-57 shows the cumulative change in storage against annual storage change and water year type. In 2015, the total fresh groundwater storage was estimated as 53.0 million acre-feet (MAF). An additional 75.0 MAF in the deepest simulated layer of the model (not pictured) is saline water. The cumulative change in storage from 1996 to 2015 was estimated as -0.91 MAF or -0.05 million acre-feet per year (MAF/year). More information about the layers of the ESJWRM and calculation of storage changes can be found in model documentation in Appendix 2-A.

Figure 2-56: Historical Modeled Change in Storage

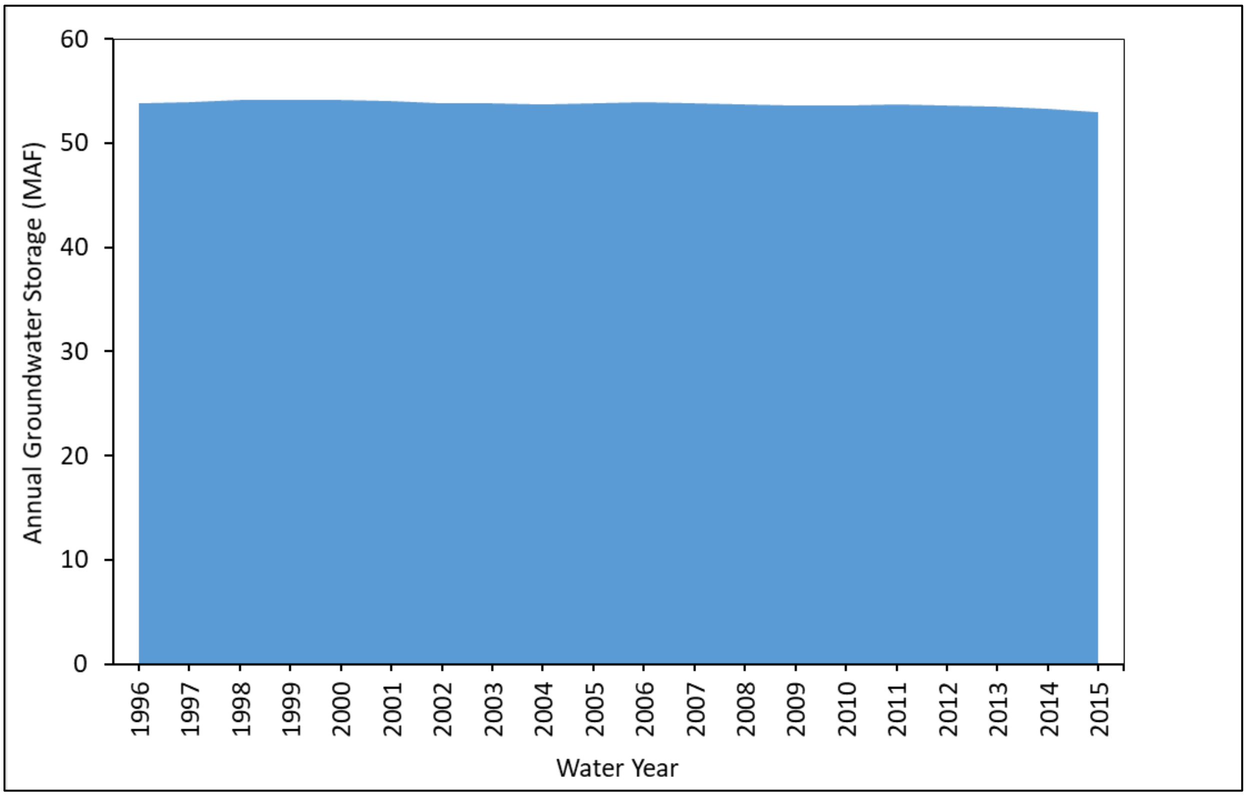
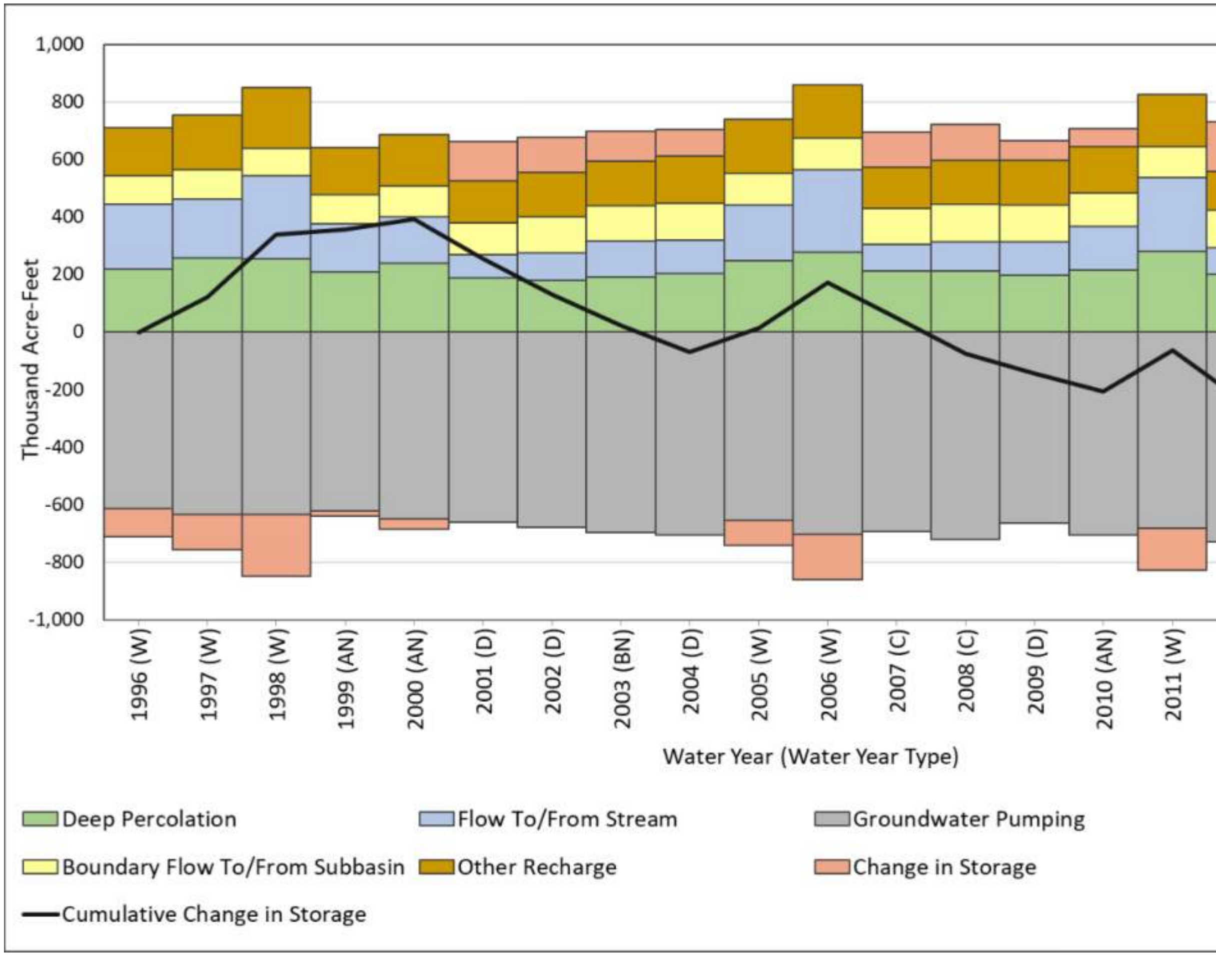


Figure 2-57: Historical Modeled Change in Annual Storage with Water Use and Year Type



X-Axis Abbreviation	Description
W	Wet year type
AN	Above normal year type
BN	Below normal year type
D	Dry year type
C	Critical year type

Notes:
1. Water Year Types based on San Joaquin Valley Water Year Index (CA DWR, 2018)
2. "Other Recharge" includes managed aquifer recharge, recharge from unlined canals and/or reservoirs, and recharge from ungauged watersheds.
3. "Change in Storage" is placed to balance the water budget. For instance, if annual outflows (-) are greater than inflows (+), there is a decrease in storage, but this would be shown on the positive side of the bar chart to balance out the increased outflows on the negative side of the bar chart.

2.2.3 Seawater Intrusion

The Eastern San Joaquin Subbasin is not in a coastal area and seawater intrusion is not present. While the Delta ecosystem evolved with a natural salinity cycle that brought brackish tidal water in from the San Francisco Bay, levees installed to allow development of agriculture, followed by development and operation of the Central Valley Project and the State Water Project, have altered the inward movement of seawater through the Delta. Current management practices endeavor to maintain freshwater flows through a combination of hydraulic and physical barriers and alterations to existing channels (Water Education Foundation, 2019). Portions of the Subbasin do, however, experience water quality issues related to salinity, which are addressed under Section 2.2.4.1 (Salinity). As described in Section 2.2.4.1, salinity in the Subbasin is due to other factors and are not the result of seawater intrusion.

2.2.4 Groundwater Quality

While groundwater quality in the Eastern San Joaquin Subbasin is generally sufficient to meet beneficial uses, a number of constituents of concern are either currently impacting groundwater use or have the potential to impact it in the future. Depending on the water quality constituent, the source may be anthropogenic in origin or naturally occurring, and the issue may be widespread or localized.

The primary naturally occurring water quality constituents of concern are salinity and arsenic, while primary water quality constituents are related to human activity include nitrates, salinity, and various point-source contaminants.

The sections herein provide information on the historical and current groundwater quality conditions for constituents including:

- Salinity (Section 2.2.4.1)
- Nitrate (Section 2.2.4.2)
- Arsenic (Section 2.2.4.3)
- Point-source contamination (Section 2.2.4.4), which includes petroleum hydrocarbons, solvents, and emerging contaminants

CCR Title 22 establishes water quality standards for drinking water contaminants. A primary maximum contaminant level (MCL) or SMCL is defined for a variety of parameters. For the purposes of this GSP, comparing parameter concentrations to their MCL or SMCL is used as the basis for describing groundwater quality concerns in the Eastern San Joaquin Subbasin. Comparisons to the MCL or SMCL must be considered in context as the measured concentrations represent raw water that may be treated or blended prior to delivery to meet the standard or may not be used for potable uses. Water quality is generally not known to have significantly adversely affected beneficial uses of groundwater in the Eastern San Joaquin Subbasin.

2.2.4.1 Salinity

As identified in prior planning efforts, and as referenced in Section 2.2 (Current and Historical Groundwater Conditions), localized salinity issues are a concern for some areas of the Eastern San Joaquin Subbasin. Pumping in excess of recharge has resulted in declining groundwater levels that have contributed to an increase of salinity in groundwater wells since the 1950s. As identified through isotopic typing, elevated salinity concentrations in the Subbasin are the result of natural processes and overlying land use activities (O'Leary et al., 2015). Within the Subbasin, there are three primary sources of salinity:

1. **Delta Sediments** – Evaporation of groundwater in discharge areas introduces naturally occurring soluble salts into Delta sediments.

2. **Deep Deposits –** Saline groundwater in the Subbasin is principally the result of the migration of a naturally occurring deep saline water body which originates in regionally deposited marine sedimentary rocks that underlie the San Joaquin Valley. This results in a saline aquifer underlying the freshwater aquifer, and well pumping can result in upwelling saline brines into the freshwater aquifer.

3. **Irrigation Return Water –** Irrigation return water is excess applied water that percolates into the groundwater system or flows to the stream system from an irrigated field following the application of irrigation water. Return water may include contaminants typical of agricultural practices (e.g., pesticides, herbicides) and can concentrate salts due to evapotranspiration. The return water may act as a conduit delivering these contaminants to the surrounding watershed or underlying groundwater aquifer. Areas in the Subbasin with salinity resulting from irrigation return water do not commonly exceed chloride concentrations of 100 mg/L (O'Leary et al., 2015).

Salinity is a measure of the mass of dissolved particles and ions in a volume of water. Salinity includes many different ions, including nitrate, but the most common are sodium, calcium, magnesium, chloride, bicarbonate, and sulfate. Chloride and TDS are two common ways to measure and analyze salinity. Each is described separately in the sections below.

2.2.4.1.1 Chloride

Chloride is one way to measure salinity and is reported as a concentration of the Cl^- ion that originates from the dissociation of salts in water. The California Department of Drinking Water (DDW) SMCL of 250 mg/L for chloride is a common approach to identifying water quality concerns for this constituent. The SMCL is a secondary drinking water standard that is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns. The 250 mg/L value is "recommended" by SWRCB as a threshold below which chloride concentrations are desirable for a higher degree of consumer acceptance of drinking water. An "upper" limit of 500 mg/L is used to define a range above the "recommended" value where chloride concentration is acceptable if it is neither reasonable nor feasible to provide more suitable waters (SWRCB, 2006). Comparisons to the SMCL must be considered in context as the measured concentrations represent raw water, which may be treated or blended prior to delivery to meet the standard or may not be used for potable uses.

As shown in Figure 2-58, the majority of observed chloride concentrations above 250 mg/L occur on the western side of the Subbasin. As shown in Figure 2-59, the number of measurements with observed concentrations above 250 mg/L has decreased since the 1970s. The GAMA dataset was used for analysis.

Figure 2-58: Maximum Chloride Concentration Greater Than 250 mg/L (1940s-2010s)

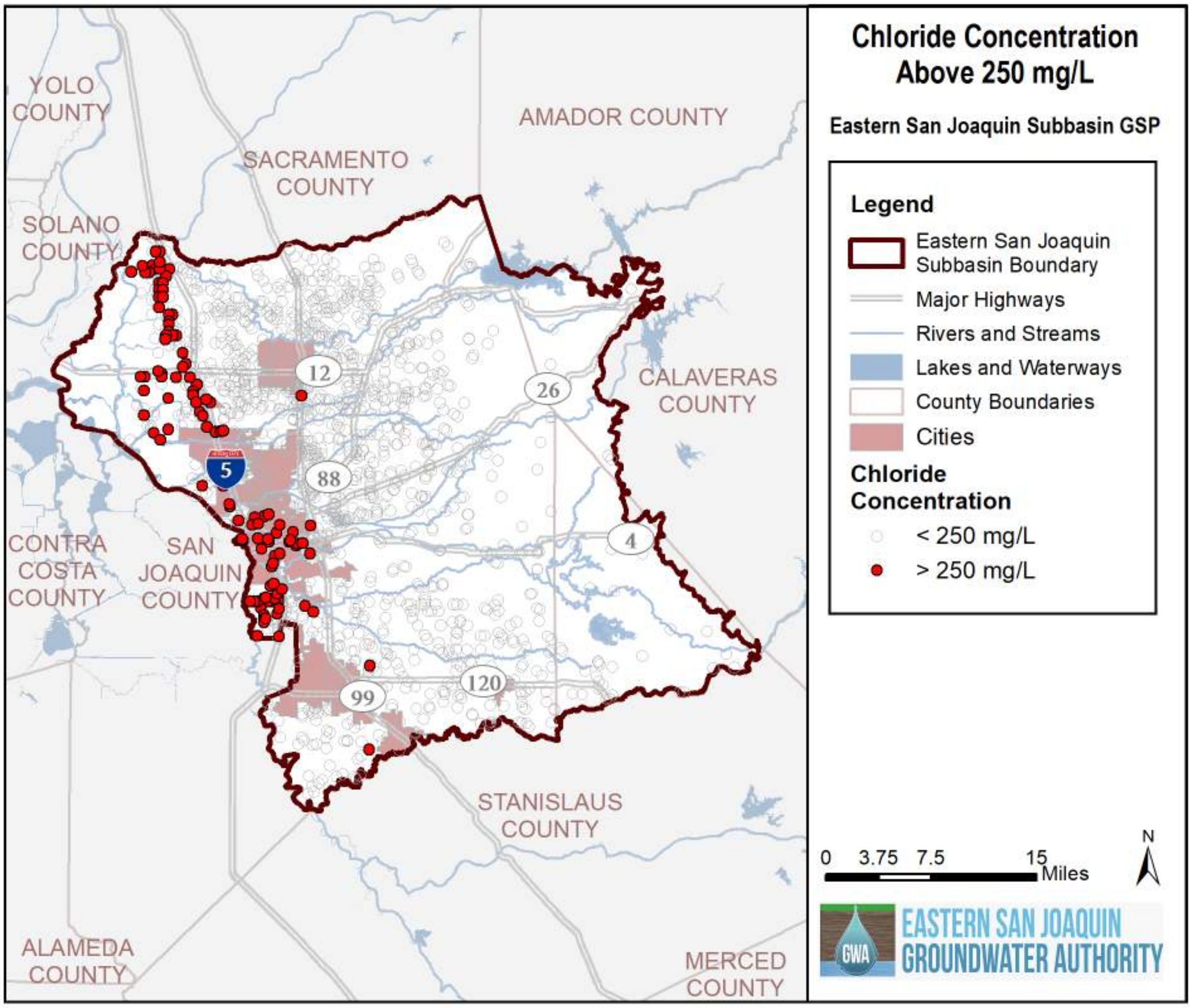


Figure 2-59: Maximum Chloride Concentration Above 250 mg/L by Decade

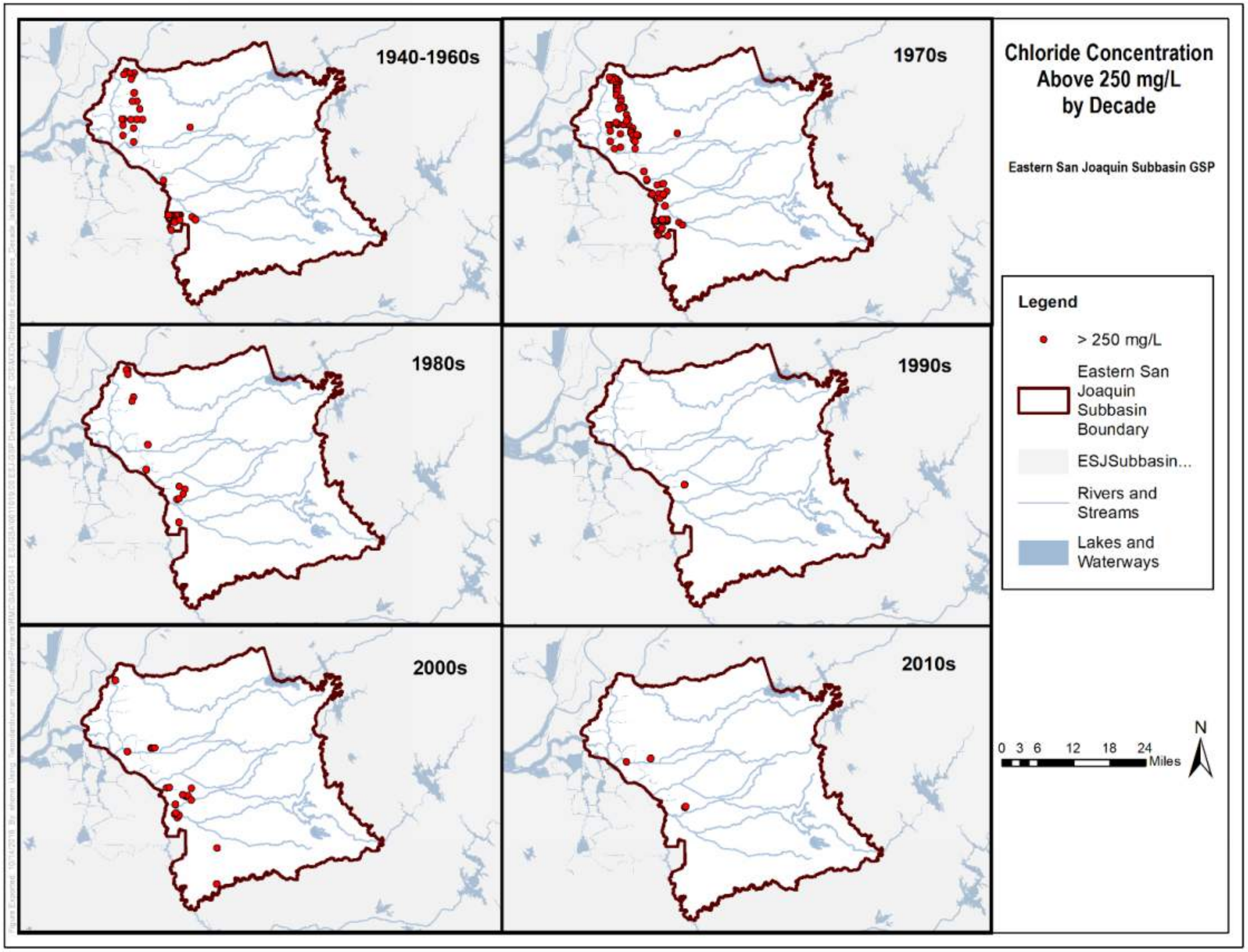


Table 2-5 shows occurrence of chloride measurements greater than 250 mg/L by decade. Chloride records have been observed above 250 mg/L both historically and recently. Sampling frequencies increased in the 1970s and 2000s.

Table 2-5: Summary of Chloride Data by Decade

Decade	Measurement Above 250 mg/L?		Range of Values (mg/L)				Total Number of Samples
	No	Yes	Minimum	Average	Median	Maximum	
1940	98%	2%	7.0	45.2	20.0	975	180
1950	93%	7%	2.3	89.4	25.0	3,750	699
1960	90%	10%	0.0	115.0	17.0	1,960	312
1970	90%	10%	1.8	85.9	19.0	3,310	1,780
1980	97%	3%	0.0	45.4	20.5	630	858
1990	99%	1%	0.0	31.2	19.0	533	663
2000	95%	5%	0.0	59.6	35.0	2,050	1,453
2010	98%	3%	0.0	34.8	39.0	2,050	986

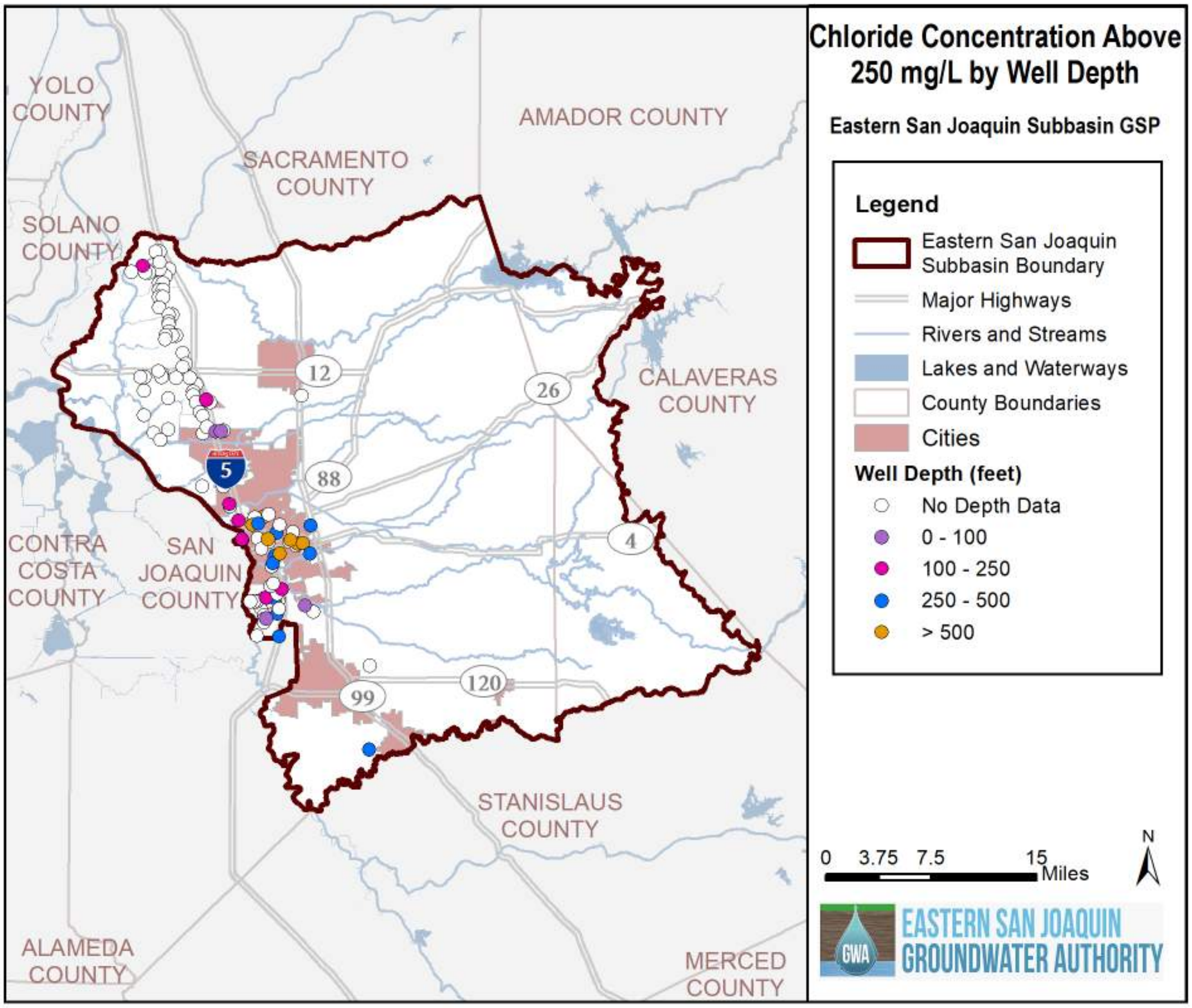
Table 2-6 shows chloride occurrences of concentrations greater than 250 mg/L by well depth. The highest proportion of readings above 250 mg/L occur in the shallowest wells, less than 100 feet deep (8 percent). The highest maximum value also occurred at this depth range (up to 2,050 mg/L).

Figure 2-60 shows the spatial distribution of chloride occurrences greater than 250 mg/L by well depth within the Subbasin.

Table 2-6: Summary of Chloride Data by Depth (1940s-2010s)

Depth (feet)	Measurement Above 250 mg/L?		Range of Values (mg/L)				Total Number of Samples
	No	Yes	Minimum	Average	Median	Maximum	
No Depth Data	92%	8%	0.0	82.5	20.0	3,750	3,566
0 - 100	92%	8%	0.8	73.5	60.0	2,050	239
100 - 250	97%	3%	1.0	44.2	36.0	1,400	1,215
250 - 500	98%	2%	0.0	32.4	16.0	1,100	1,487
> 500	95%	5%	2.7	62.1	15.6	1,940	424

Figure 2-60: Maximum Chloride Concentration Above 250 mg/L by Well Depth (1940s-2010s)



A lack of depth information presents a challenge to analyzing the vertical distribution of chloride measurements which would inform identification of chloride sources. Examples of depth information include total well construction depth or screened interval depths, which vary between wells. Some wells have total depth but not screened interval depth, or vice versa. For this analysis, screened interval depth was used first, and if this information was not available, total depth was used. Approximately 4,600 of the almost 13,000 chloride measurements in the Eastern San Joaquin Subbasin are from wells lacking any construction or screen depth information. Roughly half of the measurements above 250 mg/L occur in the wells lacking depth data, which also show the highest range in values occurring above 250 mg/L. Identifying the source of high-chloride water in wells of various depths over time requires further analysis of geochemical data; depth-specific water quality was identified as a data gap in the HCM.

2.2.4.1.2 Total Dissolved Solids (TDS)

TDS, which is a measure of all inorganic and organic substances present in a liquid in molecular, ionized, or colloidal suspended form, is commonly used to measure salinity. Recent TDS sample results show trends that match closely with the overall historical trends for chloride and highlight areas with elevated salinity concentrations in more recent years. TDS concentrations in the Eastern San Joaquin Subbasin ranged from 35 to 2,500 mg/L between 2015 and 2018. Spatially, the highest concentrations of TDS are found along the western margin of the Subbasin and the San Joaquin River and decrease significantly to the east, to typically less than 500 mg/L. TDS measurements, like chloride levels, are elevated near the cities of Stockton and Manteca, and in the Lodi GSA near the White Slough Water Pollution Control Facility.

Figure 2-61 shows the maximum and Figure 2-62 shows the average TDS concentrations from 2015 to 2018 as compared to the SMCL lower limit of 500 mg/L and upper limit of 1,000 mg/L. The GAMA dataset was used for analysis. The SMCL is a secondary drinking water standard that is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns. The 500 mg/L value is “recommended” by SWRCB as a threshold below which TDS concentrations are desirable for a higher degree of consumer acceptance of drinking water. The “upper” limit is used to define a range above the “recommended” value where TDS concentration is acceptable if it is neither reasonable nor feasible to provide more suitable waters (SWRCB, 2006). Comparisons to the SMCL must be considered in context as the measured concentrations represent raw water, which may be treated or blended prior to delivery to meet the standard or may not be used for potable uses.

Figure 2-61: Maximum TDS Concentrations 2015-2018

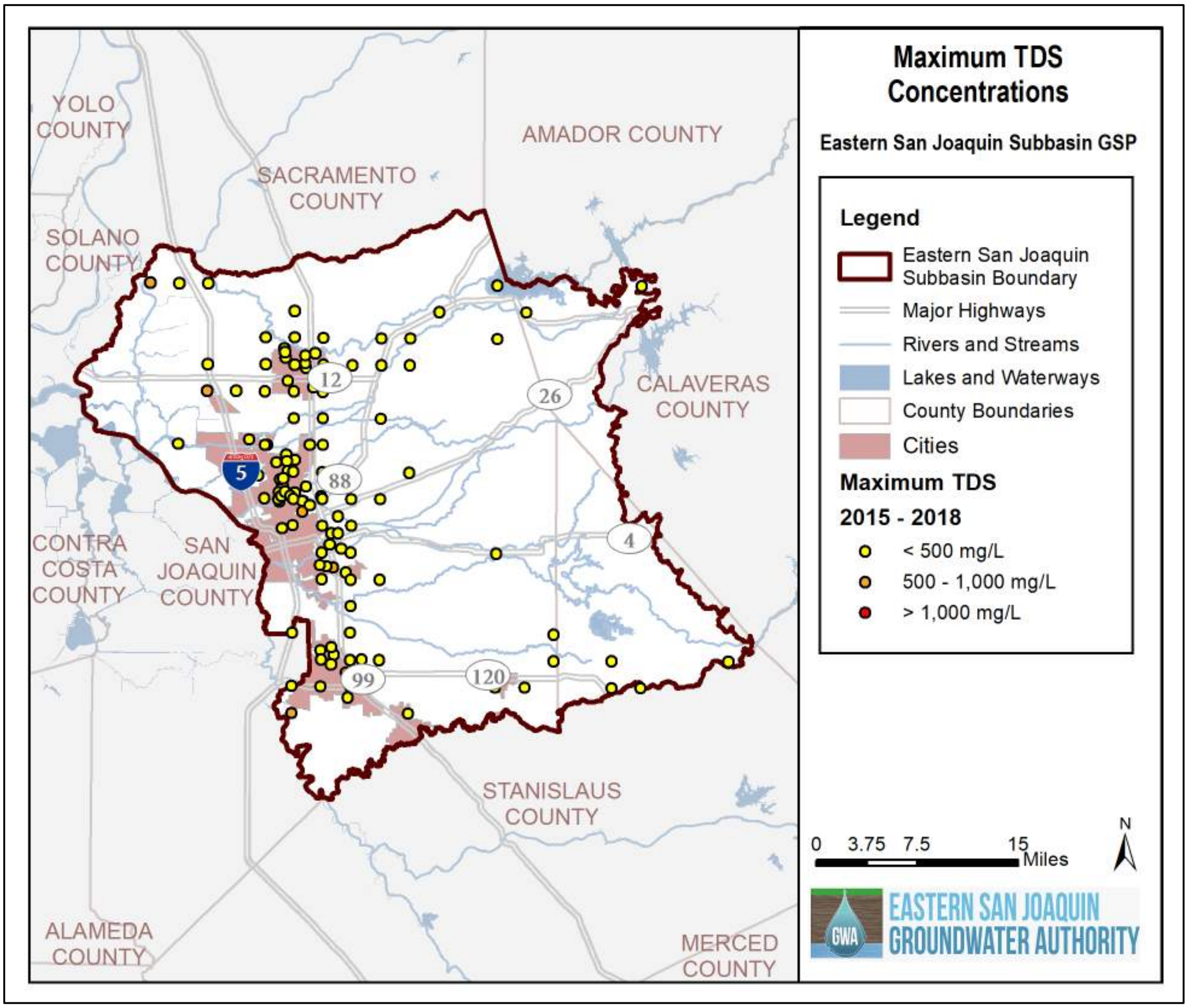
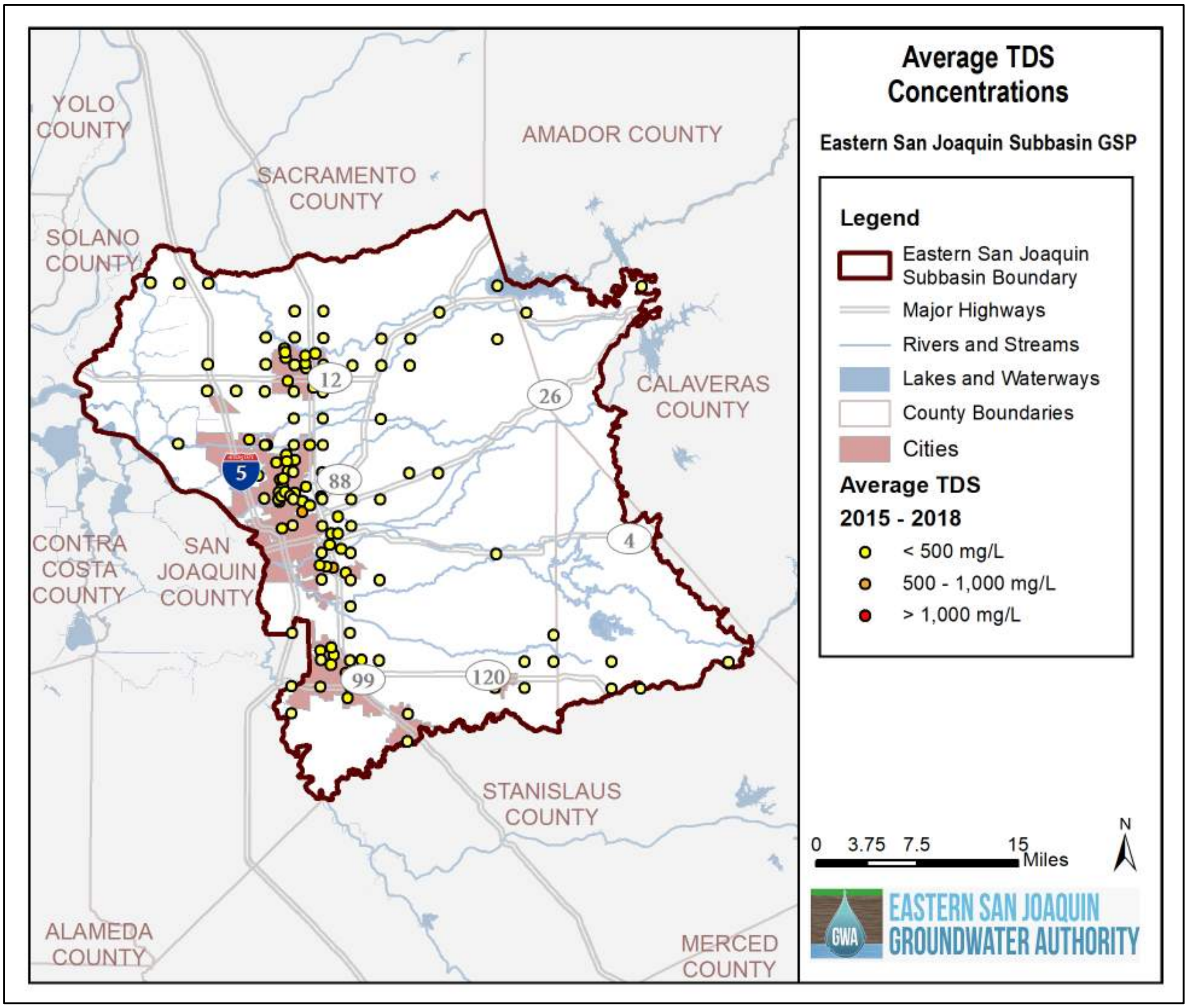


Figure 2-62: Average TDS Concentrations 2015-2018



Elevated TDS concentrations are apparent in very shallow groundwater in close proximity to the San Joaquin River, while deep wells (depths greater than 200 feet) typically have TDS concentrations below 500 mg/L. TDS trends by depth are summarized in Table 2-7.

Figure 2-63 shows the maximum TDS concentrations for shallow wells in the Eastern San Joaquin Subbasin from years 2015 to 2018, and Figure 2-64 shows the maximum TDS concentrations for deep wells in the same timeframe. As with chloride measurements, depth-dependent TDS data are not widely available. It was identified as a data gap in the HCM and will be a focus of the monitoring network for water quality, as described in the Chapter 4: Monitoring Networks.

Table 2-7: Summary of TDS Data by Depth (2015-2018)

Depth (feet)	% Measurements in Range			Range of Values (mg/L)				Total Number of Samples
	< 500 mg/L	500 – 1000 mg/L	> 1,000 mg/L	Minimum	Average	Median	Maximum	
No Depth Data	90%	8%	2%	94	339	310	1,180	451
0 - 100	N/A							0
100 - 250	54%	46%	0%	280	438	480	540	13
250 - 500	93%	7%	0%	120	344	340	560	75
> 500	N/A							0

Figure 2-63: Maximum TDS Concentrations in Shallow Wells 2015-2018

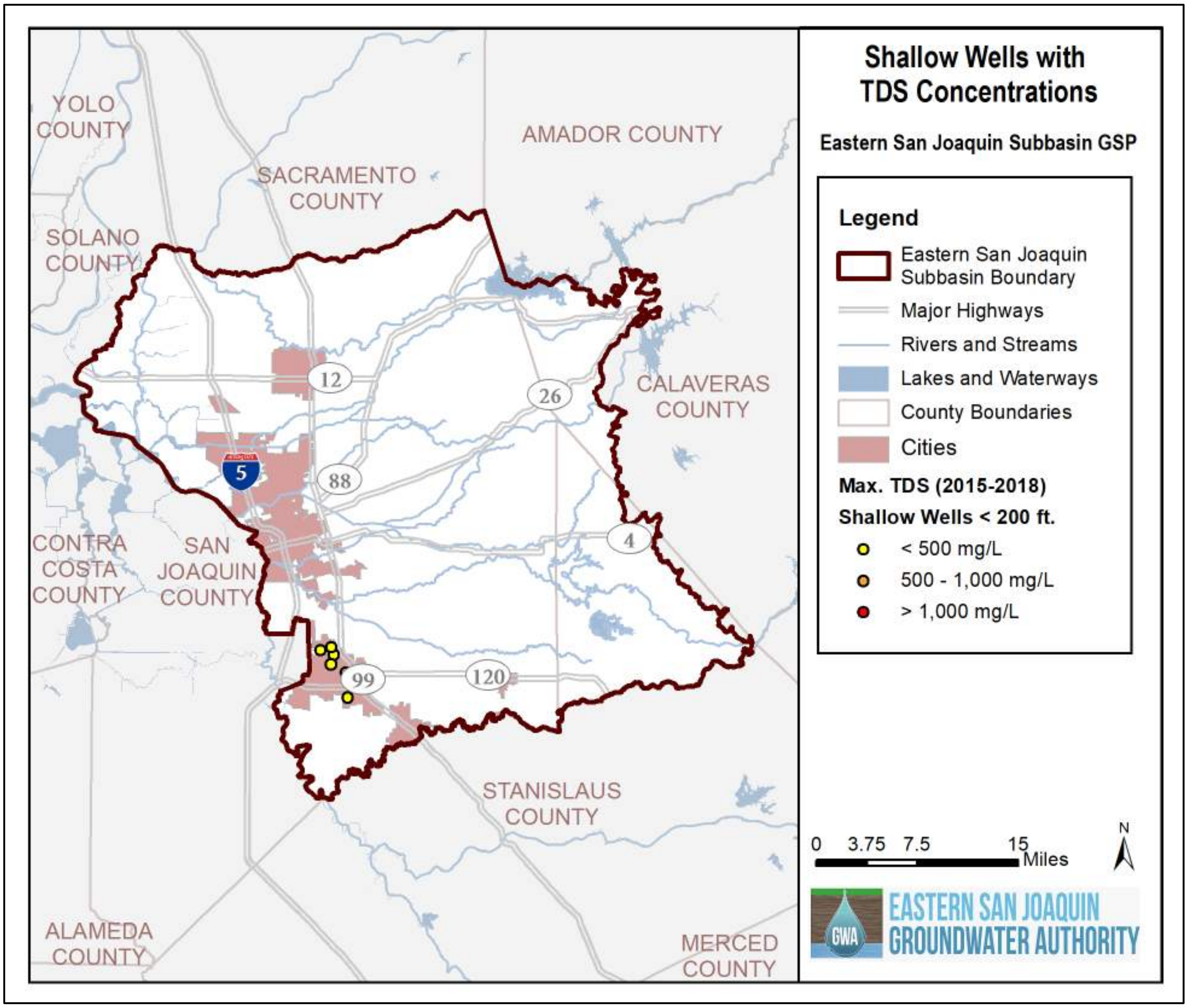
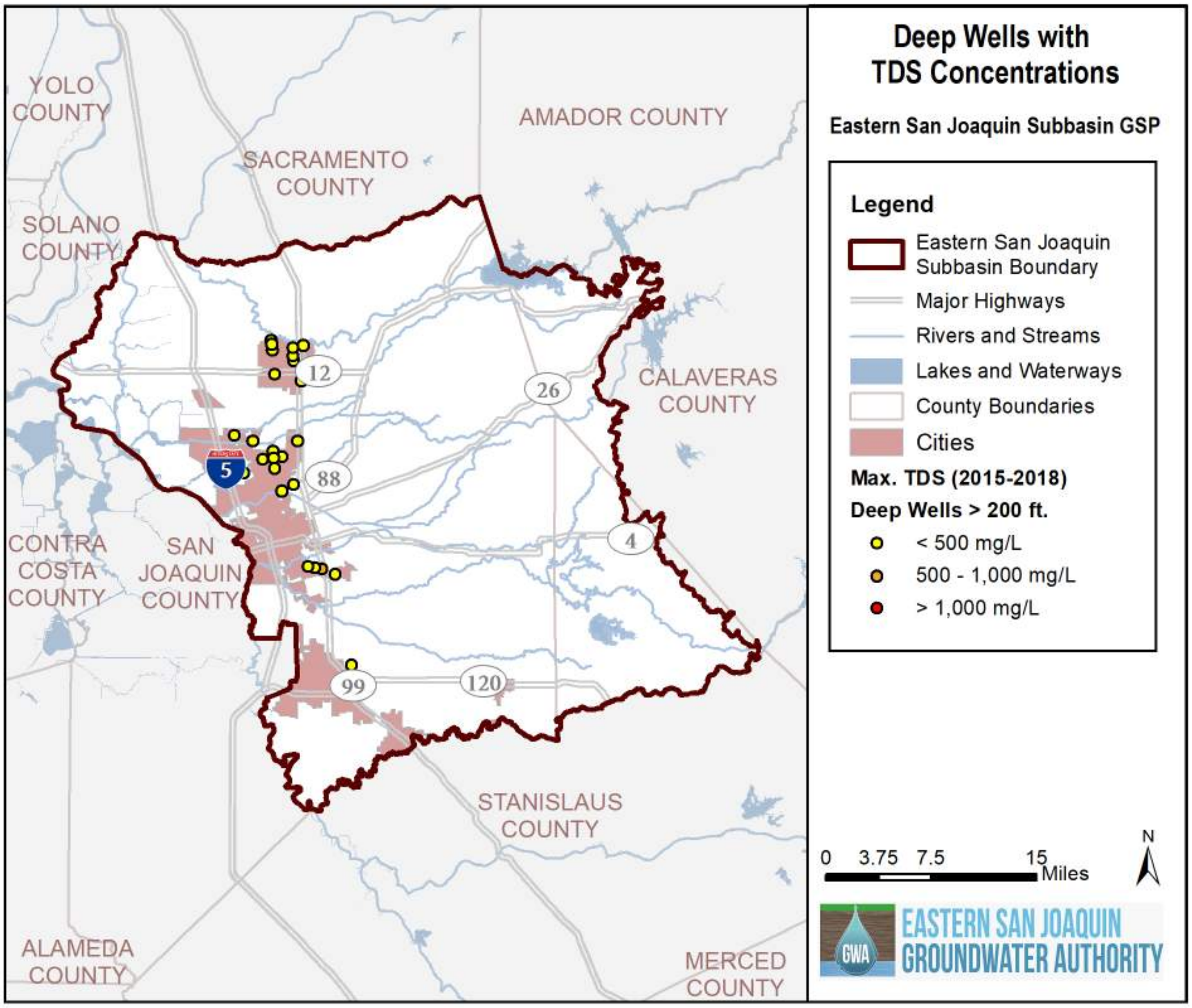


Figure 2-64: Maximum TDS Concentrations in Deep Wells 2015-2018



2.2.4.2 Nitrate

Nitrate is both naturally occurring and can be contributed a result of human activity. Nitrate can cause adverse human health effects. Anthropogenic sources of nitrate include fertilizers, septic systems, and animal waste. The DDW's MCL of 10 mg/L for Nitrate as N delimits high levels of nitrate for drinking water use. Many measured concentrations are above this value, both historically and recently. Comparisons to the MCL must be considered in context as the measured concentrations represent raw water, which may be treated or blended prior to delivery to meet the standard or may not be used for potable uses.

Table 2-8 provides the total number of nitrate values by decade and the percentage of those values greater than 10 mg/L. The total number of nitrate measurements has grown since 2000 as has the percentage of occurrences of concentrations greater than 10 mg/L. The GAMA dataset was used for analysis.

Table 2-8: Nitrate as N Concentrations by Decade

Decade	% of Samples		Number of Nitrate Samples
	<10 mg/L	>10 mg/L	
1940	88%	13%	8
1950	99%	1%	362
1960	99%	1%	240
1970	96%	4%	1,500
1980	95%	5%	420
1990	98%	2%	1,716
2000	87%	13%	9,679
2010	83%	17%	11,060

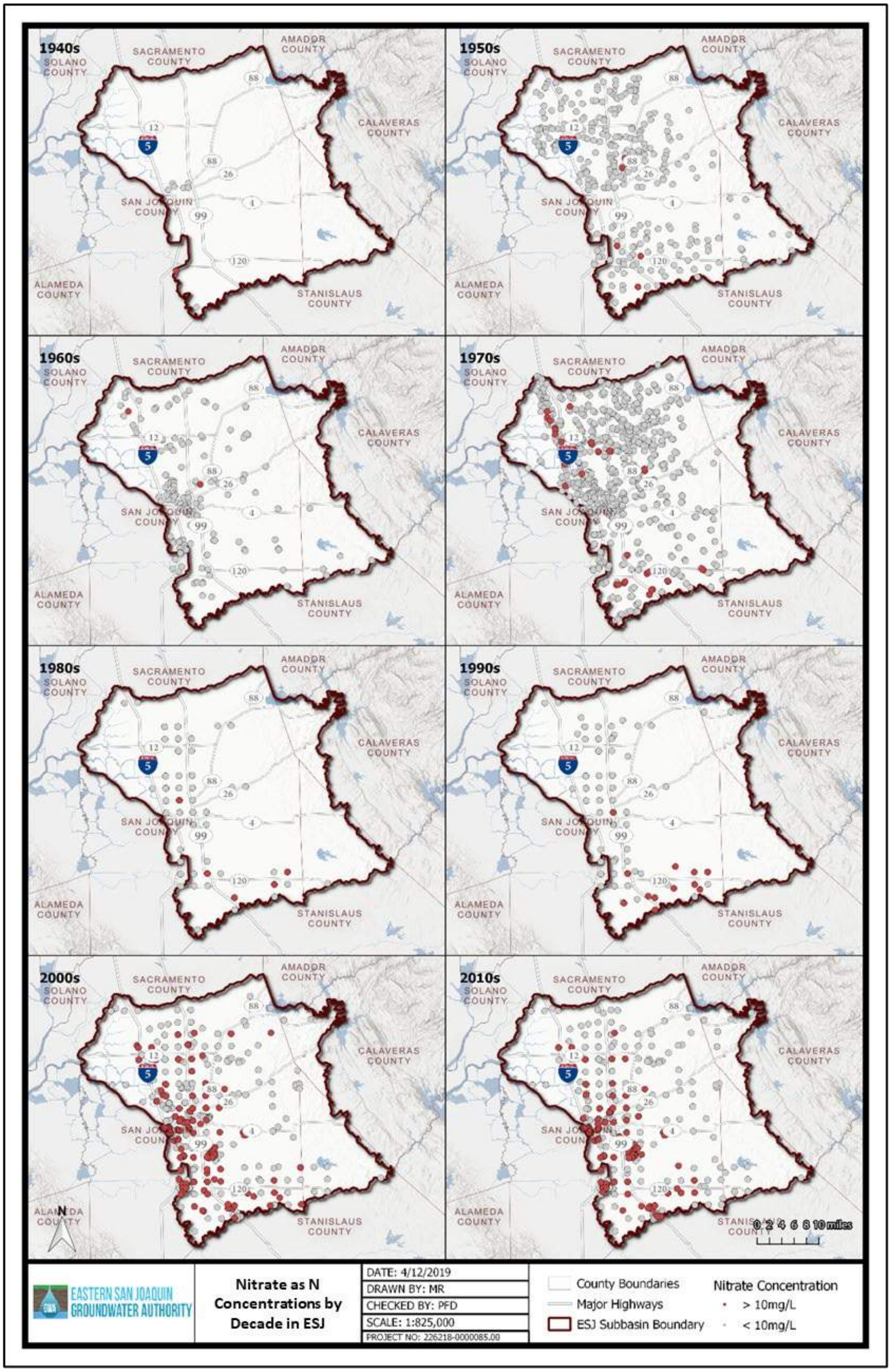
Figure 2-65 shows the historical spatial distribution of nitrate samples and detections by decade. During the 1940s, the earliest decade with nitrate measurements, very few records exist, and no significant conclusions can be made from this timeframe. The 1950s and 1960s have larger datasets, but measurements above 10 mg/L during these decades are sporadic and localized. Nitrate concentrations during the 1970s show a significant number of measurements above 10 mg/L in the northwest portion of the Eastern San Joaquin Subbasin, adjacent to Interstate 5. The 1980s and 1990s show similar patterns, with areas measurements above 10 mg/L primarily around the cities of Stockton, Lodi, and Manteca. Nitrate as N measurements above 10 mg/L are also located near the southern edge of the Eastern San Joaquin Subbasin, close to Highway 120. Although a much greater number of records exists for the 1990s than the 1980s, these decades have approximately the same spatial distribution. One possible explanation is similar wells were sampled during the 1980s and 1990s, but much more frequently in the 1990s. The 2000s and 2010s had both the greatest number of nitrate measurements and the largest number of measurements above 10 mg/L. Measurements above 10 mg/L during these decades follow previous trends: they are primarily between Highway 99 and Interstate 5, from Ripon to near Lodi.

Recent nitrate measurements above the MCL correspond to the overall historical trends and highlight areas with elevated nitrate concentrations in more recent years. These areas include the cities of Stockton and Ripon, areas of the Lodi GSA near the White Slough Pollution Control Facility, the N.A. Chaderjian Youth Correctional Facility, Republic Services Landfill on South Austin Road, and the Kruger and Sons, Inc. site off Highway 4 outside Farmington.

While the extent of groundwater quality impacts from nitrate is a data gap area, increased nitrate concentrations have not been found to have a causal nexus between SGMA-related groundwater management activities in the Subbasin. The causal nexus reflects that the degraded water quality issues are associated with groundwater pumping and other SGMA-related activities rather than water quality issues resulting from land use practices, naturally occurring water quality issues, or other issues not associated with groundwater pumping. Additional monitoring conducted through the implementation of this GSP will inform trends such that the Eastern San Joaquin Groundwater Authority (ESJGWA) can be informed to take action to address nitrite contamination if a causal nexus is identified.

Section 3.2.3.1.1 of this Plan discusses Irrigated Lands Regulatory Program (ILRP) and Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), two existing regulatory programs for the monitoring and regulation of nitrate. Under the ILRP, the San Joaquin County & Delta Water Quality Coalition is required to test and potentially mitigate for nitrate in domestic wells. Additionally, the 2017 Salt and Nitrate Management Plan developed by CV-SALTS identifies long-term nitrate management practices (CVRWQCB, 2016).

Figure 2-65: Nitrate as N Concentrations by Decade



2.2.4.3 Arsenic

Arsenic is ubiquitous in nature and is commonly found in drinking water sources in California. Determining the source of arsenic in groundwater is difficult because arsenic is both naturally occurring and used in human activities such as agriculture. Public health concerns about arsenic in drinking water related to its potential to cause adverse health effects are addressed through DDW's MCL, established at 10 micrograms per liter (µg/L). California's revised arsenic MCL of 10 µg/L became effective on November 28, 2008. A 10-µg/L federal MCL for arsenic has been in effect since January 2006. Previous California and federal MCLs for arsenic were 50 µg/L.

Figure 2-66 shows the spatial distribution of arsenic concentrations contained in the GAMA database. From the 1970s to present, the total number and percentage of arsenic values above 10 µg/L has increased (see Table 2-9). The spatial distribution of measurements above 10 µg/L is similar to nitrate, largely between Interstate 5 and Highway 99, from Manteca to Lodi. The increased arsenic concentrations near urban areas are not necessarily indicative of contamination from these areas and may partially be due to the fact that arsenic measurements are more abundant in these urban areas; GAMA water quality records are rarely evenly distributed throughout the Subbasin for any constituent. Recent arsenic samples show measurements above 10 µg/L similar to the overall trends (see Figure 2-67). Measurements above 10 µg/L in years 2015, 2016, 2017, and 2018 are primarily located in the cities of Stockton and Manteca, with fewer occurring around the City of Lodi. While the extent of groundwater quality impacts from arsenic is a data gap area, increased arsenic concentrations have not been found to have a causal nexus between SGMA-related groundwater management activities in the Subbasin. Additional monitoring conducted through the implementation of this GSP will inform trends such that the ESJGWA can be informed to take action to address arsenic contamination if a causal nexus is identified.

Figure 2-66: Arsenic Concentrations by Decade

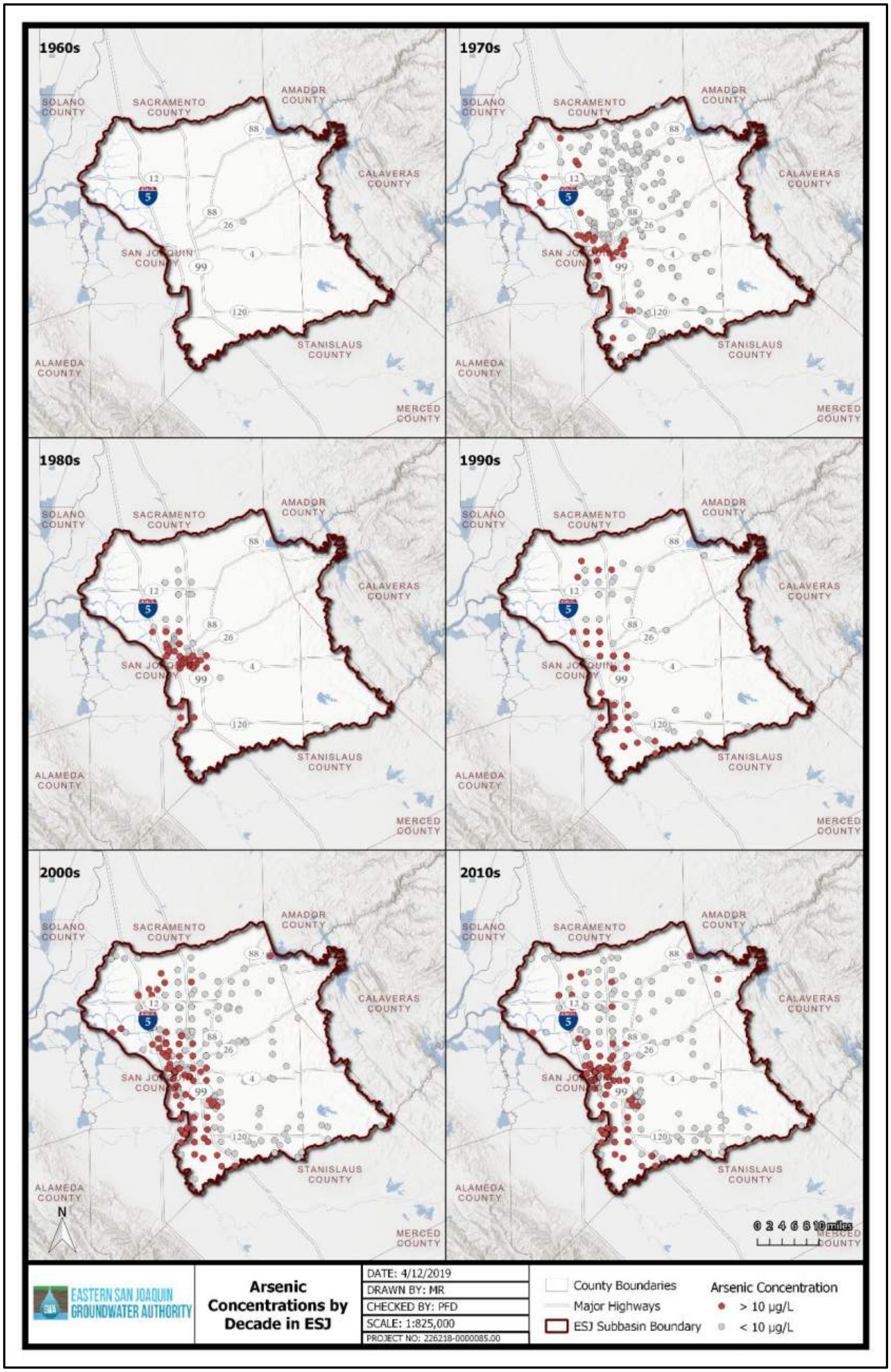
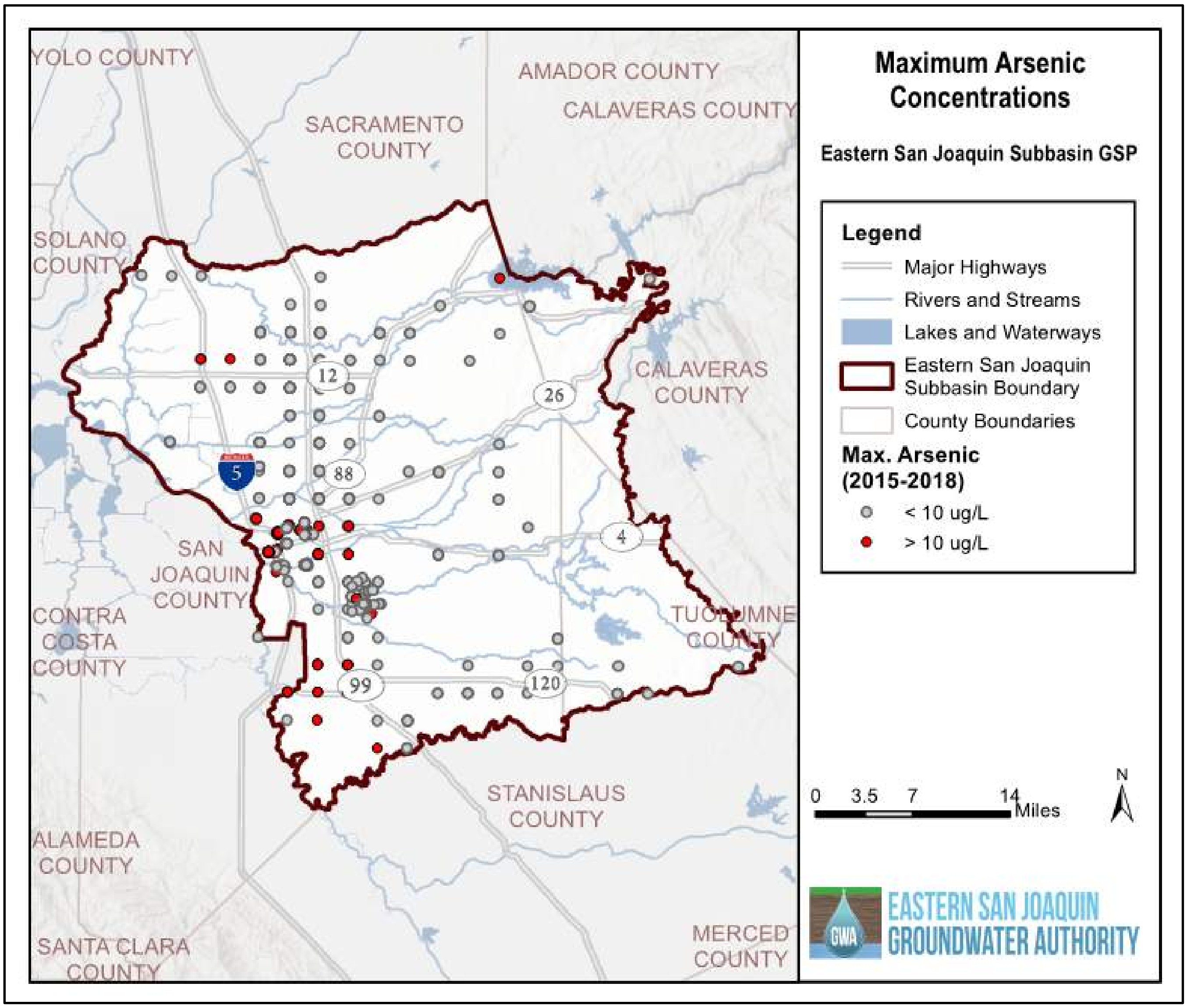


Table 2-9: Arsenic Concentrations by Decade

Decade	% of Samples		Number of Arsenic Samples
	<10 µg/L	>10 µg/L	
1960	100%	0%	1
1970	86%	14%	339
1980	72%	28%	363
1990	72%	28%	645
2000	56%	44%	4,051
2010	48%	52%	5,109

Figure 2-67: Maximum Arsenic Concentrations 2015-2018



2.2.4.4 Point Sources

Point sources are discrete or discernable sources of pollutants which may introduce undesirable constituents into groundwater and may negatively impact water quality. In the Eastern San Joaquin Subbasin, point sources include leaking underground storage tanks, landfills, dry cleaners, and others. These sites are actively investigated and monitored within the Eastern San Joaquin Subbasin in response to these known or potential sources of groundwater contamination.

The Regional Water Quality Control Board (RWQCB), the Department of Toxic Substances Control (DTSC), and the USEPA provide oversight of point-source pollution through existing regulatory programs, including management of remedial action for point-source contamination sites. Figure 2-68 shows the results of a query from both the GeoTracker database and the EnviroStor database. GeoTracker documents contaminant concerns that the RWQCB is or has been working with site owners to remediate while EnviroStor is the DTSC's data management system to track known contamination sites undergoing cleanup, permitting, enforcement, and investigation efforts. As shown in Figure 2-68, there are 258 active sites within the Eastern San Joaquin Subbasin which are color-coded based on the site's constituent(s) of concern: fuels (gas and/or diesel); synthetic organics (pesticides, herbicides, insecticides, etc.); or a mix of constituents (multiple constituents such as heavy metals and pesticides).

Most sites within the Eastern San Joaquin Subbasin are fuel sites (e.g., gas or diesel) that are under active investigation or remediation. Sites with the potential to cause plumes are mapped in Figure 2-69, which were identified by filtering for sites containing soluble and mobile constituents such as volatile organic compounds (VOCs); benzene, toluene, ethylbenzene, and xylenes (BTEX); and/or petroleum hydrocarbons (gas or diesel).

Sites with the potential to cause plumes are currently managed by existing regulatory programs through the RWQCB, DTSC, and USEPA, as described above. New projects undertaken by the GSAs as part of GSP implementation will evaluate contaminant plume movement in a CEQA document.

Specific point source sites and contaminants are discussed in the sections below.

Figure 2-68: Active Investigation and Remediation Sites

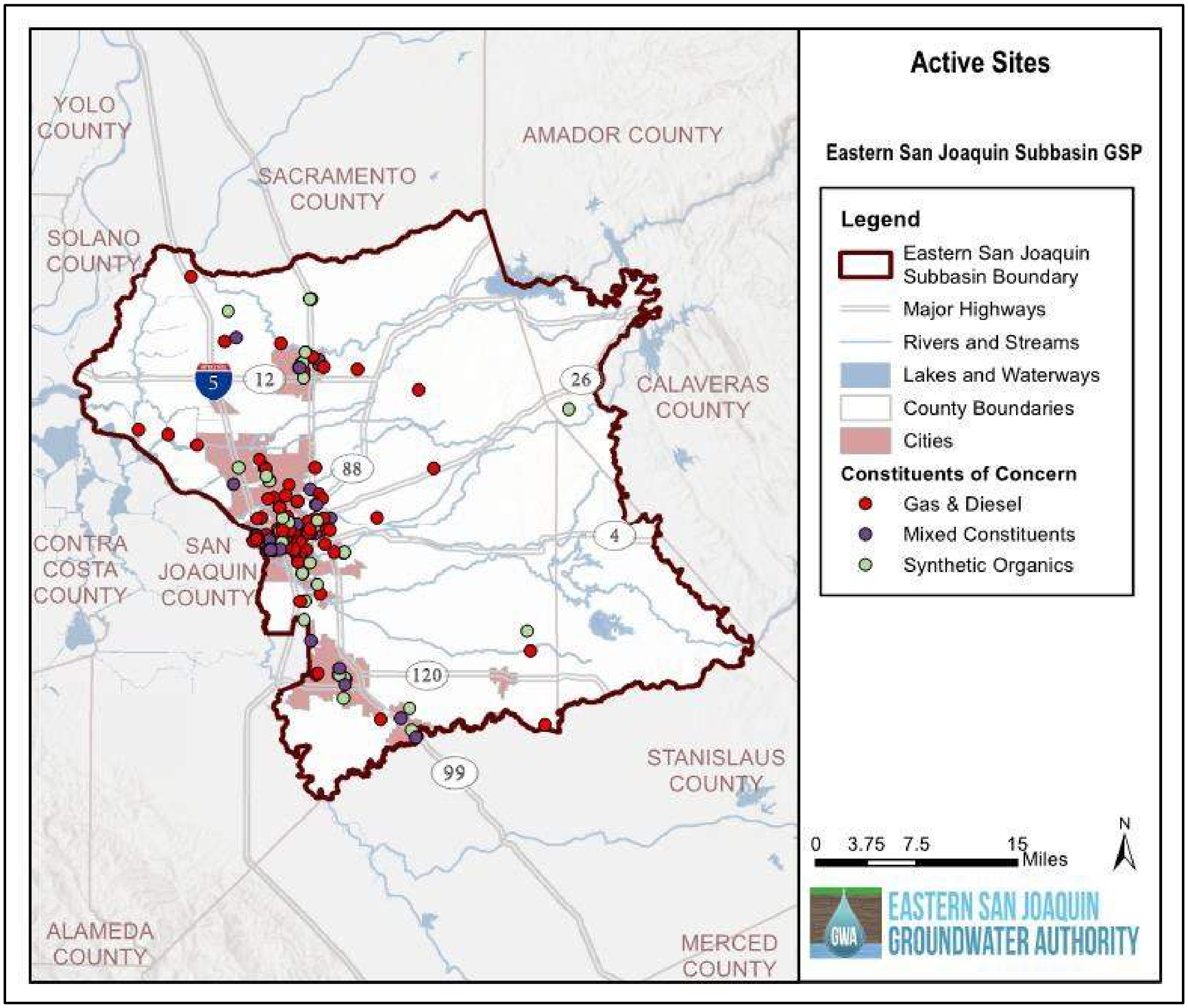
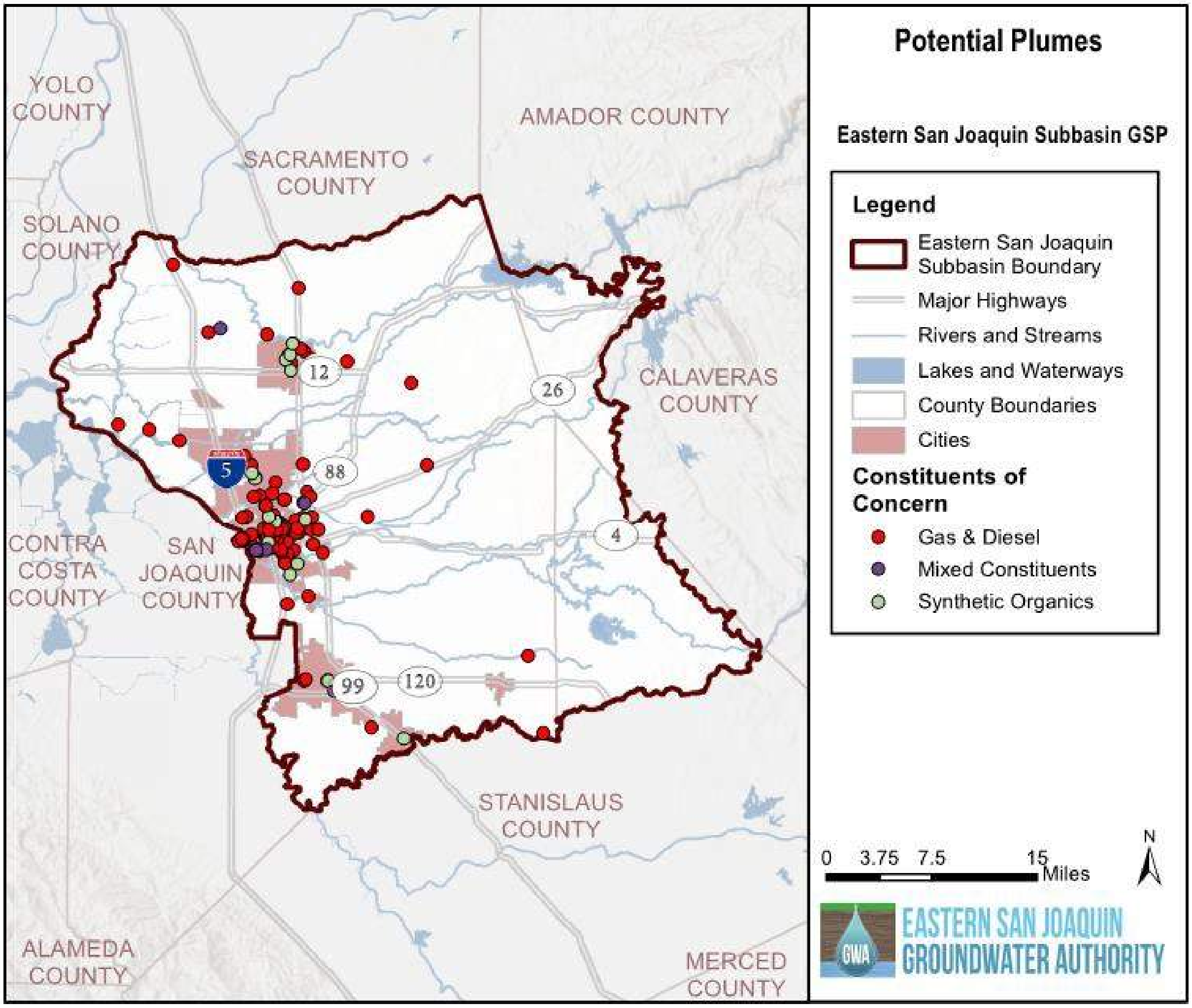


Figure 2-69: Active Sites with the Potential to Cause Plumes



2.2.4.4.1 Publicized Plumes in and near the Subbasin

As indicated above, the Eastern San Joaquin Subbasin has numerous open cleanup sites, including areas contaminated by chlorinated solvents, methyl tertiary-butyl ether (MtBE), pesticides and herbicides, and leaking underground storage tanks. Plume sites are often clustered around urban centers but are also found near sites where historical industrial or agricultural practices have released contaminants of concern. While other plumes exist in and around the Subbasin, three specific plumes have been highly publicized: the Lodi Plumes, the Sharpe Army Depot Plume, and the Occidental Chemical Corporation Plume.

In the late 1980s, the City of Lodi discovered the chlorinated solvents perchloroethylene (PCE) and trichloroethene (TCE) in drinking water supplies and pursued a groundwater investigation that revealed a series of five separate plume areas located in the northeastern portion of the city: the Northern, Western, Central, Southern, and Busy Bee plumes. The Busy Bee plume, named after a dry cleaner business that previously operated on the site, now has regulatory closure, with cleanup moving toward completion under CVRWQCB oversite (Water Resources Control Board, 2011).

Groundwater contamination plumes in the City of Lathrop, located just outside the Subbasin boundary, include the Sharpe Army Depot and Occidental Chemical Corporation sites. Contamination of groundwater at the Sharpe Army

Depot consists primarily of trichloroethene, tetrachloroethene, and cis-1,2-dichloroethene from historical industrial activities related to military activities. Due to concerns of potential contamination, the City of Lathrop abandoned their wells in the area. Three groundwater extraction and treatment systems are located at Sharpe Army Dept and are used to treat existing groundwater (EKI Environment & Water, 2015).

The Occidental Chemical Corporation Plume was discovered in the late 1970s and is the result of former leaking wastewater holding ponds containing pesticides and chemicals used for equipment cleaning by the Occidental Chemical Corporation. Contaminants of concern include the pesticides 1,2-dibromo-3-chloropropane (DBCP) and ethylene dibromide (EDB), lindane, 2,3,4,5-tetrahydrothiopene-1, 1-dioxide, sulfate, nitrate, chloride, and BHC (RWQCB, 2012). Since the discovery of these plumes in the 1980s, groundwater monitoring and evaluation at point source locations has led to the implementation of remedial activities such as the installation of groundwater extraction and remedial systems, implementation of a Salinity Reduction Plan, and mandated waste discharge requirements (WDRs) (RWQCB, 2012).

2.2.4.4.2 Petroleum Hydrocarbons

Approximately 134 sites in the Eastern San Joaquin Subbasin are identified as actively investigating or remediating an unauthorized release of petroleum hydrocarbons, according to the GeoTracker and EnviroStor databases. At these sites, petroleum hydrocarbon constituents are most commonly fuels (diesel, gasoline, motor oil, or aviation fuel) and VOCs commonly added to fuels, including MTBE and BTEX constituents. Concentrations of petroleum hydrocarbons have not been modeled across the Subbasin; concentrations are local and site specific. A summary description of the aforementioned constituents is provided in Table 2-10 below:

Table 2-10: MCLs for Common Petroleum Hydrocarbons and MTBE

Constituent	Source	Primary MCL
MTBE	Oxygenate commonly added to gasoline	13 µg/L
BTEX		
Benzene	Industrial solvent added to crude oil paint, varnish, and lacquer thinner	1 µg/L
Toluene	Aromatic hydrocarbon used in industrial feedstock, as a solvent, and to produce benzene and added to gasoline	150 µg/L
Ethylbenzene	Used as a solvent and added to fuel, asphalt, and naphthalene	300 µg/L
Xylenes	Naturally occurring in petroleum, coal and wood tar	1.750 mg/L

Source: (SWRCB, 2018)

2.2.4.4.3 Synthetic Organics

Approximately 47 sites in the Eastern San Joaquin Subbasin are identified as actively investigating or remediating an unauthorized release of synthetic organics, according to the GeoTracker and EnviroStor databases. At these sites, pesticides, herbicides, fertilizer, and pesticides are the most common constituents. Other constituents include VOCs such as PCE and TCE. Concentrations of synthetic organics have not been modeled across the Subbasin; concentrations are local and site specific. For context, a brief description of the aforementioned VOCs is provided in Table 2-11.

Table 2-11: MCLs for Common Synthetic Organic Constituents

Constituent	Source	Primary MCL[1]
TCE	Used as a solvent in manufacturing facilities and dry cleaners	5 µg/L
PCE	Used as a solvent in manufacturing facilities, dry cleaners, printing shops, and auto repair facilities	5 µg/L

Note:
[1] Source: (SWRCB, 2018)

2.2.4.4.4 Mixed Constituents

Approximately 28 sites in the Eastern San Joaquin Subbasin are identified as actively investigating or remediating an unauthorized release of mixed constituents, according to the GeoTracker and EnviroStor databases. Sites with mixed constituents are those that include a release of more than one type of contaminant, such as a mix of heavy metals, diesel, inorganics, and/or organics. At these sites, the most common constituents include a mixture of heavy metals (chromium, arsenic, and lead), inorganics, and solvents. The sources and primary MCL for many contaminants found in the 'mixed constituents' classification have been discussed throughout Section 2.2.4.

2.2.4.4.5 Emerging Contaminants

Many chemical and microbial constituents that have not historically been considered as contaminants are occasionally, and in some cases with increasing frequency, detected in groundwater. These newly recognized (or emerging) contaminants are commonly derived from municipal, agricultural, industrial wastewater, and domestic wastewater sources and pathways. These newly recognized contaminants are dispersed to the environment from domestic, commercial, and industrial uses of common household products and include caffeine, artificial sweeteners, pharmaceuticals, cleaning products, and other personal care products. Residual waste products of genetically modified organisms are also of potential concern. Several studies, such as by Watanabe et al. in 2010, have recently been published or are underway regarding the potential link between dairies and the occurrence of pharmaceuticals in shallow groundwater in the San Joaquin Valley.

Perfluorooctanesulfonic acid (PFOS) and perfluorooctantoic acid (PFOA) are organic chemicals synthesized for water and lipid resistance, used in a wide variety of consumer products as well as fire-retarding foam and various industrial processes. These chemicals tend to accumulate in groundwater, though typically in a localized area in association with a specific facility, such as a factory or airfield (California Water Boards, 2018). There are currently no MCLs for PFOS or PFOA; however, the USEPA is moving forward with establishing the MCL and is recommending municipalities notify customers at levels at or greater than 70 parts per trillion in water supplies (USEPA, 2019). California's DDW has established notification levels at 6.5 parts per trillion for PFOS and 5.1 parts per trillion for PFOA (SWRCB, 2019).

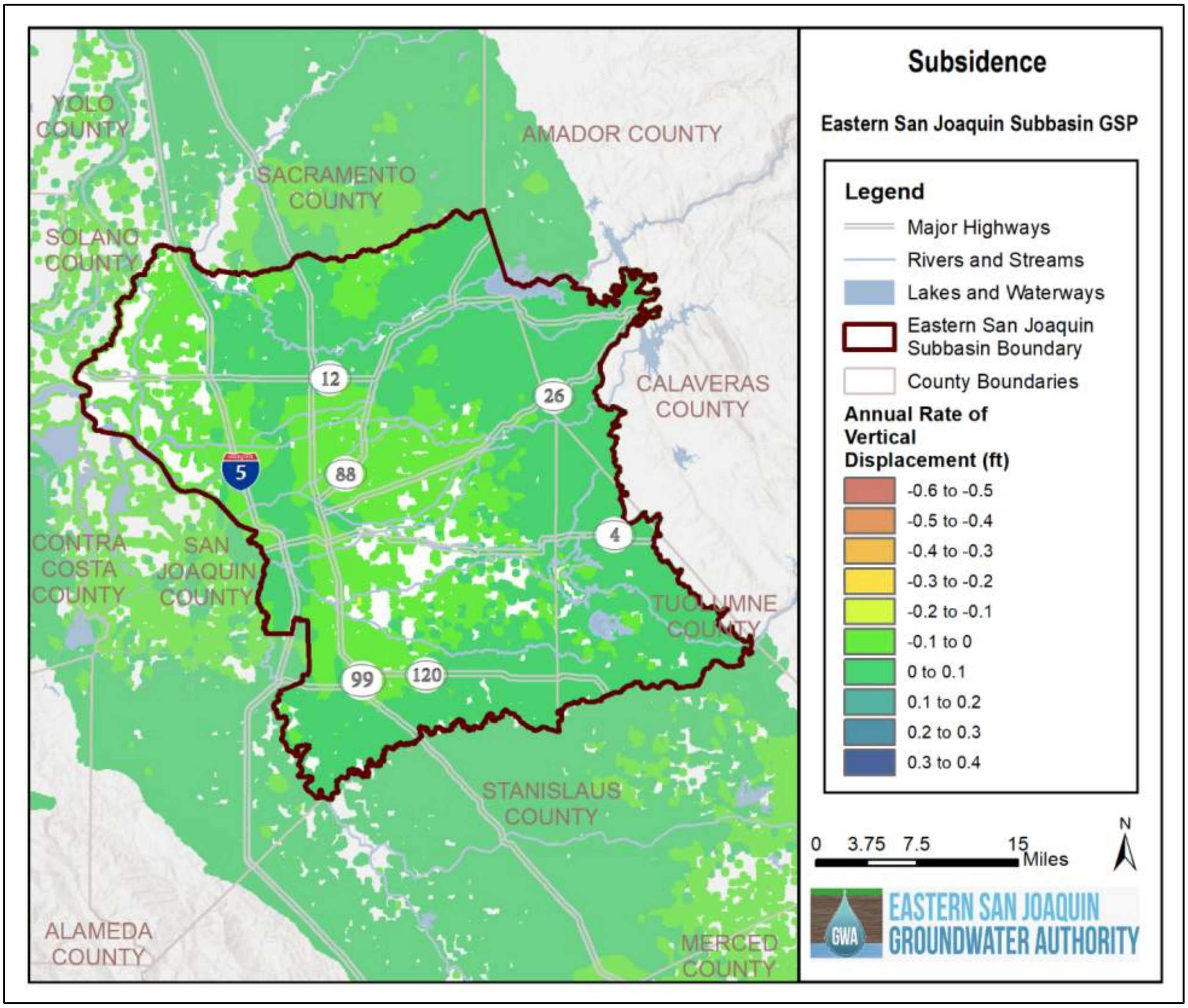
1,2,3-Trichloropropane (1,2,3-TCP) is a solvent is typically found in industrial or hazardous waste sites. Along with an industrial solvent, 1,2,3-TCP is a cleaning and degreasing agent and associated with pesticide products. Though there is currently no federal MCL, the MCL for 1,2,3-TCP in California is 0.005 µg/L (SWRCB, 2019).

Currently, data on PFOS, PFOA, and 1,2,3-TCP are limited in the Eastern San Joaquin Subbasin since these are emerging contaminants.

2.2.5 Land Subsidence

Despite long-term declining groundwater levels, there are no historical records of significant and unreasonable impacts from subsidence in the Eastern San Joaquin Subbasin. Figure 2-70 shows regional subsidence produced from TRE Altamira Interferometric Synthetic Aperture Radar (InSAR) data, provided by DWR for SGMA application. InSAR is a satellite-based method for showing ground-surface displacement over time. This figure illustrates that subsidence has historically been minimal in the Subbasin and surrounding areas (ranging from -0.1 to 0.1 feet of vertical displacement annually). The error range of a single InSAR measurement is +/- 5 millimeters (TRE Altamira, 2019). See Section 2.1.5 for a discussion of the soils and clays within the Subbasin, including the extent of Corcoran Clay.

Figure 2-70: Subsidence (Annual Rate of Vertical Displacement)



Note: This dataset represents measurements of vertical ground surface displacement in between spring 2015 and summer 2017 (TRE Altamira, 2019).

2.2.6 Interconnected Surface Water Systems

Interconnected surface waters are surface water features that are hydraulically connected by a saturated zone to the groundwater system. In these systems, the water table and surface water features intersect at the same elevations and locations. Interconnected surface waters may be either gaining or losing, wherein the surface water feature itself is either gaining water from the aquifer system or losing water to the aquifer system.

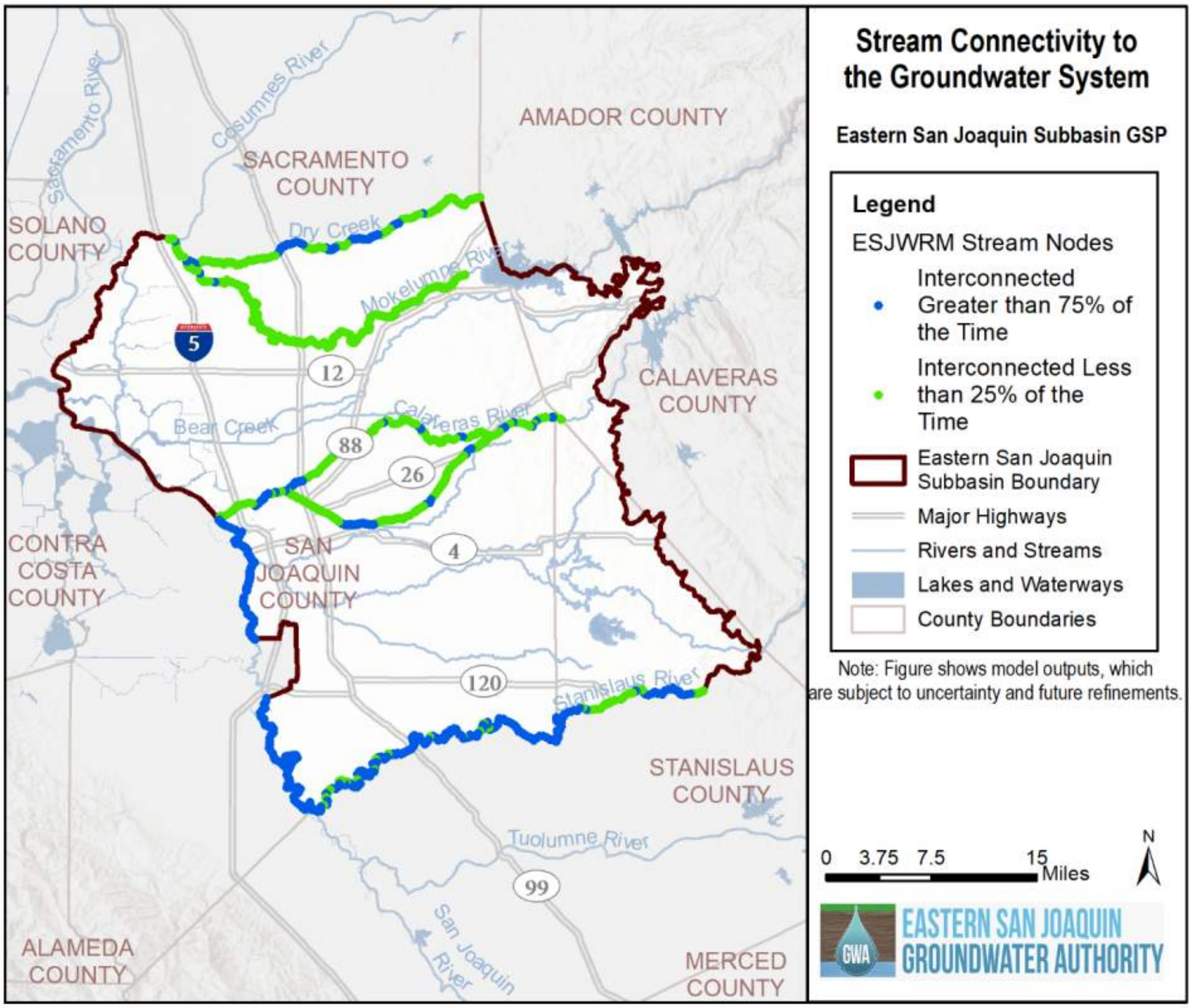
In the Eastern San Joaquin Subbasin, stream connectivity was analyzed by comparing monthly groundwater elevations from the historical calibration of the ESJWRM to streambed elevations along the streams represented in ESJWRM. This analysis was based on modeling results from the historical calibration of the ESJWRM for approximately 900 stream nodes in the Eastern San Joaquin Subbasin, which represents that best available information for current and historical conditions related to interconnected surface water systems. Figure 2-71 shows locations where streams are interconnected at least 75 percent of the time (shown in blue) or interconnected less than 25 percent of the time (shown in green).

Disconnected streams will always be losing streams, but interconnected streams may be either losing or gaining, depending on the surface water and groundwater conditions. Groundwater discharge from the aquifer is primarily through groundwater pumping, however, groundwater also discharges to streams where groundwater elevations are higher than the streambed elevations. Figure 2-72 shows mostly gaining streams in blue where groundwater discharges to rivers more than 75 percent of the time, mostly losing streams in red where streams lose water to the groundwater system more than 75 percent of the time, and mixed streams (gaining or losing less than 75 percent of the time) in orange.

Due to limited model calibration based on insufficient calibration information, stream nodes in the Delta area and along stretches of streams near the foothill boundary of the Subbasin are not shown on Figure 2-71 and Figure 2-72. Interconnected surface water is highlighted as a data gap in Section 4.7.3 due to a lack of data from shallow monitoring wells near streams. Future improvements to the understanding of interconnected surface water include proposed monitoring wells in Section 4.7.5 that are largely located along streams or in areas of the foothills where current monitoring coverage is lacking and a specific project in Section 6.2.7 to improve understanding of losses along Mokelumne River. Section 7.4.1 discusses model refinements over the next five years in order to improve calibration of the model and its use in analysis of GSP water budgets and sustainability criteria.

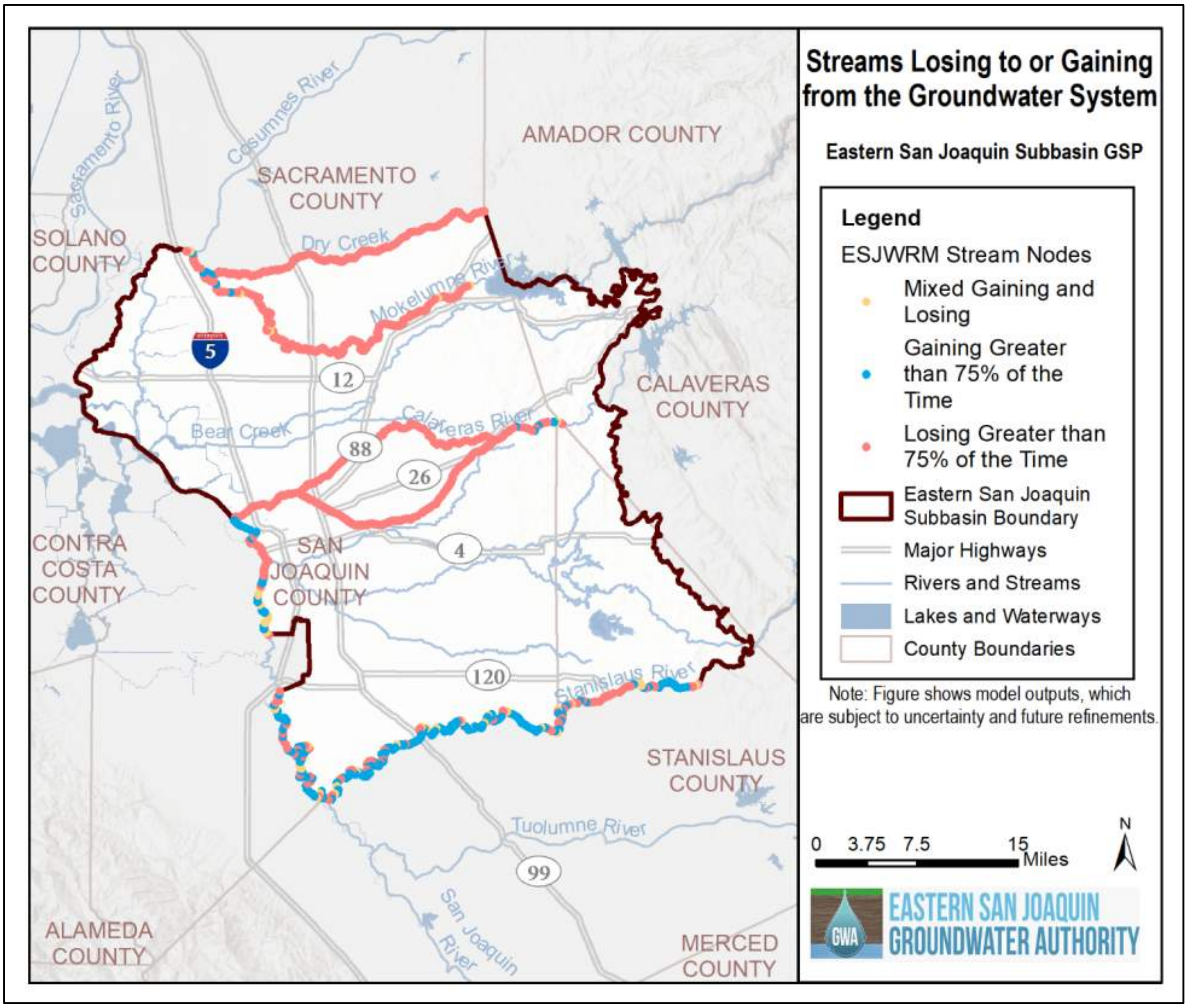
Figure 2-71 and Figure 2-72 are illustrations to describe model outputs, which are subject to uncertainty and future refinements and are not intended for regulatory purposes beyond the use in this Plan.

Figure 2-71: Stream Connectivity to the Groundwater System



Note: Analysis is based on limited data recognized to have significant gaps. Interconnected surface water is a recognized data gap in the GSP as discussed in Section 4.7.

Figure 2-72: Losing and Gaining Streams



Note: Analysis is based on limited data recognized to have significant gaps. Interconnected surface water is a recognized data gap in the GSP as discussed in Section 4.7.

2.2.7 Groundwater-Dependent Ecosystems

Groundwater-dependent ecosystems (GDEs) are defined in the GSP regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." SGMA requires the identification of GDEs. SGMA does not require that additional sustainable management criteria be established to specifically manage these areas, but rather includes GDEs as a beneficial user of water to be considered when developing other sustainable management criteria.

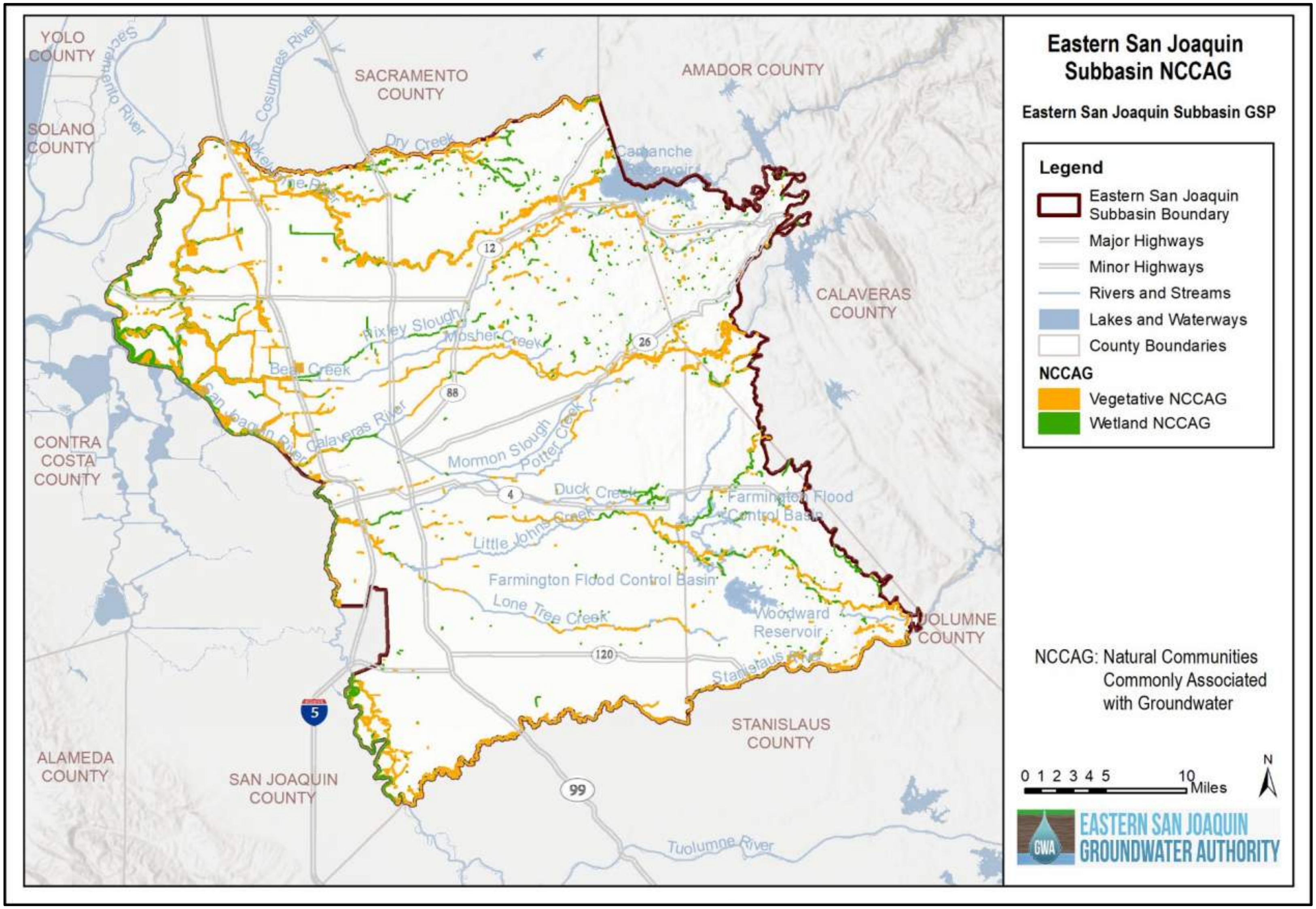
GDEs exist where vegetation accesses shallow groundwater for survival. This Plan identifies GDEs within the Eastern San Joaquin Subbasin based on determining the areas where vegetation is dependent on groundwater.

2.2.7.1 Methodology for GDE Identification

The Natural Communities Commonly Associated with Groundwater (NCCAG) database was used as a starting point to identify GDEs within the Subbasin. The NCCAG database was developed by a working group comprised of DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC). The working group reviewed publicly available datasets which mapped California vegetation, wetlands, springs, and seeps and conducted a screening process to retain communities known to be commonly associated with groundwater. The NCCAG database defines two habitat classes: wetland and vegetative. The wetland class includes wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions. The vegetative class includes vegetation types commonly associated with the shallow subsurface presence of groundwater (phreatophytes). Figure 2-73 shows the location of the two NCCAG classes within the Eastern San Joaquin Subbasin. The distribution of freshwater fish and wildlife species that may be dependent on GDEs is not well known and is not included in this analysis. A list of freshwater species in the Eastern San Joaquin Subbasin is provided in Appendix 1-F. Instream flows for rivers and streams interconnected with groundwater are evaluated through the Depletions of Interconnected Surface Water sustainability indicator (see Section 3.2.6).

EASTERN SAN JOAQUIN GROUNDWATER AUTHORITY

Figure 2-73: Natural Communities Commonly Associated with Groundwater (NCCAGs)



Source: NC Dataset Viewer, CADWR Sustainable Groundwater Management (https://gis.water.ca.gov/app/NCDatasetViewer/)

This Plan uses the NCCAG database as a starting point for identifying GDEs. To identify NCCAG areas that are GDEs, the analysis identified communities in areas where groundwater levels are shallower than 30 feet bgs, as these areas are thought to be reachable by the root zone of vegetation.[1] Oak trees are considered the deepest-rooted plant in the region with a root zone of roughly 25 feet.[2] This value is considered conservative, as this depth is unlikely to support recruitment of new oak seedlings. NCCAG-identified communities in areas with groundwater shallower than 30 feet were considered as potential GDEs. Communities in areas deeper than 30 feet were identified as data gap areas for future refinement and are labeled on Figure 2-74 as “Depth to Water > 30 ft”. These areas will be refined in future analyses to identify potential existing GDEs that may have been misclassified through this screening process. Additional information regarding plans to fill GDE-related data gaps can be found in Section 4.7.4.

The NCCAG database was then further refined to identify communities without access to alternate water supplies, as those communities would not be dependent on groundwater. This was done by screening for the following: 1) areas not close to managed wetlands, 2) areas not adjacent to irrigated agriculture, and 3) areas not near perennial surface water bodies. NCCAG-identified communities with access to shallow water (less than 30 feet bgs) and without access to alternate water supplies were classified as GDEs. Communities with access to alternate water supplies were identified as data gap areas requiring additional investigation to determine the reliability of the alternate supply.

- **<u>Proximity to Managed Wetlands</u> –** Managed wetlands receive supplemental water to support wildlife habitat. Managed wetlands, and areas within 150 feet of a managed wetland, are assumed to be able to access this supplemental delivered water regardless of the condition of the underlying aquifer. Areas farther than 150 feet from a managed wetland that meet the other GDE criteria in this section are assumed to be dependent on groundwater and were identified as GDEs. A criterion of 150 feet was used to reflect ponded conditions at the wetlands. Identified wetlands were reviewed with local water managers to verify supplemental water deliveries.

  NCCAG-identified communities not identified as GDEs through this analysis are identified as data gap areas for future refinement and are labeled on Figure 2-74 as “Managed Wetland”. These areas will be refined in future analyses to determine if the alternate source of surface water is reliable over time and to identify potential existing GDEs that may have been misclassified through this screening process.

- **<u>Adjacent to Irrigated Agriculture</u> –** Irrigated agricultural lands are dependent on regular irrigation. This irrigation benefits not only the crops, but also the surrounding vegetation. Irrigated lands, and areas within 50 feet of irrigated lands, are assumed to be able to access this supplemental delivered water regardless of the condition of the underlying aquifer. Areas farther than 50 feet from irrigated lands that meet the other GDE criteria in this section are assumed to be dependent on groundwater and were identified as GDEs. A criterion of 50 feet was used to reflect non-ponded conditions in the fields.

  NCCAG-identified communities not identified as GDEs through this analysis are identified as data gap areas for future refinement and are labeled on Figure 2-74 as “Adjacent to Agriculture”. These areas will be refined in future analyses to determine if the alternate source of surface water is reliable over time and to identify potential existing GDEs that may have been misclassified through this screening process.

- **<u>Proximity to Perennial Surface Water Bodies</u> –** Perennial surface water bodies provide year-round water supplies that can be accessed by adjacent vegetation. These water bodies include much of the Delta; large, managed rivers; and smaller water bodies that flow throughout the summer due to agricultural deliveries or

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[1] This analysis uses 2015 groundwater levels (winter, spring, summer, and fall), which may be deeper than representative levels due to drought conditions, a factor which will be considered in future GDEs analyses.

[2] *Quercus chrysolepis* (canyon live oak) has a maximum rooting depth of 7.3 meters (23.95 feet) (Canadell et al., 1996). *Quercus lobata* (valley oak) has a maximum rooting depth of 7.41 meters (24.31 feet), although available data are from fractured rock aquifers (Lewis & Burgy 1964 and Schenk, H. J. and Jackson, R. B. 2002, as cited in TNC, 2019).

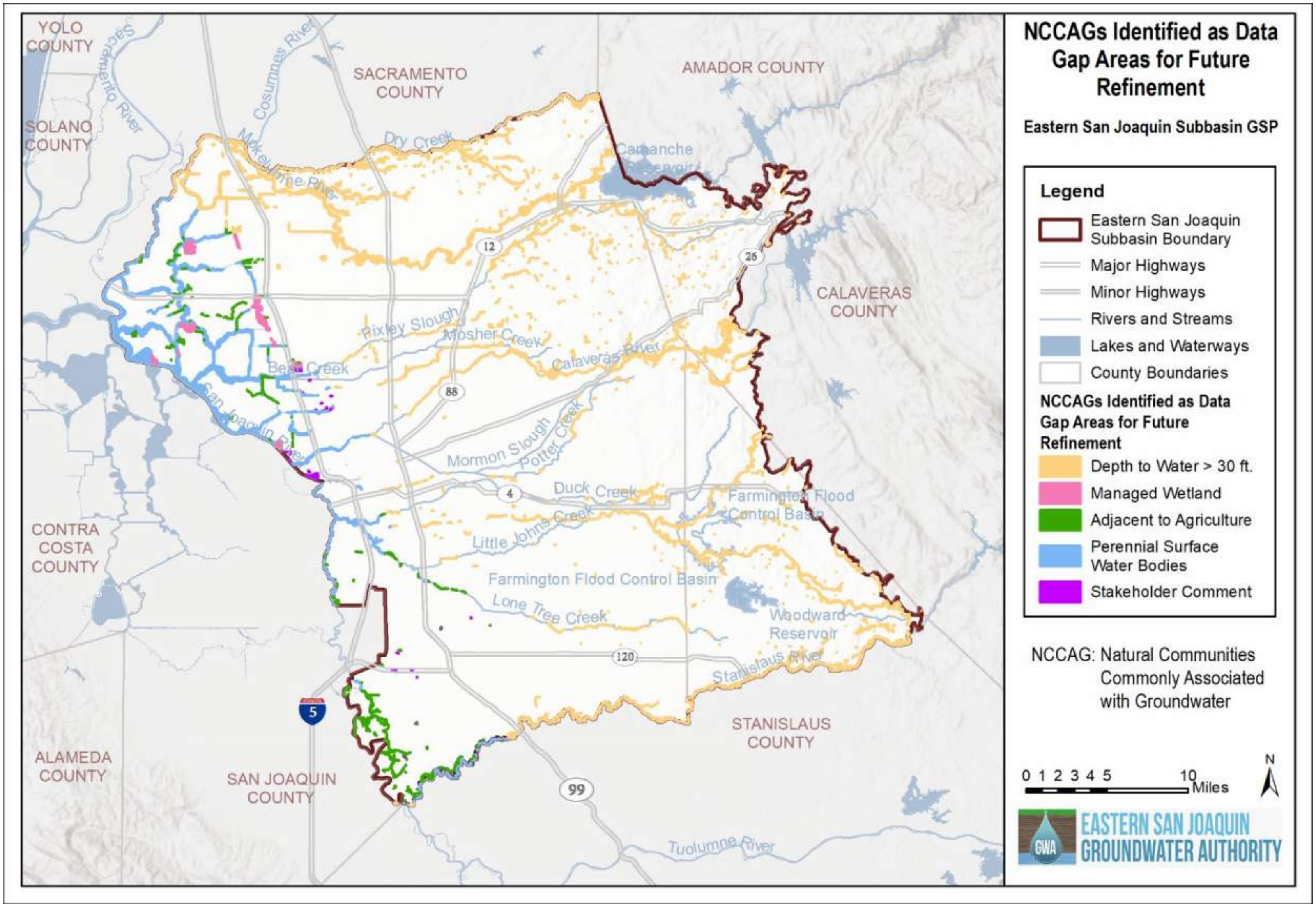
tailwater. Areas within 150 feet of such surface water bodies are assumed to be able to access that surface water regardless of the condition of the underlying aquifer. Areas father than 150 feet from such surface water bodies that meet the other GDE criteria in this section are assumed to be dependent on groundwater and were identified as GDEs. A criterion of 150 feet was used to reflect open water conditions in the surface water bodies.

NCCAG-identified communities not identified as GDEs through this analysis are identified as data gap areas for future refinement and are labeled on Figure 2-74 as “Perennial Surface Water Bodies”. These areas will be refined in future analyses to determine if the alternate source of surface water is reliable over time and to identify potential existing GDEs that may have been misclassified through this screening process.

Next, areas identified as GDEs were ground-truthed with GSA staff and Groundwater Sustainability Workgroup (Workgroup) members. Through this process, areas identified GDEs were investigated, and areas identified as known irrigated parcels such as parks were reclassified. These areas are labels on Figure 2-74 as “Stakeholder Comment.”

This methodology was developed to focus groundwater management activities on the most appropriate areas. The distinction between GDEs and other wetland or vegetative areas is important from a management perspective, as GDEs are expected to be more responsive to changes in groundwater management. Management of communities that access alternate supplies, on the other hand, may require greater focus on land use protection or irrigation activities, for which the GSAs have limited authority to manage through SGMA.

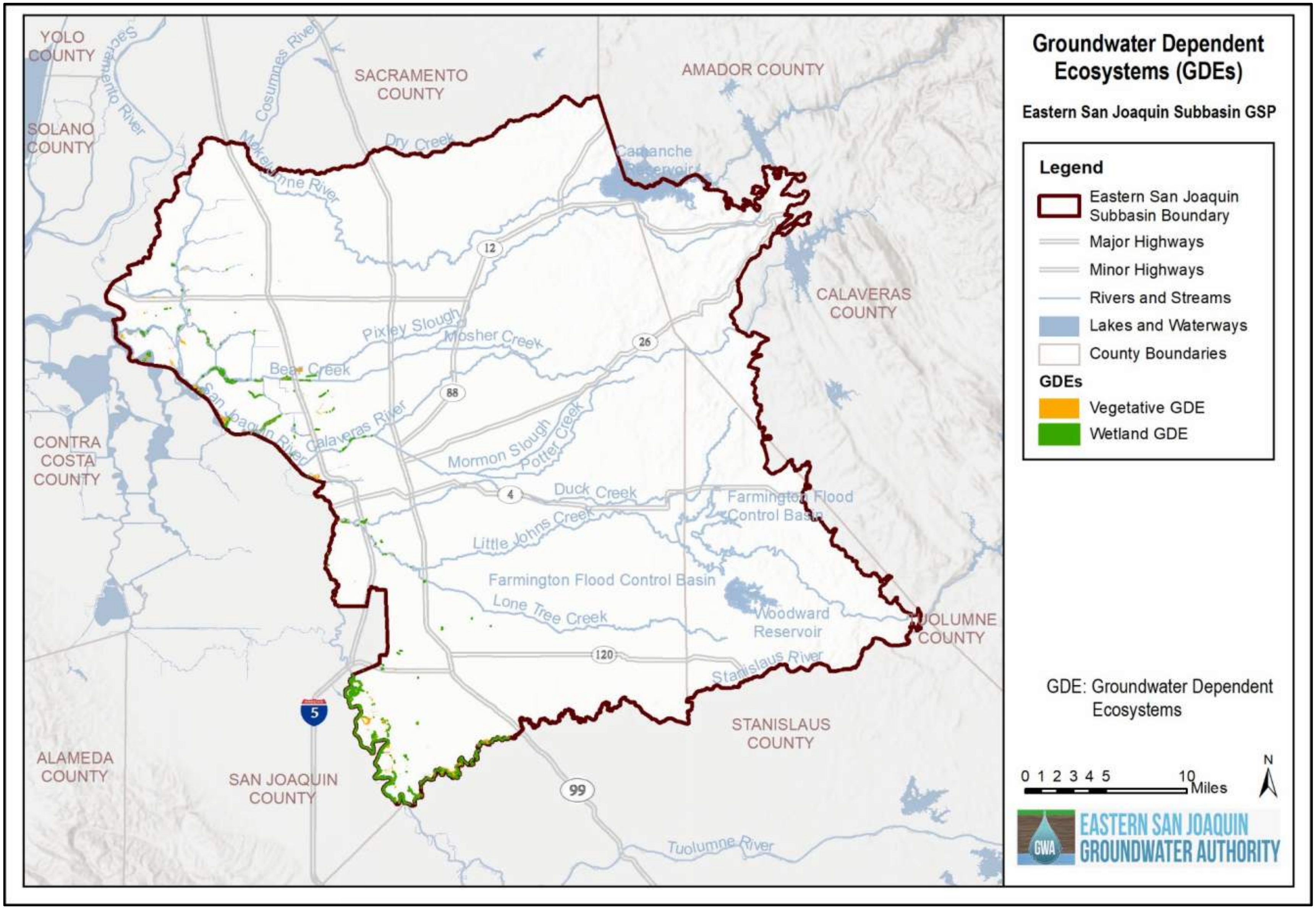
Figure 2-74: NCCAGs Identified as Data Gap Areas for Future Refinement, Likely to Access Non-groundwater Water Supplies



2.2.7.2 Areas Identified as GDEs

Following the methodology presented above, this Plan identifies several GDEs, primarily located along the western boundary of the Subbasin and in the Delta areas where groundwater is typically shallow. These areas are divided into two categories: Vegetative GDEs and Wetland GDEs, as shown in Figure 2-81.

Figure 2-75: Areas Identified as GDEs

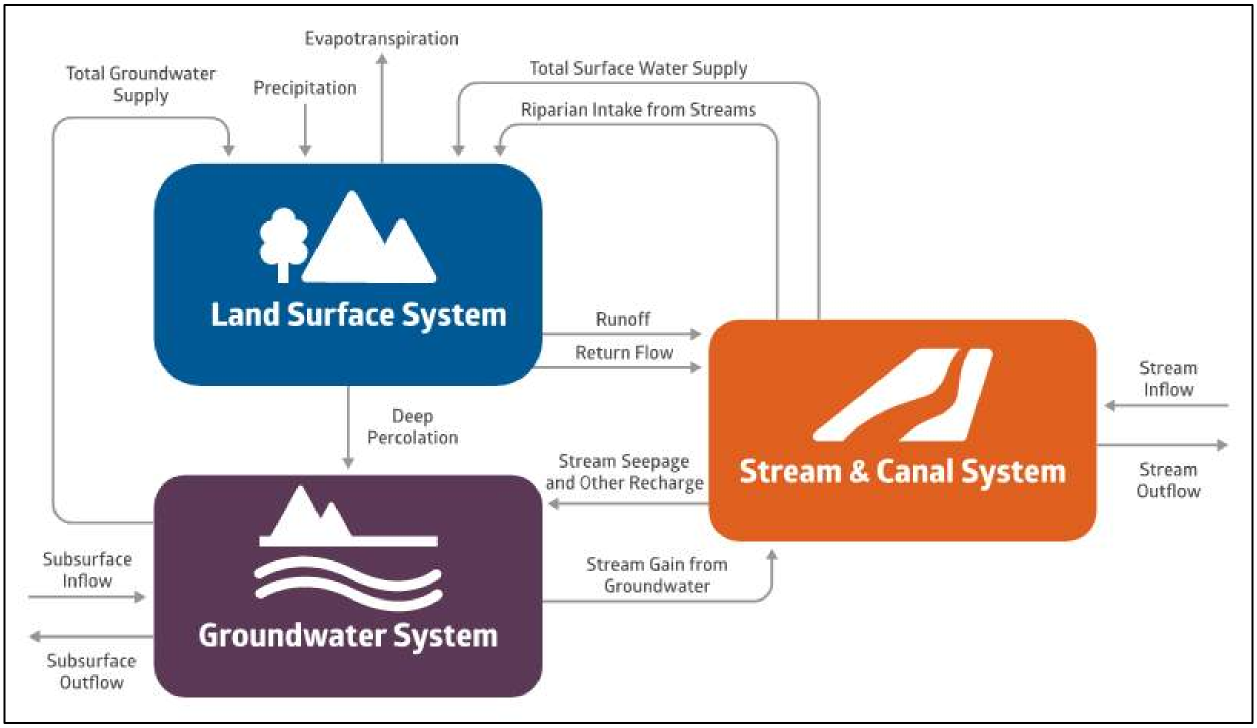


2.3 WATER BUDGETS

2.3.1 Water Budget Background Information

Water budgets are developed to provide a quantitative account of water entering and leaving the Eastern San Joaquin Subbasin. Water entering and leaving the Subbasin includes flows at the surface and in the subsurface environment. Water enters and leaves due to natural conditions, such as precipitation and streamflow, and/or through human activities, such as groundwater pumping or recharge from applied water. Additionally, interconnection between the groundwater system and rivers/streams accounts for other components of the water budget. Figure 2-76 depicts the major components of a water budget and their interconnection as presented in the context of stream, land surface, and groundwater systems.

Figure 2-76: Generalized Water Budget Diagram



Quantities presented for the water budget components of the Eastern San Joaquin Subbasin provide information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate variability, groundwater and surface water interaction, and groundwater flow. This information can assist in the management of the Subbasin by identifying the relationship between different components affecting the water budget in the Subbasin, which provides context in the development and implementation of strategies and policies to achieve Subbasin groundwater sustainability conditions. Water budget quantities presented are based on the simulation results from the ESJWRM.

The ESJWRM was developed to be the main analysis tool supporting the development of the GSP for the Subbasin. The ESJWRM is a quasi-three-dimensional finite element model developed using the Integrated Water Flow Model (IWFM) simulation code (Dogrul et al., 2017). Using data from federal, state, and local resources, the ESJWRM was calibrated for the 20-year hydrologic period of October 1995 to September 2015 (water years 1996 through 2015) by comparing simulated groundwater levels and streamflow records with historical observed records. Development of the model involved the study and analysis of hydrogeologic conditions, agricultural and urban water demands, agricultural and urban water supplies, and an evaluation of regional water quality conditions. ESJWRM development is documented in a report, "Eastern San Joaquin Water Resources Model (ESJWRM) Final Report," published in August 2018 and available in Appendix 2-A.

Consistent with CCR Title 23 § 354.18, the water budgets presented in this document encompass the combined surface and groundwater system of the Eastern San Joaquin Subbasin. The Subbasin water budget focuses on the full water year (12 months spanning October 1 of the previous year to September 30 of the year in question), with some consideration of monthly variability.

The Regulations require that the annual water budget quantify three different conditions: historical, current, and projected. Budgets are developed to capture typical conditions during these time periods. Typical conditions are developed through selecting historical hydrologic periods that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions within the budgets, the Subbasin is analyzed under certain hydrologic conditions, such as drought or very wet events, along with long-term averages. This Plan relies on historical hydrology to identify time periods for water budget analysis and uses the ESJWRM and associated data to develop the water budget and resulting budget estimates. The water budget components developed for the Eastern San Joaquin Subbasin are based upon estimates developed from historical and projected data as well as modeling assumptions. This process is new and has been developed under time constraints; the water budget assumptions will be refined in the future, the water budget may change, and the conclusions and recommendations derived from the water budget may also change.

2.3.2 Identification of Hydrologic Periods

The historical hydrologic periods used in this Plan were selected to meet the requirements of developing historical, current, and projected water budgets. The Regulations require that the projected water budget reflect a 50-year hydrologic period in order to project how the Subbasin's land and groundwater systems may react under long-term average hydrologic conditions. Consistent with the Regulations, the 50-year historical record characterizes future conditions with respect to precipitation, evapotranspiration, and streamflow. Historical precipitation or rainfall in the Eastern San Joaquin Subbasin was used to identify a hydrologic period that would provide a representation of wet and dry periods and long-term average conditions needed for water budget analyses. Rainfall data for the Subbasin are derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset of the DWR's California Simulation of Evapotranspiration of Applied Water (CALSIMETAW) model. Precipitation-Elevation Regressions on Independent Slopes Model (PRISM) is a spatial estimation of rainfall data developed using monitoring network point data and interpolated using a variety of factors (Oregon State University, 2019).

Wet and dry hydrologic periods were identified by evaluating the cumulative departure from mean precipitation. Under this method, the long-term average precipitation is subtracted from annual precipitation within each water year to develop the departure from mean precipitation for each water year. Wet years have a positive departure and dry years have a negative departure; a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, the departures are added cumulatively for each year. So, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (5 plus -2) for Year 2. Figure 2-77 graphically illustrates the cumulative departure of the spatially averaged rainfall within the Eastern San Joaquin Subbasin. The figure includes bars displaying annual precipitation for each water year from 1969 through 2018 and a horizontal line representing the mean precipitation of 15.4 inches. The cumulative departure from mean precipitation is based on these data sets and is displayed as a line that highlights wet periods with upward slopes (positive departure) and dry periods with downward slopes (negative departure). More severe events are shown by steeper slopes and greater changes. For example, the period from 1975 to 1977 illustrates a short period with dramatically dry conditions (6-inch decline per year in cumulative departure).

The PRISM estimates for rainfall in the Subbasin were confirmed by comparing the cumulative departure from mean precipitation results to the water year types in the San Joaquin Valley Water Year Hydrologic Classification (CA DWR, 2018), which classifies water years 1901 through 2018 as wet, above normal, below normal, dry, and critical based on