NORTHERN & CENTRAL DELTA-MENDOTA

Groundwater Sustainability Plan

For the Northern and Central Delta-Mendota Regions

November 2019; Modified July 2020

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

PROP 1
GOVERNOR EDMUND G. BROWN, JR.
WATER BOND 2014
RELIABILITY | RESTORATION | RESILIENCE

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NORTHERN & CENTRAL
DELTA-
MENDOTA

Northern and Central Delta-Mendota Regions

Groundwater Sustainability Plan

REGISTERED PROFESSIONAL ENGINEER
LESLIE S. DUMAS
C 43897
EXP 6/30/21
CIVIL
STATE OF CALIFORNIA

Prepared by:

WOODARD & CURRAN

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ATTN: ~~Seth Harris~~J. Scott Petersen
San Luis & Delta-Mendota Water Authority
842 6th Street
Los Banos, CA 93635
Telephone ~~(209) 324-1033~~(209) 826-9696
Email: ~~sethharris@sldmwa.org~~scott.petersen@sldmwa.org

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Acronyms

AB	Assembly Bill
ACS	U.S. Census Bureau's American Community Survey
AF	Acre-foot
AFY	Acre-feet per year
AWMP	Agriculture Water Management Plan
AWS	Amazon Web Services
BMP	Best Management Practice
CASGEM	California Statewide Groundwater Elevation Monitoring
CC	Climate Change
CCF	Climate Change Factors
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDP	Census Designated Place
CEQA	California Environmental Quality Act
cfs	Cubic feet per second
CGPS	Continuous Global Positioning System
CIMIS	California Irrigation Management Information System
COC	Chain of custody
CVP	Central Valley Project
CV-RWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWC	California Water Code
CWSRF	Clean Water State Revolving Fund
DAC	Disadvantaged Community
DACIP	Disadvantaged Community Involvement Program
DDW	Division of Drinking Water, California State Water Resources Control Board
DHS	California Department of Heath Services
DMC	Delta-Mendota Canal
DMS	Data Management System
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
EC	Electrical conductivity
EDA	Economically Distressed Area
EIR	Environmental Impact Report
EPA	United States Environmental Protection Agency
ET	Evapotranspiration
ET_0	Reference Evapotranspiration

Acronyms

FAQ	Frequently Asked Question
GAMA	Groundwater Ambient Monitoring and Assessment
GAR	Groundwater Quality Assessment Report
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GPS	Global Positioning System
GQTM	Groundwater Quality Trend Monitoring
GSA	Groundwater Sustainability Agency
GSE	Ground Surface Elevation
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
ID	Identification
ILRP	Irrigated Lands Regulatory Program
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
ITRC	Cal Poly Irrigation Training & Research Center
JPA	Joint Powers Authority
LSCE	Luhdorff & Scalmanini Consulting Engineers
MA	Management Area
MAF	Million acre-feet
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
MHI	Median Household Income
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
msl	Mean Sea Level
NASA JPL	National Aeronautics and Space Administration Jet Propulsions Laboratory
NASA UAVSAR	National Aeronautics and Space Administration Uninhabited Aerial Vehicle Synthetic Aperture Radar
NCCAG	Natural Communities Commonly Associated with Groundwater
NEPA	National Environmental Protection Act
NRCS	National Resource Conservation Service
NVRRWP	North Valley Regional Recycled Water Program
NWIS	USGS National Water Information System
P&MAs	Projects & Management Actions
PID	Patterson Irrigation District
PIP	Delta-Mendota Canal Groundwater Pump-in Program
PLSS	Public Land Survey System

Acronyms

QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Program Plan
RP	Reference point
RWMG	Regional Water Management Group
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCADA	Supervisory control data acquisition
SDAC	Severely Disadvantaged Community
SGMA	Sustainable Groundwater Management Act
SHE	Self-Help Enterprise
SJREC	San Joaquin River Exchange Contractors
SJRECWA	San Joaquin River Exchange Contractors Water Authority
SJRIP	San Joaquin River Improvement Program
SJRRP	San Joaquin River Restoration Program
SLDMWA	San Luis & Delta-Mendota Water Authority
SMC	Sustainable Management Criteria
SMCL	Secondary Maximum Contaminant Level
SNCWD	Santa Nella County Water District
SNMP	Salt and Nutrient Management Plan
SSURGO	Soil Survey Geographic Database
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TBD	To be determined
TDS	Total Dissolved Solids
TFCF	Tracy Fish Collection Facility
TNC	The Nature Conservancy
TRID	Tranquillity Irrigation District
TSS	Technical Support Services
UNAVCO	University NAVSTAR Consortium
USBR	U.S. Bureau of Reclamation
USDA	United States Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
WDL	Water Data Library
WIIN	Water Infrastructure Improvements for the Nation

Acronyms

WQO	Water Quality Objective
WRFP	Water Recycling Funding Program
WSID	West Stanislaus Irrigation District
WSIP	Water Storage Investment Program
WWD	Westlands Water District
WY	Water Year

Executive Summary

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EXECUTIVE SUMMARY

ES-1. Introduction

In 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) in response to continued overdraft of California's groundwater resources. The Delta-Mendota Subbasin (Subbasin) is one of 21 alluvial basins and subbasins identified by the California Department of Water Resources (DWR) as being in a state of critical overdraft. SGMA requires the preparation of a Groundwater Sustainability Plan (GSP) to address measures necessary to attain sustainable conditions in the Subbasin by 2040. Within the framework of SGMA, sustainability is generally defined as the long-term reliability of groundwater supply to meet the needs of uses and users of groundwater in the Subbasin with the absence of undesirable results.

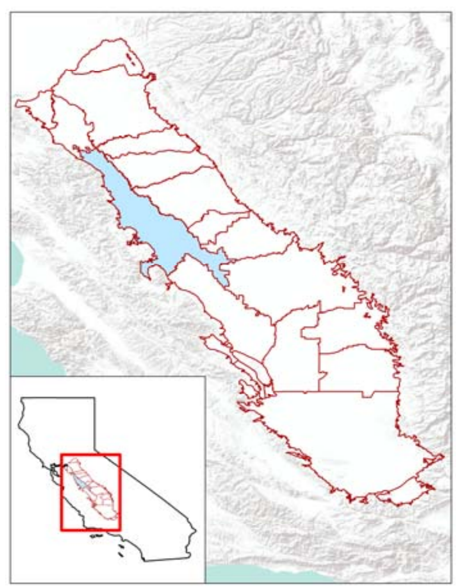
Critical Dates for the Delta-Mendota Subbasin

- 2020 By January 31: Submit GSPs to DWR
- 2025 Review and update GSPs
- 2030 Review and update GSPs
- 2035 Review and update GSPs
- 2040 Achieve sustainability for the Subbasin

Within the Delta-Mendota Subbasin, six (6) GSPs have been developed in a coordinated fashion with the goal of achieving sustainability for the Subbasin as a whole. The GSP Groups preparing the coordinated GSPs include: the Aliso Water District GSP Group, Farmers Water District GSP Group, Fresno County GSP Group, Grassland GSP Group, Northern & Central Delta-Mendota Region GSP Group, and San Joaquin River Exchange Contractors GSP Group. This GSP has been developed for the Northern and Central Delta-Mendota Regions, which are comprised of the following eight Groundwater Sustainability Agencies (GSAs): Central Delta-Mendota, City of Patterson, DM-II, Northwestern Delta-Mendota, Oro Loma Water District, Patterson Irrigation District, West Stanislaus Irrigation District, and Widren Water District. The Northern & Central Delta-Mendota Region GSP has been developed by these GSAs to meet SGMA regulatory requirements while reflecting local needs and preserving local control over water resources. This GSP provides a path to achieve and document sustainable groundwater management within 20 years following adoption, promoting the long-term sustainability of locally-managed groundwater resources now and into the future.

SGMA requires development of a GSP that achieves groundwater sustainability in the Plan area and Subbasin as a whole by 2040. This GSP outlines the need to address overdraft and related conditions and has identified projects and management actions for implementation to offset increasing reliance on groundwater and to meet current and future groundwater demands in a sustainable fashion. While no regulatory actions are anticipated to occur during the first five years of GSP implementation, additional efforts will be taken during this period to fill data gaps, to confirm benefits provided by projects and management actions implemented in the first five years, and to assess the need to modify the projects or management actions, or identify additional projects and management actions required, to achieve sustainability.

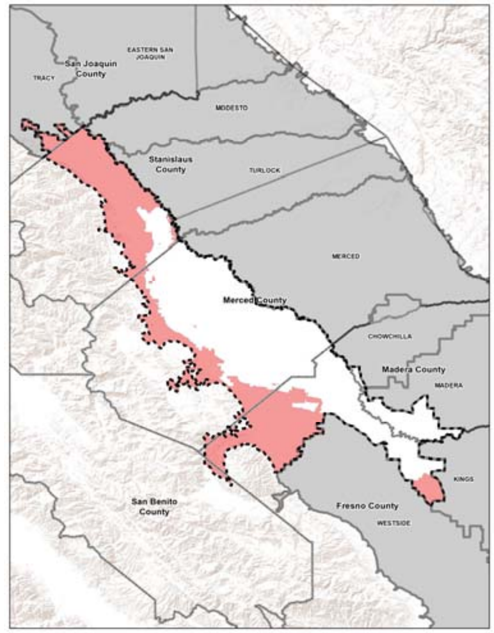
Figure ES-1. Delta-Mendota Subbasin within the San Joaquin Valley



As previously stated, the Northern & Central Delta-Mendota Region GSP is one of six GSPs developed for implementation in the Delta-Mendota Subbasin under SGMA. Coordinated efforts required under SGMA regulations in basins and subbasins developing more than one GSP are documented in the *Delta-Mendota Subbasin Groundwater Sustainability Plan Common Chapter*, which is included as a supplemental document to this GSP (Appendix B).

ES-2. Plan Area

Figure ES-2. Plan Area within the Delta-Mendota Subbasin



The Delta-Mendota Subbasin is defined by DWR's 2003 Bulletin 118 and subsequently updated in 2016 and 2018. The Delta-Mendota Subbasin is one of 19 subbasins that comprise the San Joaquin Valley Groundwater Basin and neighbors the following subbasins: Tracy, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, Madera, Kings and Westside (Figure ES-1). The Northern & Central Delta-Mendota Region GSP generally encompasses the area along the western boundary of the Delta-Mendota Subbasin and lies within five counties: San Joaquin, Stanislaus, Merced, Fresno, and San Benito (Figure ES-2).

Agriculture is the primary land use type within the Northern and Central Delta-Mendota Regions, with the City of Patterson and several communities (including Grayson, Westley, Crows Landing, Santa Nella, and Volta) comprising the urban sector of the Plan area. The predominant land use planning entities in the Plan area include the overlying counties, the City of Patterson, the City of Modesto (serving Community of Grayson), and the larger communities of Santa Nella, Crows Landing, and Westley. Changes to land use have the potential to change water demands or impact sustainable groundwater management in the Plan area.

The Delta-Mendota Canal (DMC) and California Aqueduct extend nearly the entire length of the Plan area and provide water from the Central Valley Project and State Water Project, respectively, to water districts, irrigation districts, and private land owners south of the Sacramento-San Joaquin Delta and throughout the Delta-Mendota Subbasin. The San Joaquin River is the primary feature defining the eastern boundary of the Delta-Mendota Subbasin and serves as a water supply source for Patterson Irrigation District, West Stanislaus Irrigation District, and private landowners in the Northern and Central Delta-Mendota Regions. The Kings River, located south of the Subbasin, serves as a water supply for entities in the southern portion of the Subbasin. Groundwater is used as a supplemental water supply source by water purveyors throughout the Delta-Mendota Subbasin, with several entities reliant in whole or in part on groundwater as their primary water supply. Existing water resources monitoring and management plans are currently in place throughout the Delta-Mendota Subbasin and include the California Statewide Groundwater Elevation Monitoring (CASGEM) program and Irrigated Lands Regulatory Program (ILRP), in addition to county well standards and permitting. These existing programs can help inform SGMA activities by coordinating with monitoring and management entities on overlapping activities and goals.

ES-3. Governance and Administration

As previously noted, the Northern & Central Delta-Mendota Region GSP was developed in a coordinated fashion by the eight GSAs comprising the Regions. All eight of these GSAs each have their own organization and management structure as well as legal authority under which they operate in order to enforce SGMA and the contents of this GSP. The Northern Delta-Mendota Region and Central Delta-Mendota Region coordinate with the San Luis & Delta-Mendota Water Authority (SLDMWA) as Plan Manager to prepare and implement a single GSP for their portion of the Delta-Mendota Subbasin.

The Northern Delta-Mendota Region is comprised of the following GSAs: DM-II, Patterson Irrigation District, West Stanislaus Irrigation District, City of Patterson, and Northwestern Delta-Mendota. The Central Delta-Mendota Region is comprised of the following GSAs: Central Delta-Mendota, San Benito County (under a Memorandum of Understanding with the Central Delta-Mendota GSA), Oro Loma Water District, and Widren Water District. The Northern Delta-Mendota Management Committee and Central Delta-Mendota Management Committee coordinate on all aspects of GSP development and implementation through joint management committee meetings. At the Subbasin-level, representatives from the Northern & Central Delta-Mendota Region GSP Group participate as members on the Delta-Mendota Subbasin Coordination Committee during regular meetings, where all SGMA-required coordination efforts regarding GSP development and implementation occurs.

ES-4. Outreach and Communication

Figure ES 3. Public Workshop Events

A stakeholder engagement strategy was developed to solicit and discuss the interests of all beneficial users of groundwater in the Plan area and Subbasin. The strategy incorporated monthly meetings of the Northern and Central Delta-Mendota Management Committees and the Northern and Central Delta-Mendota Technical Advisory Committee; monthly meetings of the Delta-Mendota Subbasin Coordination Committee, Subbasin Technical Working Group, and Subbasin Communications Working Group; bi-annual public workshops (including outreach presentations on GSP development progress to solicit feedback); a monthly newsletter distributed to targeted stakeholders; a website where all meeting and public workshop materials, as well as supplemental resources, are posted; and information distributed to property owners and residents in the Subbasin. Figure ES-3 shows attendees at one of the public workshop events conducted during development of the GSP.

The Northern and Central Delta-Mendota Management Committees, as well as the Delta-Mendota Subbasin Coordination Committee, were established to encourage active involvement from diverse social, cultural, and economic elements of the population of the Plan area and Subbasin, in addition to meeting SGMA requirements for intrabasin coordination. Members of these committees include representatives from water and irrigation districts, representing large and small landowners and growers, and municipal water providers. Environmental interest groups, state agencies, and disadvantage community representatives were also consulted during regular meetings, special meetings, and workshops early on in the GSP development process to consider the interest of all users of groundwater in the Plan area and Subbasin as a whole. Participating stakeholders were invited to provide comments during these meetings (subject to the Brown Act) as well as provide comments and feedback during public workshops hosted throughout the Subbasin during GSP development. Spanish translation was provided at the public workshops and associated materials were provided in Spanish and English, along with other SGMA-related informational materials, at the meetings and on the Subbasin website (http://deltamendota.org/), creating an opportunity for local Spanish-speaking individuals to engage in the GSP development process.

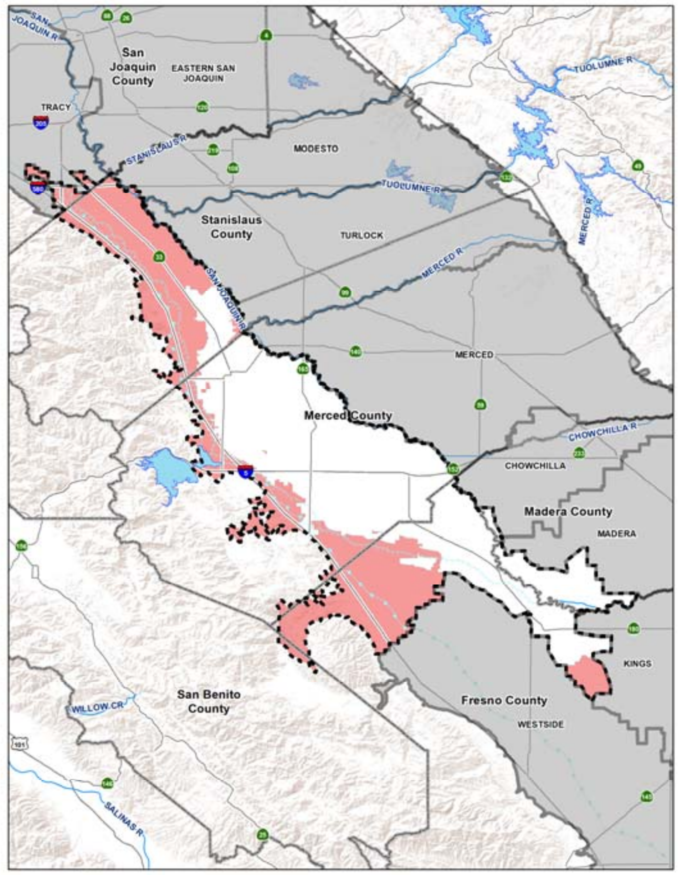
ES-5. Basin Setting

The Northern & Central Delta-Mendota Region GSP contains the required sections for establishing the Basin Setting. These sections contain descriptions of the Regions' physical setting, characteristics, and current conditions, and include the Hydrogeologic Conceptual Model, Groundwater Conditions, Water Budgets, and Management Areas sections. Combined, these sections serve as a basis for defining and assessing reasonable sustainable management criteria and projects and management actions.

Hydrogeologic Conceptual Model

The Delta-Mendota Subbasin is located in the northwestern portion of the San Joaquin Valley Groundwater Basin within the southern portion of the Central Valley. The Subbasin is bounded on the west by the Tertiary and older marine sediments of the Coast Range, on the north generally by the San Joaquin-Stanislaus County line, on the east generally by the San Joaquin River and Fresno Slough, and on the south by the Tranquillity Irrigation District boundary near the community of San Joaquin. Surface waters culminate from the Fresno, Merced, Tuolumne, and Stanislaus rivers into the San Joaquin River, which drains toward the Sacramento-San Joaquin Delta. The location of the Subbasin and Plan area are shown in Figure ES-4.

Figure ES-4. Basin Setting



A two-aquifer system is created by the Corcoran Clay layer and is generally pervasive throughout the Subbasin, creating a semi-confined aquifer above the Corcoran Clay layer (Upper Aquifer) and confined aquifer below the Corcoran Clay (Lower Aquifer). The Corcoran Clay layer largely inhibits vertical flow between aquifers, except in areas where the Corcoran Clay layer is thin or wells perforated in both principal aquifers provides a conduit for vertical flow.

Prevailing horizontal groundwater flow within the Upper Aquifer and Lower Aquifer systems is predominantly in the general northeasterly direction from the Coast Range towards and parallel to the San Joaquin River. While local pumping depressions are present, the prevailing northeasterly flow direction for groundwater in the Subbasin has remained.

Groundwater Conditions

Groundwater levels in some portions of the Northern and Central Delta-Mendota Regions have been declining for many years, while groundwater levels in other areas of the Subbasin have remained stable or increased in recent years. Groundwater levels have varied over time within the Delta-Mendota Subbasin where historically, groundwater levels decreased with increased groundwater pumping and the expansion of irrigated agriculture. As large-scale water projects, such as the Central Valley Project and State Water Project, began making imported surface water deliveries south of the Sacramento-San Joaquin Delta, groundwater levels increased as imported water was conjunctively used with groundwater and diverted San Joaquin River waters. During prolonged periods of drought, groundwater levels are observed to decline as groundwater extractions increase to offset loss of imported surface water, with groundwater levels rebounding following increased surface water deliveries during wet conditions.

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 Plan area, particularly in the Lower Aquifer (below the Corcoran Clay layer) as there are large volumes of fresh water in storage. Despite periods of wet conditions, with recharge outpacing extractions, an overall declining trend in groundwater storage can be observed in both the Upper Aquifer and Lower Aquifer, with storage typically declining more rapidly in the Upper Aquifer than the Lower Aquifer.

Groundwater quality in the Plan area varies by location. Concerns related to groundwater quality are largely related to non-point sources and/or naturally occurring constituents. Seawater intrusion is not applicable to the Delta-Mendota Subbasin as the Subbasin is located inland from the Pacific Ocean. Primary constituents of concern throughout the Plan area are total dissolved solids (TDS), nitrate as Nitrogen (nitrate as N), and boron, which all have anthropogenic as well as natural sources. In recent years, TDS concentrations in the Upper Aquifer are generally stable near or below the Secondary Maximum Contaminant Level (MCL) of 1,000 milligrams per liter (mg/L). In the Lower Aquifer, TDS concentrations are largely stable though have been found to exceed the Secondary MCL in some locations. Nitrate concentrations are largely below the Primary MCL of 10 mg/L, with elevated concentrations above the Primary MCL found south of Los Banos and northwest toward Patterson in the Upper Aquifer, and at elevated concentrations below the Primary MCL in the Lower Aquifer in locations where the Corcoran Clay is thin or non-existent. While boron does not have a drinking water standard, many crops are sensitive to high boron concentrations. Boron concentrations are greater than the agricultural goal within the Grassland Drainage Area (at about 2 mg/L), where near the City of Patterson, boron concentrations are generally stable and below agricultural objectives at 0.4 mg/L.

Inelastic land subsidence is a prevalent issue throughout the Delta-Mendota Subbasin as it has impacted prominent infrastructure of statewide importance as well as local canals, causing serious operational, maintenance, and construction design issues. Land subsidence monitoring in the Delta-Mendota Subbasin as a result of the most recent drought demonstrated significant inelastic land subsidence as a result of increased groundwater pumping, with effects continuing to the present time (as evidenced by recent surveys). While the impacts appear to have slowed, the temporal and spatial impacts of continued land subsidence have not yet been evaluated.

Interconnected surface waters are surface water features that are hydraulically connected by a saturated zone to the groundwater system. If the water table adjacent to a river or stream declines as a result of groundwater pumping, the river or stream may “lose” water to the underlying aquifer. Within the Northern & Central Delta-Mendota Region GSP Plan area, the portion of the San Joaquin River adjacent to the Northern Delta-Mendota Region is identified as a gaining stream and will be managed under the GSP to protect against significant and unreasonable stream depletion.

Water Budgets

Groundwater evaluations conducted as part of GSP development have provided estimates of historic, current, and future groundwater budget conditions. Based on these analyses, at projected groundwater pumping levels, overall change in groundwater storage within the Upper Aquifer and Lower Aquifer is estimated to decline at a rate of 43,000 acre-feet per year (AFY) and 7,000 AFY, respectively, indicating long-term decline in groundwater storage. As such, it is anticipated that future groundwater conditions in the Plan area will continue to show decreased groundwater levels and/or storage as projected pumping and land use continue. Projects and management actions that offset projected groundwater pumping and/or increase recharge will help the Plan area reach sustainability.

The projected water budget was evaluated under climate change conditions (e.g., climate change factors were applied), as well as climate change conditions with the addition of future projects and management actions. Under the immediate climate scenario prescribed by DWR, the estimated change in groundwater storage would continue to decline by 42,000 AFY in the Upper Aquifer and 6,000 AFY in the Lower Aquifer. With the addition of projects and management actions, the negative trend in change in groundwater storage is reversed where it is estimated to decline by 4,000 AFY in the Upper Aquifer and increase by 3,000 AFY in the Lower Aquifer. These values are considered to be within a reasonable level of error given the quality of data available for the analyses.

Water Budget Scenario	Upper Aquifer Average Annual Change in Storage (AFY)	Lower Aquifer Average Annual Change in Storage (AFY)
Historic (2003-2012)	-42,000	-8,000
Current (2013)	-73,000	-15,000
Baseline Projected (2014-2070)	-43,000	-7,000
Projected with Climate Change (2014-2070)	-42,000	-6,000
Projected with Climate Change and Projects & Management Actions (2014-2070)	-4,000	+3,000

The water budget analyses were prepared using the best available information in the development of the Northern & Central Delta-Mendota Region GSP spreadsheet model. It is anticipated that, as additional information becomes available, the model can be updated and more refined estimates of the Regions' water budgets can be developed.

Management Areas

Under SGMA, management areas (or MAs) can be identified within a basin or subbasin for which the GSP may identify different numeric sustainable management criteria, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors. MAs have been established in the Northern & Central Delta-Mendota Region GSP for the purposes of monitoring and managing for the land subsidence sustainability indicator.

Land subsidence within the Plan area has the potential to impact water conveyance infrastructure of state-wide and local importance, where such impacts have the potential to cause undesirable results within the Plan area, Subbasin, and outside the Subbasin. MAs have been delineated jointly for the West Stanislaus Irrigation District and Patterson Irrigation District (WSID-PID MA) and for the Tranquillity Irrigation District (TRID MA) service areas to account for their respective unique, localized circumstances and conditions and to help facilitate implementation of the GSP to aid in achieving the sustainability goal for the Subbasin by 2040.

ES-6. Sustainable Management Criteria

SGMA introduces several terms to measure sustainability including:

Sustainability Indicators – Sustainability indicators refer to adverse 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
- Reduction of groundwater storage
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Depletions of interconnected surface water

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

Minimum Thresholds – Minimum thresholds are a numeric value for each sustainability indicator and are used to define when undesirable results occur.

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 monitoring sites.

> Categories of Undesirable Results
>
> - 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

Representative monitoring sites were identified throughout the Northern and Central Delta-Mendota Regions to provide a basis for measuring groundwater conditions throughout the Plan area. Representative monitoring sites were selected based on their potential to effectively represent the groundwater conditions using criteria specific to each sustainability indicator at each location.

A total of 35 representative wells (17 in the Upper Aquifer and 18 in the Lower Aquifer) have been identified for measurement of groundwater levels, change in groundwater storage, and groundwater quality, with two (2) representative wells selected for measurement of depletions of interconnected surface water. A total of 31 representative sites were selected for the measurement of land subsidence. This GSP uses groundwater levels as a basis for evaluating change in groundwater storage as well as depletions of interconnected surface water.

Minimum thresholds and measurable objectives were developed for each of the representative monitoring sites for each sustainability indicator. Figure ES-5 shows a typical relationship of the minimum thresholds, measurable objectives, and other data for a sample groundwater level well. Minimum thresholds for groundwater levels were developed with reference to the hydrologic low for the available hydrograph record, where a 95 percent of the hydrologic low was established for Lower Aquifer wells to avoid undesirable results related to the land subsidence sustainability indicator. Measurable objectives were established based on the historic seasonal high average over the available hydrograph, Spring 2012, or Spring 2017, whichever value is lowest.

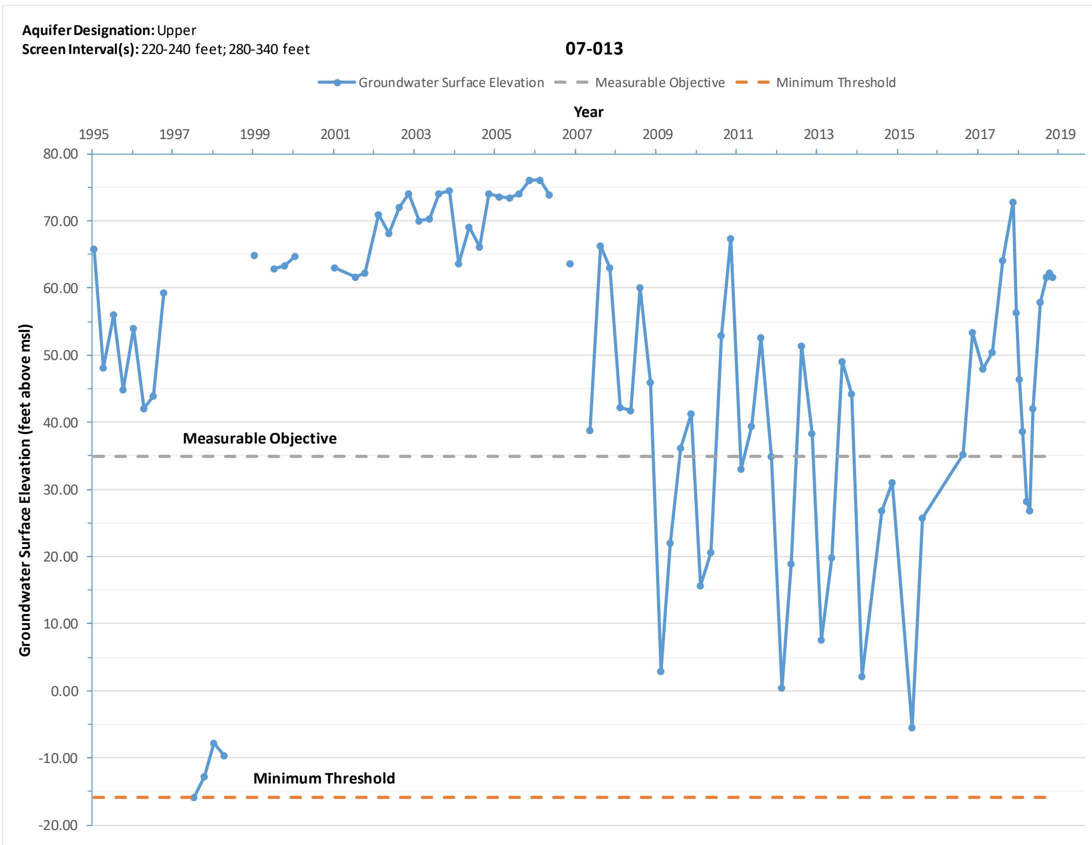
Tables summarizing minimum thresholds and measurable objectives are included in the GSP. Hydrographs showing the minimum threshold and measurable objective for each of the representative wells are contained in an appendix to the GSP (Appendix E).

Minimum thresholds for groundwater quality are defined by the Secondary MCL for TDS, Primary MCL for nitrate as N, and the water quality objective (WQO) for irrigation for boron, or the current groundwater quality where it exceeds the MCL or WQO as of December 2018. Measurable objectives for groundwater quality are to maintain current ambient groundwater quality conditions in each identified GSP subregion.

The minimum thresholds and measurable objectives for land subsidence vary by established MA and remaining Plan area. Within the WSID-PID MA, the minimum threshold is set as the acceptable loss of distribution capacity as a result of subsidence resulting from groundwater pumping as based on a future capacity study, where the measurable objective is no loss in distribution capacity as a result of subsidence related to groundwater pumping (numeric values to be established during the first GSP update). In the TRID MA, the minimum threshold is established as four (4) feet additional subsidence compared to 2019 benchmark elevation, where the measurable objective is set as two (2) feet additional subsidence compared to 2019 benchmark elevation. Within the remaining Plan area, the minimum threshold is set as the target rate/goal by monitoring subregion based on the average 2014-2016 elevation change from recent DMC surveys, where the measurable objective is the target rate/goal by monitoring subregion based on the average 2016-2018 elevation change from recent DMC surveys.

Minimum thresholds for depletion of interconnection of surface water systems has been set as an X percent increase in surface water depletions along interconnected stretches of surface water as a result of groundwater pumping, where 'X' is the percent increase in depletions to be determined by monitoring data collected prior to the first GSP update and associated analyses of these data. The measurable objective for depletions of interconnected surface water is set as no increased depletions of surface water as a result of groundwater pumping. Numeric values will be included in the first update to this GSP following data collection and associated analysis.

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



ES-7. Sustainability Implementation

The Northern & Central Delta-Mendota Region GSP contains the required sections for sustainability implementation, including Projects and Management Actions as well as Monitoring.

Projects and Management Actions

The six Delta-Mendota Subbasin GSP Groups will work together in a coordinated fashion to implement projects and management actions within their respective GSP Plan areas in order to achieve sustainability Subbasin-wide. The Northern & Central Delta-Mendota Region GSP has identified projects that can either replace (offset) or supplement (recharge) groundwater to aid in reaching sustainability by 2040. Currently, no pumping restrictions have been proposed for the Northern and Central Delta-Mendota Regions; however, GSAs maintain the flexibility to implement such demand-side management actions in the future if needed. Management activities identified in the Northern & Central Delta-Mendota Region GSP include a variety of strategies, from implementing rules to limit puming that may result in undesirable results to maximizing the use of other water supplies and incentivizing the use of those supplies over groundwater.

As previously noted, several projects to increase water supply availability in the Subbasin have been identified in the Northern & Central Delta-Mendota Region GSP. The initial set of projects was reviewed by the Northern and Central Delta-Mendota Technical Advisory Committee and recommended for approval by the Northern and Central Delta-Mendota Management Committees. A final list of 25 potential projects and management actions is included in this GSP, representing a variety of project types, including recharge and recovery, demand-side management, recycled water development and use, and reservoir expansion.

Projects and management actions are classified into three tiers, where Tier 1 indicates near-term projects and management actions to be completed and operational within the next five years; Tier 2 includes projects and management actions that currently require further development before implementation can occur and are anticipated to be developed over the next five years and implemented in 2026 or later; and Tier 3 includes long-term projects and management actions that may be implemented in the future as needed and/or are outside of the GSAs' control. The projects and management actions contained in this GSP, along with the projects and management actions implemented by the other five GSP Groups in the Subbasin, are anticipated to bring the Subbasin into sustainability by 2040. These projects and management actions require further analysis and permitting to determine feasibility and cost effectiveness and the project/management action list will be reviewed and revised, as appropriate, during GSP implementation. Projects and management actions are summarized in the table below.

Tier	Category	Project / Management Action	Project Type	Project Proponent
Tier 1	Projects	Los Banos Creek Recharge and Recovery Project	Recharge and Recovery	San Luis Water District
		Orestimba Creek Recharge and Recovery Project	Recharge and Recovery	Del Puerto Water District
		North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years	Recycled Water	Del Puerto Water District
		City of Patterson Percolation Ponds for Stormwater Capture and Recharge	Recharge and Recovery	City of Patterson
		Kaljian Drainwater Reuse Project	Recycled Water	San Luis Water District
		West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	Reservoir Creation/Expansion	West Stanislaus Irrigation District
		Revision to Tranquillity Irrigation District Lower Aquifer Pumping	Demand-side Management	Tranquillity Irrigation District
	Management Actions	Lower Aquifer Pumping Rules for Minimizing Subsidence	Demand-side Management	N/A
		Maximize Use of Other Water Supplies	Demand-side Management	N/A
		Increasing GSA Access to and Input on Well Permits	Demand-side Management	N/A
		Drought Contingency Planning in Urban Areas	Demand-side Management	N/A
		Fill Data Gaps	Various	N/A
Tier 2	Projects	Del Puerto Canyon Reservoir Project	Reservoir Creation/Expansion	Del Puerto Water District
		Little Salado Creek Groundwater Recharge and Flood Control Basin	Recharge and Recovery	Stanislaus County
		Patterson Irrigation District Groundwater Bank and/or Flood-Managed Aquifer Recharge (MAR)-type Project	Recharge and Recovery	Patterson Irrigation District
		West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	Reservoir Creation/Expansion	West Stanislaus Irrigation District
		Ortigalita Creek Groundwater Recharge and Recovery Project	Recharge and Recovery	San Luis Water District
	Management Action	Develop Program to Incentivize Use of Surface Water and Reduce Groundwater Demand	Demand-side Management	N/A
Tier 3	Projects	Pacheco Reservoir Expansion	Reservoir Creation/Expansion	Santa Clara Valley Water District
		Raising San Luis Reservoir	Reservoir Creation/Expansion	U.S. Bureau of Reclamation (Reclamation)
		Sites Reservoir	Reservoir Creation/Expansion	Sites Project Authority
		Los Vaqueros Expansion Phase 2	Reservoir Creation/Expansion	Contra Costa Water District
	Management Actions	Groundwater Extraction Fee with Land Use Modifications	Pumping Charges	N/A
		City of Patterson Reduced Groundwater Use Portfolio	Demand-side Management	City of Patterson
		Rotational Fallowing of Crop Lands	Demand-side Management	N/A

Monitoring

The Northern & Central Delta-Mendota Region GSP includes monitoring networks for the five sustainability indicators applicable to the Delta-Mendota Subbasin, where seawater intrusion is not applicable to the Delta-Mendota Subbasin. The objective of these monitoring networks is to monitor conditions across the Plan area and to detect trends toward undesirable results. Specifically, the monitoring networks were developed to:

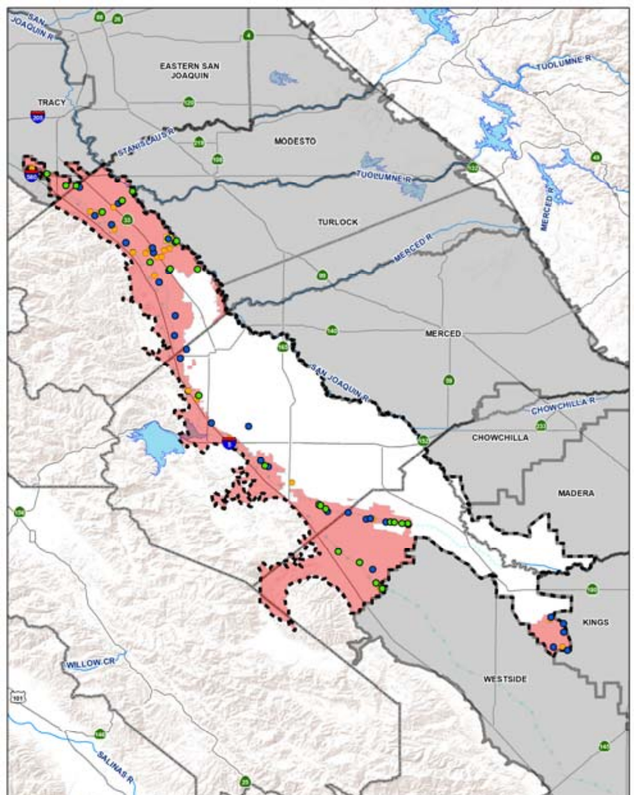
- Monitor impacts to the beneficial uses or users of groundwater resulting from groundwater use
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Demonstrate progress toward achieving measurable objectives described in the GSP

> **Five Sustainability Indicators Applicable to the Delta-Mendota Subbasin**
> - Chronic lowering of groundwater levels
> - Reduction of groundwater storage
> - Degraded water quality
> - Land subsidence
> - Depletions of interconnected surface water

Five monitoring networks were developed for the Northern & Central Delta-Mendota Region GSP: groundwater levels (including both Upper Aquifer and Lower Aquifer wells), groundwater quality (including both Upper Aquifer and Lower Aquifer wells), land subsidence, and interconnected surface water. The same networks for the Upper and Lower Aquifers are used for assessing changes in groundwater elevations, groundwater storage, and groundwater quality. A subset of the montioring wells is used along with stream gauge data for assessing changes to inteconnected surface waters (using groundwater levels as a proxy for those changes). All monitoring networks described in this GSP are representative monitoring networks and are used to determine compliance with the measurable objectives and minimum thresholds established for the individual locations.

The monitoring networks were designed by evaluating existing monitoring programs within the Subbasin, such as CASGEM, the DMC Pump-in Program, ILRP Groundwater Quality Trend Monitoring Program, United States Bureau of Reclamation DMC subsidence monitoring program, and local agency monitoring programs, and supplementing those monitoring sites with other potential monitoring locations in the Plan area. The monitoring networks consist largely of monitoring sites that are already being used for monitoring in the Subbasin. Additional monitoring sites are being added as data gaps are filled through downhole video surveys to be conducted under DWR's Technical Support Services (TSS) program. The updated monitoring networks will be included in updates to this GSP. Figure ES-6 shows the location of existing and planned monitoring sites (wells and survey benchmarks) for all sustainability indicators.

Figure ES-6. Representative Monitoring Sites
(including wells and survey benchmarks)



Monitoring frequencies vary by sustainability indicator and management area. For groundwater levels, measurements will be taken during seasonal high (February through April) and seasonal low (September through October) conditions. Groundwater quality for the identified constituents of concern (TDS, nitrate as N, and boron) will be analyzed annually between May and August, where wells will be tested for additional water quality constituents every five years. Measurements for interconnected surface waters will be collected concurrently with those for groundwater levels.

Land subsidence will be measured twice during the first five years of GSP implementation in the WSID-PID MA, following a baseline elevation survey to be conducted in 2019. Annual elevation surveys will take place in the TRID MA. Elevation surveys will take place every other year during even years in the remaining Plan area. Publicly-available land subsidence and stream gauge data will be downloaded periodicly for GSP monitoring efforts and combined with data collected via the monitoring networks. Historical measurements have been entered into the Subbasin Data Management System (DMS) and future data will be added to the DMS. A summary of the monitoring sites established for this GSP is shown in the table above.

Summary of GSP Monitoring Networks	
Representative Networks	
Groundwater Level Wells	
Upper Aquifer	17
Lower Aquifer	18
Groundwater Quality Wells	
Upper Aquifer	17
Lower Aquifer	18
Land Subsidence Benchmarks and Continuous GPS Sites	31
Interconnected Surface Water Wells	2

ES-8. Plan Implementation

Implementing the Northern & Central Delta-Mendota Region GSP will require numerous management activities that will be undertaken by the GSAs within the Region and throughout the Subbasin, including:

- Monitoring conditions relative to applicable sustainability indicators at specified frequency and timing
- Entering updated monitoring data into the Subbasin DMS
- Refining Subbasin model and water budget planning estimates
- Preparing annual reports summarizing the conditions of the Subbasin and progress towards sustainability and submitting them to DWR
- Updating the GSP once every five years

A preliminary schedule for GSP implementation and projects and management actions has been developed and agreed upon by the Northern and Central Delta-Mendota Management Committees for the first five years of GSP implementation (2020 through 2025). Implementation of projects and management actions is scheduled to begin in 2020, with full implementation achieved by 2040. The proposed schedule provides time to refine water budget estimates and re-evaluate projects and management actions in terms of benefits, technical feasibility, and cost effectiveness.

Implementation of the Northern & Central Delta-Mendota Region GSP will require both funding by GSAs and external sources. Outside grants will be sought to assist in reducing the cost of implementation to participating agencies, residents, and landowners of the Plan area. Ultimately, it is up to individual GSAs to determine the means by which they will achieve both the Delta-Mendota Subbasin sustainability goal and financial goals for GSP implementation. Costs associated with GSP implementation and Plan Administrator operations include the following:

- GSP-associated administration
- Stakeholder/Board engagement
- Project and management action implementation
- Monitoring
- Data management

GSAs will individually fund implementation of projects and management actions within their boundaries. GSAs will evaluate options for securing the needed funding on an individual basis.

For budgetary purposes, the estimated cost of implementing this GSP is on the order of $1.5 million to $2.5 million per year over the first five years of implementation (2020 to 2025), with an additional $6.6 million to $40 million per year over the 20-year planning horizon for the implementation of projects and management actions. Annual reports and five-year assessment reports (or periodic evaluation assessment reports) will be developed in a manner consistent with the GSP Emergency Regulations and using DWR-provided formats and supplemental resources. Annual reports will be a coordinated effort among the six Delta-Mendota Subbasin GSP Groups with five-year or periodic evaluation assessment reports developed by the Northern and Central Delta-Mendota Regions in coordination with updates to the coordinated Common Chapter by all GSP Groups.

The Delta-Mendota Subbasin DMS, a subbasin-wide coordinated DMS, is a secured web-based application that is designed to support data visualization and aggregation as well as annual report generation. The web application functionality includes an embedded GIS viewer, screens to view tables of time series data, and charting capabilities for hydrographs as well as map layers. The DMS has been developed as part of a coordinated effort among the six Delta-Mendota GSP Groups with each GSP Group and their respective GSA member agencies responsible for conducting their own monitoring programs and associated data collection efforts (including quality control and quality assurance) and ensuring that these data are available at the Subbasin-level for analysis and annual reports. The DMS will be maintained by SLDMWA, while acting as the Plan Manager, with a contract with the software vendor as needed.

ES-9. Technical Studies

Lists of references used to develop this GSP are included following each GSP chapter. Technical studies relied upon in developing the Northern & Central Delta-Mendota Region GSP are included as a chapter to this GSP.

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Section 1

Introduction

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1. INTRODUCTION

1.1 PURPOSE OF THE GROUNDWATER SUSTAINABILITY PLAN

In 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA), which is comprised of regulatory requirements set forth in a three-bill legislative package consisting of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley). 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" (SGMA Regulations § 10721(v)) which are defined by SGMA as any of the following effects caused by groundwater conditions occurring throughout the basin (SGMA Regulations § 10721(x)):

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

The Delta-Mendota Groundwater Subbasin (Delta-Mendota Subbasin or Subbasin) has been identified by the California Department of Water Resources (DWR) as being in a state of critical overdraft. Groundwater Sustainability Agencies (GSAs) in the Subbasin are therefore tasked with developing and submitting one or more Groundwater Sustainability Plans (GSPs or Plans) to DWR by no later than January 31, 2020. Six (6) coordinated GSPs have been prepared for the Delta-Mendota Subbasin; the Plan area for this GSP, prepared by the Northern & Central Delta-Mendota Region GSP Group, is show in Figure 1-1 along with the Plan areas of the other five (5) Delta-Mendota Subbasin GSP Groups. All six GSPs have been prepared in a coordinated manner under the oversight of the Delta-Mendota Subbasin Coordination Committee (Coordination Committee) and in accordance with the Delta-Mendota Subbasin Coordination Agreement (Coordination Agreement) for the Subbasin. A Common Chapter, included in Appendix B, has been prepared as means of integrating key parts of the six GSPs to meet subbasin-level requirements per the Sustainable Groundwater Management Act (SGMA) and the Emergency GSP regulations (DWR, 2016).

This GSP has been developed by the GSAs of the Northern and Central Delta-Mendota Regions and meets SGMA regulatory requirements while reflecting local needs and preserving local control over water resources. The Northern & Central Delta-Mendota Region GSP provides a path to achieve and document sustainable groundwater management within twenty years following Plan adoption, promoting the long-term sustainability of locally-managed groundwater resources now and into the future.

While the Northern & Central Delta-Mendota Region GSP offers a new and significant framework for groundwater resource protection and management, it was developed within an existing framework of comprehensive planning efforts. Throughout the Delta-Mendota Subbasin, several separate yet related planning efforts are concurrently proceeding, including Integrated Regional Water Management program, Urban Water Management requirements, Agricultural Water Management requirements, Irrigated Lands Regulatory Program, and California Statewide Groundwater Elevation Monitoring (CASGEM) program. This GSP has been developed to coordinate with these other planning efforts, building on existing local management and basin characterization. A description of existing planning efforts can be found in Chapter 2 *Plan Area* of this GSP.

1.2 DESCRIPTION OF THE DELTA-MENDOTA SUBBASIN

The Delta-Mendota Subbasin is identified by DWR in Bulletin 118 as Subbasin No. 5-022.07 (DWR, 2016). The Subbasin is one of nine subbasins in the greater San Joaquin Valley Basin in the San Joaquin River Hydrologic Region of California. The Subbasin encompasses an area of approximately 765,000 acres, of which approximately 316,000 acres are located in the Northern and Central Delta-Mendota Regions. The Subbasin boundaries, as currently defined by DWR, are located in San Joaquin, Stanislaus, Merced, Madera, Fresno, and San Benito Counties.

As previously noted, six (6) GSPs have been prepared in a coordinated fashion to cover the Delta-Mendota Subbasin. For this Northern & Central Delta-Mendota Region GSP, eight GSAs worked together to develop the organizational structure and means by which they will jointly manage the underlying portions of the Subbasin. Chapter 3 *Governance* describes how these entities have coordinated both within the Northern and Central Delta-Mendota Regions and with GSAs in the other five (5) GSP Groups in the Subbasin. Figure 1-1 shows the location of the Northern & Central Delta-Mendota Region GSP and Plan area within the Delta-Mendota Subbasin.

1.3 GROUNDWATER SUSTAINABILITY PLAN ORGANIZATION

This GSP has been organized to generally follow the GSP Emergency Regulations (California Code of Regulations, Title 23. Waters, Division 2. Department of Water Resources, Chapter 1.5. Groundwater Management. Subchapter 2. Groundwater Sustainability Plans) as released by DWR in 2016. The Preparation Checklist for GSP Submittal in DWR formatting can be found in Appendix C *DWR Preparation Checklist* (DWR, December 2016).

As this GSP is one of six (6) being submitted for the Delta-Mendota Subbasin, it is linked to and coordinated with the other five GSPs through the separate *Common Chapter for the Delta-Mendota Subbasin*.

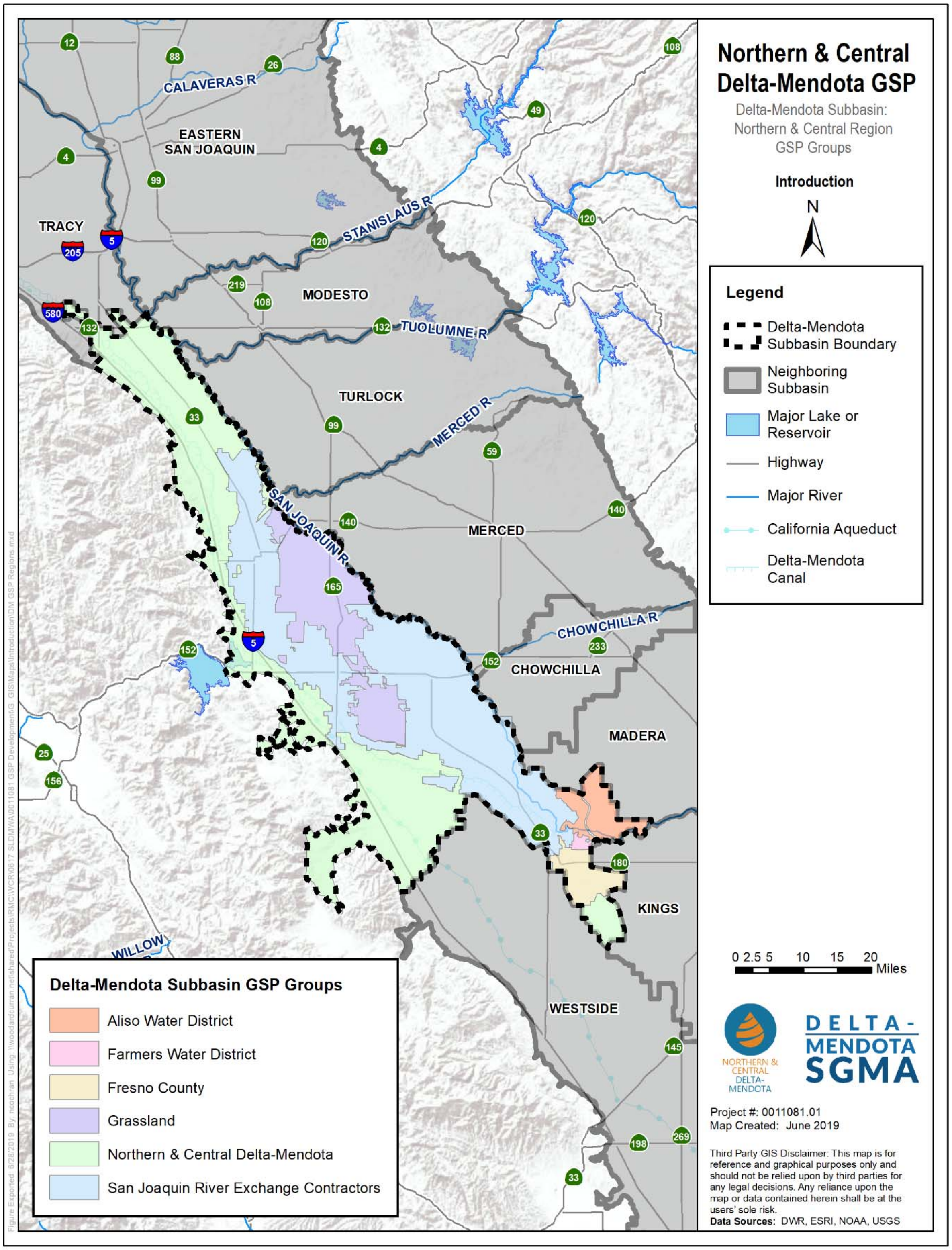

Figure 1-1. Delta-Mendota Subbasin Groundwater Sustainability Plan Groups

1.4 REFERENCES

California Department of Water Resources (DWR). 2016. 2016 Bulletin 118 Basin Boundary Descriptions: 5-022.07 San Joaquin Valley – Delta-Mendota. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/B118-Basin-Boundary-Descriptions-2016/B118-Basin-Boundary-Description-2016---5_022_07.pdf. Accessed on July 1, 2019.

California Department of Water Resources (DWR). December 2016. *Guidance Document for the Sustainable Management of Groundwater: Groundwater Sustainability Plan (GSP) Annotated Outline*. https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf. Accessed on July 1, 2019.

Section 2

Plan Area

Groundwater Sustainability Plan for the Northern and Central Delta-Mendota Regions

Section 2

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2. PLAN AREA

2.1 PLAN AREA DESCRIPTION

This chapter describes the Northern and Central Delta-Mendota Regions of the Delta-Mendota Subbasin. Specifically, this chapter describes the location of the areas within the Delta-Mendota Subbasin covered by this Groundwater Sustainability Plan (GSP), including a detailed description of geographic areas covered by this GSP in relation to Sustainable Groundwater Management Act (SGMA) governing entities, jurisdictional boundaries, existing land use and related water sources, well density, areas of *de minimis* groundwater pumping, and groundwater-dependent communities. Existing water resource monitoring and management programs are described herein, along with a discussion as to how they may limit operational flexibility in the Northern and Central Delta-Mendota Regions of the Delta-Mendota Subbasin and how this Plan will adapt to such limits, and descriptions of existing conjunctive use programs in the subbasin. A discussion of general plans and other land use plans and how implementation of existing land use plans, both within and outside of the Subbasin, may change water demands or impact sustainable groundwater management and how the Plan addresses such potential effects is of concern to local land and water managers in the Plan is also included. Finally, local relevant well permitting processes as they relate to land use planning, as well as any additional Plan elements included in California Water Code (CWC) Section 10727.4 as appropriate are discussed. Implementation of this GSP may affect water supply assumptions of relevant land use plans; discussion of these potential impacts is included in Chapter 7, Sustainability Implementation.

The portion of the Delta-Mendota Subbasin covered by this GSP is shown in Figure 2-1. The Northern and Central Delta-Mendota Regions are not contiguous and abut several other areas in the Subbasin covered by other GSPs. As many of the planning documents and monitoring programs have been prepared for the Subbasin as a whole or for other contiguous portions of the Subbasin, some of the discussions below will focus solely on the Northern and Central Delta-Mendota Regions, while others will discuss the Subbasin as a whole. However, in total, this section of the Northern & Central Delta-Mendota Region GSP satisfies §354.8 of the GSP Emergency Regulations under SGMA.

2.1.1 Plan Area Definition

The Delta-Mendota Subbasin (California Department of Water Resources [DWR] Basin 5-022.07) is located in the San Joaquin Valley Groundwater Basin and adjoins the following nine (9) subbasins of the San Joaquin Valley Groundwater Basin: Tracy, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, Madera, Kings, and Westside. The Delta-Mendota Subbasin is bounded on the west by the Tertiary and older marine sediments of the Coast Ranges; on the north by San Joaquin-Stanislaus County line, except where Del Puerto Water District and West Stanislaus Irrigation District service areas extend into San Joaquin County; on the east generally by the San Joaquin River, Fresno Slough, James Bypass, and Mendota Pool, Aliso Water District, Farmers Water District, Mid-Valley Water District, Reclamation District 1606, James Irrigation District, Tranquillity Irrigation District, and Fresno Slough Water District service areas (except to include the entirety of the Columbia Canal Company); and on the south by the Tranquility Irrigation District and Westlands Water District boundaries and including the San Luis Water District service area until reaching the Coastal Range. The Northern and Central Delta-Mendota Regions extend into five (5) counties: San Joaquin, Stanislaus, Merced, Fresno, and San Benito. The Northern & Central Delta-Mendota Region GSP Plan area is generally defined as the area of the Delta-Mendota Subbasin in San Joaquin and Stanislaus Counties, with the exception of the City of Newman area and east of Crows Landing; following the western boundary of the Delta-Mendota Subbasin to the west and south of the Delta-Mendota Canal; and the Tranquillity area at the southeastern tip of Delta-Mendota Subbasin in Fresno County (Figure 2-1). The portion of the Northern & Central Delta-Mendota Region GSP within each of the five counties is shown in Figure 2-2 through Figure 2-5.

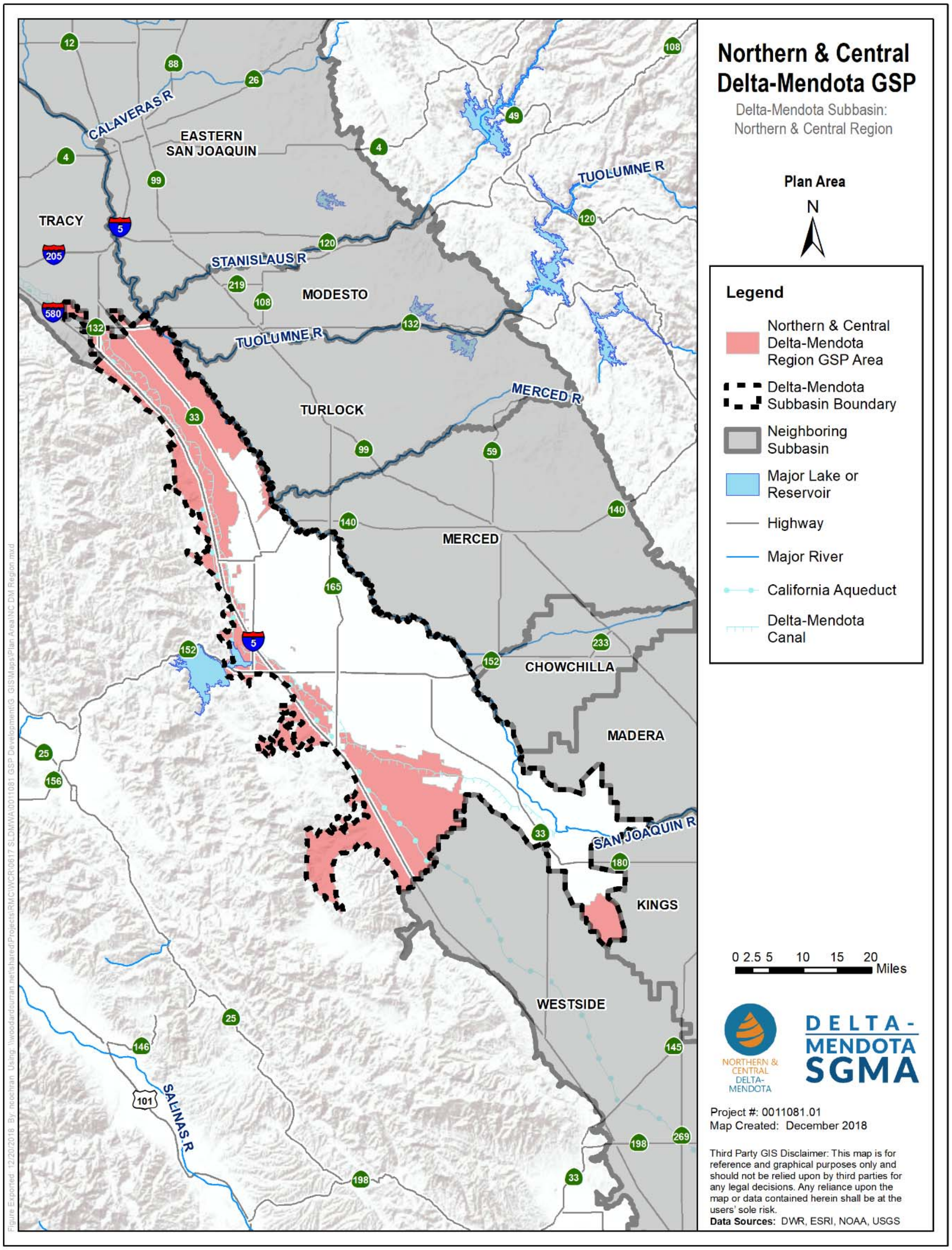


Figure 2-1. Plan Area Covered by the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan

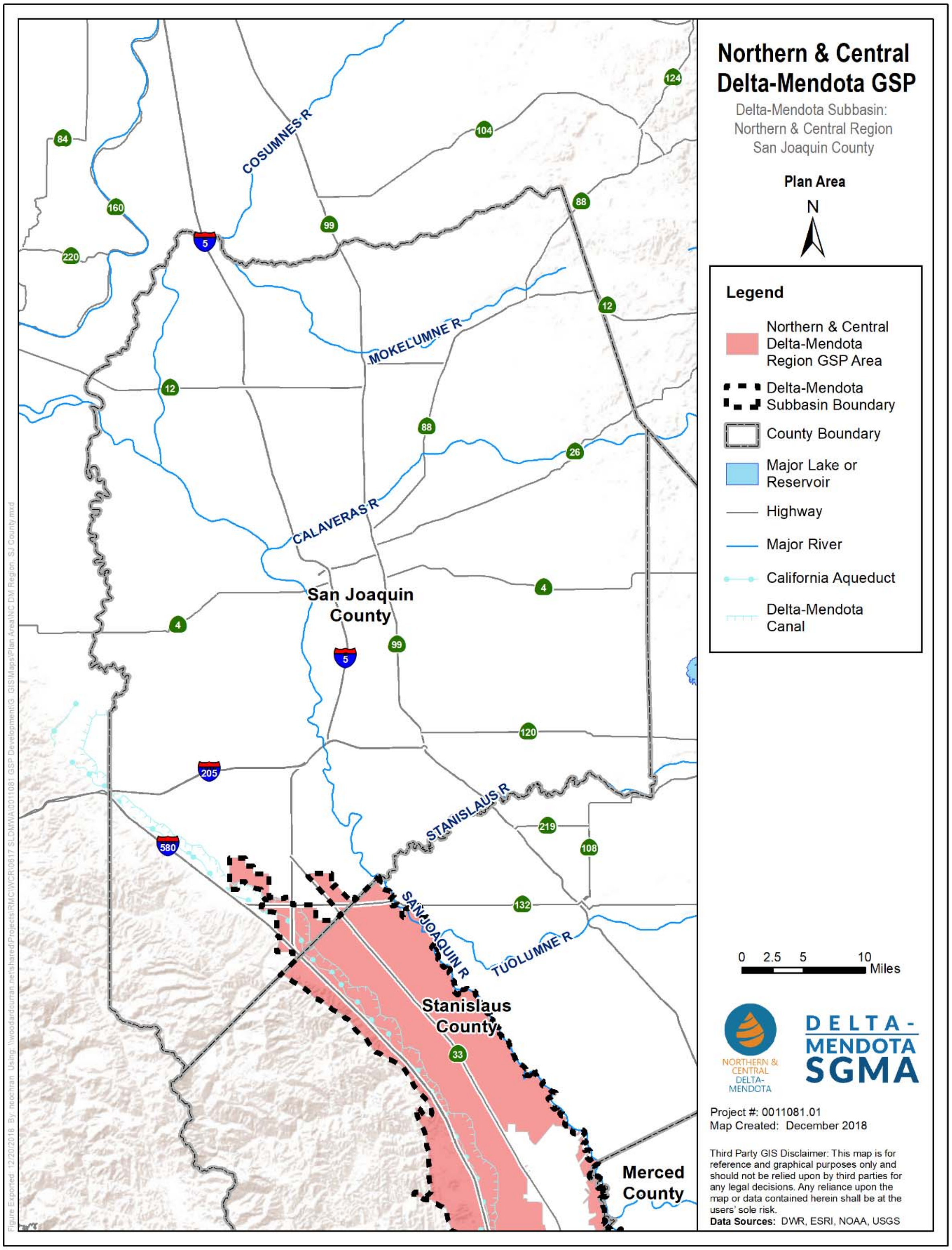


Figure 2-2. Plan Area Covered by the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan in San Joaquin County

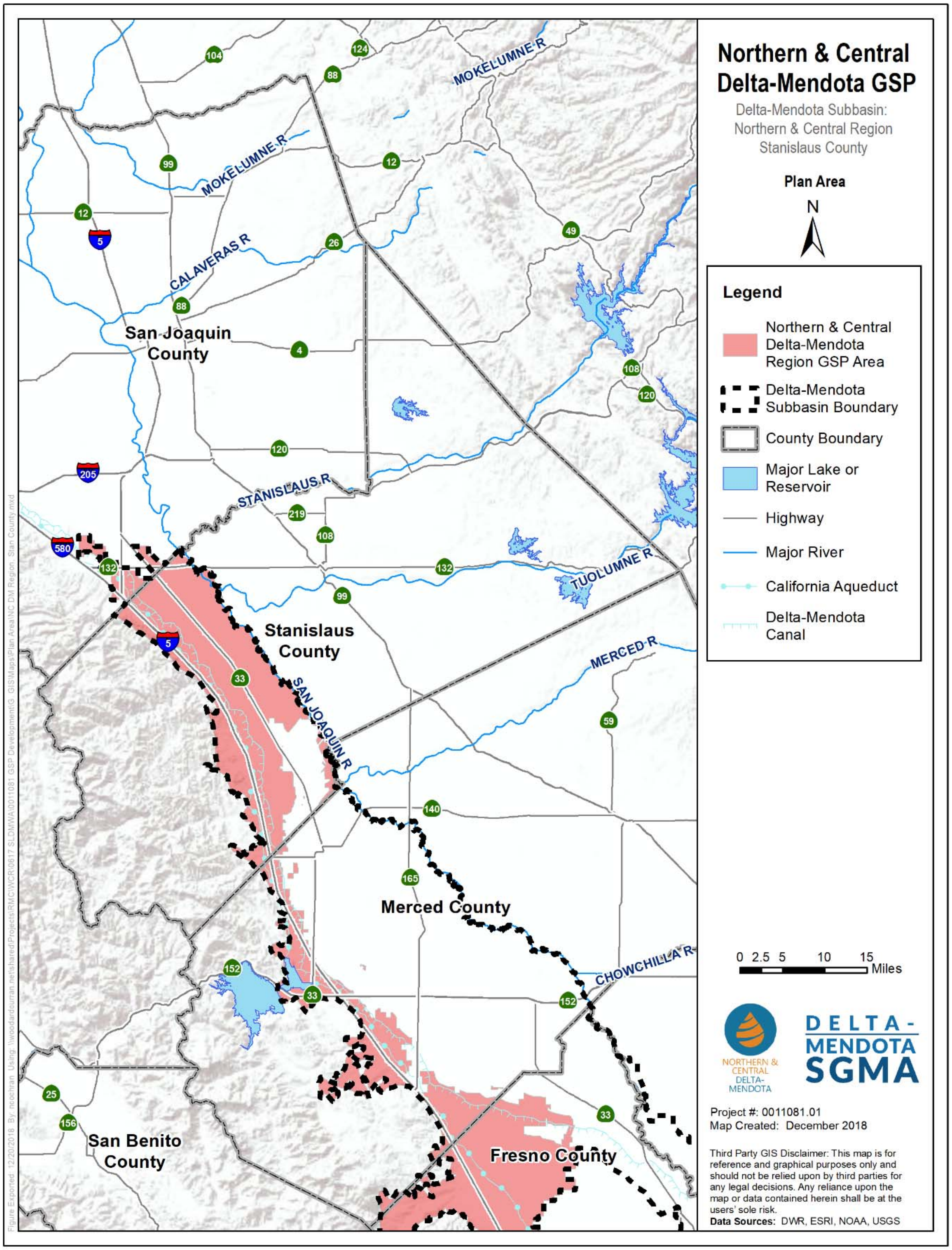


Figure 2-3. Plan Area Covered by the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan in Stanislaus County

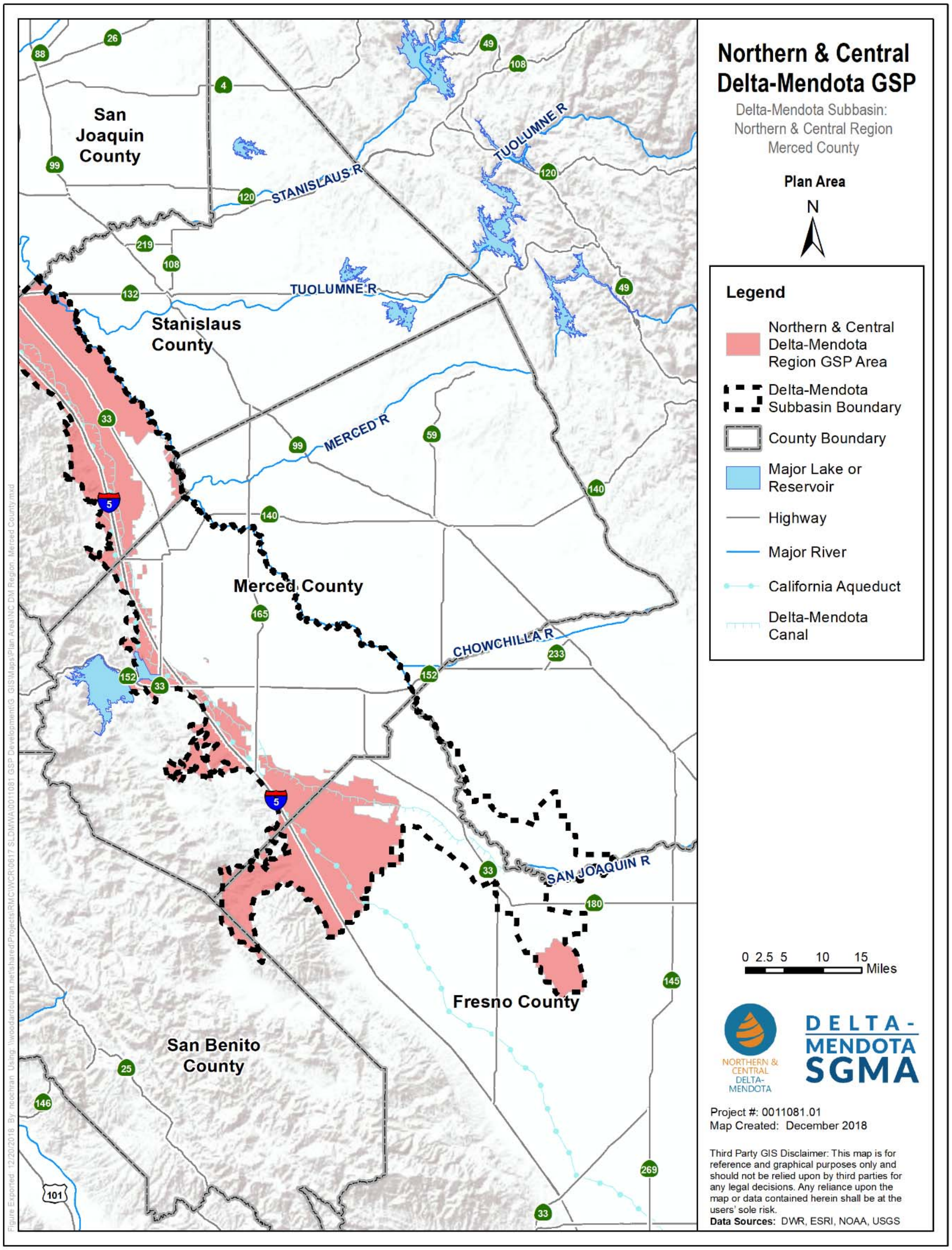


Figure 2-4. Plan Area Covered by the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan in Merced County

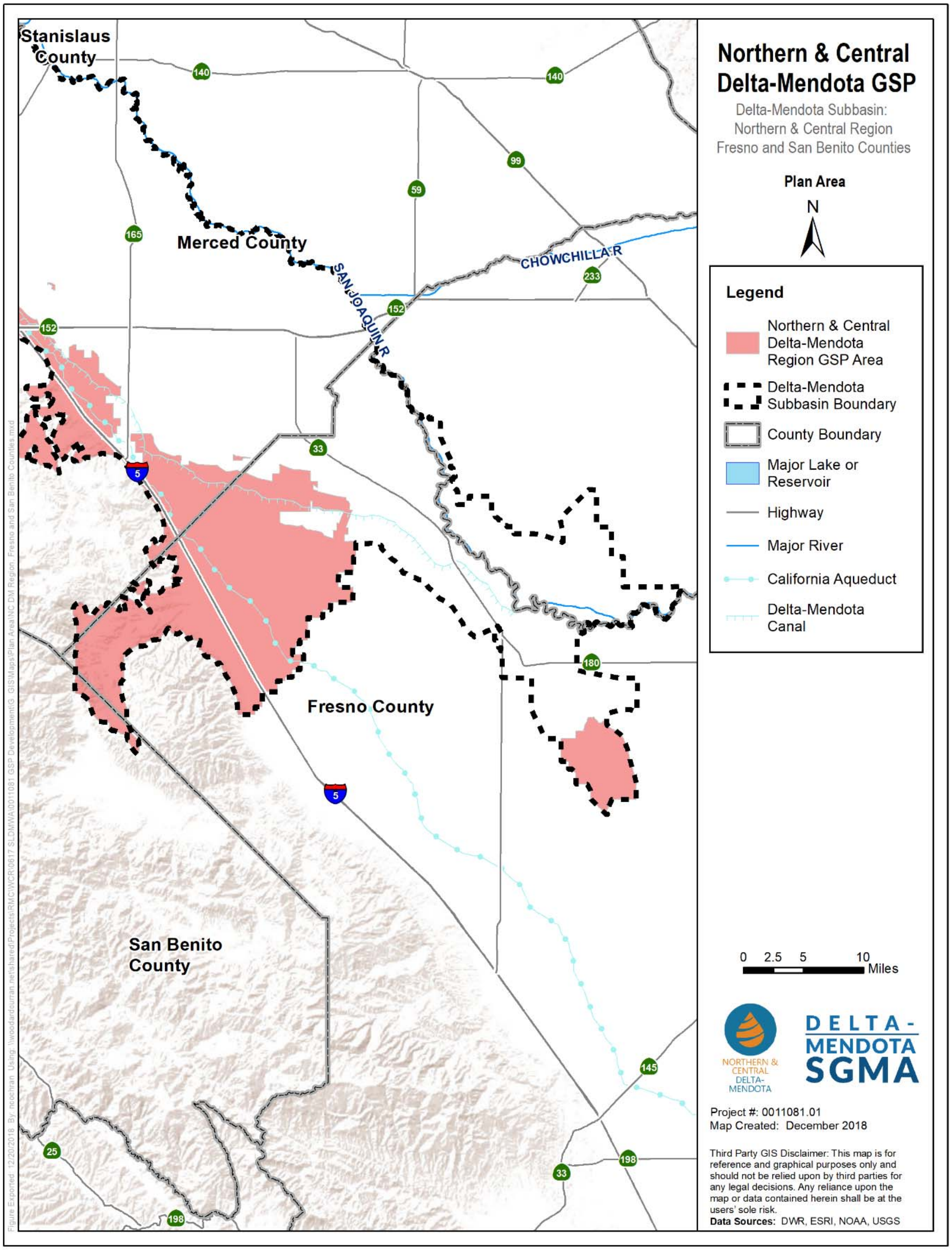


Figure 2-5. Plan Area Covered by the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan in Fresno and San Benito Counties

2.1.2 Plan Area Setting

As previously noted, the Delta-Mendota Subbasin lies along the western margin of the San Joaquin Valley. This valley is part of the large, northwest-to-southeast-trending asymmetric trough of the Central Valley, which has been filled with up to six vertical miles of sediment. This sediment includes both marine and continental deposits ranging in age from Jurassic to Holocene. The San Joaquin Valley lies between the Coast Range Mountains on the west and the Sierra Nevada on the east, and extends northwestward from the San Emigdo and Tehachapi Mountains to the Sacramento-San Joaquin Delta (Delta) near the City of Stockton. The San Joaquin Valley is 250 miles long and 50 to 60 miles wide. The relatively flat alluvial floor is interrupted occasionally by low hills. Foothills adjacent on the west are composed of folded and faulted beds of mainly marine shale in the north and sandstone and shale in the south.

The San Joaquin Valley floor is divided into several geomorphic land types, including dissected uplands, low alluvial fans and plains, river floodplains and channels, and overflow lands and lake bottoms. Alluvial plains cover most of the valley floor and comprise some of the most intensely developed agricultural lands in the San Joaquin Valley. In general, alluvial sediments of the western and southern parts of the San Joaquin Valley tend to have lower permeability than east side deposits.

This section provides additional information relating to water resources in and around the Delta-Mendota Subbasin.

2.1.2.1 Watersheds

The Delta-Mendota Subbasin lies in the Middle San Joaquin-Lower Merced-Lower Stanislaus watershed and the Middle San Joaquin-Lower Chowchilla watershed (Figure 2-6). Historically, the San Joaquin River basin was a large floodplain of the San Joaquin River that supported vast expanses of permanent and seasonal marshes, lakes, and riparian areas. Almost 70 percent of the basin has been converted to irrigated agriculture, with wetland acreage estimated to have been reduced to approximately 120,300 acres. In combination with the adjacent uplands, the wetland complex is referred to as “the Grasslands” and consists of approximately 160,000 acres of private and public lands. Approximately 53,300 acres of the Grasslands are permanently protected in state or federal wildlife refuges or in federal conservation easements (Figure 2-7).

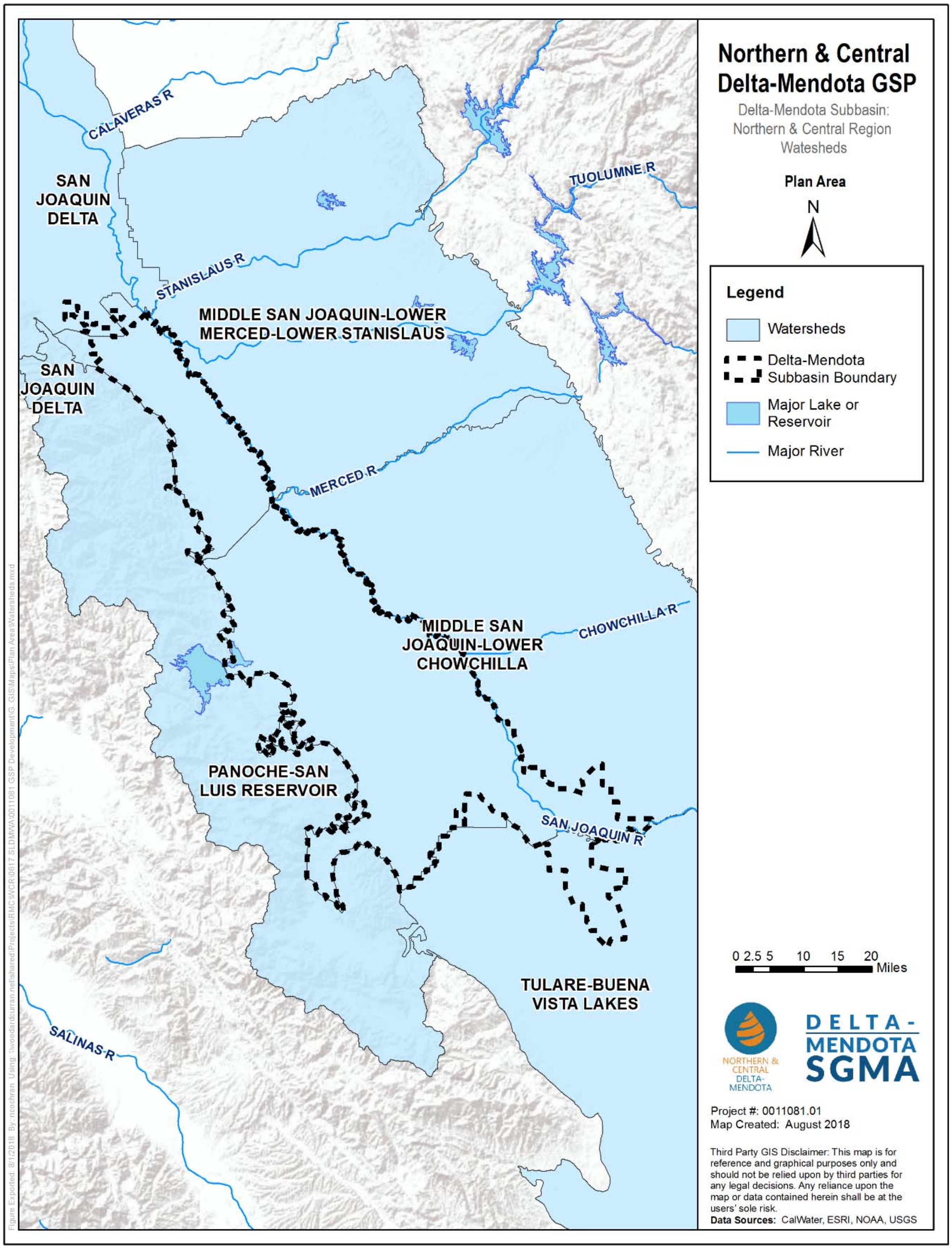


Figure 2-6. Watersheds in the Delta-Mendota Subbasin

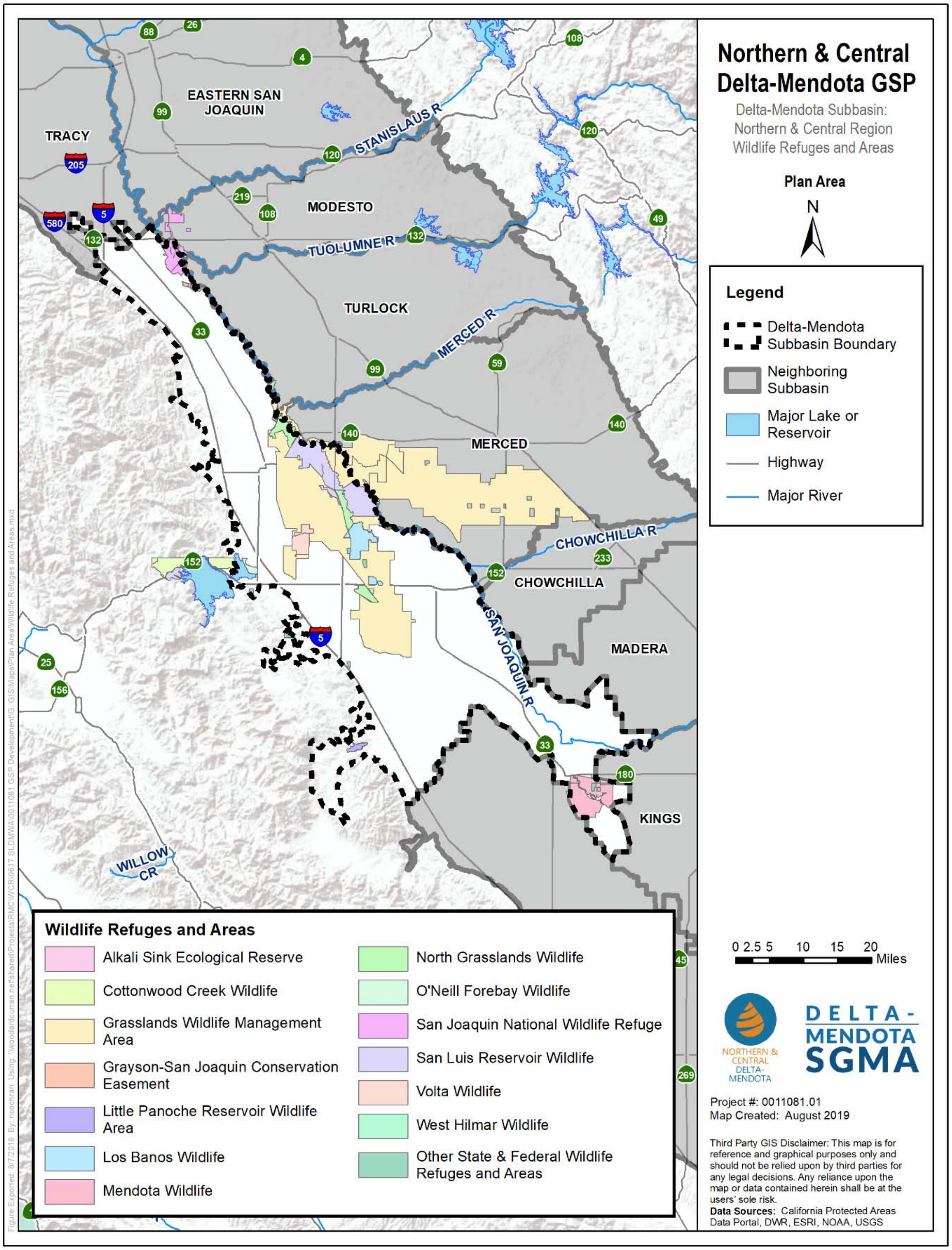


Figure 2-7. Wildlife Refuges and Areas in the Delta-Mendota Subbasin

2.1.2.2 Major Water-Related Infrastructure

Within the Delta-Mendota Subbasin lies an extensive series of water systems relied upon by multiple water agencies, cities, and private water users. Major water-related infrastructure in the Subbasin includes the facilities required to deliver the Central Valley Project (CVP) supplies to the Member Agencies in addition to key infrastructure of the State Water Project (SWP) utilized to deliver water to SWP Water Supply Contractors.

The San Luis & Delta-Mendota Water Authority (SLDMWA) consists of water agencies representing approximately 2.1 million acres of 28 federal and exchange water service contractors. The SLDMWA operates and maintains portions of the CVP, including the Delta Cross Channel, the C.W. "Bill" Jones Pumping Plant, the Delta-Mendota Canal (DMC), O'Neill Pumping-Generating Plant, San Luis Drain, Grassland Drainage Project, and the Tracy Fish Collection Facility. DWR operates and maintains the SWP facilities, designed to deliver nearly 4.2 million acre-feet of water per year to 29 long-term SWP Water Supply Contractors. SWP facilities include the California Aqueduct, Banks Pumping Plant, O'Neill Dam and Forebay, Sisk Dam and San Luis Reservoir, Los Banos Detention Dam and Reservoir, Little Panoche Detention Dam and Reservoir and Dos Amigos Pumping Plant.

The Northern and Central Delta-Mendota Regions lie adjacent to the San Joaquin River, approximately from its confluence with the Merced River to just south of Vernalis. There are no instream flow requirements on the San Joaquin River over this reach (nor on any of the creeks stemming from the Coast Range on the west).

2.1.2.2.1 CVP Facilities

Delta Cross Channel

The Delta Cross Channel, located near Walnut Grove, diverts water from the Sacramento River into Snodgrass Slough and is critical in controlling salinity as part of the CVP Delta Division. From the Slough, the water flows through natural channels for about 50 miles to the vicinity of the C.W. Bill Jones Pumping Plant. The Channel is designed to divert approximately 3,500 cubic feet per second (cfs) of water.

C.W. "Bill" Jones Pumping Plant

Surface water conveyed into the Delta-Mendota Subbasin is pumped from the Delta by the C.W. "Bill" Jones Pumping Plant and conveyed in the DMC by gravity. The pumping plant is located about 12 miles northwest of Tracy and is essential to agricultural, urban, and wildlife water deliveries to parts of the Delta and the San Luis and San Felipe Units of the CVP. Six pumps, each powered by a 22,500-horsepower electric motor, lift the Delta water about 200 feet from the intake through discharge pipes about one mile to the DMC. Power to operate the pumps is generated by CVP facilities. Total capacity of the plan is approximately 5,200 cfs, where each unit has a pumping capacity between 850 cfs and 1,050 cfs.

Delta-Mendota Canal

The Delta-Mendota Canal, a 116.6-mile-long canal completed in 1951, carries water southeasterly from the C.W. "Bill" Jones Pumping Plant to the Mendota Pool in the San Joaquin River and Fresno Slough (30 miles west of Fresno). DMC water is used for irrigation of land along the west side of the San Joaquin Valley and to replace San Joaquin River water stored at Friant Dam. Initial conveyance capacity is 4,600 cfs, decreasing to 3,211 cfs at the terminus. Water delivery facilities providing irrigation service to lands in the San Luis Unit were not completed until the 1980s. Today, the DMC and associated facilities are essential to provide irrigation supply to the San Luis Unit and the CVP Delta Division.

DMC/California Aqueduct Intertie

The Intertie connects the DMC and the California Aqueduct (part of the State Water Project) via two 108-inch diameter pipes with a pumping capacity of 467 cfs. The connection is approximately 500 feet long and helps to address DMC conveyance conditions that have restricted use of the C.W. “Bill” Jones Pumping Plant to less than its design capacity, restoring as much as 35,000 acre-feet (AF) of average annual deliveries to the CVP. The intertie also provides redundancy in the CVP distribution system.

O’Neill Pumping-Generating Plant

The O’Neill Pumping Plant, located at Mile 70 of the DMC about 12 miles west of Los Banos, lifts water between 45 and 53 feet from the DMC into the O’Neill Forebay. This plant is essential in delivering water to the O’Neill Forebay, San Luis, and San Felipe Units of the CVP. The Plant was completed in 1968 and consists of an intake channel leading off the DMC and six pumping-generating units, each of which can discharge about 650 cfs and has a rating of 6,000 horsepower. When operating as turbines/generators, each unit can generate about 4,000 kilowatts.

San Luis Drain

The San Luis Drain, partially completed in 1974, was designed to convey and dispose of subsurface irrigation return flows from the San Luis service area in an attempt to keep saline irrigation drainage water out of the San Joaquin River. It is part of the San Luis Unit, West San Joaquin Division of the CVP, and consists of a concrete-lined channel with a design capacity of 300 cfs. Except for the portion being used by the Grassland Drainage Project, the drain was closed in 1986 due to waterfowl deaths and deformities occurring at Kesterson Reservoir, the San Luis Drain terminus at the time.

Grassland Bypass Project

The Grassland Bypass Project prevents discharge of subsurface agricultural drainage water into wildlife refuges and wetlands in those areas where the Grassland Drainage Area is located (within the southern portion of the Northern and Central Delta-Mendota Regions). The Bypass Project conveys drainage water through a segment of the San Luis Drain to Mud Slough, a tributary to the San Joaquin River. The Bypass Project improves water quality in the wildlife refuges and wetlands, sustains the productivity of 97,000 acres of farmland, and fosters cooperation between area farmers and regulatory agencies in drainage management reduction of selenium and salt loading. Since the implementation of the Project in 1996, all discharges of water from the Grassland Drainage Area into wetlands and refuges have been eliminated. The Project has reduced the load of selenium discharged from the Grassland Drainage Area by 61 percent (from 9,600 lbs to 3,700 lbs) and the salt load has been reduced by 39 percent (from 187,300 tons to 113,600 tons), as of 2017. The Project is operated jointly by the United States Bureau of Reclamation and SLDMWA.

Tracy Fish Collection Facility

The Tracy Fish Collection Facility (TFCF) intercepts fish from the Old River and the C.W. “Bill” Jones Pumping Plant. The facility, located about 2.5 miles upstream from the pumping plant, is vital for the preservation of various delta species as part of the Central Valley Project, Delta Division. Due to significant on-going research, the United States Bureau of Reclamation continues performing the operation and maintenance at the TFCF and the SLDMWA has a service contract to provide emergency assistance when requested. The TFCF was primarily built to intercept downstream migrant fish so they could be transported to the main delta channel to resume their journey to the ocean.

2.1.2.2.2 SWP Facilities

California Aqueduct

The California Aqueduct is the primary method of transporting water from Northern California to Southern California for water supply. The concrete-lined canal originates at the Clifton Court Forebay in the Sacramento-San Joaquin Delta, and extends down the San Joaquin Valley, to and past the Tehachapi Mountains down to Lake Perris, the SWP’s southernmost reservoir. The federally-built portion of the California Aqueduct is called the San Luis Canal and carries both CVP and SWP water from San Luis Reservoir and O’Neill Forebay and terminates in Kettleman City.

Harvey O. Banks Pumping Plant

The Banks Pumping Plant lies in the southern portion of the Sacramento-San Joaquin Delta, almost 20 miles southwest of the city of Stockton. Marking the beginning of the California Aqueduct, the plant provides the initial lift of water 244 feet into the canal.

O'Neill Dam and Forebay

Located along the western side of the San Joaquin Valley in Merced County, the California Aqueduct enters O'Neill Forebay from the north. Created by a dam across San Luis Creek, O'Neill Forebay is a forebay to the San Luis Reservoir and offers a variety of recreational activities including camping, boating, windsurfing, and fishing.

Sisk Dam and San Luis Reservoir

San Luis Reservoir, impounded by Sisk dam, lies at base of foothills on the west side of the San Joaquin Valley in Merced County, about 2 miles west of O'Neil Forebay and abutting the western side of the Delta-Mendota Subbasin. A key conservation facility of the SWP, the reservoir provides offstream storage for excess winter and spring flows diverted from the Sacramento-San Joaquin Delta. It is sized to provide seasonal carryover storage and provides a variety of recreational activities, as well as fish and wildlife benefits.

Los Banos Detention Dam and Reservoir

Los Banos Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta-Mendota Canal, the City of Los Banos, and other downstream developments. The facility is located on the west side of the San Joaquin Valley in Merced County, about seven miles southwest of the city of Los Banos.

Little Panoche Detention Dam and Reservoir

Situated in Fresno County, 20 miles southwest of the city of Los Banos, Little Panoche Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta-Mendota Canal, and other downstream developments. Water is stored behind the dam above dead storage of 315 acre-feet only during the period that inflow from Little Panoche Creek exceeds the capacity of the outlet works.

Dos Amigos Pumping Plant

Dos Amigos Pumping Plant is located on the San Luis Canal, about 10 miles south of the City of Los Banos and 18 miles southeast of Sisk Dam in Merced County. It lifts water 113 feet from the aqueduct as it flows south of O'Neill Forebay.

2.1.2.3 Groundwater Use

Groundwater is a key component of water supplies in the Delta-Mendota Subbasin. To protect the long-term sustainability of groundwater resources, pumping has been significantly reduced in past years, allowing the groundwater subbasin to recover to some extent. During the most recent drought period, groundwater was heavily relied upon throughout the Subbasin for irrigation as surface water deliveries were essentially non-existent for many water users (especially those with junior surface water rights), resulting in increased groundwater pumping.

There are many communities within and neighboring the Northern and Central Delta-Mendota Regions that are reliant, in whole or in part, on groundwater for municipal and domestic water supplies, such as the City of Patterson and the communities of Grayson, Westley, Crows Landing, Santa Nella, and Tranquillity, as well as unincorporated communities within Oro Loma Water District's service area (Figure 2-8). Other unincorporated areas of the Subbasin also rely on groundwater as the sole water supply source. There are several areas of *de minimis* groundwater extractors in the Subbasin, which are defined as a well owner who extracts two acre-feet or less per year from a parcel for domestic purposes (SWRCB, n.d. (f)) (Figure 2-9). Areas with *de minimis* extractors were identified using

Public Land Survey System (PLSS) Sections where available well completion reports indicated that wells other than municipal, irrigation, and industrial wells (i.e. private domestic wells) are present.

Groundwater quality also affects water supply availability in the Subbasin. In general, groundwater in the Subbasin has high levels of total dissolved solids (TDS or salts) in the semiconfined aquifer overlying the Corcoran Clay. In the Patterson area, salt levels are high and could eventually reach concentrations that would require treatment. In response to the elevated salt concentrations and associated taste concerns, many customers have installed salt-regenerative water softeners, which have resulted in significant salt loading to the City's wastewater treatment plant. In addition, the hexavalent chromium in the Patterson area has the potential to impact drinking water supplies (pending passage of a hexavalent chromium-specific drinking water standard). The City has begun installing deeper wells, below the Corcoran Clay, to provide protection from source water contaminants and to provide water with lower salinity concentrations. In 2008, the City approved a non-potable water program that is currently being used to irrigate public and commercial landscaping using the lower quality shallower groundwater, helping to match quality to use and reduce demands on the high quality, potable groundwater supply below the Corcoran Clay. Infrastructure for the non-potable use program is being designed and constructed to also convey recycled water in the future for non-potable use. Los Banos has had to remove one well from service due to uranium concentrations exceeding the Primary Maximum Contaminant Level (MCL). Another well was put on standby in 2010 due to arsenic levels but became active again in 2012.

Figure 2-10 through Figure 2-12 show the density per square mile (PLSS Section) of domestic, production, and public wells in the Delta-Mendota Subbasin as identified by the California Department of Water Resources' (DWR) Well Completion Report Map Application. Domestic wells are defined as individual domestic wells which supply water for the domestic needs of an individual residence or systems of four or less service connections (DWR, 1981). Within the Northern and Central Delta-Mendota Regions, there are an estimated total of 1,426 domestic wells, where the majority of PLSS Sections contain five or fewer domestic wells (261 out of 330 PLSS sections with at least one domestic well) (Figure 2-10). Production well statistics include wells that are designated as irrigation, municipal, public, and industrial on well completion reports, generally indicating wells designed to obtain water from productive zones containing good-quality water (DWR, 1991). There are estimated to be 690 production wells within the Northern and Central Delta-Mendota Regions, where the majority of PLSS Sections contain only one or two production wells (238 out of 333 PLSS sections with at least one production wells) and only three PLSS Sections have seven or eight production wells (Figure 2-11). Public wells are defined as wells that provide water for human consumption to 15 or more connections or regularly serves 25 or more people daily for at least 60 days out of the year (SWRCB, n.d. (g)). Within the Northern and Central Delta-Mendota Regions, there are 37 public wells listed in the DWR database where 19 PLSS Sections have only one public well and nine PLSS Sections have two public wells (28 total PLSS Sections with at least one public well) (Figure 2-12). The status of the wells (e.g. active, abandoned, destroyed) contained in the DWR Well Completion Report Map Application have not been independently confirmed and it should be noted the well quantities are only estimated since not all well completion reports are in the map application and, at times, the well location has been misallocated on the well completion report.

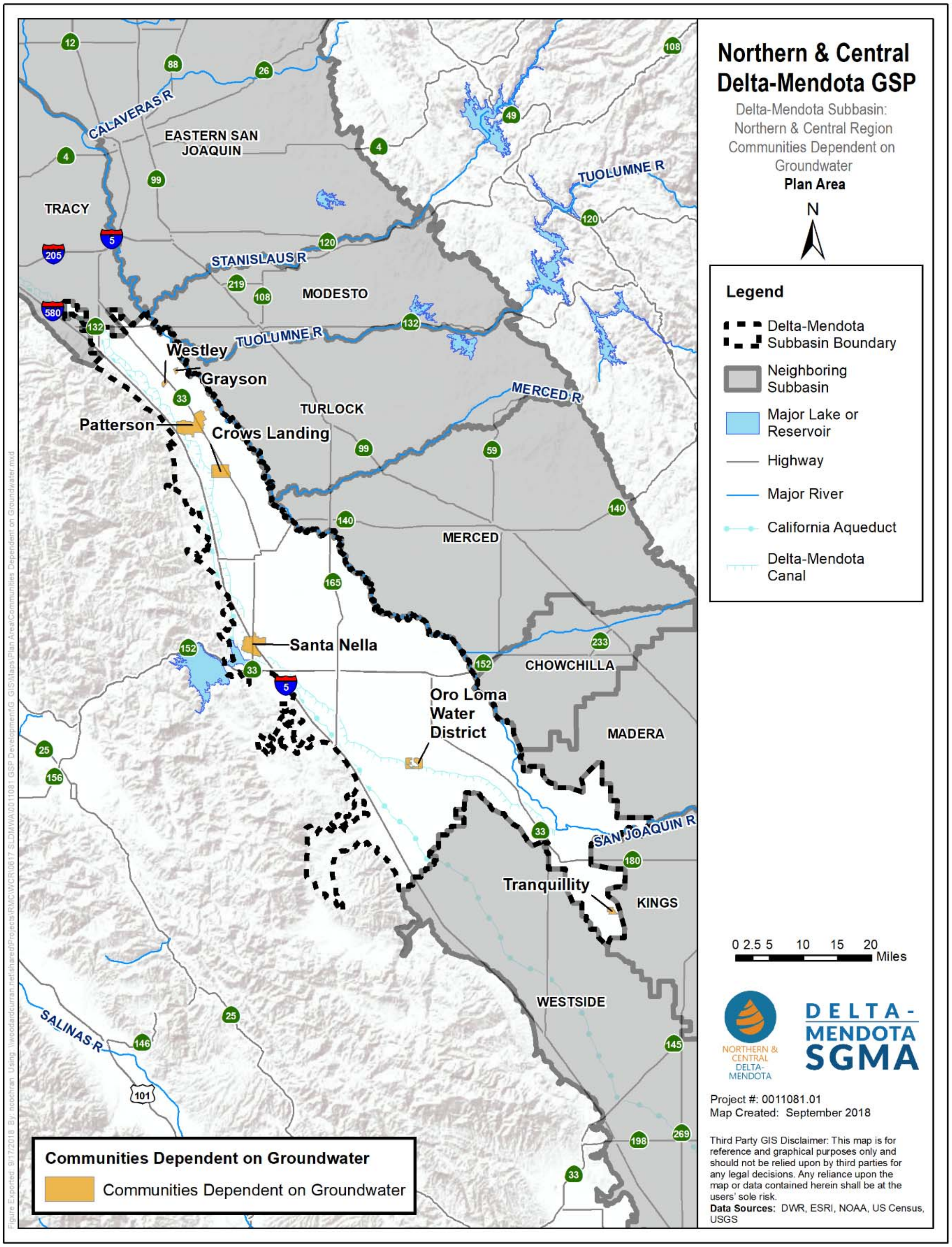


Figure 2-8. Communities Dependent on Groundwater in the Northern and Central Delta-Mendota Regions

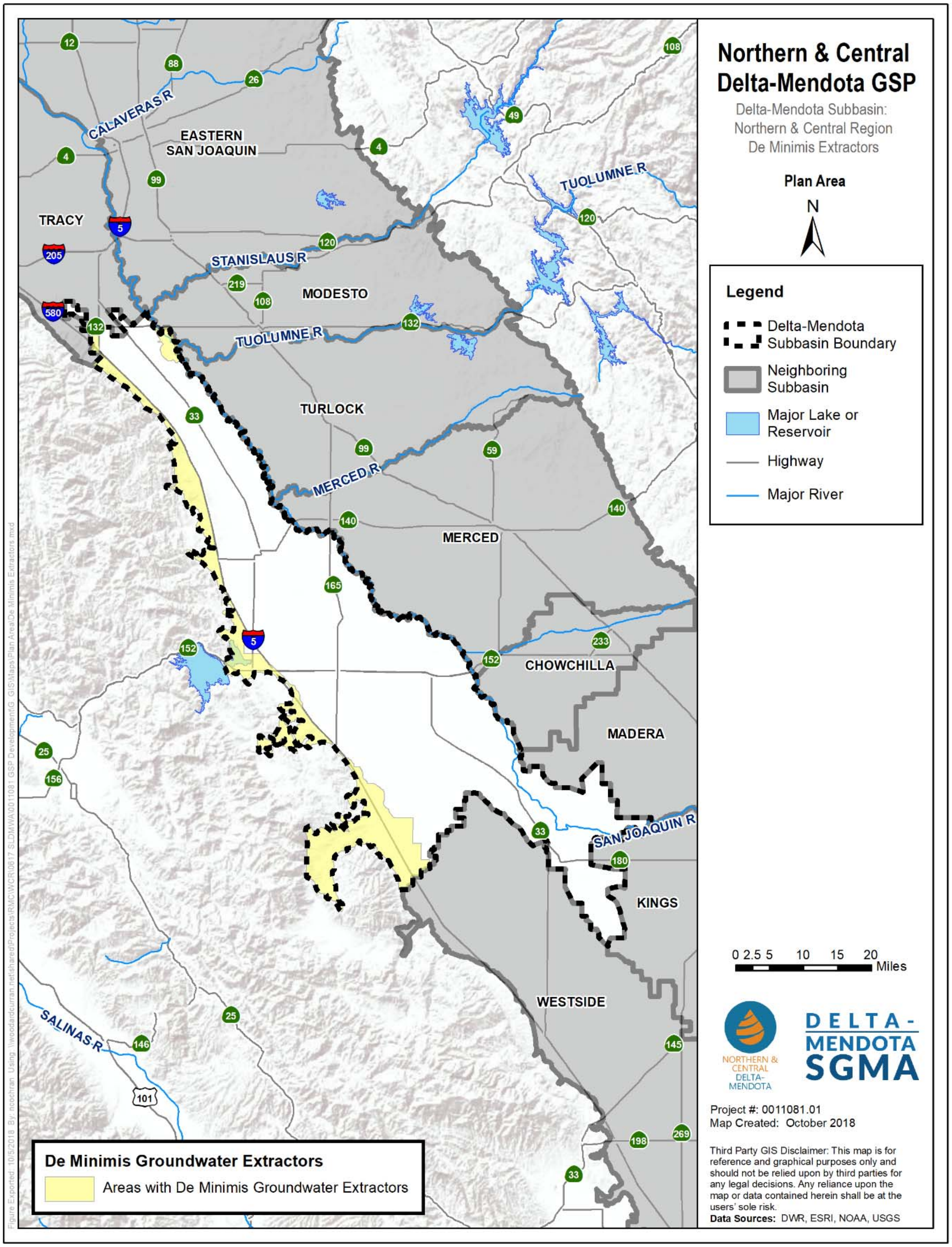


Figure 2-9. De Minimis Groundwater Extractors in the Northern and Central Delta-Mendota Regions

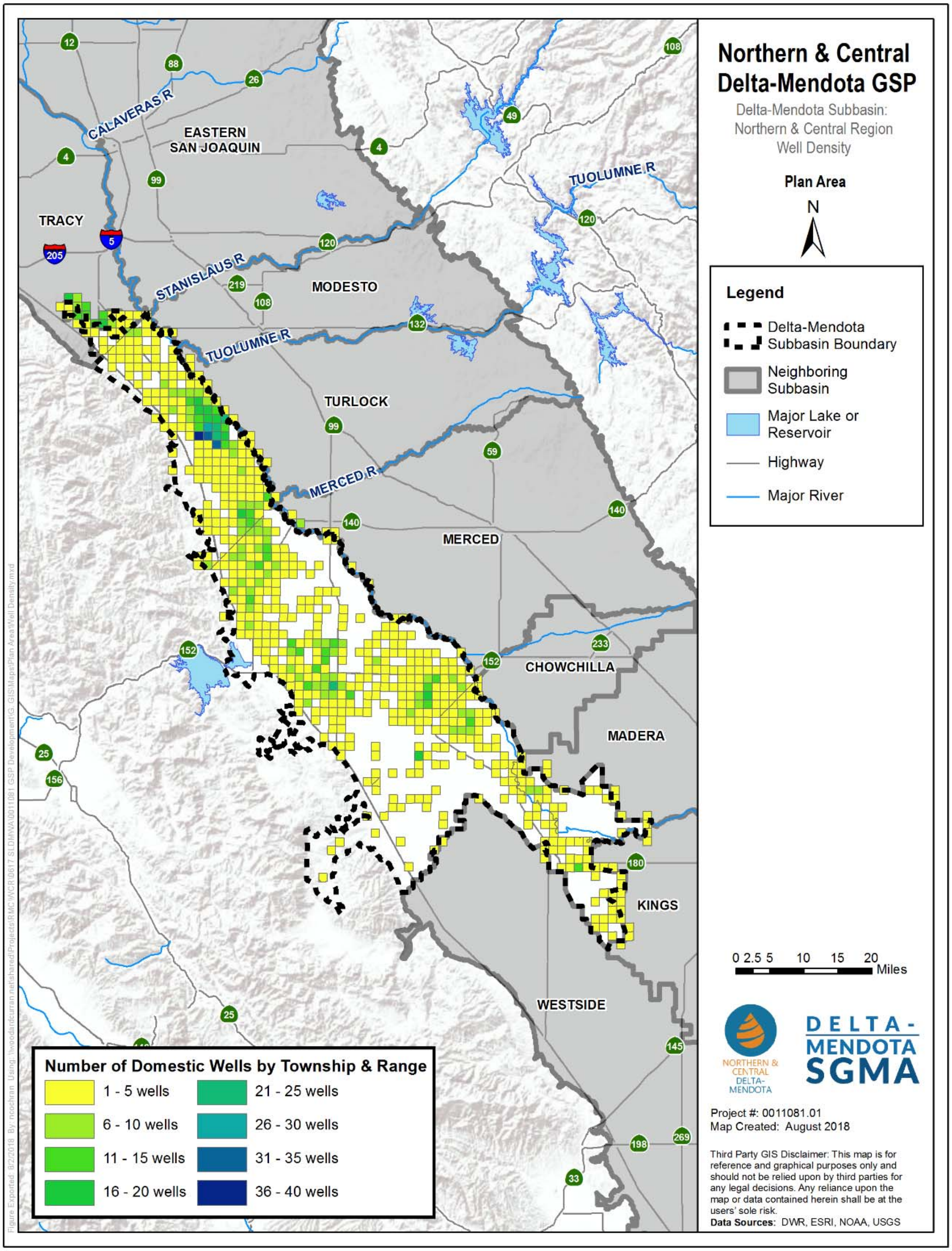


Figure 2-10. Estimated Domestic Well Density in the Delta-Mendota Subbasin

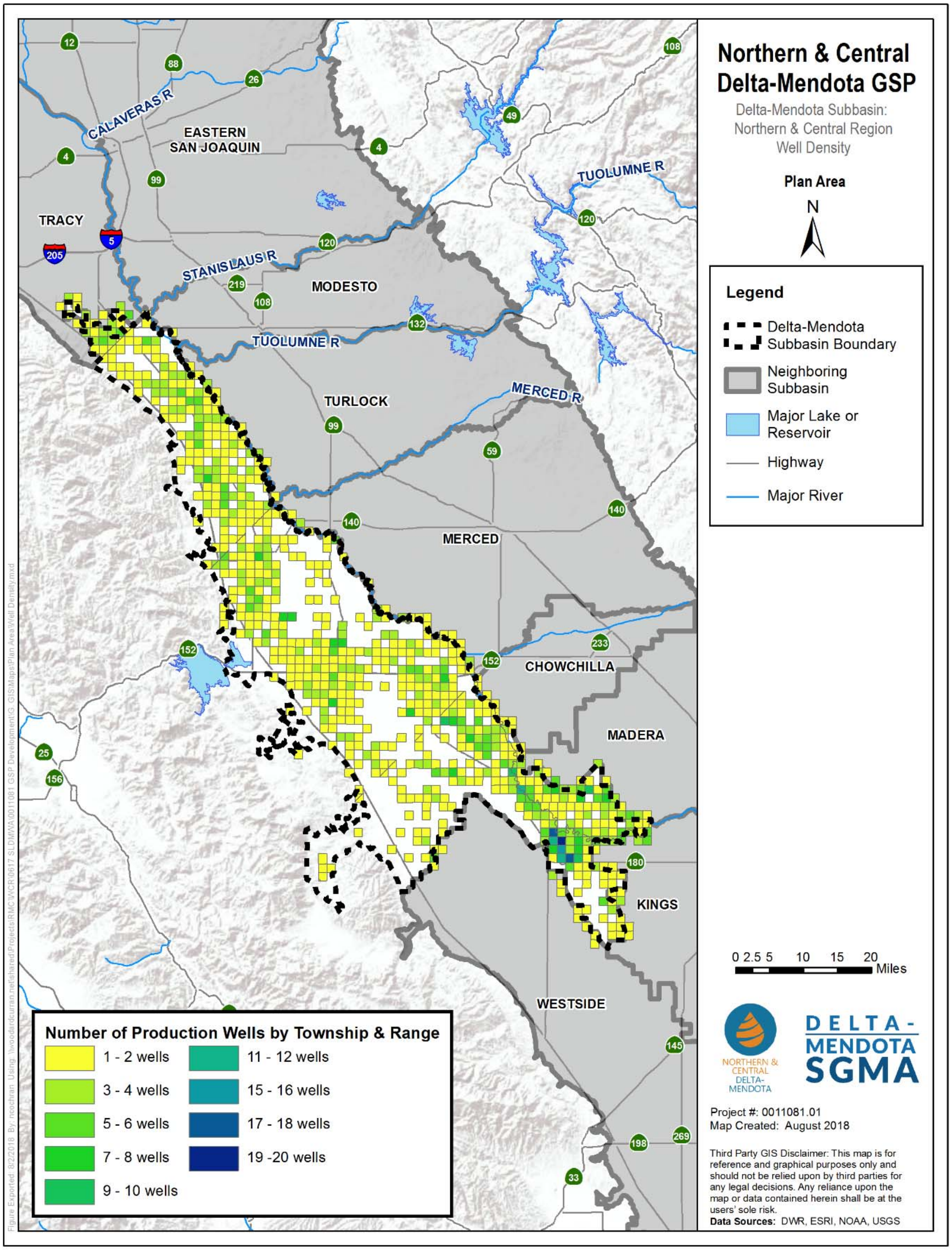


Figure 2-11. Estimated Production Well Density in the Delta-Mendota Subbasin

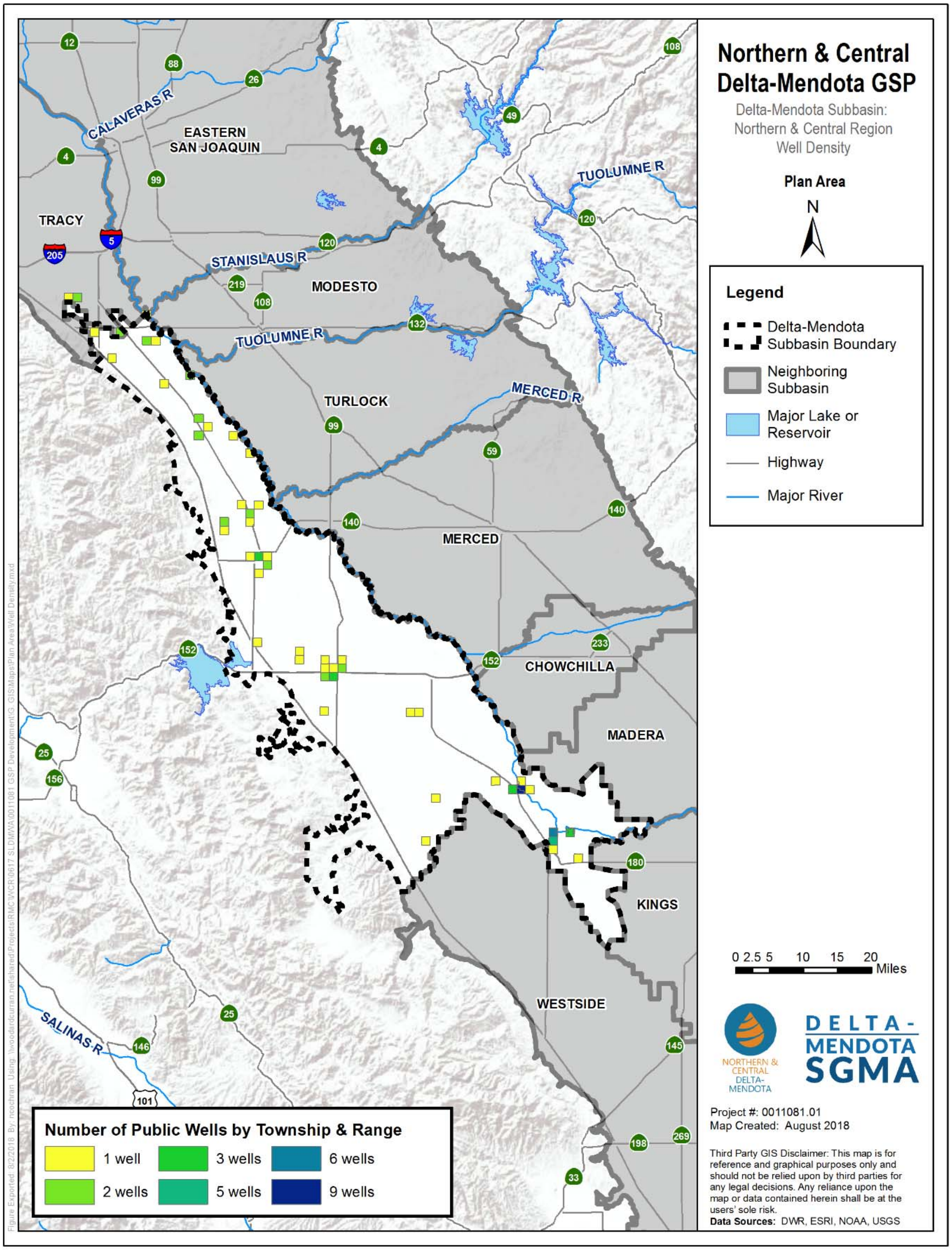


Figure 2-12. Estimated Public Well Density in the Delta-Mendota Subbasin

2.1.2.4 Flood Management

In general, the Delta-Mendota Subbasin slopes toward the San Joaquin River with steeper slopes along the western boundary (near the Coastal Mountain Range), tapering off closer to the San Joaquin River. The flood management system in the San Joaquin Valley includes reservoirs to regulate snowmelt from elevations greater than 5,000 feet, bypasses at lower elevations, and levees that line major rivers.

There has been significant localized flooding in recent years due to severe rain events in 1997/98, 2005/2006 and 2017, where some of the communities adjacent to the San Joaquin River in the Delta-Mendota Subbasin (specifically the communities of Firebaugh, Newman, and Gustine) were flooded and some localized flooding of farmland was caused by runoff impoundment by elevated canal banks. Based on the recent historical events, the primary threat of flooding to urban areas will be for those along (and immediately adjacent to) the San Joaquin River. Areas within the 100-year floodplain within the Northern and Central Delta-Mendota Regions are relatively minimal, as shown in Figure 2-13.

2.1.2.5 Major Land Use Divisions

The Delta-Mendota Subbasin consists mostly of agricultural land use types (Figure 2-14). Typical land uses in the Northern and Central Delta-Mendota Regions are described in the following sections and consist predominantly of the following:

- Grassland and Rangeland
- Agricultural Land
- Deciduous Forest (Riparian)
- Idle and Retired Farmland/Rangeland

The primary land use planning entities in the Northern and Central Delta-Mendota Regions of the Subbasin include the Counties, as well as the City of Patterson and Community of Santa Nella, as shown in Figure 2-15.

<u>Grassland and Rangeland</u>

Grasslands in the Central Valley were originally dominated by native perennial grasses such as needlegrass and alkali sacaton. Currently, grassland vegetation is characterized by a predominance of annual or perennial grasses in an area with few or no trees and shrubs. Annual grasses usually found in grassland vegetation include wild oats, soft chess, ripgut grass, medusa head, wild barley, red brome, and slender fescue. Perennial grasses found in grassland vegetation often include purple needlegrass, Idaho fescue, and California oatgrass. Forbs commonly encountered in grassland vegetation include long-beaked filaree, redstem filaree, dove weed, clovers, Mariposa lilies, popcornflower, and California poppy. Vernal pools found in small depressions with an underlying impermeable layer are isolated wetlands within grassland vegetation.

Most of the grasslands in California are dominated by naturalized annual grasses with perennial grasses existing in relict prairie communities or on sites with soil or water conditions unfavorable for annual grasses, such as on serpentine. Grassland vegetation occurs from sea level to about 3,900 feet in elevation. Grassland communities as a whole have relatively high species diversity when compared to other California plant communities.

Rangeland communities are composed of similar grasses, grass-like plants, forbs, or shrubs which are grazed by livestock. Rangelands are classified into three basic types: shrub and brush rangeland, mixed rangeland, and herbaceous rangeland. The shrub and brush rangeland is dominated by woody vegetation and is typically found in arid and semiarid regions such as the San Luis Unit. Mixed rangelands are ecosystems where more than one-third of the land supports a mixture of herbaceous species and shrub or brush rangeland species. Herbaceous rangelands are dominated by naturally occurring grasses and forbs as well as some areas that have been modified to include grasses and forbs as their principal cover. Rangelands are, by definition, areas where a variety of commercial livestock are actively maintained.

Agricultural Land

General agricultural types occurring in the Northern and Central Delta-Mendota Regions include cropland, pasture, orchards, and vineyards. Management of agricultural lands often includes intensive management, including soil preparation activities, crop rotation, grazing, and the use of chemicals.

Cropland and Pasture

Pastures can consist of both irrigated and unirrigated lands dominated by perennial grasses and various legumes. The composition and height of the vegetation varies with management practices. Most crops grown in the San Joaquin Valley are annual species and are managed with a crop rotation system. During the year, several different crops may be produced on a given parcel of land. Typical crops grown in the Delta-Mendota Subbasin include, tomatoes, sugar beets, melons, grain crops (such as barley, wheat, corn, and oats), rice, cotton, and beans.

Orchards and Vineyards

Orchard and vineyard habitats consist of cultivated fruit or nut-bearing trees or grapevines. Orchards are typically open, single-species, tree-dominated habitats and are planted in a uniform pattern and intensively managed. Understory vegetation is usually sparse. In vineyards, the rows under the vines are often sprayed with herbicides to prevent the growth of herbaceous plants.

Deciduous Forest

Deciduous forests are composed of trees that lose their leaves in the winter. These include species such as the various California oaks, California buckeye, Fremont Cottonwoods, Goodding Willows, and California Sycamores. The interior live oak, which is not deciduous, is also found in deciduous forests. Valley oak woodlands are found in the Sacramento and San Joaquin Valleys and usually occur below elevations of 2,000 feet.

Idle or Retired Farmland/Rangeland

Lands of this category are similar to abandoned farmlands in ruderal (disturbed) areas. Plants on these parcels may consist of either native and/or non-native species.

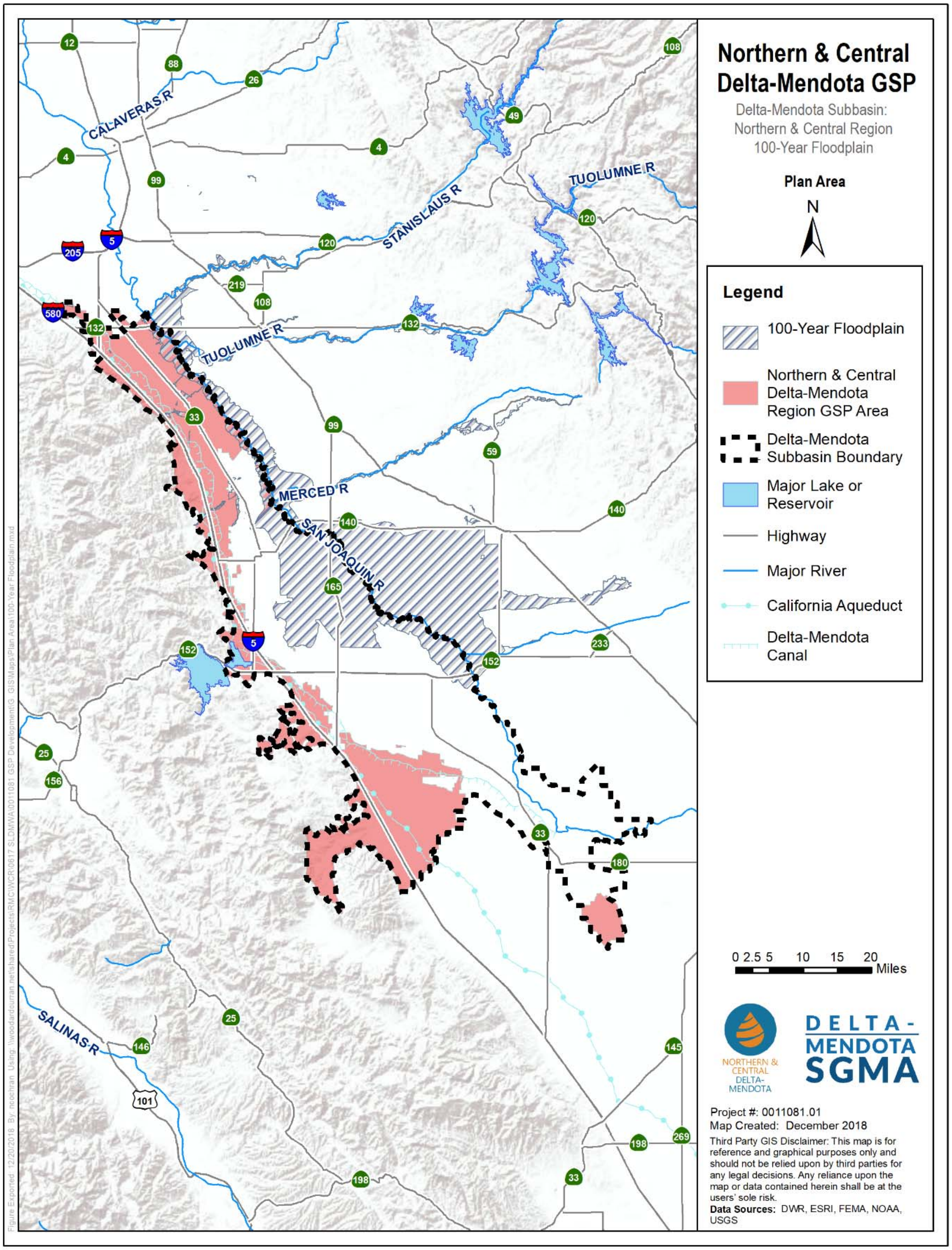


Figure 2-13. 100-Year Floodplain, Delta-Mendota Subbasin

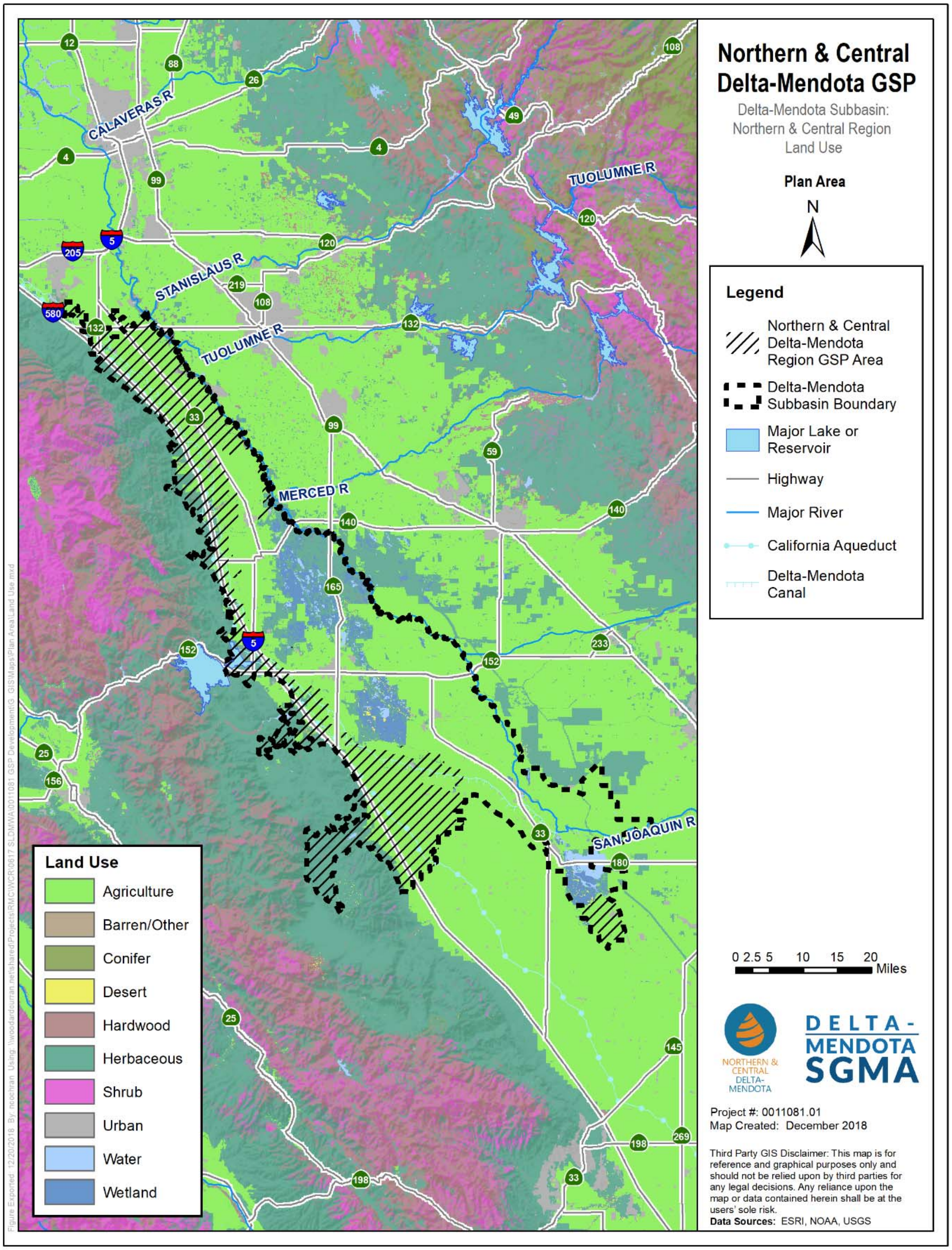


Figure 2-14. Land Cover, Delta-Mendota Subbasin

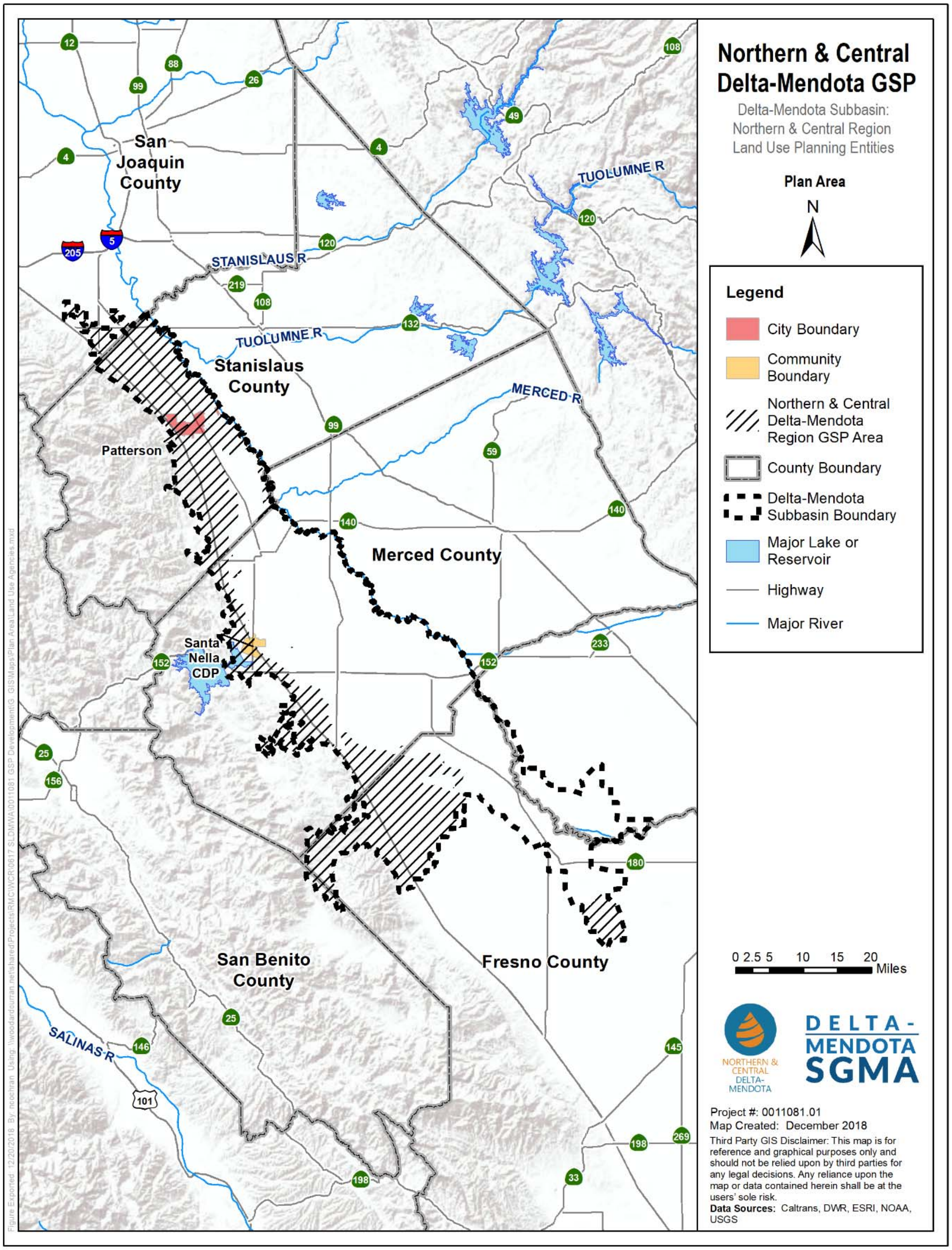


Figure 2-15. Land Use Planning Entities, Northern and Central Delta-Mendota Regions

2.1.2.6 Regional Economic Issues and Trends

The western San Joaquin Valley is a highly agricultural region. There are no large cities or industries in the Subbasin to provide an alternative economic base. The economy of this region is predominately driven by agricultural production and therefore, the availability of CVP agricultural water is an essential element to the economic health of the region. Other uses of CVP water in the Subbasin are used for municipal and industrial (M&I) purposes and wildlife refuge water supply.

Depending on water supply conditions, about 800,000 acres are partially or solely irrigated with CVP water. Other economic base industries include travel on the Interstate-5 (I-5) corridor, some petroleum extraction, and tourism. Wetlands benefit the local economies by attracting hunters, naturalists, and bird-watchers.

M&I water use, which is a small share of total water use in the Subbasin, occurs primarily within the cities. The largest M&I use areas in the Delta-Mendota Subbasin, based on 2015 population estimates from the U.S. Census Bureau, are the cities of Patterson (population 21,498) and Los Banos (population 37,457) (U.S. Census Bureau, 2015).

All communities within the Delta-Mendota Subbasin have economies greatly dependent on agricultural production. These communities include San Joaquin, Tranquillity, Mendota, Firebaugh, Dos Palos, Los Banos, Santa Nella, Newman, Gustine, Crows Landing, Westley, and Vernalis. All of these communities are strongly affected by the reliability of CVP agricultural water. Some of them are dependent upon agricultural water from the CVP for M&I use, and most have experienced dramatic rates of growth and urbanization over the last decade.

Disadvantaged Communities within the Delta-Mendota Subbasin

A disadvantaged community (DAC) is defined as a community with a Median Household Income (MHI) less than 80% of the California statewide MHI. DWR compiled U.S. Census Bureau's American Community Survey (ACS) data from 2012 to 2016; these data were used in Geographic Information System (GIS) software to identify DACs within the Delta-Mendota Subbasin. California's average statewide MHI from 2012 to 2016 is $63,783; thus, a community with an MHI less than or equal to $51,026 is considered a DAC. Based on these criteria, 93% of the geographic area of the Subbasin is considered disadvantaged. Furthermore, a community with an MHI of less than 60% of the California statewide MHI, meaning an MHI of less than or equal to $38,270, is considered a severely disadvantaged community (SDAC). According the U.S. Census ACS 2012-2016 data, there are a number of SDACs throughout the Subbasin. See Figure 2-16 for a map of the DACs and SDACs throughout the Delta-Mendota Subbasin showing a combination of Census Tract, Census Block Group, and Census Place geographies.

As noted above, a significant portion of the Subbasin contains DACs. Of the total population of 117,120 within the Subbasin, 80% of the population lives within a DAC, with 93% of the Subbasin's total geographic area consisting of DACs. Table 2-1 includes the proportion of DACs in the Subbasin based on population and geographic area.

Table 2-1. DACs as a Percentage of the Delta-Mendota Subbasin

Area	Geographic Area (Square Miles)	% Based on Geographic Area	Population	% Based on Population
DAC (including SDAC)	1,109	93%	93,786	80%
Delta-Mendota Subbasin	1,194		117,120	

Table 2-2 includes Census Designated Places that are DACs in the Delta-Mendota Subbasin, with their associated MHIs and percentage of the California MHI from the ACS 5-Year 2012-2016 average. Several DACs in the Subbasin have considerably lower MHI than 80% of the California Statewide MHI and are further designated as SDACs. In Table 2-2, SDACs are indicated in bold text.

Table 2-2. DAC and SDAC Census Designated Places in Delta-Mendota Subbasin

Census Designated Place (CDP)	Median Household Income (MHI)	% of CA MHI
City of Dos Palos	**$36,509**	**57%**
City of Firebaugh	**$36,181**	**57%**
City of Gustine	$37,770	59%
City of Los Banos	$45,751	72%
City of Mendota	**$26,094**	**41%**
City of Newman	$52,783	83%
Crows Landing	**$26,786**	**42%**
Dos Palos Y (CDP)	**$16,656**	**26%**
Grayson	**$29,787**	**47%**
Madera County	$45,490	74%
Merced County	$43,066	70%
Fresno County	$45,963	72%
Santa Nella	**$27,778**	**44%**
South Dos Palos	$41,992	66%
Tranquillity	**$30,441**	**48%**
Volta	$48,250	76%
Westley	**$23,375**	**37%**

Data Source: U.S. Census ACS data from 2012 to 2016 provided by DWR Mapping Tool.

MHI data are from the 2016 Census, and percent of CA MHI is calculated based on the 2012-2016 Statewide MHI. Bold rows indicate severely disadvantaged communities (less than 60% of CA Statewide MHI).

The Delta-Mendota Subbasin is also home to a large Hispanic or Latino population, which is greatly dependent upon production agriculture as a source of employment. At the county level, the percentage of Hispanic population runs from a low of 41.6% in San Joaquin County to a high of 59.6% in Merced County, according to U.S. Census Bureau estimates from 2017 (U.S. Census Bureau, 2017). However, Hispanic populations on the west side of the San Joaquin Valley are usually the majority in a given area and can be much higher percentages of the population. Improving water supply reliability and quality, and otherwise enhancing the conditions for production agriculture in the western San Joaquin Valley, will expand source of employment opportunities for these disadvantaged populations.

Note that according to the U.S. Department of the Interior Indian Affairs, as of January 2017 there are no listed federally recognized tribes within the Region (Mosley, 2017).

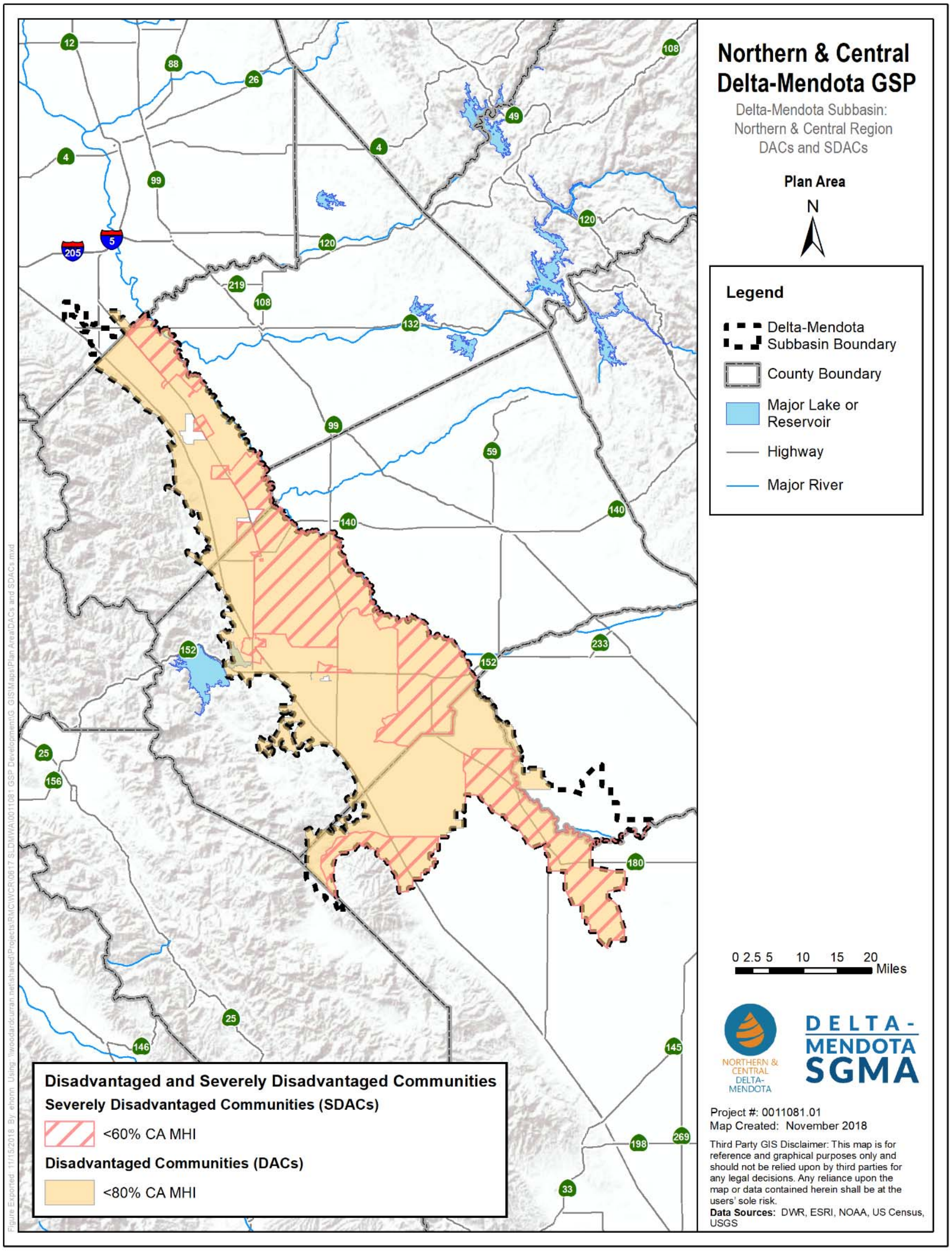


Figure 2-16. Disadvantaged and Severely Disadvantaged Communities in the Delta-Mendota Subbasin

Economically Disadvantaged Areas within the Delta-Mendota Subbasin

An economically distressed area (EDA) is defined by the State of California as a "municipality with a population of 20,000 persons or less, a rural county, or a reasonably isolated and divisible segment of a larger municipality where the segment of the population is 10,000 persons or less, with an annual median household income that is less than 85% of the statewide median household income, and with one or more of the following conditions as determined by the department:

1. Financial hardship
2. Unemployment rate at least two percent higher than the statewide average
3. Low population density (CA Assembly, 2014).

U.S. Census GIS data provided by DWR were used to identify EDAs in the Delta-Mendota Subbasin. Figure 2-17 shows the location of EDAs within the Delta-Mendota Subbasin showing a combination of Census Tract, Census Block Groups, and Census Place geographies.

A significant portion of the Subbasin contains EDAs. Of the total population of 117,120 within the Subbasin, 87% live in areas that meet EDA Criterion 2, 20% live in areas that meet EDA Criterion 3, and 87% live in areas that meet Criteria 2 or 3. In all, 93% of the geographic area within the Subbasin consists of areas considered to meet either EDA Criteria 2 or 3. Table 2-3 includes the proportion of EDAs in Subbasin based on population and geographic area.

Table 2-3. EDAs as a Percentage of the Delta-Mendota Subbasin

Area	Geographic Area (Square Miles)	% Based on Geographic Area	Population	% Based on Population
EDA Criterion 2	1,112	93%	102,407	87%
EDA Criterion 3	1,004	84%	23,688	20%
EDA Criteria 2 or 3	1,112	93%	102,316	87%
Delta-Mendota Subbasin	1,194		117,120	

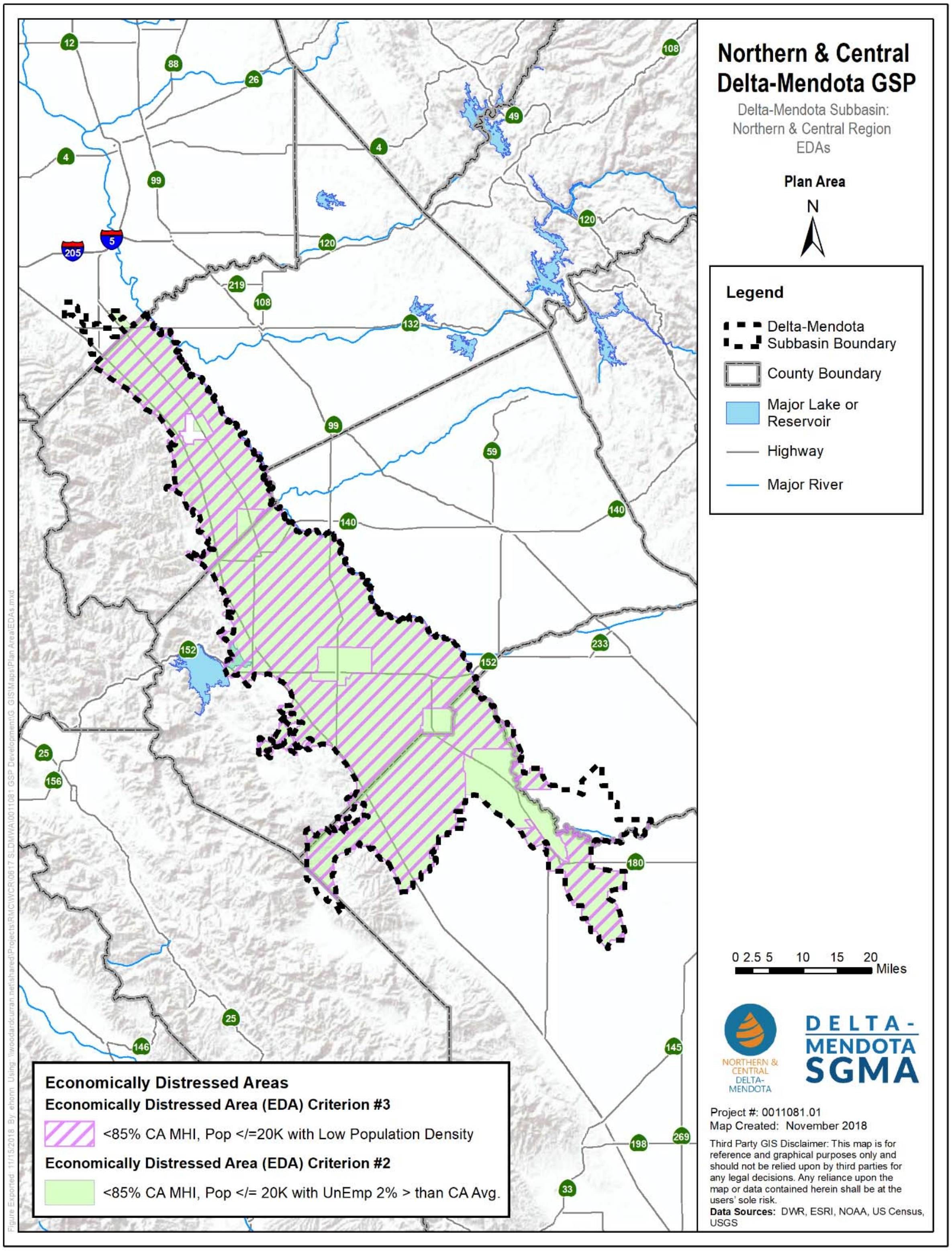


Figure 2-17. Economically Distressed Areas in the Delta-Mendota Subbasin

2.1.3 Plan Area Jurisdictional Boundaries

The Plan area for this GSP consists of the Northern and Central Delta-Mendota Regions, which is formed by the following Groundwater Sustainability Agencies (GSAs) (**Figure 2-18**):

- Central Delta-Mendota GSA
- City of Patterson GSA
- DM-II GSA
- Northwestern Delta-Mendota GSA
- Oro Loma Water District GSA
- Patterson Irrigation District GSA
- West Stanislaus Irrigation District GSA
- Widren Water District GSA

All GSAs within the Northern & Central Delta-Mendota Region GSP Plan area are exclusive Agencies.

The Northern & Central Delta-Mendota Region GSP is one of six GSP areas within the Delta-Mendota Subbasin. Other GSP Regions within the Subbasin include the following GSAs (**Figure 2-19**):

- San Joaquin River Exchange Contractors GSP Region (City of Dos Palos GSA, City of Firebaugh GSA, City of Gustine GSA, City of Los Banos GSA, City of Mendota GSA, City of Newman GSA, Portion of Merced County – Delta-Mendota GSA, Turner Island Water District – 2 GSA, County of Madera – 3 GSA, Portion of Fresno County Management Area B GSA, and San Joaquin River Exchange Contractors Water Authority GSA)
- Aliso Water District GSP Region (Aliso Water District GSA)
- Farmers Water District GSP Region (Farmers Water District GSA)
- Grassland Water District GSP (Grassland Water District GSA and Portion of Merced County – Delta-Mendota GSA)
- Fresno County Management Areas A and B GSP Region (Fresno Management Area A GSA and Fresno Management Area B GSA)

There are no adjudicated areas or areas covered by an Alternative Plan within the Delta-Mendota Subbasin.

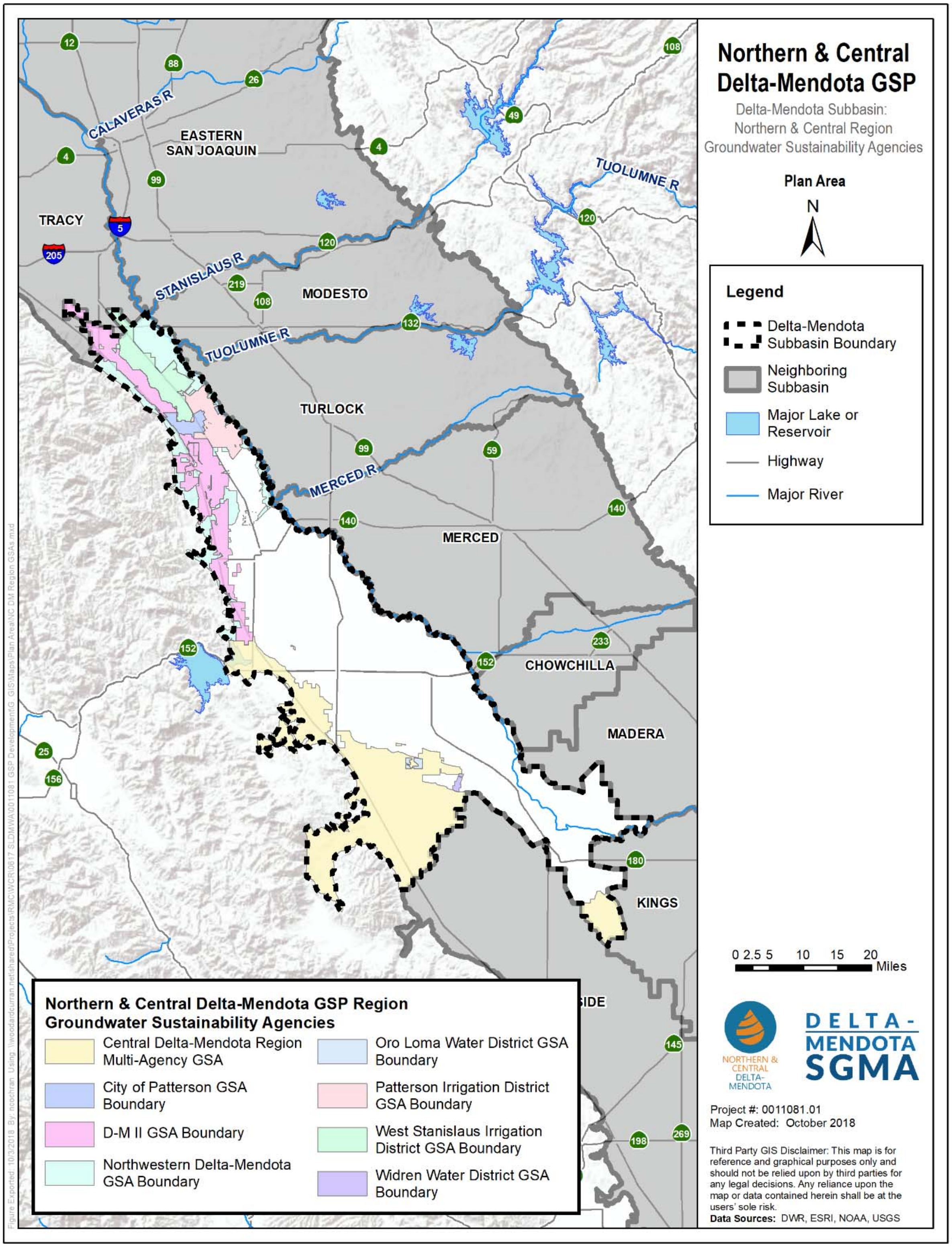


Figure 2-18. Northern & Central Delta-Mendota Region GSP GSAs

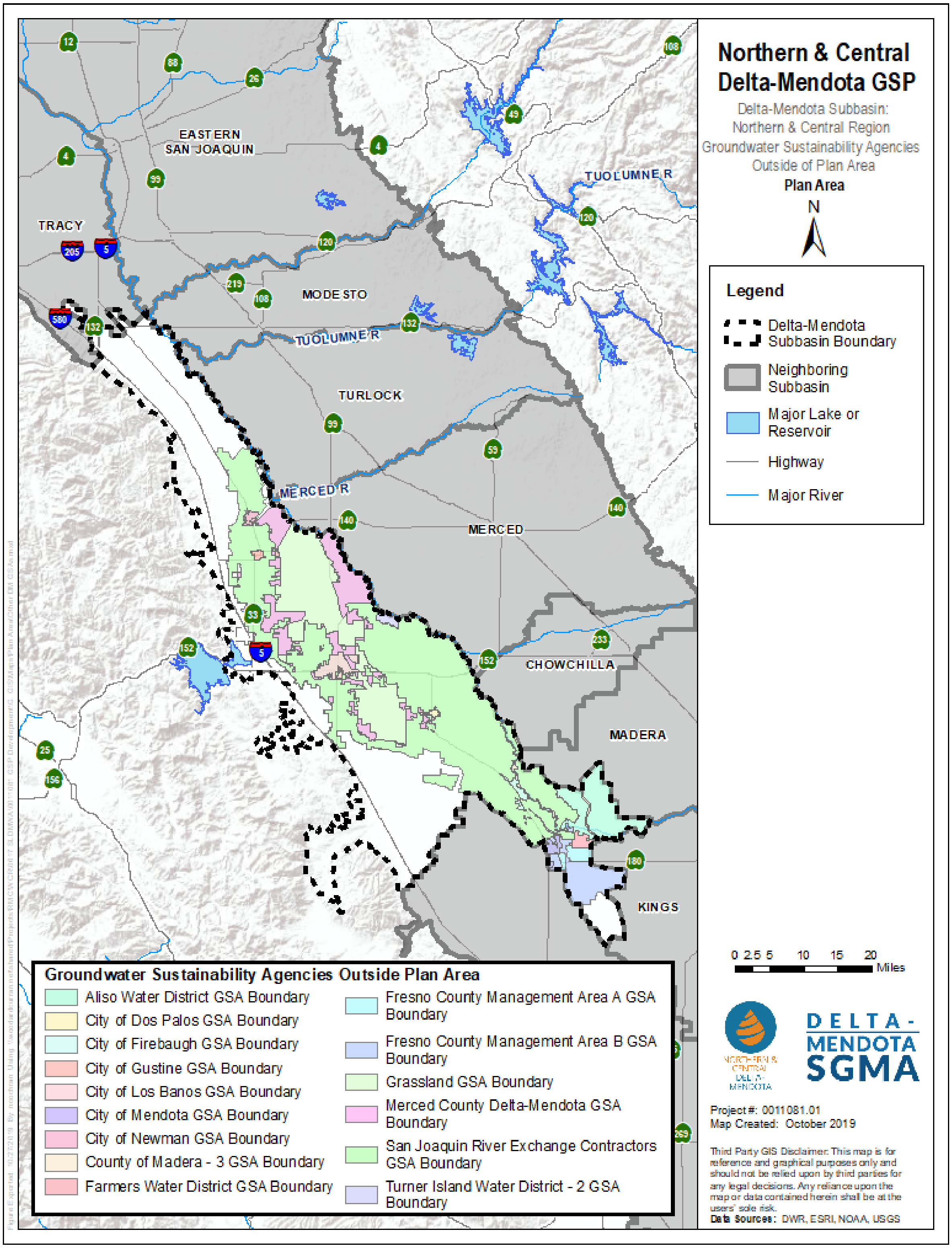


Figure 2-19. Other GSAs in the Delta-Mendota Subbasin

Table 2-4 and Table 2-5 summarizes the jurisdictional areas within the Northern and Central Delta-Mendota Regions, respectively. These include counties, cities, water districts, irrigation districts, mutual water companies, and federal and state agencies. There are no federal- or state-recognized tribal communities in the Subbasin. The jurisdictional areas of these entities are shown on Figure 2-20 through Figure 2-22.

In general, all municipal, water/irrigation districts and counties within the Northern and Central Delta-Mendota Regions are participating in GSP development either as a separate GSA or as members of a GSA. The California Department of Fish and Wildlife boundaries and the U.S. Fish and Wildlife Service boundaries overlay the wildlife refuges and areas and state parks within the Northern and Central Delta-Mendota Regions. The California Department of Water Resources manages the State Water Project and the California Aqueduct, and the U.S. Bureau of Reclamation, through the San Luis & Delta-Mendota Water Authority, manages the Delta-Mendota Canal. The California Department of Transportation (Caltrans) is responsible for managing the State and Interstate highways in the Region, including Interstate- (I-) 5, and State Highways 132, 33, 140, and 165.

Table 2-4. Jurisdictional Areas in the Northern Delta-Mendota Region

	Jurisdictional Area
Northern Delta-Mendota Region	Del Puerto Water District
	Oak Flat Water District
	City of Patterson
	Patterson Irrigation District
	Twin Oaks Irrigation District
	West Stanislaus Irrigation District
	City of Grayson
	Westley Community Services District
	San Joaquin County
	Stanislaus County
	Merced County
	Crows Landing Community Services District
	Blewett Mutual Water Company
	El Solyo Water District
	Eastin Water District
	White Lakes Mutual Water Company
	Stevinson Water District
	San Luis & Delta-Mendota Water Authority
	California Department of Fish and Wildlife
	California Department of Water Resources
	California Department of Transportation
	U.S. Fish and Wildlife Services
	U.S. Bureau of Reclamation

Table 2-5. Jurisdictional Areas in the Central Delta-Mendota Region

	Jurisdictional Area
Central Delta-Mendota Region	Eagle Field Water District Fresno County Fresno Slough Water District Merced County Mercy Springs Water District Oro Loma Water District Pacheco Water District Panoche Water District San Benito County San Luis Water District Santa Nella County Water District Tranquillity Irrigation District Widren Water District San Luis & Delta-Mendota Water Authority California Department of Fish and Wildlife California Department of Water Resources California Department of Transportation U.S. Fish and Wildlife Service U.S. Bureau of Reclamation

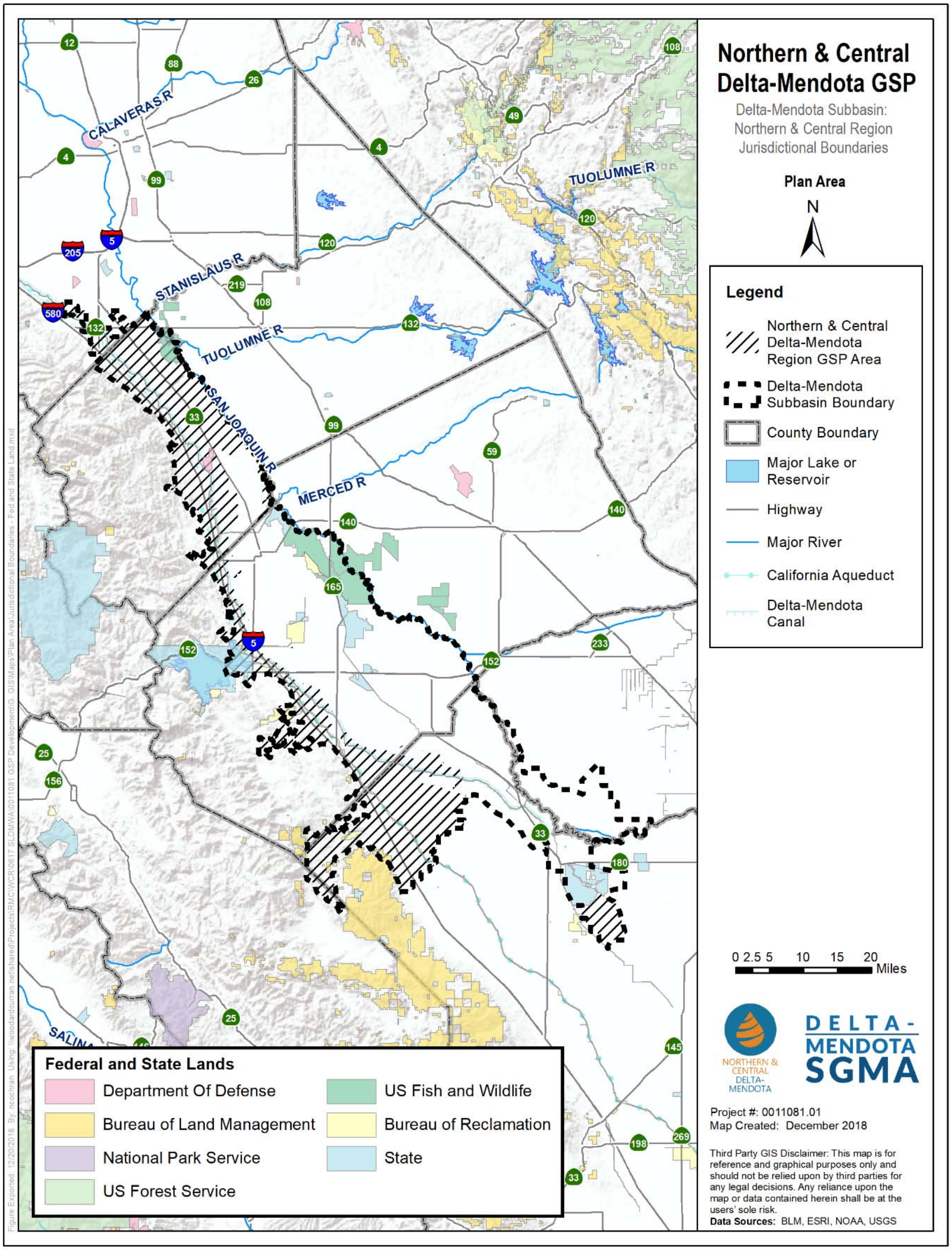


Figure 2-20. Federal and State Lands in the Northern and Central Delta-Mendota Regions

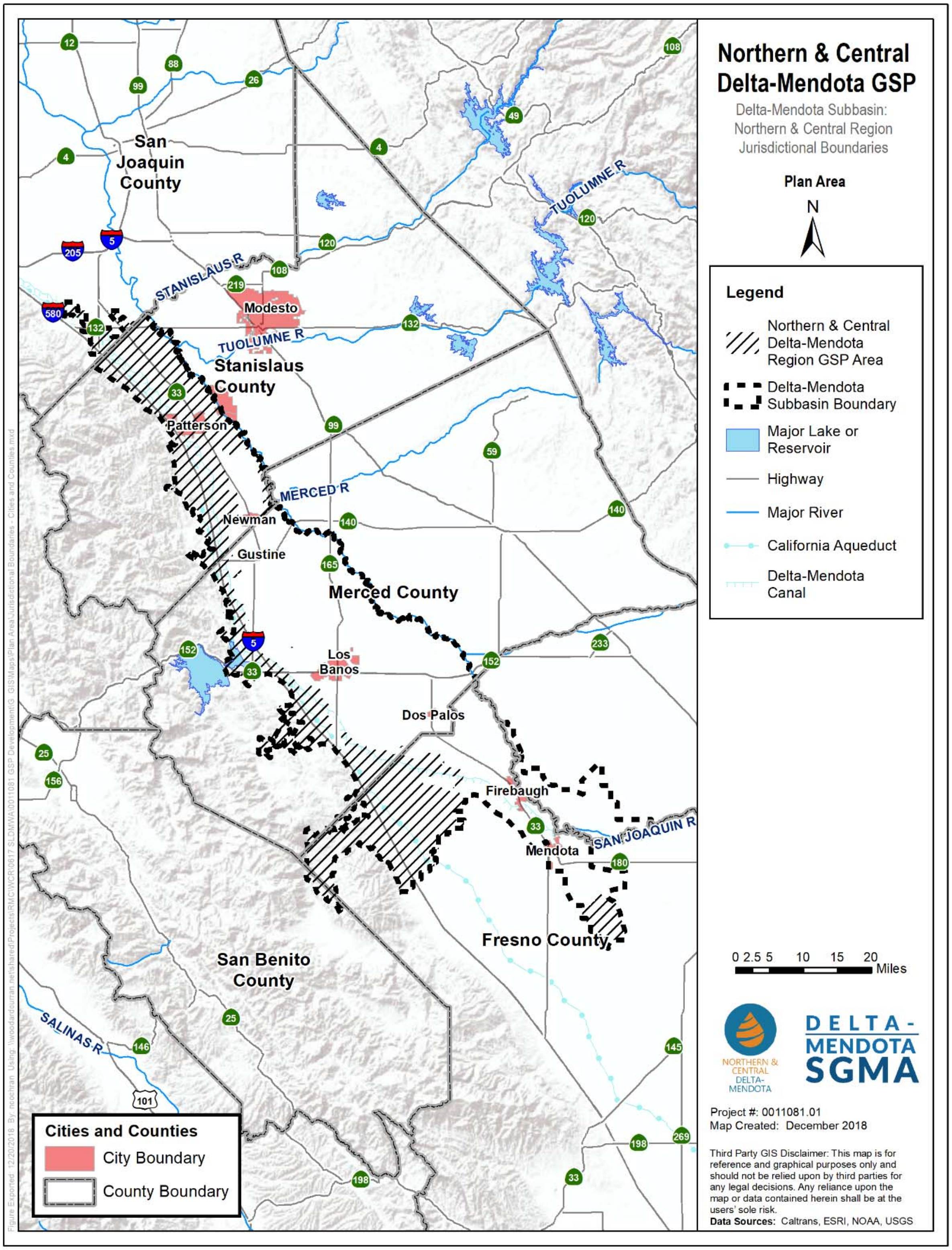


Figure 2-21. Cities and Counties in the Northern and Central Delta-Mendota Regions

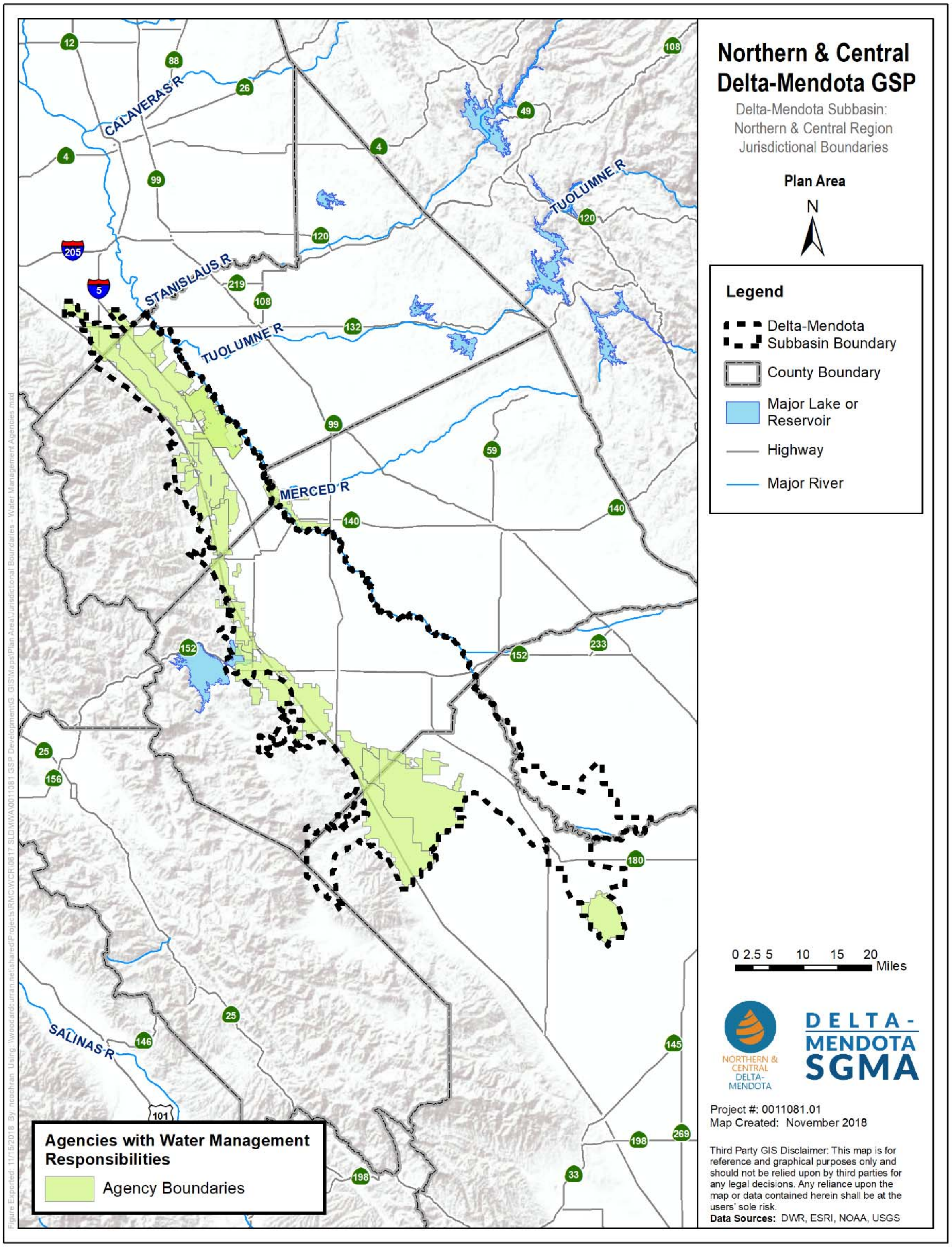


Figure 2-22. Agencies with Water Management Responsibilities in the Northern and Central Delta-Mendota Regions

2.2 LAND USE ELEMENTS

Land use in the Northern and Central Delta-Mendota Regions is predominantly agricultural with areas of municipal, industrial and commercial use. Predominant crops grown in the Regions include rice, grain and hay crops, nut and fruit trees, truck nursery crops, berries, and field crops. Figure 2-23 shows the distribution of different land use types across the Delta-Mendota Subbasin, while

Table 2-6 summarizes the respective acreage of land use in the Northern and Central Delta-Mendota Regions by land use type.

Figure 2-24 shows land use by water source in the Northern and Central Delta-Mendota Regions. Conjunctive use of surface water and groundwater is practiced throughout much of the Northern and Central Delta-Mendota Regions. Urban centers, such as the City of Patterson, and most unincorporated county areas rely solely on groundwater for their water supplies. Oak Flat Water District receives water from the SWP and meets remaining demand with groundwater. Twin Oaks Irrigation District, El Solyo Water District, Patterson Irrigation District, and West Stanislaus Irrigation District all hold water rights to divert from the San Joaquin River, with additional demand met by groundwater. Additionally, the San Joaquin National Wildlife Refuge, which straddles the San Joaquin River in Stanislaus County practices conjunctive use, where groundwater is relied upon when surface water is not available. However, for this refuge, all of the wells and water deliveries are on the east side of the San Joaquin River (in the Modesto Subbasin), except for agricultural tailwater deliveries which is entirely on the west side of the river (in the Delta-Mendota Subbasin). The following entities in the Northern and Central Delta-Mendota Regions receive water from the CVP and use groundwater as a supplemental source: Del Puerto Water District, Patterson Irrigation District, Eagle Field Water District, Fresno Slough Water District, Mercy Springs Water District, Oro Loma Water District, Pacheco Water District, Panoche Water District, San Luis Water District, West Stanislaus Irrigation District, and Tranquillity Irrigation District.

Agriculture is the predominant water use sector throughout the Northern and Central Delta-Mendota Regions (Figure 2-25). Urban water uses are mostly concentrated within and surrounding the City of Patterson. Non-irrigated land includes any idle or native riparian land classifications, which are scattered throughout the Regions.

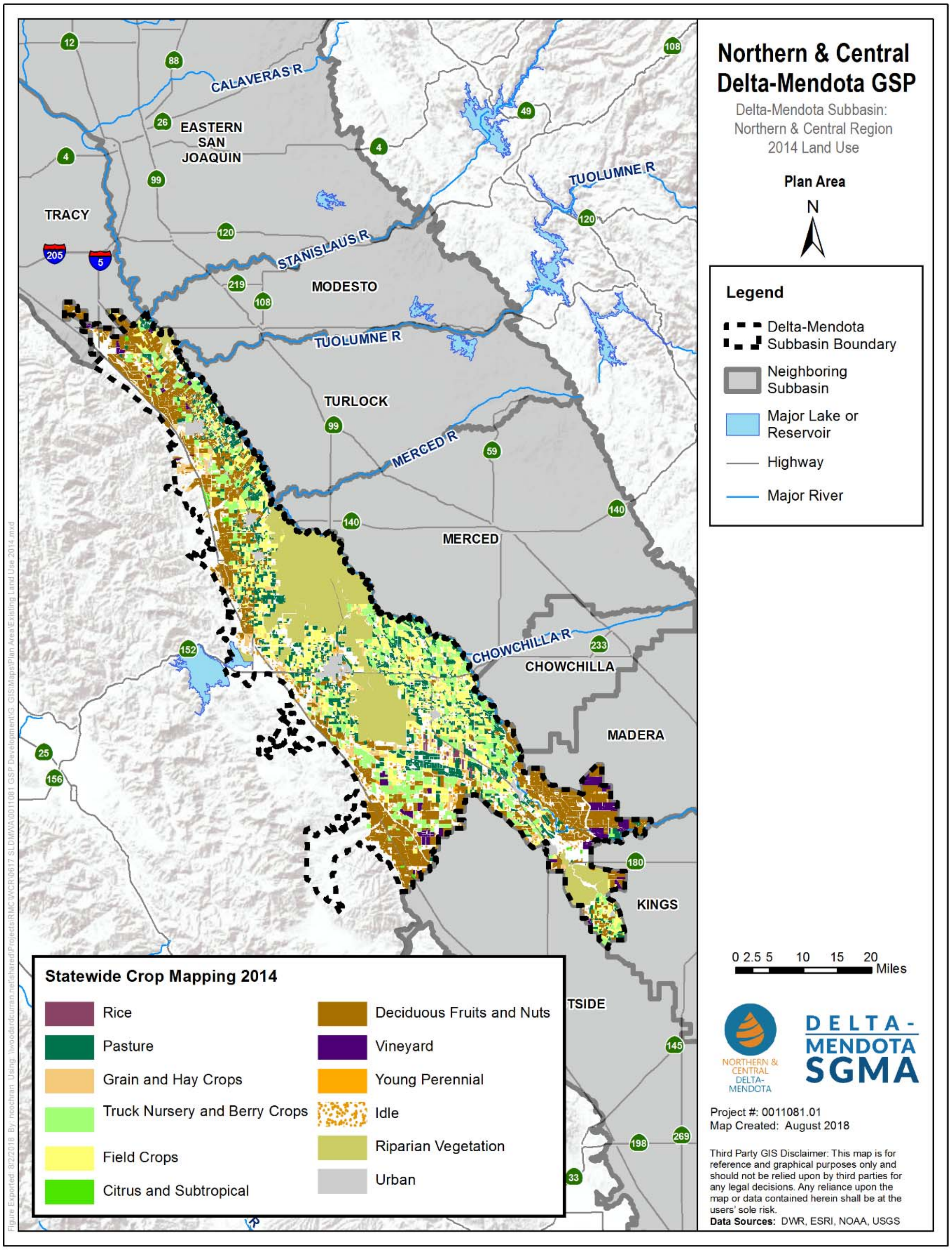


Figure 2-23. Existing Land Use Designations in the Delta-Mendota Subbasin

Table 2-6. 2014 State Crop Mapping Acreage by Crop Category
Northern and Central Delta-Mendota Regions

Statewide Crop Mapping Category	Acres
Citrus and Subtropical	1,089
Deciduous Fruit and Nuts	83,506
Field Crops	18,699
Grain and Hay Crops	10,471
Idle	34,022
Native Riparian	11,299
Pasture	18,911
Truck Nursery and Berry Crops	27,729
Urban	4,279
Vineyard	5,676
Young Perennial	677
Total Acreage	216,360

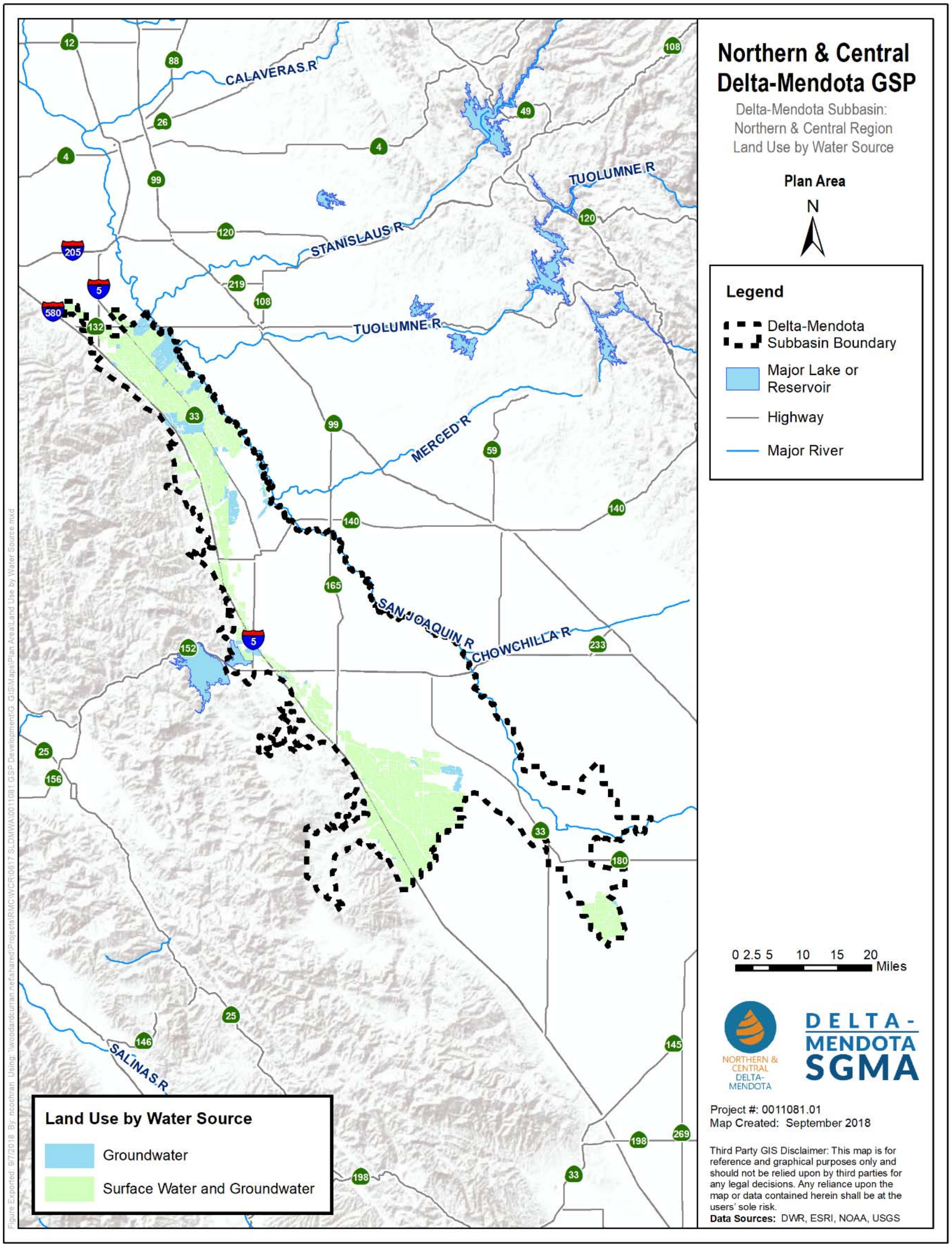


Figure 2-24. Land Use by Water Source in the Northern and Central Delta-Mendota Regions

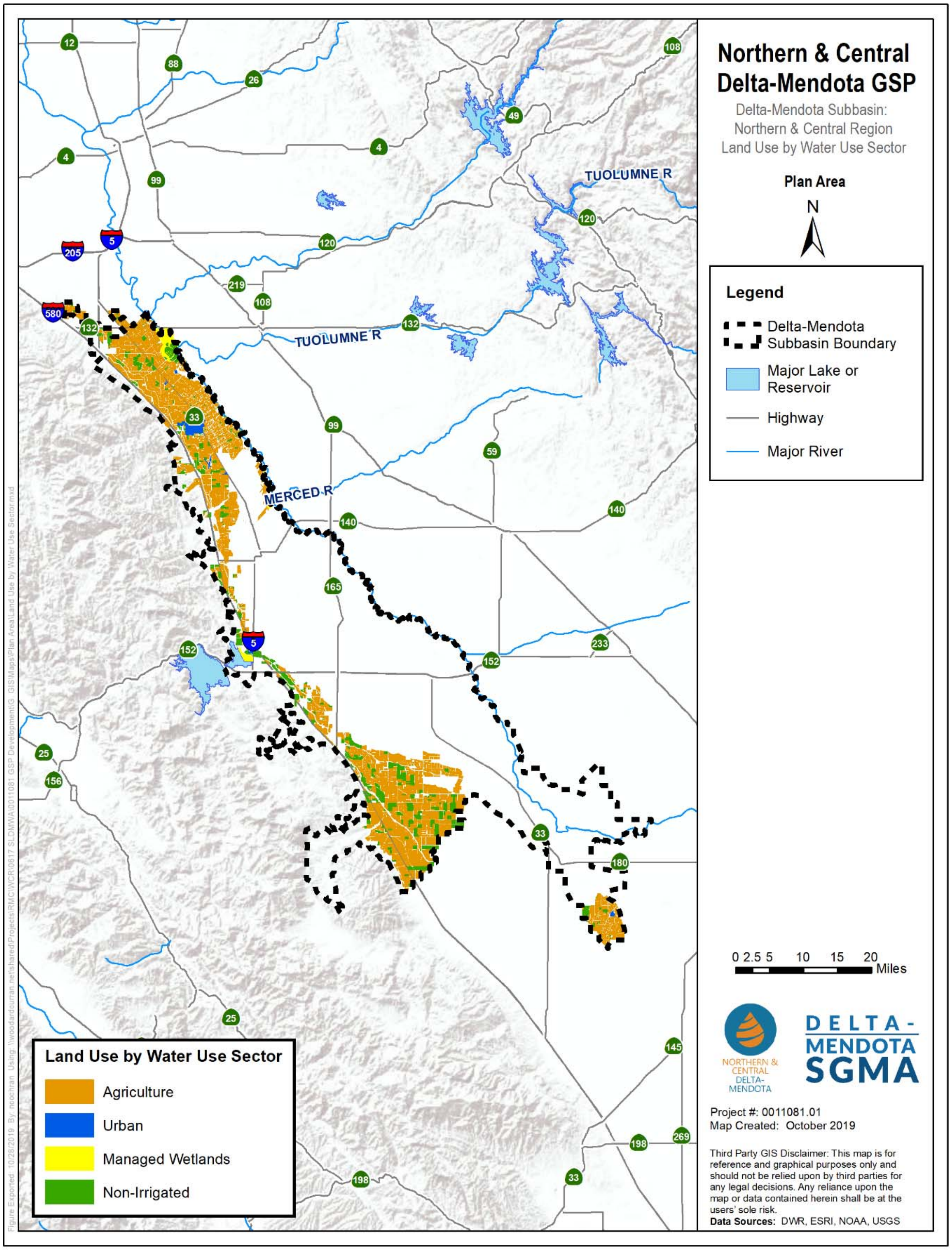


Figure 2-25. Land Use by Water Use Sector in the Northern and Central Delta-Mendota Regions

2.2.1 General Plans in Plan Area

Ten General Plans or Community Specific Plans overlie the Northern and Central Delta-Mendota Regions. These include:

- Fresno County General Plan
- Merced County General Plan
- San Benito County General Plan
- San Joaquin County General Plan
- Stanislaus County General Plan
- City of Patterson General Plan
- Santa Nella Community Specific Plan
- City of Modesto Urban Area General Plan (incorporating the Grayson Area)
- Crows Landing Community Plan
- Westley Community Plan

Figure 2-26, below, shows the locations of relevant plans and communities. The following section describes the General Plan policies and objectives relevant to water resources management in the Northern and Central Delta-Mendota Regions.

This section satisfies §354.8(f) of the GSP Emergency Regulations under SGMA.

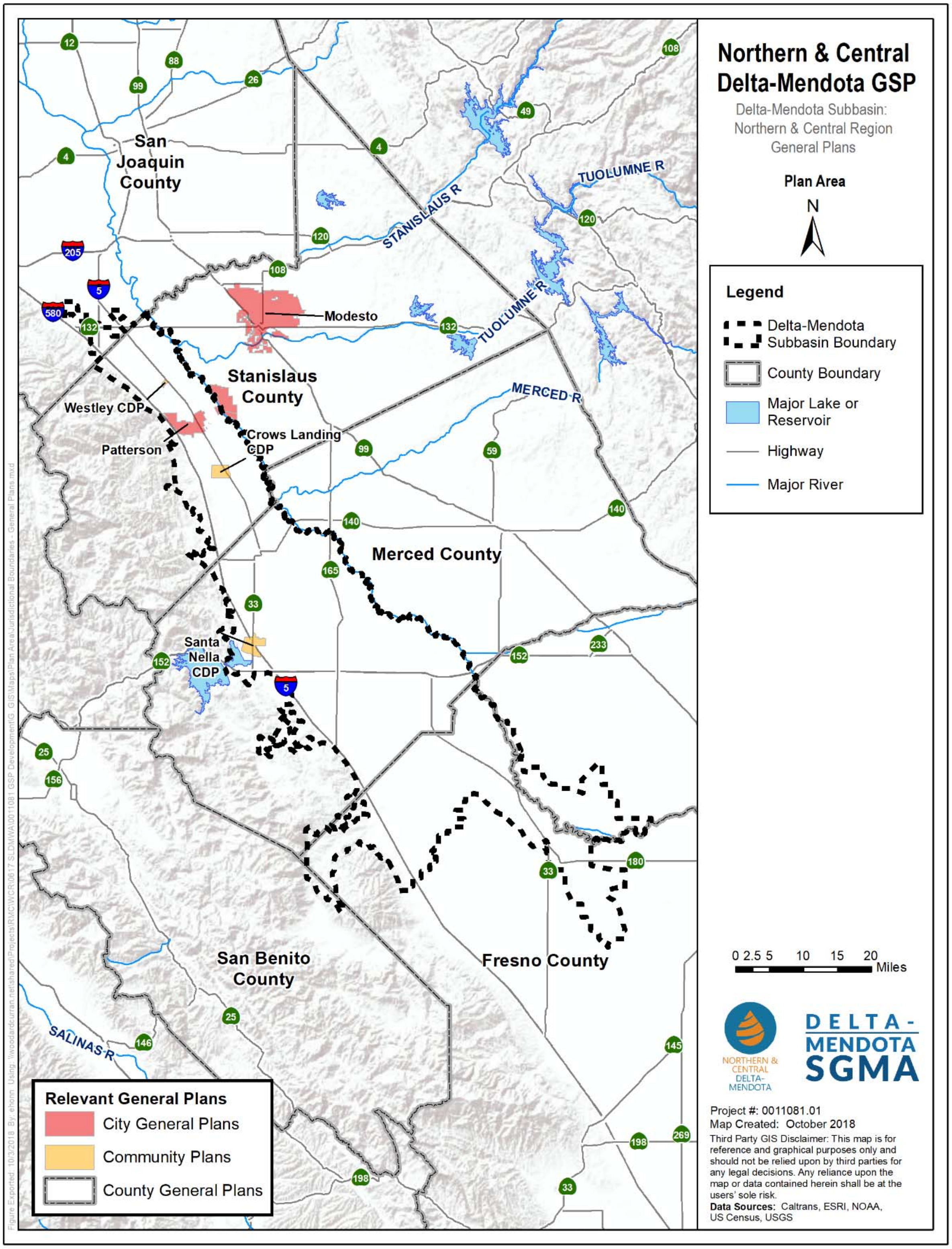


Figure 2-26. Relevant General Plans in the Northern and Central Delta-Mendota Regions

2.2.1.1 Fresno County General Plan

The Fresno County General Plan is a comprehensive, long-term framework for the protection of the County's agricultural, natural, and cultural resources and for development in the County. Designed to meet State general plan requirements, it outlines policies, standards, and programs and sets out plan proposals to guide day-to-day decisions concerning Fresno County's future.

The following policies from each relevant Element may potentially influence implementation of the GSP or be influenced by GSP implementation.

Economic Development Element

- Policy ED-A.19: The County shall actively develop, adopt, and implement measures to ensure an adequate water supply for municipal and industrial use and agricultural production. The County shall explore and implement where feasible innovative new arrangements for providing additional water. (See Section PF- C, Water Supply and Delivery).

Health and Safety Element

- Policy HS-C.6: The County shall promote flood control measures that maintain natural conditions within the 100-year floodplain of rivers and streams and, to the extent possible, combine flood control, recreation, water quality, and open space functions. Existing irrigation canals shall be used to the extent possible to remove excess storm water. Retention-recharge basins should be located to best utilize natural drainage patterns.
- Policy HS-F.4: For redevelopment or infill projects or where past site uses suggest environmental impairment, the County shall require that an investigation be performed to identify the potential for soil or groundwater contamination. In the event soil or groundwater contamination is identified or could be encountered during site development, the County shall require a plan that identifies potential risks and actions to mitigate those risks prior to, during, and after construction.
- Policy HS-F.6: The County shall work cooperatively with the State Department of Toxic Substances Control and Regional Water Quality Control Board to promote the timely and efficient cleanup of contaminated sites under the regulatory oversight of these agencies.

Land Use Element

- Policy LU-A.20: The County shall adopt and support policies and programs that seek to protect and enhance surface water and groundwater resources critical to agriculture.
- Policy LU-E.8: The County shall not allow further parcelization of uncommitted Rural Residential areas lying northeast of the Enterprise Canal due to potential groundwater supply problems. These areas shall be zoned to a Limited Agricultural Zone District. However, rezoning and development for Rural Residential use may be permitted.
- Policy LU-E.10: The County shall require new subdivisions within areas designated Rural Residential be designed to utilize individual on-site sewer and water systems.
- Policy LU-E.11: The County shall require subdividers of rural residential lots to install, provide, or participate in an effective means for utilization of available surface water entitlements for the area included in the subdivision.
- Policy LU-E.23: The County may approve land divisions in areas designated Rural Settlement Area when community water facilities are available and soils are suitable for individual septic systems.
- Policy LU-E.27: The County shall allow development within the designated Quail Lakes Planned Rural Community to proceed in accordance with the Specific Plan adopted at the time the designation was granted by the County. The County may grant amendments to the Specific Plan provided the overall density of development is not increased and the plan continues to demonstrate the development will have no significant adverse impacts on groundwater.

- Policy LU-F.21: The County shall require community sewer and water services for urban residential development in accordance with the Fresno County Ordinance Code or as determined by the State Water Quality Control Board.
- Policy LU-F.23: The County shall require community sewer and water services for commercial development in accordance with the provisions of the Fresno County Ordinance Code, or as determined by the State Water Quality Control Board.
- Policy LU-F.30: The County shall generally require community sewer and water services for industrial development. Such services shall be provided in accordance with the provisions of the Fresno County Ordinance, or as determined by the State Water Quality Control Board.
- Policy LU-H.8: The County shall prepare a regional plan for the Friant-Millerton area. The new regional plan shall at a minimum address the key issues including groundwater and surface water availability.

Open Space and Conservation Element

- Policy OS-A.1: The County shall develop, implement, and maintain a plan for achieving water resource sustainability, including a strategy to address overdraft and the needs of anticipated growth.
- Policy OS-A.2: The County shall provide active leadership in the regional coordination of water resource management efforts affecting Fresno County and shall continue to monitor and participate in, as appropriate, regional activities affecting water resources, groundwater, and water quality.
- Policy OS-A.3: The County shall provide active leadership in efforts to protect, enhance, monitor, and manage groundwater resources within its boundaries.
- Policy OS-A.4: The County shall update, implement, and maintain its Groundwater Management Plan.
- Policy OS-A.5: The Fresno County Water Advisory Committee shall provide advice to the Board of Supervisors on water resource management issues.
- Policy OS-A.6: The County shall support efforts to create additional water storage that benefits Fresno County, and is economically, environmentally, and technically feasible.
- Policy OS-A.7: The County shall develop a repository for the collection of County water resource information and shall establish and maintain a centralized water resource database. The database shall incorporate surface and groundwater data and provide for the public dissemination of water resource information.
- Policy OS-A.8: The County shall develop and maintain a water budget (i.e., an accounting of all inflows and outflows of water into a specified area) for the County to aid in the determination of existing and future water resource needs. The water budget shall be incorporated into the County GIS and included in the water resource database.
- Policy OS-A.9: The County shall develop, implement, and maintain a program for monitoring groundwater quantity and quality within its boundaries. The results of the program shall be reported annually and shall be included in the water resource database.
- Policy OS-A.10: The County shall develop and maintain an inventory of sites within the county that are suitable for groundwater recharge. The sites shall be incorporated into the County GIS and included in the water resource database.
- Policy OS-A.12: The County shall promote preservation and enhancement of water quality by encouraging landowners to follow the "Fresno County Voluntary Rangeland and Foothill Water Quality Guidelines."
- Policy OS-A.13: The County shall encourage, where economically, environmentally, and technically feasible, efforts aimed at directly or indirectly recharging the County's groundwater.
- Policy OS-A.14: The County shall support and/or engage in water banking (i.e., recharge and subsequent extraction for direct and/or indirect use on lands away from the recharge area).
- Policy OS-A.15: The County shall, to the maximum extent possible, maintain local groundwater management authority and pursue the elimination of unwarranted institutional, regulatory, permitting, and policy barriers to groundwater recharge within Fresno County.
- Policy OS-A.16: The County shall permit and encourage, where economically, environmentally, and technically feasible, over-irrigation of surface water to maximize groundwater recharge.

- Policy OS-A.17: The County shall directly and/or indirectly participate in the development, implementation, and maintenance of a program to recharge the aquifers underlying the county. The program shall make use of flood and other waters to offset existing and future groundwater pumping.
- Policy OS-A.19: The County shall require the protection of floodplain lands and, where appropriate, acquire public easements for purposes of flood protection, public safety, wildlife preservation, groundwater recharge, access, and recreation.
- Policy OS-A.20: The County shall support the policies of the San Joaquin River Parkway Master Plan to protect the San Joaquin River as an aquatic habitat, recreational amenity, aesthetic resource, and water source.
- Policy OS-A.21: The County shall, where economically, environmentally, and technically feasible, encourage the multiple use of public lands, including County lands, to include groundwater recharge
- Policy OS-A.22: The County shall not approve the creation of new parcels that rely on the use of septic systems of a design not found in the California Plumbing Code. (California Code of Regulations, Title 24, Part 5).
- Policy OS-A.23: The County shall protect groundwater resources from contamination and overdraft by pursuing the following efforts:
    - Identifying and controlling sources of potential contamination;
    - Protecting important groundwater recharge areas;
    - Encouraging water conservation efforts and supporting the use of surface water for urban and agricultural uses wherever feasible;
    - Encouraging the use of treated wastewater for groundwater recharge and other purposes (e.g., irrigation, landscaping, commercial, and non- domestic uses);
    - Supporting consumptive use where it can be demonstrated that this use does not exceed safe yield and is appropriately balanced with surface water supply to the same area;
    - Considering areas where recharge potential is determined to be high for designation as open space; and
    - Developing conjunctive use of surface and groundwater.
- Policy OS-A.24: The County shall require new development near rivers, creeks, reservoirs, or substantial aquifer recharge areas to mitigate any potential impacts of release of pollutants in storm waters, flowing river, stream, creek, or reservoir waters.
- Policy OS-A.25: The County shall minimize sedimentation and erosion through control of grading, cutting of trees, removal of vegetation, placement of roads and bridges, and use of off-road vehicles. The County shall discourage grading activities during the rainy season unless adequately mitigated to avoid sedimentation of creeks and damage to riparian habitat.
- Policy OS-A.28: The County shall only approve new wastewater treatment facilities that will not result in degradation of surface water or groundwater. The County shall generally require treatment to tertiary or higher levels.
- Policy OS-A.29: In areas with increased potential for groundwater degradation (e.g., areas with prime percolation capabilities, coarse soils, and/or shallow groundwater), the County shall only approve land uses with low risk of degrading groundwater.
- Policy OS-D.7: The County shall support the management of wetland and riparian plant communities for passive recreation, groundwater recharge, nutrient storage, and wildlife habitats.
- Policy OS-E.11: The County shall protect significant aquatic habitats against excessive water withdrawals that could endanger special-status fish and wildlife or would interrupt normal migratory patterns.
- Policy OS-E.12: The County shall ensure the protection of fish and wildlife habitats from environmentally-degrading effluents originating from mining and construction activities that are adjacent to aquatic habitats.
- Policy OS-H.11: The County shall support the policies of the San Joaquin River Parkway Master Plan to protect the San Joaquin River as an aquatic habitat, recreational amenity, aesthetic resource, and water source.

Public Facilities and Surfaces Element

- Policy PF-C.1: The County shall actively engage in efforts and support the efforts of others to retain existing water supplies within Fresno County.
- Policy PF-C.2: The County shall actively engage in efforts and support the efforts of others to import flood, surplus, and other available waters for use in Fresno County.
- Policy PF-C.3: To reduce demand on the county's groundwater resources, the County shall encourage the use of surface water to the maximum extent feasible.
- Policy PF-C.4: The County shall support efforts to expand groundwater and/or surface water storage that benefits Fresno County.
- Policy PF-C.5: The County shall develop a County water budget to determine long-term needs and to determine whether existing and planned water resource enhancements will meet the county's needs over the twenty (20) year General Plan horizon.
- Policy PF-C.6: The County shall support water banking when the program has local sponsorship and involvement and provides new benefits to the County.
- Policy PF-C.7: The County shall recommend to all cities and urban areas within the county that they adopt the most cost-effective urban best management practices (BMPs) published and updated by the California Urban Water Agencies, California Department of Water Resources, or other appropriate agencies as a means of meeting some of the future water supply needs.
- Policy PF-C.8: The County shall require preparation of water master plans for areas undergoing urban growth.
- Policy PF-C.9: The County shall work with local irrigation districts to preserve local water rights and supply.
- Policy PF-C.10: The County shall require any community water system in new residential subdivisions to be owned and operated by a public entity.
- Policy PF-C.11: The County shall assure an on-going water supply to help sustain agriculture and accommodate future growth by allocation of resources necessary to carry out the water resource management programs.
- Policy PF-C.12: The County shall approve new development only if an adequate sustainable water supply to serve such development is demonstrated.
- Policy PF-C.13: In those areas identified as having severe groundwater level declines or limited groundwater availability, the County shall limit development to uses that do not have high water usage or that can be served by a surface water supply.
- Policy PF-C.14: The County shall require that water supplies serving new development meet US Environmental Protection Agency and California Department of Health Services and other water quality and quantity standards.
- Policy PF-C.16: If the cumulative effects of more intensive land use proposals are detrimental to the water supplies of surrounding areas, the County shall require approval of the project to be dependent upon adequate mitigation. The County shall require that costs of mitigating such adverse impacts to water supplies be borne proportionately by all parties to the proposal.
- Policy PF-C.17: The County shall, prior to consideration of any discretionary project related to land use, undertake a water supply evaluation.
- Policy PF-C.18: In the case of lands entitled to surface water, the County shall approve only land use-related projects that provide for or participate in effective utilization of the surface water entitlement such as:
    - Constructing facilities for the treatment and delivery of surface water to lands in question;
    - Developing facilities for groundwater recharge of the surface water entitlement.
- Policy PF-C.19: The County shall discourage the proliferation of small community water systems.
- Policy PF-C.20: The County shall not permit new private water wells within areas served by a public water system.
- Policy PF-C.21: The County shall promote the use of surface water for agricultural use to reduce groundwater table reductions.

- Policy PF-C.22: The County supports short-term water transfers as a means for local water agencies to maintain flexibility in meeting water supply requirements. The County shall support long-term transfer, assignment, or sale of water and/or water entitlements to users outside of the County only under limited circumstances.
- Policy PF-C.23: The County shall regulate the transfer of groundwater for use outside of Fresno County The regulation shall extend to the substitution of groundwater for transferred surface water.
- Policy PF-C.24: The County shall encourage the transfer of unused or surplus agricultural water to urban uses within Fresno County.
- Policy PF-C.25: The County shall require that all new development within the County use water conservation technologies, methods, and practices as established by the County.
- Policy PF-C.27: The County shall adopt, and recommend to all cities that they also adopt, the most cost-effective urban best water conservation management practices circulated and updated by the California Urban Water Agencies, California Department of Water Resources, or other appropriate agencies.
- Policy PF-C.28: The County shall encourage agricultural water conservation where economically, environmentally, and technically feasible.
- Policy PF-C.30: The County shall generally not approve land use-related projects that incorporate a man-made lake or pond that will be sustained by the use of groundwater.
- Policy PF-D.1: The County shall encourage the installation of public wastewater treatment facilities in existing communities that are experiencing repeated septic system failures and lack sufficient area for septic system repair or replacement and/or are posing a potential threat to groundwater.
- Policy PF-E.14: The County shall encourage the use of retention-recharge basins for the conservation of water and the recharging of the groundwater supply.
- Policy PF-E.16: The County shall minimize sedimentation and erosion through control of grading, cutting of trees, removal of vegetation, placement of roads and bridges, and use of off-road vehicles. The County shall discourage grading activities during the rainy season, unless adequately mitigated, to avoid sedimentation of creeks and damage to riparian habitat.
- Policy PF-E.17: The County shall encourage the local agencies responsible for flood control or storm drainage retention-recharge basins located in soil strata strongly conducive to groundwater recharge to develop and operate those basins in such a way as to facilitate year-round groundwater recharge.
- Policy PF-E.18: The County shall encourage the local agencies responsible for flood control or storm drainage to plan retention-recharge basins on the principle that the minimum number will be the most economical to acquire, develop, operate, and maintain.
- Policy PF-E.20: The County shall require new development of facilities near rivers, creeks, reservoirs, or substantial aquifer recharge areas to mitigate any potential impacts of release of pollutants in flood waters, flowing rivers, streams, creeks, or reservoir waters.

Transportation and Circulation Element

- Policy TR-A.17: The County should utilize road construction methods that minimize the air, water, and noise pollution associated with street and highway development.

2.2.1.2 Merced County General Plan

The 2030 Merced County General Plan is a legal document that serves as Merced County's "blueprint" or "constitution" for all future land use, development, preservation, and resource conservation decisions. Per the County's General Plan, general plans must be comprehensive and long-term.

The following policies from each relevant Element may potentially influence implementation of the GSP or be influenced by GSP implementation.

Agricultural Element

- Policy AG-2.12 Antiquated Subdivisions: Encourage the voluntary merger of antiquated subdivision lots that conflict with adjacent agricultural uses, and continue to require environmental review of permits that could result in adverse environmental impacts in agricultural and rural areas, including traffic generation, groundwater contamination, stormwater drainage disposal, and air quality deterioration.

Health and Safety Element

- Policy HS-5.4 Contamination Prevention: Require new development and redevelopment proposals that have suspected or historic contamination to address hazards concerns and protect soils, surface water, and groundwater from hazardous materials contamination by conducting Phase I Environmental Site Assessments (ESA) according to the American Society for Testing and Materials (ASTM) standards and applicable Department of Toxic Substances Control (DTSC) remediation guidelines. Also, complete additional Phase II Environmental Site Assessments and soil investigations, and any identified or needed remediation when preliminary studies determine such studies are recommended.

Housing Element

- Policy 6.5: The County shall encourage the use of solar, wind, other renewable energy resources, and use of water conservation and water recycling systems in residential buildings.

Land Use Element

- Policy LU-4.4 Efficient Development: Require efficient and environmentally sound development, which minimizes impacts on sensitive habitat/species, protects water quality and supply, and provides adequate circulation, within Rural Centers.
- Policy LU-5.A.3 Growth Limitations: Limit growth in existing Urban Communities that lack public sewer and water systems to only include land use designations and densities which can be accommodated by individual septic systems and/or wells.
- Policy LU-5.F.1 New Urban Community Size and Location Requirements: Only accept applications for the establishment of additional new Urban Communities if they encompass a minimum area of 320 acres in order to achieve efficiencies in urban service delivery and provide for long-range growth needs. In addition, require that proposed new Urban Communities be located only in areas that are not located within areas that recharge to already compromised source water aquifers (i.e., in overdraft condition) or areas highly susceptible to groundwater contamination.
- Policy LU-5.F.4 Water Impacts: Prohibit new Urban Communities, or the expansion of existing urban communities, if they will negatively impact the water supply of existing users.

Natural Resources Element

- Policy NR-1.1: Habitat Protection: Identify areas that have significant long-term habitat and wetland values including riparian corridors, wetlands, grasslands, rivers and waterways, oak woodlands, vernal pools, and wildlife movement and migration corridors, and provide information to landowners.
- Policy NR-1.4 Important Vegetative Resource Protection: Minimize the removal of vegetative resources which stabilize slopes, reduce surface water runoff, erosion, and sedimentation.
- Policy NR-1.10: Aquatic and Waterfowl Habitat Protection (MPSP): Cooperate with local, State, and Federal water agencies in their efforts to protect significant aquatic and waterfowl habitats against excessive water withdrawals or other activities that would endanger or interrupt normal migratory patterns or aquatic habitats.

Public Facilities and Services Element

- Policy PFS-1.5 Public Facility Master Plans: Require regular updates of County Facility Master Plans to coordinate with local service districts to ensure that sufficient water/wastewater treatment is available for unincorporated communities prior to directing additional growth to them.

- Policy PFS-2.5 Ground or Surface Water Contamination: Prohibit wastewater disposal facilities, including private residential facilities, that are determined to have the potential to contaminate the groundwater or surface water, on either a site-specific or cumulative basis.
- Policy PFS-3.4 Agency Coordination: Coordinate with the U.S. Army Corps of Engineers and other appropriate agencies to develop stormwater detention/retention facilities and recharge facilities that enhance flood protection and improve groundwater recharge.

Water Element

- Goal W-1: Ensure a reliable water supply sufficient to meet the existing and future needs of the County.
- Policy W-1.1 Countywide Water Supply: Ensure that continued supplies of surface and groundwater are available to serve existing and future uses by supporting water districts and agencies in groundwater management and water supply planning; requiring that new development have demonstrated long-term water supply; and assisting both urban and agricultural water districts in efforts to use water efficiently.
- Policy W-1.2 Demonstrating Sufficient Water Supply for New Development: Require all new development within the adopted service area of a water purveyor to demonstrate adequate quantity and quality of water will be available prior to issuing building permits.
- Policy W-1.3 Agricultural Water Study: In cooperation with local water agencies and districts, maintain the detailed General Plan study of countywide water use and needs for agriculture with periodic updates and with information that can be widely shared and publicized.
- Policy W-1.4 Groundwater Recharge Projects: Support implementation of groundwater recharge projects consistent with adopted Integrated Regional Water Management Plans to minimize overdraft of groundwater and ensure the long-term availability of groundwater.
- Policy W-1.5 New Well Guidelines: Coordinate with the cities and special districts in developing County-wide guidelines regarding the location and construction of new water wells.
- Policy W-1.6 Surface Water Storage: Support water agencies in the exploration of additional surface water storage opportunities.
- Policy W-1.7 Water Sufficiency Requirement: Require new developments to prepare a detailed source water sufficiency study and water supply assessment per Title 22 and Senate Bill 610, consistent with any Integrated Regional Water Management Plan or similar water management plan. This shall include studying the effect of new development on the water supply of existing users, with public input.
- Policy W-1.8 Single User Well Consolidation: Encourage consolidation of single user wells into local water districts (with management plans) where feasible.
- Policy W-1.10 Groundwater Overdraft Protection: Where a water supply source is nearby and accessible, encourage large water consumers to use available surface irrigation water (secondary water) for school athletic fields, sports complexes, and large landscape areas.
- Policy W-2.1 Water Resource Protection: Ensure that land uses and development on or near water resources will not impair the quality or productive capacity of these water resources.
- Policy W-2.2 Development Regulations to Protect Water Quality: Prepare updated development regulations, such as best management practices, that prevent adverse effects on water resources from construction and development activities.
- Policy W-2.3 Natural Drainage Channels: Encourage the use of natural channels for drainage and flood control to benefit water quality and other natural resource values.
- Policy W-2.4 Agricultural and Urban Practices to Minimize Water Contamination: Encourage agriculture and urban practices to comply with the requirements of the Regional Water Quality Control Board for irrigated lands and confined animal facilities, which mandate agricultural practices that minimize erosion and the generation of contaminated runoff to ground or surface waters by providing assistance and incentives.
- Policy W-2.5 Septic Tank Regulation: Enforce septic tank and onsite system regulations of the Regional Water Quality Control Board to protect the water quality of surface water bodies and groundwater quality.

- Policy W-2.6 Wellhead Protection Program: Enforce the wellhead protection program to protect the quality of existing and future groundwater supplies by monitoring the construction, deepening, and destruction of all wells within the County.
- Policy W-3.1 Water Availability and Conservation: Support efforts of water agencies and districts to prevent the depletion of groundwater resources and promote the conservation and reuse of water.
- Policy W-3.4 High Water Use Processing Activities: Prohibit any processing activities with high water use practices near areas where groundwater overdraft problems exist, unless the facility uses water recycling and conservation techniques that minimize effects of water use to the groundwater table.
- Policy W-3.14 Agricultural Water Conservation: Encourage farmers to use irrigation methods which conserve water in areas where flood irrigation is used for groundwater recharge.
- Policy W-4.1 Water Resource Protection and Replenishment: Protect watersheds, aquifer recharge areas, and areas susceptible to ground and surface water contamination by identifying such areas and implementing requirements for their protection.
- Policy W-5.1 Countywide Water Supply Study: Prepare and regularly update a comprehensive water supply study that includes all four groundwater basins and three hydrologic zones and takes into consideration activities in neighboring counties and the region. The plan shall consider reductions in Federal and State water deliveries in the western part of the County and anticipated reductions in water supplies due to climate change.

2.2.1.3 San Joaquin County General Plan

The 2035 General Plan for San Joaquin County presents a vision for the County's future. It is comprehensive, providing a framework for the County's physical, economic, and social development and environmental resources preservation. It addresses all geographic areas in the unincorporated county. The plan looks ahead to 2035, while at the same time presenting policies to guide day-to-day decisions. The 2035 San Joaquin County General Plan is a legal document that serves as San Joaquin County's "blueprint" or "constitution" for all future land use, development, preservation, and resource conservation decisions.

The following policies from each relevant Element may potentially influence implementation of the GSP or be influenced by GSP implementation.

Community Development Element

- Policy C-2.1 Planning for Urban Communities: The County shall plan Urban Communities to accommodate most of the unincorporated County's projected growth; provide a variety of land uses; receive urban services, including community wastewater treatment, water, and storm drainage.
- Policy C-3.2 Development in Rural Communities: The County shall limit development in Rural Communities to those that have adequate public services to accommodate additional population and commercial services that provide for immediate needs of the community's residents or the surrounding agricultural community.
- Policy C-5.2 Community Expansion Considerations: As part of any General Plan amendment to expand a community, the County shall consider the availability of water for all existing and planned development.
- Policy C-6.17 New Urban Community Services: The County shall require new Urban Communities to be served by public water, wastewater, and terminal storm drainage systems and provide for urban levels of police, fire, and flood protection. Public services shall be designed in such a manner as to be capable of serving only the proposed new Urban Community.
- Policy C-6.18 New Urban Community Water Supply: The County shall require new Urban Communities demonstrate access to adequate water supplies to meet the ultimate buildout of the community, consistent with General Plan policies for reducing further groundwater aquifer overdraft and maintaining sufficient water supplies for agriculture. Applicants for new Urban Communities shall be required to study and guarantee, through a development agreement, that existing and future water supply needs can be met and that existing users water supplies will not be negatively impacted.

- Policy ED-2.4 Green Economy: The County shall encourage the development and expansion of industries and businesses that rely on environmentally-sustainable products and services, such as renewable energy, green building, clean transportation, water conservation, waste management and recycling, and sustainable land management.
- Policy ED-3.2 Considerations for New Commercial and Industrial Development: The County shall consider the factors when reviewing proposed non-agricultural commercial and industrial development applications including water; new developments must have long-term water supplies to meet the ultimate demand of the development and surrounding area and ensure the continued viability of existing and future development.

Land Use Element

- Policy LU-2.2 Sustainable Building Practices: The County shall promote and, where appropriate, require sustainable building practices that incorporate a "whole system" approach to designing and constructing buildings that consume less energy, water and other resources, facilitate natural ventilation, use daylight effectively, and are healthy, safe, comfortable, and durable.
- Policy LU-6.8 Sustainable Technologies: The County shall encourage all employment and industrial projects to incorporate sustainable technologies including energy and water efficient practices.
- Policy LU-8.1 Open Space Preservation: The County shall limit, to the extent feasible, the conversion of open space and agricultural lands to urban uses, and place a high priority on preserving open space lands for recreation, habitat protection and enhancement, flood hazard management, public safety, water resource protection, and overall community benefit.

Natural and Cultural Resources Element

- Policy NCR-3.1 Preserve Groundwater Recharge Areas: The County shall strive to ensure that substantial groundwater recharge areas are maintained as open space.
- Policy NCR-3.2 Groundwater Recharge Projects: The County shall encourage the development of groundwater recharge projects of all scales within the County and cities to increase groundwater supplies.
- Policy NCR-3.3 Multi-Jurisdictional Groundwater Management Evaluation: The County shall support multi-jurisdictional groundwater management that involves adjacent groundwater basins.
- Policy NCR-3.4 Eliminate Pollution: The County shall support efforts to eliminate sources of pollution and clean up the County's waterways and groundwater.
- Policy NCR-3.6 Prohibit Discharge of Sewage Sludge: The County shall prohibit the discharge of sewage sludge or septage to surface waters or surface water drainage sources, including wetlands and waterways.
- Policy NCR-3.7 Septic Tank Regulation: The County shall enforce its septic tank and onsite system regulations consistent with Central Valley Regional Water Quality Control Board policy that recognizes the County as the responsible agency to protect the water quality of surface water and groundwater.
- Policy NCR-3.9 Require Water Projects to Mitigate Impacts: The County shall require water projects to incorporate safeguards for fish and wildlife and mitigate erosion and seepage to adjacent lands.
- Policy D-6.5 Water Storage Options: The County shall advocate for the study of above- and below-ground storage options as part of a statewide improved flood management and water supply system.

Public Facilities and Services Element

- Policy IS-4.1 Water Agency Support: The County shall support efforts of local water agencies, special district, and water conservation districts to ensure that adequate high-quality water supplies are available to support existing and future residents and businesses.
- Policy IS-4.2 Interagency Cooperation: The County shall work with local water agencies to address existing and future water needs for the County.
- Policy IS-4.3 Water Supply Availability: The County shall consider the availability of a long-term, reliable potable water supply as a primary factor in the planning of areas for new growth and development.

- Policy IS-4.4 Water Rights Protection: The County shall support local water agencies in their efforts to protect their water rights and water supply contracts, including working with Federal and State water projects to protect local water rights.
- Policy IS-4.5 Drought Response: The County shall encourage all local water agencies to develop and maintain drought contingency and emergency services plans, emergency inter-ties, mutual aid agreements, and related measures to ensure adequate water service during drought or other emergency water shortages.
- Policy IS-4.6 Coordinate Efforts for Adequate Water Supply: The County shall support coordinated efforts to obtain adequate water supplies and develop water storage facilities to meet expected water demand.
- Policy IS-4.7 Conjunctive Use: The County shall support conjunctive use of groundwater and surface water by local water agencies to improve water supply reliability.
- Policy IS-4.8 Water Conservation Measures: The County shall require existing and new development to incorporate all feasible water conservation measures to reduce the need for water system improvements.
- Policy IS-4.9 Groundwater Management: The County shall continue to support cooperative, regional groundwater management planning by local water agencies, water users, and other affected parties to ensure a sustainable, adequate, safe, and economically viable groundwater supply for existing and future uses within the County.
- Policy IS-4.10 Groundwater Monitoring Program: The County shall continue to evaluate the quantity and quality of groundwater.
- Policy IS-4.11 Integrated Regional Water Management: The County shall support and participate in the development, implementation, and update of an integrated regional water management plan.
- Policy IS-4.12 Water Supply Planning: The County shall encourage local water agencies to develop plans for responding to droughts and the effects of global climate change, including contingency plans, water resource sharing to improve overall water supply reliability, and the allocation of water supply to priority users.
- Policy IS-4.13 Water Quality Standards: The County shall require that water supplies serving new development meet State water quality standards. If necessary, the County shall require that water be treated to meet State standards and that a water quality monitoring program be in place prior to issuance of building permits.
- Policy IS-4.14 Sufficient Water Supply Assessments: The County shall require new developments over 500 dwelling units in size to prepare a detailed water source sufficiency study and water supply analysis for use in preparing a Water Supply Assessment, consistent with any Integrated Regional Water Management Plan or similar water management plan. This shall include analyzing the effect of new development on the water supply of existing users.
- Policy IS-4.15 Test Wells: Prior to issuing building permits for new development that will rely on groundwater, the County shall require confirmation for existing wells or test wells for new wells to ensure that water quality and quantity are adequate to meet the needs of existing, proposed, and planned future development.
- Policy IS-4.16 Permit for Groundwater Export: The County shall continue to require a permit for the extraction of groundwater that is intended to be exported outside County boundaries.
- Policy IS-4.20 Water Efficient Agricultural Practices: The County shall encourage farmers to implement irrigation practices, where feasible and practical, to conserve water.

Public Health and Safety Element

- Policy PHS-7.2 Avoid Contamination of Resources: The County shall strive to ensure that hazardous materials and wastes do not contaminate air, water, or soil resources.

2.2.1.4 San Benito County General Plan

The San Benito County 2035 General Plan is a framework for implementing a clear direction for the County's future. The plan considers sustainability, environmental protection, economic expansion and diversification, and equity to consider goals, policies, and programs that will help the county achieve the community's long-term vision.

The following policies and goals from each relevant Element in the General Plan may potentially influence implementation of the GSP or be influenced by GSP implementation.

Land Use Element

- Policy LU-1.2 Sustainable Development Patterns: The County shall promote compact, clustered development patterns that use land efficiently; reduce pollution and the expenditure of energy and other resources; and facilitate walking, bicycling, and transit use; and encourage employment centers and shopping areas to be proximate to residential areas to reduce vehicle trips. Such patterns would apply to infill development, unincorporated communities, and the New Community Study Areas. The County recognizes that the New Community Study Areas comprise locations that can promote such sustainable development. (RDR)
- Policy LU-1.3 Future Development Timing: The County shall ensure that future development does not outpace the ability of either the County or other public/private service providers to provide adequate services and infrastructure. The County shall review future development proposals for their potential to reduce the level of services provided to existing communities or place economic hardships on existing communities, and the County may deny proposals that are projected to have these effects. (RDR/MPSP)
- Policy LU-1.8 Site Plan Environmental Content Requirements: The County shall require all submitted site plans, tentative maps, and parcel maps to depict all environmentally sensitive and hazardous areas, including: 100-year floodplains, fault zones, 30 percent or greater slopes, severe erosion hazards, fire hazards, wetlands, and riparian habitats. (RDR)
- Policy LU-1.10 Development Site Suitability: The County shall encourage specific development sites to avoid natural and manmade hazards, including, but not limited to, active seismic faults, landslides, slopes greater than 30 percent, and floodplains. Development sites shall also be on soil suitable for building and maintaining well and septic systems (i.e., avoid impervious soils, high percolation or high groundwater areas, and provide setbacks from creeks). The County shall require adequate mitigation for any development located on environmentally sensitive lands (e.g., wetlands, erodible soil, archaeological resources, important plant and animal communities). (RDR)
- Policy LU-2.1 Sustainable Building Practices: The County shall promote, and where appropriate, require sustainable building practices that incorporate a "whole system" approach to designing and constructing buildings that consume less energy, water, and other resources; facilitate natural ventilation; use daylight efficiently; and are healthy, safe, comfortable, and durable. (RDR)
- Policy LU-3.1 Agricultural Diversification: The County shall support existing farms, vineyards, and other agricultural operations and encourage the agricultural industry to continue diversification that includes organic, value-added, small-scale, sustainable, and community-supported agricultural practices throughout the county. (RDR/MPSP)
- Policy LU-3.3 Increased Agricultural Sustainability and Energy Efficiency: The County shall encourage and support farms, vineyards, and ranches that seek to implement programs that increase the sustainability of resources, conserve energy, and protect water and soil in order to bolster the local food economy, increase the viability of diverse family farms and improve the opportunities for farm workers. (RDR)
- Policy LU-3.4 Lower-Impact Agricultural Practices: The County shall encourage and support farms, vineyards, and ranches that use lower-impact agricultural and/or organic practices and shall recognize the benefits that a flourishing organic sector industry can provide. (RDR)
- Policy LU-3.9 Right to Farm and Ranch: The County shall protect the rights of operators of productive agricultural properties (as defined in the Glossary) and ranching properties to commence and continue their

agricultural and ranching practices (a “right to farm and ranch”) even though established urban uses in the general area may foster complaints against those agricultural and ranching practices. The “right to farm and ranch” shall encompass the processing of agricultural and ranching products and other activities inherent in the definition of productive agriculture and in ranching activities. The County shall require all parcel maps approved for locations in or adjacent to productive agricultural areas and ranching areas to indicate the “right to farm and ranch” policy. The County shall require the program to be disclosed to buyers of property in San Benito County. (RDR)

- Policy LU-3.13 Illegal Dumping: The County shall work with property owners, waste collection providers, and law enforcement to find solutions to illegal dumping on agricultural properties such as offering free trash drop-off days and increased penalties for illegal dumping. (MPSP)
- Policy LU-4.5 Innovative Site Planning and Residential Design: The County shall encourage new residential developments to use innovative site planning techniques and to incorporate design features that increase the design quality, and energy efficiency, and water conservation of structures and landscapes while protecting the surrounding environment. (RDR)
- Policy LU-6.4 Sustainable Technologies: The County shall encourage all employment and industrial projects to incorporate sustainable technologies including energy and water efficient practices. (RDR)
- Policy LU-9.7 County General Plan Consistency Report: The County shall monitor and report to the Local Agency Formation Commission (LAFCO) regarding the consistency with the General Plan with any proposed changes in the sphere of influence or other urban boundaries for governmental entities that provide water or sewer services. (RDR/IGC)
- Policy LU-9.8 Sewer and Water Service Commitments: The County shall require new development within the spheres of influence of Hollister or San Juan Bautista to obtain sewer and water service commitments from either the Cities or appropriate special districts prior to project approval. (RDR)

Economic Development Element

- Policy ED-1.5 Quality of Life Improvements: The County shall focus economic development efforts on creating positive change in the county relative to residents and workers’ quality of life. This should include considering air quality, education opportunities, safety, water quality, scenic beauty, and recreational opportunities during economic development decisions. (RDR/MPSP)
- Policy ED-6.1 Workforce Education and Training Promotion: The County shall support programs that educate the local workforce on conventional, productive, sustainable, and organic agriculture concepts, including water conservation strategies; emerging high-tech industries; and alternative energy production. (MPSP/IGC)

Housing Element

- Policy HOU-2O: The County shall assist where possible with the removal of infrastructure constraints for the provision of wastewater and water service.

Public Facilities and Services Element

- Policy PFS-1.3 Efficient Infrastructure and Facilities: The County shall update and replace public facilities and infrastructure with technologies that improve energy efficiency and conserve water, when feasible. (MPSP)
- Policy PFS-1.12 New Development Requirements: The County shall require new development, incompliance with local, State, and Federal law, to mitigate project impacts associated with public facilities and services, including, but not limited to, fire, law enforcement, water, wastewater, schools, infrastructure, roads, and pedestrian and bicycle facilities through the use of annexation fees, connection fees, facility construction/expansion requirements, or other appropriate methods. (RDR/FB)
- Policy PFS-2.4 Monitoring Efficiency and Conservation: The County shall monitor and regularly report on its progress in implementing energy efficiency, water conservation, and waste reduction measures and in meeting its greenhouse gas reduction targets and goals for County facilities and activities. (PSR/PI)

- Policy PFS-2.5 Sustainability Retrofits: The County shall increase energy efficiency in older County buildings through energy efficiency and retrofits (e.g., compact florescent light bulbs, motion-activated lighting, computerized HVAC systems), renewable energy generation (e.g., photovoltaic cells), and water conservation retrofits (e.g., low flow toilets and sinks, drip irrigation, water reuse). (MPSP/SO)
- Goal PFS-3: To ensure reliable supplies of water for unincorporated areas to meet the needs of existing and future agriculture and development, while promoting water conservation and the use of sustainable water supply sources.
- Policy PFS-3.1 Water District Support: The County shall support efforts of the San Benito County Water District to ensure that adequate high-quality water supplies are available to support current residents and businesses and future development projects. (MPSP/IGC)
- Policy PFS-3.2 Interagency Coordination: The County shall cooperate with public and private water agencies in order to help address existing and future water needs for the county. (IGC)
- Policy PFS-3.3 Water Rights Protection: The County shall support public and private water agencies in their efforts to protect their water rights and water supply contracts, including working with Federal and State water projects to protect local water rights. (IGC)
- Policy PFS-3.4 Drought Response: The County shall encourage all public and private water agencies to develop and maintain drought contingency and emergency services plans, emergency inter-ties, mutual aid agreements and related measures to ensure adequate water services during drought or other emergency water shortage. (MPSP/IGC)
- Policy PFS-3.5 Water Supply Development: The County shall support plans to develop new reliable future sources of supply, including, but not limited to, the expansion of surface water storage and conjunctive use of surface water and groundwater, while promoting water conservation and water recycling/reuse. (RDR/MPSP/IGC)
- Policy PFS-3.6 Conjunctive Use: The County shall support conjunctive use of groundwater and surface water to improve water supply reliability. (MPSP/IGC)
- Policy PFS-3.7 Groundwater Management: The County shall support cooperative, regional groundwater management planning by water resource agencies, water users, and other affected parties to ensure a sustainable, adequate, safe, and economically viable groundwater supply for existing and future uses within the county. (MPSP/IGC)
- Policy PFS-3.8 Integrated Management: The County shall support and participate in the integrated management of surface water and groundwater resources, wastewater, stormwater treatment and use, and the use of reclaimed water. (MPSP/IGC)
- Policy PFS-3.9 Sufficient Water Supply for New Development: The County shall require new developments to prepare a source water sufficiency study and water supply analysis for use in preparing, where required, a Water Supply Assessment per SB 610 and a Source Water Assessment per Title 22. This shall include studying the effect of new development on the water supply of existing users. The County encourages the development of integrated regional water management plans or similar plans. (RDR)
- Policy PFS-4.1 Adequate Water Treatment and Delivery Facilities: The County shall ensure, through the development review process, that adequate water supply, treatment and delivery facilities are sufficient to serve new development and are able to be expanded to meet capacity demands when needed. Such needs shall include capacities necessary to comply with water quality and public safety requirements. (RDR)
- Policy PFS-4.2 Water Facility Infrastructure Fees: As a condition of approval for discretionary developments, the County shall not issue approval for a final map until verification of adequate water and wastewater service has been provided, which may include verification of payment of fees imposed for water and wastewater infrastructure capacity per the fee payment schedule from the water and wastewater provider. (RDR)
- Policy PFS-4.3 Minimum Lot Size: The County shall require a minimum lot size for properties that have on-site septic systems to minimize adverse water quality impacts on groundwater. (RDR)
- Policy PFS-4.4 Single User Well Consolidation: The County shall encourage consolidation of single user wells into public water districts. (RDR/MPSP)

- Policy PFS-4.5 Water System Rehabilitation: The County shall encourage the rehabilitation of irrigation systems and other water delivery systems to reduce water losses and increase the efficient use and availability of water. (RDR/MPSP)
- Policy PFS-4.6 New Community Water Systems: The County shall require any new community water system, in the unincorporated area of the county, serving residential, industrial, or commercial development to be owned and operated by a public or private entity that can demonstrate to the County adequate financial, managerial, and operational resources. (RDR/IGC)
- Policy PFS-4.8 Water Supply Planning: The County shall encourage water purveyors to develop plans for responding to droughts and the effects of global climate change, including contingency plans, the sharing of water resources to improve overall water supply reliability, and the allocation of water supply to priority users. (MPSP/IGC)
- Policy PFS-5.1 Water and Sewer Expansion: The County shall encourage public wastewater system operators to maintain and expand their systems to meet the development needs of the county. (MPSP/IGC)
- Policy PFS-5.3 Adequate Water Treatment and Disposal: The County shall ensure through the development review process that wastewater collection, treatment, and disposal facilities are sufficient to serve existing and new development and are able to be expanded to meet capacity demands when needed. (RDR)
- Policy PFS-5.5 Individual Onsite Septic Systems: The County shall permit onsite septic systems only when connection to an existing wastewater system or sewer system is not reasonably available. Approval, installation, and use of individual septic systems shall be consistent with Regional Water Quality Control Board regulations. (RDR)
- Policy PFS-5.6 Septic System Design: The County shall require individual septic systems to be properly designed, constructed, and maintained to avoid degradation of ground and surface water quality. (RDR)
- Goal PFS-6: To manage stormwater from existing and future development using methods that reduce potential flooding, maintain natural water quality, enhance percolation for groundwater recharge, and provide opportunities for reuse.
- Policy PFS-6.1 Adequate Stormwater Facilities: The County shall require that stormwater drainage facilities are properly designed, sited, constructed, and maintained to efficiently capture and dispose of runoff and minimize impacts to water quality. (RDR)
- Policy PFS-6.2 Best Management Practices: The County shall require best management practices in the development, upgrading, and maintenance of stormwater facilities and services to reduce pollutants from entering natural water bodies while allowing stormwater reuse and groundwater recharge. (RDR)
- Policy PFS-6.3 Natural Drainage Systems: The County shall encourage the use of natural stormwater drainage systems (e.g., swales, streams) to preserve and enhance the environment and facilitate groundwater recharge. (RDR)
- Policy PFS-6.4 Development Requirements: The County shall require project designs that minimize stormwater drainage concentrations and impervious surfaces, complement groundwater recharge, avoid floodplain areas, and use natural watercourses in ways that maintain natural watershed functions and provide wildlife habitat. (RDR)
- Policy PFS-6.5 Stormwater Detention Facilities: Where necessary, the County shall require on-site detention/retention facilities and/or velocity reducers to maintain pre-development runoff flows and velocities in natural drainage systems. (RDR)
- Policy PFS-6.6 Stormwater Detention Basin Design: The County shall require stormwater detention basins be designed to ensure public safety, be visually unobtrusive, provide temporary or permanent wildlife habitat, and where feasible, provide recreation opportunities. (RDR)
- Policy PFS-6.7 Runoff Water Quality: The County shall require all drainage systems in new development and redevelopment to comply with applicable State and Federal non-point source pollutant discharge requirements. (RDR)

- Policy PFS-6.8 Reduce Erosion and Sedimentation: The County shall ensure that drainage systems are designed and maintained to minimize soil erosion and sedimentation and maintain natural watershed functions. (RDR)
- Policy PFS-13.5 Water Service Standards: The County shall require all development within unincorporated communities to have adequate water supply, pressure, and capacity for fire protection. (RDR)
- Policy PFS-13.10 Adequate Fire Flows for Agricultural Facilities: The County shall require all agricultural commercial facilities to have adequate water supply and fire flows to meet the State Fire Code and other appropriate State laws. (RDR)

Natural and Cultural Resources Element

- Policy NCR-1.1 Maintenance of Open Space: The County shall support and encourage maintenance of open space lands that support natural resources, agricultural resources, recreation, tribal resources, wildlife habitat, water management, scenic quality, and other beneficial uses. (RDR)
- Goal NCR-4: To protect water quantity and quality in natural water bodies and groundwater basins and avoid overdraft of groundwater resources.
- Policy NCR-4.1 Mitigation for Wetland Disturbance or Removal: The County shall consider implementing Regional Water Quality Control Board Basin Plan policies to improve areas of low water quality, maintain water quality on all drainage, and protect and enhance habitat for fish and other wildlife on major tributaries to the Pajaro River (San Benito River, Pacheco Creek) and the Silver Creek watershed. (RDR/MPSP/IGC)
- Policy NCR-4.2 Water Quality Tests: The County shall require new development to prepare water quality tests prior to project approval, demonstrating whether proposed domestic water supply will meet State primary and secondary drinking water standards. (RDR)
- Policy NCR-4.3 Agricultural Water: The County shall require well tests for nonagricultural development to provide evidence that 100 percent of the water needs may be met without connecting to the San Felipe Water system. (RDR)
- Policy NCR-4.4 Open Space Conservation: The County shall encourage conservation and, where feasible, creation or restoration of open space areas that serve to protect water quality such as riparian corridors, buffer zones, wetlands, undeveloped open space areas, and drainage canals. (RDR/MPSP)
- Policy NCR-4.5 Groundwater Recharge: The County shall encourage new development to preserve, where feasible, areas that provide important groundwater recharge and stormwater management benefits such as undeveloped open spaces, natural habitat, riparian corridors, wetlands, and natural drainage areas. (RDR)
- Policy NCR-4.6 Groundwater Studies for New Development: To ensure an adequate water supply, large-scale development projects that meet the criteria in California Water Code section 10912 shall prepare an analysis of the sufficiency of the groundwater from the basin or basins from which the proposed project will be supplied to meet the projected water demand associated with the proposed project in accordance with SB 610. (RDR)
- Policy NCR-4.7 Best Management Practices: The County shall encourage new development to avoid significant water quality impacts and protect the quality of water resources and natural drainage systems through site design, source controls, runoff reduction measures, and BMPs. (RDR)
- Policy NCR-4.8 Water Education: The County shall encourage water districts to provide public education to encourage existing homeowners to adopt water conservation practices for landscaping and interior plumbing. (IGC/PI)
- Policy NCR-4.9 Water Conservation Plan: The County shall maintain and implement the San Benito County Water Conservation Plan as necessary to promote water conservation and efficient use. (MPSP)
- Policy NCR-4.10 Water Efficient Landscape Ordinance: The County shall develop, maintain, and implement a Water Efficient Landscape Ordinance, consistent with the Model Water Efficient Landscape Ordinance prepared by the California Department of Water Resources, to require greater use of regionally

native drought-tolerant vegetation, limitations on the amount of turf in residential development, and other measures as appropriate. (RDR)

- Policy NCR-4.11 Reclaimed Water: The County shall require, where feasible, the use of reclaimed water irrigation systems in new development wherever possible. (RDR)
- Policy NCR-4.12 Rainwater Catchment: The County shall encourage homeowners to install roof catchment systems and use rainwater for non-potable uses in order to reduce the need for groundwater. (RDR)
- Policy NCR-4.13 Shared Water Systems: The County shall develop, maintain, and implement an ordinance to allow for shared water systems to facilitate the clustering of homes and preservation of agricultural land, where an entity is established to provide maintenance or financing for the maintenance of the water system. (RDR)
- Policy NCR-4.14 Wastewater Treatment: The County shall require wastewater treatment systems to be designed to promote the long-term protection of groundwater resources in San Benito County. Domestic wastewater treatment systems shall be required to use tertiary wastewater treatment as defined by Title 22. (RDR/MPSP)
- Policy NCR-4.15 Septic Systems: The County shall require septic systems to be limited to areas where sewer services are not available and where it can be demonstrated that septic systems will not contaminate groundwater. (RDR)
- Policy NCR-4.16 Develop in Existing Areas: The County shall encourage development to occur in or near existing developed areas in order to reduce the use of individual septic systems in favor of domestic wastewater treatment in an effort to protect groundwater quality. (RDR)
- Policy NCR-5.5 Hydrologic Report: The County may require developers of new or expanded mining operations to prepare a hydrologic report to evaluate the up-and down-stream effects of the proposed operations. (RDR)
- Policy NCR-6.4 Large-Scale Alternative Energy Installations: The County shall encourage large-scale solar and wind energy production facilities in Rangeland designated areas, so long as they do not result in such major impacts as a tax burden to the County, result in permanent water transfers off of productive agricultural land, or pose a health or safety risk to existing residents. In addition, these facilities should include dedications of agricultural land and habitat mitigation, measures to control erosion, and financial assurances for decommissioning. (RDR)
- Policy NCR-7.9 Tribal Consultation: The County shall consult with Native American tribes regarding proposed development projects and land use policy changes consistent with the State’s Local and Tribal Intergovernmental Consultation requirements. (RDR/IGC)

Health and Safety Element

- Policy HS-1.7 Multi-Hazard Mitigation Plan: The County shall develop, maintain, and implement a Multi-Hazard Mitigation Plan to address disasters such as earthquakes, flooding, dam or levee failure, hazardous material spills, epidemics, fires, extreme weather, major transportation accidents, and terrorism. (MPSP)
- Policy HS-1.16 Public Awareness of Climate Change: The County shall support public awareness of water conservation measures, agricultural changes, storm and flood preparedness, forest/range fire protection, air quality issues, extreme weather events, and disease prevention to help prepare for the potential impacts of climate change. (PI)
- Policy HS-2.6 Multi-Purpose Flood Control Facilities: The County shall encourage multi-purpose flood control facilities that incorporate recreation, resource conservation, preservation of natural riparian habitat, and scenic values of the of the county’s streams, creeks, rivers, and lakes. (RDR)
- Policy HS-4.2 Fire Protection Water Standard: The County shall develop, maintain, and implement an appropriate fire protection water standard to be applied to all urban and rural development. (RDR)
- Policy HS-4.3 Improve Water Systems: The County shall coordinate with water purveyors to improve water systems in areas where substandard water supplies and/or flow currently exist. (RDR/IGC)

2.2.1.5 Stanislaus County General Plan

The Stanislaus County General Plan is a comprehensive, long-term plan to guide development within Stanislaus County through 2035. It provides a land-use framework responsive to the needs and conditions of the unincorporated area of Stanislaus County in compliance with State General Plan laws.

The following policies from each relevant Element may potentially influence implementation of the GSP or be influenced by GSP implementation.

Agricultural Element

- Policy 2.7: Proposed amendments to the General Plan Diagram that would allow the conversion of agricultural land to non-agricultural uses shall be approved only if they are consistent with the County's conversion criteria, including:
    - Availability of water;
    - Avoidance of adverse effects agricultural water supplies;
    - Availability of adequate and necessary public services and facilities; and
    - Mitigate impacts to agricultural lands, fish and wildlife resources, air quality, water quality and quantity, or other natural resources.
- Policy 3.4: The County shall encourage the conservation of water for both agricultural, rural domestic, and urban uses.
- Policy 3.5: The County will continue to protect the quality of water necessary for crop production and marketing.
- Policy 3.6: The County will continue to protect local groundwater for agricultural, rural domestic, and urban use in Stanislaus County.

Conservation and Open Space Element

- Policy 5: Protect groundwater aquifers and recharge areas, particularly those critical for the replenishment of reservoirs and aquifers.
- Policy 6: Preserve natural vegetation to protect waterways from bank erosion and siltation.
- Policy 7: New development that does not derive domestic water from pre-existing domestic and public water supply systems shall be required to have a documented water supply that does not adversely impact Stanislaus County water resources.
- Policy 8: The County shall support efforts to develop and implement water management strategies.
- Policy 9: The County will investigate additional sources of water for domestic use.

Land Use Element

- Policy 4: Urban development shall be discouraged in areas with growth-limiting factors such as high water table or poor soil percolation, and prohibited in geological fault and hazard areas, flood plains, riparian areas, and airport and private airstrip hazard areas, unless measures to mitigate the problems are included as part of the application.
- Policy 5: Residential densities, as defined in the General Plan, shall be the maximum based upon environmental constraints, the availability of public services, and acceptable service levels. The densities reflected may not always be achievable and shall not be approved unless there is proper site planning and provision of suitable open space and recreational areas consistent with the supportive goals and policies of the General Plan.
- Policy 24: Future growth shall not exceed the capabilities/capacity of the provider of services such as sewer, water, public safety, solid waste management, road systems, schools, health care facilities, etc.
- Policy 29: Support the development of a built environment that is responsive to decreasing air and water pollution, reducing the consumption of natural resources and energy, increasing the reliability of local water supplies, and reduces vehicle miles traveled by facilitating alternative modes of transportation, and

promoting active living (integration of physical activities, such as biking and walking, into everyday routines) opportunities.

2.2.1.6 City of Patterson General Plan

The City of Patterson's General Plan serves as the community's 'constitution' for development and the use of land within its planning area. The City's 2010 General Plan covers two timeframes – 20 year and 40 years into the future (2030 and 2050, respectively). The following policies from each relevant Element may potentially influence implementation of the GSP or be influenced by GSP implementation.

Community Design Element

- Policy CD-1.1 Qualities desired in new residential neighborhoods: The qualities desired in residential expansion areas shall include elements that foster the sustainable use of scarce or non-renewable resources.
- Policy CD-1.8 Green building practices: The City supports the use of green building practices in the planning, design, construction, management, renovation, operations, and demolition of all private buildings and projects, including water conservation indoors and outdoors.

Health and Safety Element

- Policy HS-2.18 Low Impact Development: New development shall incorporate provisions for low impact development as defined by as minimizing or eliminating pollutants in storm water through natural processes and maintaining pre-development hydrologic characteristics, such as flow patterns, surface retention, and recharge rates.
- Policy HS-4.3 Water sources for firefighting: The City shall identify alternative water sources for firefighting purposes for use during a disaster.
- Policy HS-7.3 Management of hazardous materials: The City shall regulate the storage of hazardous and waste materials consistent with state and federal law. The City shall not permit above ground tanks without considering the potential hazards that would result from the release of stored liquids caused by possible rupture or collapse, and may request applicants to have an emergency response plan.
- Policy HS-7.6 Remediation: The City shall work with other responsible agencies on efforts to clean up or contain identified soil or water contamination in the city limits.
- Policy HS-7.7 Written confirmation of remediation: The City shall require written confirmation from applicable local, regional, state, and federal agencies that known contaminated sites have been deemed remediated to a level appropriate for land uses proposed prior to the City approving site development or provide an approved remediation plan that demonstrates how contamination will be remediated prior to site occupancy. This documentation shall specify the extent of development allowed on the remediated site as well as any special conditions and/or restrictions on future land uses.

Land Use Elements

- Policy LU-1.3 Planned development requirement --Residential Expansion Areas: Development of areas outside the current (2010) City limits designated Low Density Residential shall be accompanied by an application for a general plan amendment, tentative subdivision map, pre-zoning and reorganization, as necessary, consistent with a planned development.
- Policy LU-1.4 Planned development requirement — Mixed Use Hillside Development: Development of areas designated Mixed Use Hillside Development shall be accompanied by an application for a general plan amendment, tentative subdivision map, pre-zoning and reorganization, as necessary, consistent with a planned development.
- Policy LU-1.12 Status of land prior to urban development: Land within the General Plan Area shall ultimately be developed to urban standards described in Part I – Land Use and Development Standards. Pending connection to City services, such land shall remain in agricultural, open space, or other low intensity uses.

- Policy LU-1.13 Development of unincorporated land within the General Plan area: The City shall encourage the County to require development on unincorporated lands within the Patterson Planning Area to be developed to standards consistent with City standards, including architectural compatibility, provision of adequate infrastructure improvements, and provision of City sewer service, and to ensure that such development adequately mitigates potential adverse impacts to the City.
- Policy LU-1.15 Provision of public services: Consistent with the policies and implementation measures of this General Plan, the City shall consider the adequacy of public services prior to approving new development.
- Policy LU-7.4 Clean industries: The City shall promote the development of clean industries that do not pose health risks associated with water and air pollution or potential leaks or spills.

Natural Resources Element

- Policy NR-1.1 Open space conservation: The City shall conserve open space areas and drainage canals to protect water resources within the local watershed and the San Joaquin River.
- Policy NR-1.2 Stormwater quality: The City shall implement measures to minimize the discharge of pollutants and sediment into Salado Creek, Del Puerto Creek and the San Joaquin River.
- Policy NR-1.3 Inter-agency cooperation: The City shall continue to work with local, state, and federal agencies and other watershed organizations to improve water quality.
- Policy NR-1.4 Sedimentation: The City shall continue to support local, regional, and statewide efforts to minimize the discharge of sediment into waterways, including Salado Creek, Del Puerto Creek and the San Joaquin River.
- Policy NR-1.5 New development: The City shall require new development to protect the quality of water bodies and drainage systems through adaptive site design, stormwater management, and the implementation of best management practices (BMPs).
- Policy NR-1.6 Septic tanks: The City shall seek the elimination of existing septic tanks in urbanized areas.
- Policy NR-1.8 Well monitoring: The City shall regularly monitor water quality in City wells for evidence of toxics, saltwater intrusion, and other contaminants.
- Policy NR-1.10 Water conservation: The City shall promote the efficient use of water.
- Policy NR-1.11 Groundwater recharge areas: Groundwater recharge is an important component of the City’s long-term water supply program. Areas within the General Plan area suitable for groundwater recharge shall be preserved and incorporated into the design of new development.
- Policy NR-3.2 Protection of sensitive species: A project with the potential to adversely impact special status species or their habitat, shall provide evidence of compliance with the relevant provisions of state and federal laws relating to the preservation of rare, threatened, or endangered species and their habitat prior to project approval and/or prior to construction as determined by the requirements set forth in the federal and state Endangered Species Acts, the federal Clean Water Act, the federal Rivers and Harbors Act and the Implementation Measures provided in Appendix NR.
- Policy NR-3.3 On-site resource preservation: The City shall encourage new development to preserve on-site natural elements that contribute to the community’s native plant and wildlife species value and to its aesthetic character.
- Policy NR-3.7 Riparian habitat protection: The City shall preserve the ecological integrity of creek corridors, canals, and drainage ditches that support riparian resources by preserving native riparian plants and, to the extent feasible, removing invasive nonnative plants. If preservation of the ecological integrity of existing resources is found to be infeasible, adverse impacts to riparian resources shall be fully mitigated consistent with the requirements of applicable state and federal regulations.
- Policy NR-3.8 Wetland protection: The City shall preserve and protect wetland resources including creeks, rivers, ponds, marshes, vernal pools, and other seasonal wetland areas, to the extent feasible. If preservation of the ecological integrity of existing wetland resources is found to be infeasible, adverse impacts to such resources shall be fully mitigated consistent with the requirements of applicable state and federal regulations.

- Policy NR-3.9 Monitoring: Monitoring of mitigation and restoration activities shall be consistent with requirements for each species or habitat as prescribed by the relevant regulatory jurisdictional agencies. For listed or candidate species, species of special concern, or sensitive habitats for which no mitigation or avoidance measures have been published, the City shall require evidence of coordination with the responsible agencies prior to acceptance of mitigation, avoidance measures, or monitoring requirements.
- Policy NR-6.6 Landscaping options: The City shall evaluate existing landscaping and options to convert reflective and impervious surfaces to landscaping, and shall, as feasible, install or replace vegetation with drought-tolerant, low maintenance native species that can also provide shade and reduce heat-island effects.

Parks and Recreation Element

- Policy PR-1.11 Design for droughts: The City shall emphasize the use of drought-tolerant, drought-resistant and low use irrigation landscaping in the development of City parks.

Public Services Element

- Policy PS-1.1 Water Supply: The City shall continue to use groundwater as a source of domestic water for the city. The City shall also pursue, as expeditiously as possible, a water supply program consisting of the development of multiple sources of water, the maximum use of recycled water, water conservation and groundwater management to accommodate projected water demand and provide for water supply security.
- Policy PS-1.2 City-owned systems: The City shall continue to expand water treatment, distribution, and storage facility systems for potable and non-potable systems as necessary to accommodate the needs of existing and planned development.
- Policy PS-1.3 Supply for new development: The City shall not approve any new development without the demonstrated assurance of an adequate water supply to support such development that meets City criteria for both potable and non-potable demands, and a City-approved funding mechanism to pay for necessary improvements.
- Policy PS-1.4 Agency coordination: The City shall coordinate, to the extent feasible, with other agencies involved in water resource development in the region.
- Policy PS-1.5 Water conservation: To minimize the need for the development of new water sources and facilities and sewer treatment needs, the City shall promote water conservation both in City operations and in private development.
- Policy PS-1.6 Reclaimed water: Where available, the City shall require the use of reclaimed water by industrial, commercial, recreational, agricultural and roadway landscaping uses.
- Policy PS-1.7 Leaking water lines: The City shall systematically replace or repair leaking water lines.
- Policy PS-1.8 Agricultural uses: The City shall discourage the use of treated, potable water supplies for commercial agricultural uses.
- Policy PS-1.9 Improvement costs: The City shall, through a combination of water development fees and other funding mechanisms, ensure that new development pays its share of the costs of water system improvements.
- Policy PS-1.10 New development conservation measures: The City shall require all new development to use best available technologies for water conservation including, but not limited to, water-conserving toilets, showerheads, faucets, and irrigation systems.
- Policy PS-3.5 Pollutant requirements: Future drainage system discharges shall comply with applicable state and federal pollutant discharge requirements.
- Policy PS-3.12 Detention basins: The City shall ensure that stormwater detention basin designs provide safety for the public, are visually appealing and unobtrusive, incorporate wildlife habitat, and, where feasible, offer recreational opportunities.
- Policy PS-3.13 Surface pollutant control: The City shall require new development to incorporate runoff control measures to minimize discharge of surface pollutants into drainage systems.

- Policy PS-3.14 Erosion control: The City shall require new development to incorporate erosion control measures to minimize sedimentation of streams and other natural drainage features.
- Policy PS-3.15 Groundwater recharge: Where feasible, storm drainage facilities shall be designed to assist with, and complement, the water supply program in regard to groundwater recharge.

2.2.1.7 Santa Nella Community Specific Plan

The community of Santa Nella lies within Merced County, with water service provided locally by the Santa Nella County Water District. General Plan policies affecting the development of Santa Nella are captured in both the Merced County General Plan (as described in Section 2.2.1.2, above), and in the Santa Nella Community Specific Plan. The following are policies from that Specific Plan that may potentially influence implementation of the GSP or be influenced by GSP implementation.

Agriculture Concept

- Policy 1: Investigate the use of groundwater and intermediate treated wastewater to irrigate adjacent agricultural lands in exchange for fresh surface water supplies for the community.

Housing Concept

- Policy 6: The available water supply within the Specific Urban Development Plan (SUDP) must be balanced between the demand by housing and by other urban uses.

Infrastructure Concept

- Policy 1: Water and wastewater infrastructure is implemented with each phase of development, as necessary to adequately provide potable water delivery, treatment and distribution, wastewater collection and treatment.
- Policy 2: The Santa Nella County Water District (SNCWD) shall coordinate with the State of California, Department of Health Services, Department of Water Resources, The Regional Water Quality Control Board, Merced County Department of Public Works, and other agencies as necessary to ensure compatibility with respective agency requirements.
- Policy 3: Apply the Sewer and Water Infrastructure Concept, found in the Santa Nella Water Resources Plan, the Master Water Plan and Master Sewer Plan, to ensure commitment of adequate water supply sources, development of potable water treatment facilities and distribution infrastructure systems with each development phase.
- Policy 4: The SNCWD will ensure that water and wastewater infrastructure services and facilities for each development phase, identified and approved through the Implementation Plan, are adequately funded.
- Policy 5: Prior to processing any discretionary application (tentative map, administrative permit or conditional use permit), a preliminary "can and will serve" letter must be obtained from the Santa Nella County Water District indication that adequate water supply, treatment and disposal capacity exists or is being made available to the project.

Land Use Concept

- Policy 3: All new urban development within the SUDP shall connect to existing or new public sewer and water systems.
- Policy 4: Ensure that Public facilities are adequate and available to serve the demand generated by new development.

Open Space, Conservation, and Recreation Concept

- Policy 2: Ensure that land uses and development on or near water resources will not impair the quality or productive capacity of these resources.
- Policy 3: Methods to prevent the depletion of groundwater resources and promote the conservation and reuse of water should be encouraged.

- **Policy 5:** Encourage water conservation in the community by using drought tolerant landscaping, by water conservation measures administered by the SNCWD and by avoiding overwatering.

2.2.1.8 City of Modesto Urban Area General Plan as applicable to Grayson

The community of Grayson lies within Stanislaus County, with water service provided locally by the City of Modesto. General Plan policies affecting the development of Grayson are captured in both the Stanislaus County General Plan (as described in Section 2.2.1.4, above), and in the City of Modesto's Urban Area General Plan. The following are policies from the City of Modesto's Urban Area General Plan that may potentially influence implementation of the GSP or be influenced by GSP implementation.

Community Growth Strategy

- **Criteria for Analysis of General Plan Amendment:** Any proposal to amend the Modesto Urban Area General Plan must be analyzed for the amendment's effects compared to the adopted General Plan on the issues including:
    - Water quality impacts, as addressed in the Master Environmental Impact Report (EIR); and
    - Water supply and wastewater, as addressed in the Master EIR.

Community Services and Facilities

- **Water Policies – Baseline Developed Area:**
    - **f.** The City of Modesto shall prepare and adopt an Urban Water Management Plan every five years in accordance with Water Code Section 10621.
    - **g.** The City shall implement the Demand Measurement and Conservation Measures identified in the City's adopted Urban Water Management Plan.
    - **h.** The City of Modesto shall prepare and maintain a Water Master Plan. The Water Master Plan shall be updated, as needed, to incorporate changes in growth projections, water supplies, and demands.
    - **i.** The City of Modesto should continue to pursue additional potential water supply alternatives available to the City to accommodate growth and meet future demand in both normal and dry years.
    - **j.** The City of Modesto will encourage the optimum beneficial use of water resources within the City. The City shall strive to maintain an adequate supply of high-quality water for urban uses. At a minimum, potable water supplies (including well water) delivered to water customers shall conform to the primary maximum contaminant levels as defined in the California Code of Regulations, Title 22, Section 64431-64444.
    - **k.** The City of Modesto will strive to stabilize groundwater levels and eliminate groundwater overdraft, as part of a conjunctive groundwater–surface water management program. The City shall view regional water resources, such as groundwater, surface water, and recycled wastewater, as an integrated hydrologic system when developing water management programs.
    - **l.** The City of Modesto will be the sole provider of municipal and industrial water services to the area within the City's Sphere of Influence, with the exception of private wells. The City will cooperate with the overlying agricultural water providers, Modesto Irrigation District and Turlock Irrigation District, and with adjacent municipal and industrial providers for the mutually beneficial management of the limited water resources. The City will also take into consideration its public trust duty with regard to environmental uses of water resources.
    - **q.** The City of Modesto shall implement Local Basin Management Objectives (BMOs) discussed in the Integrated Regional Groundwater Management Plan that relate to the specific approaches to water management goals including groundwater supply, groundwater quality, and protection against inelastic land surface subsidence.
    - **r.** The City of Modesto shall support the Regional BMOs discussed in the Integrated Regional Groundwater Management Plan.

   - u. When approving a proposed residential subdivision of over 500 dwelling units, the City of Modesto must include a condition requiring a sufficient water supply to be available. Proof of availability of water supply depends upon several factors.
- Stormwater Drainage Policies—Baseline Developed Area: The City shall prevent water pollution from urban storm runoff as established by the Central Valley Regional Water Quality Control Board Basin Plan for surface discharges and the Environmental Protection Agency for underground injection.

2.2.1.9 Crows Landing Community Plan

The community of Crows Landing is a census-designated place in Stanislaus County. The Crows Landing Community Plan describes the community and available urban services, while the Stanislaus County General Plan (described in Section 2.2.1.4, above) provides policies relating to the larger region.

While there are no specific policies relating to water resources management in the Crows Landing Community Plan, the Plan does note that the Crows Landing Community Service District provides public water via two groundwater wells and that the water delivery pipelines are aging and the system is at capacity, limiting the District's ability to expand.

2.2.1.10 Westley Community Plan

Similar to Crows Landing, the community of Westley is a census-designated place in Stanislaus County. The Westley Community Plan describes the community and available urban services, while the Stanislaus County General Plan (described in Section 2.2.1.4, above) provides policies relating to the larger region.

While there are no specific policies relating to water resources management in the Westley Community Plan, the Plan does provide a description of the area and available public services.

2.2.2 Existing Land Use Plans and Impacts to Sustainable Groundwater Management

Numerous policies in each County's and Community's General Plan compliment this GSP's plan to conserve and sustainably manage groundwater resources. In general, the County and City General Plans guide future growth and development (and associated demands) within their respective jurisdictional areas. This additional growth may impact groundwater sustainability by placing additional demands on groundwater resources in an area where surface water resources are scarce or are otherwise unavailable. The General Plans also promote water conservation (in both the urban and agricultural sectors), which could potentially offset the additional demands associated with future development. In addition to conservation, some (though not all) General Plans promote groundwater recharge, the protection of recharge areas, and the use of water transfers to further benefit groundwater sustainability

Most General Plans within the Northern and Central Delta-Mendota Regions include goals focused on preserving and expanding agriculture, efficient use of existing and future water sources in both the urban and agricultural sectors, connecting smaller rural communities to larger water systems, and water quality protection. With respect to the protection of water quality and groundwater dependent ecosystems, the General Plans generally protect riparian habitats, encourages the protection of water quality (including through the remediation of contamination that may impact groundwater quality, requiring the use of septic systems in rural areas that are design to be protective of groundwater quality and the use of community wastewater systems in urban areas), and promotes flood control and management (including the associated impacts of erosion and sedimentation of surface water courses).

Finally, the Fresno County General Plan, in particular, promotes sustainability by managing new wells in urban areas, supporting monitoring of water resources and associated habitats, and through the formation of a water resources document repository.

While the magnitude of impacts of these policies over the planning and implementation horizon are not known, such policies have been considered in this GSP, primarily through the use of the General Plans and associated zoning maps to identify future land use types and projected growth areas. These General Plans and mapping were used along with available water master plans, urban water management plans, agricultural water management plans, and other relevant planning documents to determine projected future land use and estimate future water demands by land use sector for use in the projected future water budgets.

Just as the General Plans complement the GSP, the Northern & Central Delta-Mendota Region GSP, along with the other five coordinated GSPs in the Delta-Mendota Subbasin, may influence the General Plans' goals and policies. Sustainable management of groundwater resources through the GSP may change the pace, location and type of development and/or land use that will occur in the Subbasin. GSP implementation is anticipated to be consistent with the General Plans' goals to sustainably manage land development and water resources in the Subbasin.

2.3 EXISTING WATER RESOURCES MONITORING AND MANAGEMENT PROGRAMS

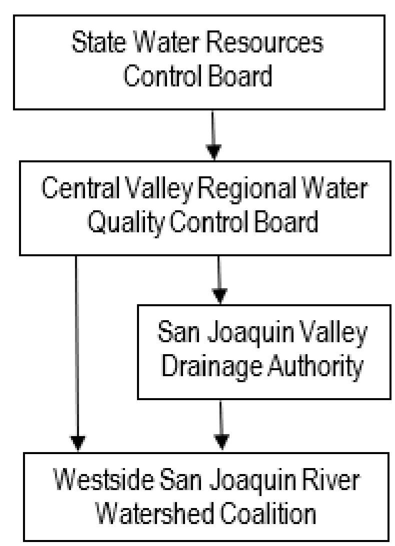
As required by §354.8(c) and (d) of the GSP Emergency Regulations, the following section describes existing water resources-related management and monitoring programs, and a discussion of how these programs will either impact GSP implementation and/or will be incorporated into the GSP.

2.3.1 Water Resources Management Programs

2.3.1.1 Irrigated Lands Regulatory Program (ILRP)

In 1999, the California Legislature passed Senate Bill 390, which eliminated a blanket waiver for agricultural waste discharges. The Bill required the Water Boards to develop a program to regulate agricultural lands under the Porter-Cologne Water Quality Control Act. In 2003, the Central Valley Regional Water Quality Control Board (CV-RWQCB) issued an order that sets Waste Discharge Requirements (WDRs) from irrigated lands to protect both surface and groundwater throughout the Central Valley, primarily to address nitrates, pesticides, and sediment discharge. The resulting ILRP regulates wastes from commercial irrigated lands that discharge into surface and groundwater. The program is administered by the CV-RWQCB working directly with a regional or crop-based coalition as well as directly with growers. The goal of the ILRP is to protect surface water and groundwater and to reduce impacts of irrigated agricultural discharges to waters of the State. As a result of the ILRP, monitoring reports, assessment reports, management plans, surface water quality data, and groundwater quality data are made available to the public.

Implementation of the IRLP in the Delta-Mendota Subbasin is managed primarily by the Westside San Joaquin River Watershed Coalition under the San Joaquin Valley Drainage Authority, a California Joint Powers Authority (JPA). This region specifically emphasizes nitrogen, sediment, and erosion control. Management of waste discharge in the Westside Coalition area includes:



- Farm-scale evaluation surveys and management plans submitted by growers. In high vulnerability groundwater areas, growers must submit a plan with more stringent levels of certification.
- Comprehensive Groundwater Quality Management Plans (GQMP) submitted by the Western San Joaquin Coalition to the Central Valley Water Board for approval.
- Evaluation of the effectiveness of management practices by the regional Water Quality Management Practices Evaluation Program (MPEP) Group.
- Surface water Monitoring Plans, Annual Monitoring Reports, Management Plans, and Sediment Discharge and Erosion Assessment Reports.

A portion of the southern area of the Northern and Central Delta-Mendota Regions fall within the Grassland Drainage Area Coalition, which must meet the same management and reporting requirements as the Westside San Joaquin River Watershed Coalition.

2.3.1.2 CV-SALTS

The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is an initiative to reduce salt and nitrate impacts, restore groundwater quality, and provide safe drinking water supplies. Developed by a group of stakeholders (federal, state, and local agencies, dischargers and growers, and environmental groups) called the Central Valley Salinity Coalition, the Central Valley Salt and Nitrate Management Plan (SNMP) was released in 2017.

The Central Valley SNMP recommends revised and flexible regulations for existing Basin Plans and includes recommended interim solutions for salt and nutrient management in high priority basins in addition to long-term salt management strategies. Under the Central Valley SNMP, dischargers are provided two compliance pathways: (1) traditional permitting as an individual discharger or as a coalition (i.e. irrigated lands coalition), or (2) groundwater management zone permitting. Zone permitting allows dischargers to work as a collective in collaboration with the CV-RWQCB to provide safe drinking water with the option to extend time to achieve nitrogen balance.

The Delta-Mendota Subbasin is ranked “Priority 2” in the Central Valley SNMP and enforcement of the SNMP (once begun) will initially focus on other higher priority basins. At present, the Central Valley SNMP is in draft form, with comments due to the CV-RWQCB by August 13, 2018.

2.3.1.3 Integrated Regional Water Management Program

Three Integrated Regional Water Management Plans (IRWMPs) overlie the Delta-Mendota Subbasin. The Westside-San Joaquin IRWMP covers most of the Subbasin, while smaller portions of the Subbasin are covered by the East Stanislaus and Madera IRWMP.

2.3.1.3.1 Westside-San Joaquin 2019 Integrated Regional Water Management Plan

The 2019 Westside-San Joaquin (W-SJ) Integrated Regional Water Management Plan (2019 IRWMP) encompasses the majority of the Delta-Mendota Subbasin, as shown in **Figure 2-27**. The 2019 W-SJ IRWMP emphasizes multi-agency collaboration, stakeholder involvement, regional approaches to water management, water management involvement in land use decisions, and project monitoring to evaluate results of current practices. The W-SJ IRWMP identifies projects that help achieve regional objectives and targets while working to address water-related challenges in the region.

The SLDMWA, acting as the Regional Water Management Group (RWMG) for the region, has coordinated the evolution of planning documents and the regional objectives since 2001. Plan development and updates has been iterative and driven by stakeholder participation and has resulted in this Plan’s overarching goal of providing a more reliable water supply, protecting agricultural, municipal, and environmental water uses, and meeting community needs (including those of disadvantaged communities), by improving water supply sustainability, water quality, and drainage. Working off this overarching goal, the Integrated Regional Water Management (IRWM) Region identified the following 2019 W-SJ IRWMP objectives as they relate to integrated water resources management:

Objective A: Provide for more reliable water supply south of the Delta

Objective B: Improve regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts

Objective C: Provide reasonable opportunity to advance ecosystem restoration through balanced project implementation

Objective D: Provide potential for environmental and habitat improvement, including wetlands

Objective E: Promote projects that meet the needs of disadvantaged communities

Objective F: Promote and enhance water conservation, water use efficiency, and sustainable water use

Objective G: Promote and enhance water recycling

Objective H: Maximize utility of Regional aquifers while improving sustainability

Objective I: Minimize risk of loss of life, infrastructure, and resources caused by significant storm events by utilizing uncontrolled flow beneficially

Objective J: Capture stormwater for higher beneficial use whenever practicable

Objective K: Develop Regional solutions that protect and enhance the quality of water supply, particularly in disadvantaged communities that are unable to meet water quality standards

Objective L: Consider recreational potential in project development

Objective M: Minimize energy consumption and associated greenhouse gas emissions, including use of renewable energy when appropriate

Objective N: Promote projects that increase operational flexibilities and supply management tools

These objectives connect to regional conjunctive use of groundwater and surface water supplies and therefore have the potential to influence implementation of this GSP.

The 2019 W-SJ IRWMP provides valuable resources related to potential concepts, projects and monitoring strategies that can be incorporated into the Northern & Central Delta-Mendota Region GSP, especially as this is the primary IRWM region overlying the Delta-Mendota Subbasin.

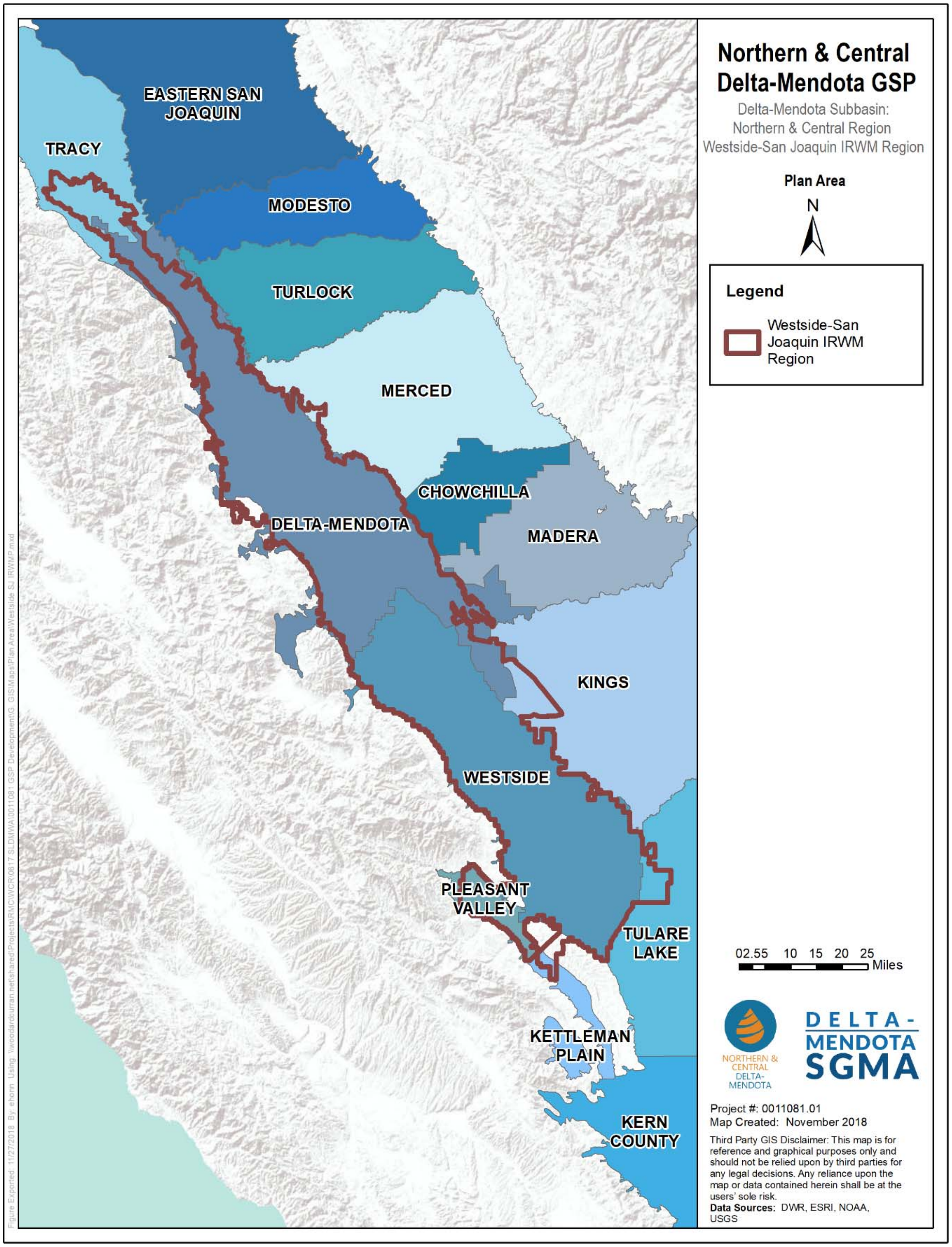


Figure 2-27. Delta-Mendota Subbasin underlying the Westside-San Joaquin IRWM Region

2.3.1.3.2 2018 East Stanislaus Integrated Regional Water Management Plan

The 2018 East Stanislaus Integrated Regional Water Management Plan (ESIRWMP) area overlies a small portion of the Delta-Mendota Subbasin along the western side of San Joaquin River (**Figure 2-28**). This IRWM region is managed by the East Stanislaus Regional Water Management Partnership (ESRWMP), the Regional Water Management Group for the region, and is composed of representatives from the Cities of Modesto, Hughson, Ceres, Turlock, Waterford, and Stanislaus County.

In forming the East Stanislaus IRWM Region, the ESRWMP engaged regional stakeholders in the identification of regional conflicts and issues, discussions regarding goals and objectives for regional water resources management, and in the development of IRWMPs that contain a living list of projects, studies, and programs that, when implemented, will aid the Region in resolving the identified water-related conflicts. Specific to this, the IRWM Region has identified the following goals and objectives in the categories of Water Supply, Flood Protection, Water Quality, Environmental Protection and Enhancement, Regional Communication and Cooperation, and Economic and Social Responsibility:

Water Supply Goals and Objectives

Goal: Protect existing water supplies and water rights and improve regional water supply reliability.

Objectives:

- Provide a variety of water supply sources, including recycled water, to meet all current and future demands (urban, agricultural and the environment) under various hydrologic conditions.
- Promote the use of groundwater storage and conjunctive use options to reduce groundwater overdraft.
- Protect existing water rights, including permitted diversions and extractions.
- Implement water conservation plans for both urban and agricultural uses.
- Support monitoring and research to improve understanding of water supplies and needs.
- Address intra- and inter-regional conveyance infrastructure needs.
- Address changes in runoff and recharge due to climate change, including amount, intensity, timing, and variability.

Flood Protection Goals and Objectives

Goal: Ensure flood protection strategies are developed and implemented through a collaborative process, utilizing both local and watershed-wide approaches designed to maximize opportunities for comprehensive water resource management that meet multiple objectives.

Objectives:

- Develop outlines of regional projects and plans necessary to protect infrastructure from flooding and erosion from the 100-year event.
- Work with stakeholders to preserve existing flood attenuation by implementing land management strategies throughout the watershed.
- Develop approaches for adaptive management that minimize maintenance requirements and protect water quality and availability while preserving and enhancing ecologic and stream functions, including addressing adaptation to changes in timing and intensity of runoff due to climate change, as appropriate.
- Provide community benefits beyond flood protection, such as public access, open space, recreation, agricultural preservation, and economic development.
- Protect, restore, and enhance the natural ecological, geomorphic, and hydrologic functions and processes of rivers, creeks, streams and their floodplains.
- Address changes in timing and intensity of runoff due to climate change.

- Increase and improve the quantity, diversity, and connectivity of riparian, wetland, floodplain, aquatic, and shaded riverine aquatic habitats, including the agricultural and ecological values of these lands.
- Identify opportunities and incentives for expanding or increasing use of floodway corridors.

Water Quality Goals and Objectives

Goal: Protect and improve water quality for beneficial uses consistent with regional interests and the Regional Water Quality Control Board (RWQCB) Basin Plan in cooperation with local, state and federal agencies and regional stakeholders.

Objectives:

- Meet or exceed all applicable water quality regulatory standards, including drinking water standards.
- Deliver agricultural water to meet water quality guidelines established by stakeholders.
- Aid in meeting Total Maximum Daily Loads (TMDLs) established, or to be established, for the Tuolumne, Stanislaus, Merced, and San Joaquin River watersheds.
- Protect surface waters and groundwater basins from contamination and threat of contamination.
- Manage existing land uses while preserving or enhancing environmental habitats.
- Minimize impacts from storm water through implementation of Best Management Practices, Low Impact Development or other similar projects.
- Promote programs and projects to reduce the quantity and improve the quality of urban and agricultural runoff.
- Promote and support regional monitoring to further understanding of water quality issues.

Environmental Protection and Enhancement Goals and Objectives

Goal: Protect the environmental resources of the Stanislaus, Tuolumne, Merced and San Joaquin River watersheds by identifying, promoting and implementing opportunities to assess, restore and enhance natural resources of these watersheds.

Objectives:

- Identify and incorporate (where possible and reasonable) opportunities to assess, protect, enhance, and/or restore natural resources when developing water management strategies.
- Minimize adverse effects on biological and cultural resources, including riparian habitats, habitats supporting sensitive plant or animal species, and archaeological sites when implementing strategies and projects.
- Identify opportunities for open spaces, trails and parks along creeks and other recreational projects in the watershed to be incorporated with water supply, water quality, or flood protection projects.
- Contribute to the long-term sustainability of agricultural, commercial, industrial, and urban land uses and activities within the basin.
- Identify opportunities to protect, enhance, or restore habitat to support all watersheds in the Region in conjunction with water supply, water quality, or flood protection projects.
- Support projects to understand, protect, improve and restore the region’s ecological resources.
- Promote the recovery and stability of regionally present native species and populations.

Regional Communication and Cooperation Goals and Objectives

Goal: Implement and promote this IRWMP through regional communication, cooperation, and education.

Objectives:

- Develop a forum for consensus decision-making and IRWMP implementation by regional entities.

- Build relationships with State and Federal regulatory agencies and other water forums and agencies to facilitate permitting of water-related projects and ensure continued consistency with state water plans.
- Facilitate dialogues between regional and inter-regional entities to reduce inconsistencies and conflicts in water management and to maximize benefits from water-related projects.
- Maintain avenues of communication with the general public and offering opportunities to provide feedback on the IRWM and water-related projects through the regional websites and other public forums.
- Identify opportunities for public education about water supply, water quality, flood management, and environmental protection.
- Implement focused outreach to DACs and EDAs relative to opportunities for water supply, water quality, flood management, and environmental protection projects.

Economic and Social Responsibility Goals and Objectives

Goal: Promote development and implementation of projects, programs and policies that are socially impartial and economically sound.

Objectives:

- Support the participation of disadvantaged communities and economically distressed areas in the development, implementation, monitoring and long-term maintenance of water resource projects.
- Develop cost-effective multi-benefit projects.
- Consider disproportionate community impacts to ensure environmental justice.
- Maximize economies of scale and governmental efficiencies.
- Protect cultural resources.
- Reduce energy use and associated greenhouse gas emissions and/or use renewable resources where appropriate.
- Adopt carbon sequestration strategies where appropriate.

As with the 2018 Westside-San Joaquin IRWMP, the East Stanislaus IRWMP provides valuable resources related to potential concepts, projects, and monitoring strategies that can be incorporated into the Northern & Central Delta-Mendota Region GSP. However, most of the IRWM Region does not overlie the Delta-Mendota Subbasin, so implementation of these projects may, for the most part, have little to no impact on groundwater management in the Delta-Mendota Subbasin.

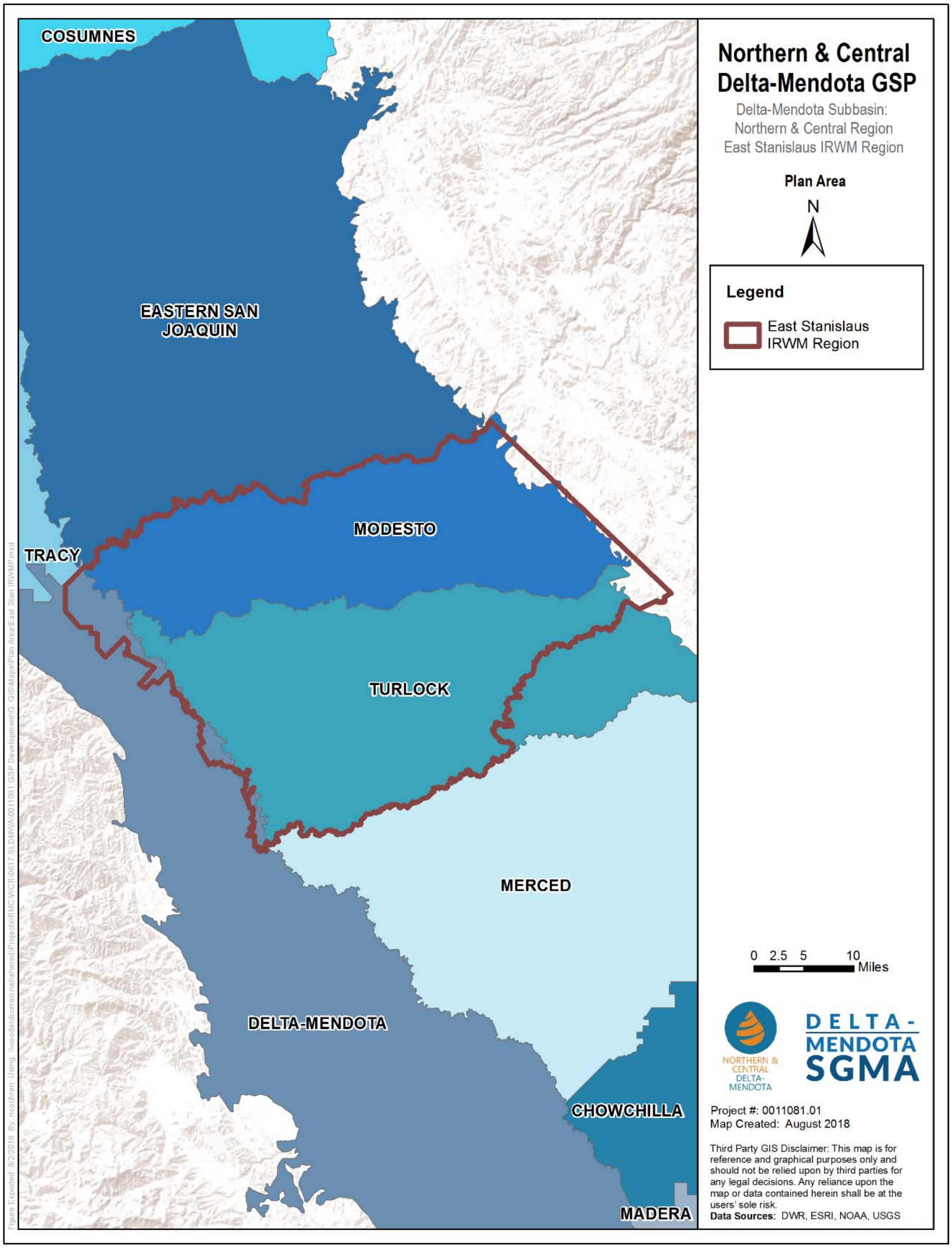


Figure 2-28. Delta-Mendota Subbasin underlying the East Stanislaus IRWM Region

2.3.1.3.3 2014 Madera Integrated Regional Water Management Plan

The Madera IRWMP was last updated in 2014 and represents a collaborative effort among 17 public, private, and not-for-profit groups and agencies which are signatory to the Memorandum of Understanding (MOU) forming the Madera Regional Water Management Group. The IRWMP was prepared in coordination with other interested groups and agencies who have participated in the process and who are not signatory to the agreement, but who share an interest in managing water resources throughout Madera County and its watersheds. The portion of the Delta-Mendota Subbasin underlying the Madera IRWM Region is shown in Figure 2-29.

As with the IRWMP from other regions overlying the Delta-Mendota Subbasin, the Madera IRWMP included a mission, goal and set of measurable objectives designed to promote effective water resources management in the Region. As stated in the Madera IRWMP:

> "…[The] mission of the Regional Water Management Group (RWMG) will facilitate future coordination, collaboration, and communication for comprehensive management of water resources in the Madera Region. Through the mutual understanding among entities in the Madera Region regarding their joint efforts toward Integrated Regional Water management governance, development, planning, funding, and implementation to ensure that clean, adequate and affordable water supplies are available now and in the future to sustain this region and its responsible growth." (Madera Regional Water Management Group, 2014).

The Madera IRWMP included separate goals for the Valley portion of the Region and for the Foothills/Mountain portion of the Region. The Valley goals are to:

- Achieve groundwater sustainability by 2024;
- Create an independent organization to manage groundwater resources;
- Expand stakeholder education;
- Assure groundwater quality meets drinking and irrigation water quality standards; and
- Improve flood control and protection.

Under each of these goals are measurable actions and methods (objectives) intended to help achieve the goals. Specific objectives that could affect groundwater management under SGMA include:

Valley Goal 1: Achieve Groundwater Sustainability by 2024

- Increase regional capacity for direct recharge by 50,000 acre-feet per year (AFY).
- Integrate flood/storm water conveyance infrastructure and regional irrigation system.
- Expand California Statewide Groundwater Elevation Monitoring (CASGEM) groundwater monitoring network to semi-annually measure regional groundwater on a per-aquifer basis.
- Improve water reliability.
- Expand water conservation efforts.

Valley Goal 2: Create an Independent Local Organization to Manage Groundwater Resources

- Determine most desirable form of organization and achieve buy-in from RWMG member agencies.
- Identify sources for ongoing operational funding for the independent local organization.
- Seek special legislation as required to create the chosen special district.

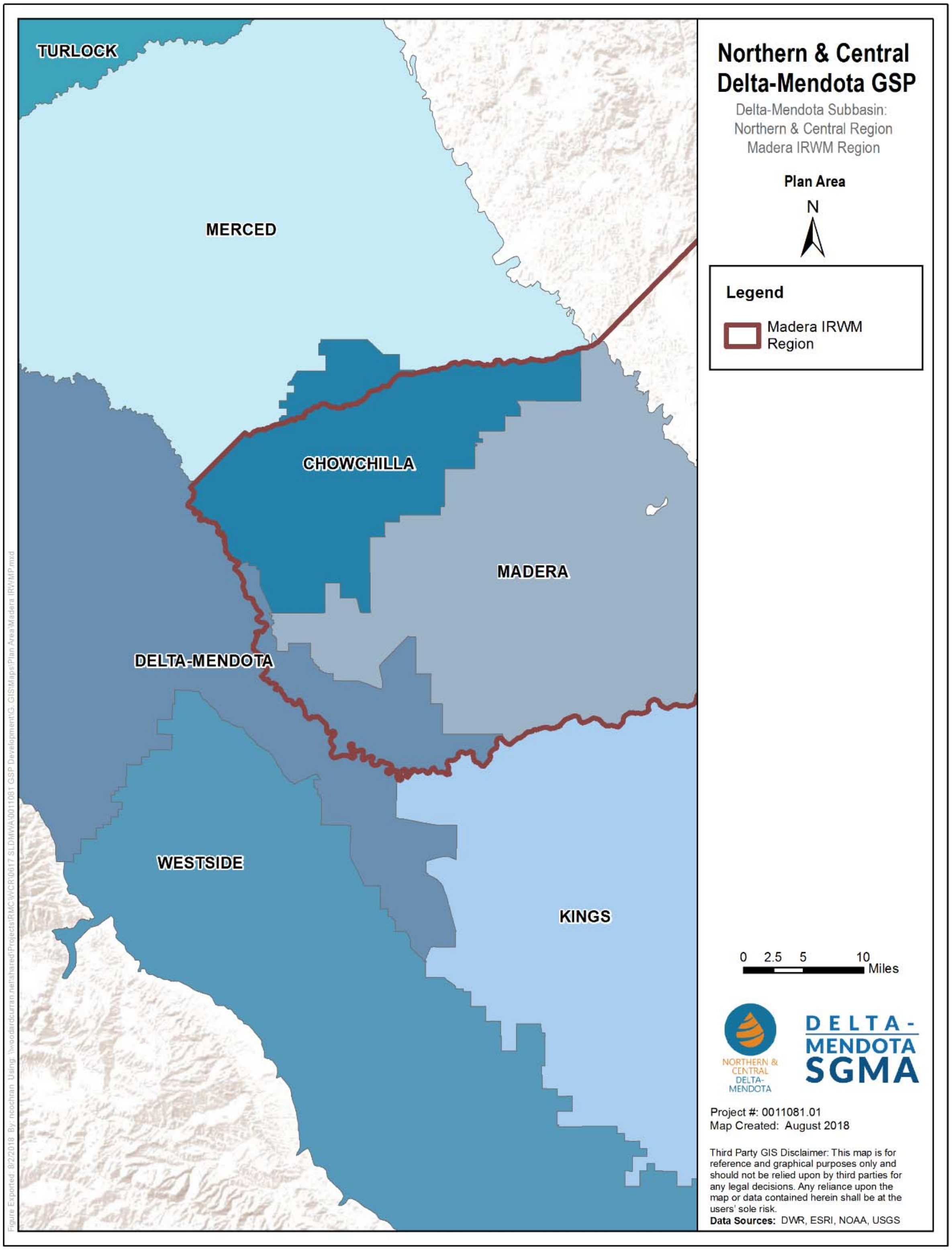


Figure 2-29. Delta-Mendota Subbasin underlying the Madera IRWM Region

Valley Goal 4: Assure Groundwater Quality Meeting Drinking and Irrigation Water Quality Standards

- Identify problem areas.
- Identify strategies to address chemical Constituents of Concern.
- Propose projects to address waters which do not meet State Public Health Goals or irrigation standards.

Valley Goal 5: Improve Flood Control and Protection

- Improve water storage capacity.

As the Foothill and Mountain portions of the Madera IRWMP do not overlie the Delta-Mendota Subbasin, they are not directly applicable to this GSP.

The Madera IRWMP is currently being updated to meet 2016 IRWM program guidelines, with an expected public draft completed by fall 2018.

2.3.2 County Well Construction/Destruction Standards and Permitting

DWR has developed well standards for the state per California Water Code Section 13700 to 13806. These standards have been adopted by the State Water Resources Control Board (SWRCB) into a statewide model well ordinance (Resolution No. 89-98) for use by the Regional Boards for enforcing well construction standards where no local well design ordinance exists that meets or exceeds the DWR standards. DWR's Well Standards are presented in Bulletin 74-81 and Bulletin 74-90.

Table 2-7 lists the counties in the Delta-Mendota Subbasin and the respective permitting agencies and local ordinances for well construction and destruction standards. A discussion of these standards and the respective permitting process as well as well abandonment and destruction procedures follows.

<u>Fresno County</u>

In Fresno County, the County Environmental Health Division issues permits for construction of new water wells, reconstruction, repair or deepening of existing wells, and for destroying abandoned wells to properly licensed water well drilling contractors in unincorporated Fresno County. To obtain a permit to construct a new well, properly licensed contractors must submit a completed Water Well Permit Form, along with applicable permit fees, to the Environmental Health Division. Once the permit application is approved, a well permit number is assigned and drilling may commence. The permit is valid for 180 days. Once the well construction, deepening, or destruction work is completed, the contractor is required to provide a Notice of Completion, also known as a Well Driller's Report or Well Log, to the Environmental Health Division within thirty (30) days of completion. The report is required to document that the work was completed in accordance with the Well Standards Ordinance. Once the report is received by the Environmental Health Division, the property owner is contacted by letter to schedule a final inspection of the new well. The inspection is required to ensure that the well has been completed in an approved manner and there are no apparent direct openings into the well that may allow the entry of contamination into the water supply. During the inspection, Environmental Health staff, if possible, conducts sampling of the new or deepened domestic wells to determine if there are certain contaminants of health concern.

Table 2-7. Summary of Applicable Well Construction/Destruction Standards in the Northern and Central Delta-Mendota Regions

County	Permitting Agency	Local Ordinance
Fresno (unincorporated areas)	Fresno County Department of Public Health, Environmental Health Division	Special considerations include well location and positioning of perforations listed in Bulletin 74-6.
Merced (Except cities of Atwater, Dos Palos, Gustine, Livingston, Los Banos, and Merced as well as on any federal or state land)	Merced County Department of Public Health, Division of Environmental Health	Chapter 9.28 of the Merced County Code (Well Ordinance) specifies use of the State's Well Construction Standards for the design of wells and includes setback and permitting requirements. The County's Ordinance preventing the mining and export of groundwater within unincorporated areas of Merced County (Chapter 9.27 of the Merced County Code) minimizes unsustainable groundwater extractions.
San Benito (all of the county)	San Benito County Water District or San Benito County Department of Environmental Health, Public Health Division	Individual wells are permitted by the San Benito County Water District across the whole county. If the well is part of a "local small water system," a small water system permit must also be obtained from the County Dept. of Environmental Health.
San Joaquin (Except Stockton, Ripon, and Tracy)	San Joaquin County Environmental Health Department	Special requirements include determination of water quality during construction, depth limitations, perforation specification, and sealing-off strata listed in Bulletin 74-5. The County also has a Groundwater Export Ordinance (Division 8, Chapter 1, Section 5-8100 of the County Code) that is designed to protect local groundwater users from groundwater exports and unsustainable groundwater extractions as part of the well permitting process.
Stanislaus (unincorporated areas)	Stanislaus County Department of Environmental Resources	While the County does not have any specific changes/additions to the State's Well Construction Standards, the County's Groundwater Ordinance (Chapter 9.37 of the Stanislaus County Code) requires a specific well permit application review process to minimize unsustainable groundwater extractions.

Fresno County Department of Public Health, Environmental Health Division enforces the provisions of the California Well Standards Ordinance and the construction standards set forth in the California Well Standards, Bulletins 74-81 and 74-90. As mentioned in Table 2-7, Fresno County has a local well ordinance approved by DWR, Bulletin 74-6. Additionally, Fresno County Code of Ordinances, Chapter 14.08 – Well Construction, Pump Installation and Well Destruction Standards includes adopted standards that fall under the following categories:

- Well location
- Sealing
- Surface construction features
- Disinfection and sanitary requirements
- Sealing-off strata
- Well development
- Water quality sampling
- Special provisions for large diameter shallow wells, driven wells, repair or deepening of wells, and temporary covers
- Well destruction standards
- Requirements for abandoned wells and their destruction
- Standards for cathodic production wells

Program PF-C.B of the County General Plan states the County will adopt a well construction and destruction ordinance that will include, among other requirements, the mapping of location information on abandoned wells in the County GIS database and which includes a procedure for ensuring the abandoned wells are properly destroyed.

Fresno County Department of Public Health, Environmental Health considers a well "abandoned" when it has not been used for a period of one year, unless the owner demonstrates intention to use the well again (following the California Well Standards Ordinance). Wells must be destroyed by a licensed C-57 water well contractor with an active license. Proper maintenance of inactive wells is enforced according to Section 115700 of California Health and Safety Code, where the top of the well or well casing is secured by a locked, water-tight cover. The inactive well shall be marked to be easily visible, located, and identified as a well, where the area around the well shall be kept clear of brush, debris and waste materials.

All well destructions are performed according to Water Well Standards Bulletins 74-81 and 74-90 published by DWR. Before destroying a well, a permit must be issued by the Fresno County Department of Public Health where all available construction data shall be submitted with the application for a well destruction permit. Following the destruction of a well, a State of California Well Completion Report shall be submitted to the Fresno County Department of Public Health within thirty (30) days of the completion of any well destruction.

Merced County

The well permitting process in Merced County begins with applicants filling out the Well Construction, Destruction, Mining, and Export Application/Permit, as appropriate. Merced County has published a User Guide for filling out this application, which includes step-by-step information for filling out the application and relevant links and resources. In addition to the Well Construction, Destruction, Mining, and Export Application/Permit, a Letter of Intent must be submitted to the County for each existing well on a parcel at the time a new domestic, irrigation, or out-of-service well permit application is submitted. Well applications are reviewed to determine the purpose of the well, the proposed pumping volume, and possible environmental impacts. If the well meets all screening and environmental review requirements, as per the Merced County Groundwater Mining and Export Ordinance (Chapter 9.27 of the Merced County Code), it may be eligible for approval. Among other exemptions, replacement wells with the same size and capacity are exempted from the Merced County Groundwater Ordinance.

Prior to the construction, modification, abandonment, or destruction of a well, the well contractor shall apply for and obtain a permit from the health officer. Construction of a proposed well cannot commence until the permit application has been approved by the health officer and the owner and contactor are in receipt of the approved permit. The well contactor is required to possess a valid C-57 license and contactor's bond. The health officer is to be notified by the well contractor at least twenty-four (24) hours prior to commencement of the work authorized by the permit. Within thirty (30) days of completing the work, the well contractor is required to submit an official copy of the well completion report to the health officer, which will then be submitted to DWR. When one or more wells are existing on a parcel, an application for a permit to construct a water well on the same parcel must be accompanied by a "letter of intent" for each well, signed by the property owner which elects one of the following options concerning the future of the existing well(s): destruction at the time the new well is placed in service; the existing well will continue to be used; or take the well out of service and maintain it in accordance with the provisions of the Merced County Well Ordinance for a period of no more than one year, after which the well will be restored to service or destroyed.

As mentioned in Table 2-7, Chapter 9.28 (Wells) of the Merced County Code specifies use of the State's Well Construction Standards for the design of wells and includes setback and permitting requirements. The County General Plan includes Policy W-1.5 which encourages coordination between cities and special districts in developing County-wide guidelines regarding location and construction of new water wells.

Merced County Department of Public Health, Division of Environmental Health (MCDEH) requires individuals to fill out a Well Construction, Destruction, Mining, and Export Application/Permit before commencing any well destruction activities. Merced County Code, Title 9, Chapter 9.28 Wells outlines the standards that must be adhered to when abandoning and destroying a well.

San Benito County

The San Benito County Code of Ordinances, Chapter 15.05 *Water* lists multiple types of permits that must be obtained for different well applications.

To construct an individual well, the San Benito County Water District is considered the enforcing agency. A permit must be obtained to "dig, bore, drill, deepen, modify, repair or destroy a water well, cathodic protection well, observation well, monitoring well or any other excavation that may intersect groundwater" (Code of Ordinances Chapter 15.05.075). If a person fails to obtain a permit, the initial fee is doubled to form the price of the fine, unless the work is done in an emergency to maintain drinking water or agricultural supply.

A permit can be acquired by submitting an application to the enforcing agency that includes information about the proposed construction and a filing fee. Only persons permitted to work on wells must carry out the construction, reconstruction, or destruction work. Standards for well construction in San Benito County are in accordance with California Department of Water Resources Bulletin 74-81. Variances from these standards can be obtained under special circumstances. There are general standards, however, that the enforcing agency complies with for well and well seal inspections. Agency representatives have the right to make an inspection or test at all reasonable times in the day. A well completion report for new wells shall be provided to the enforcing agency within 30 days of a well construction, reconstruction, or destruction job.

Landowners are prohibited from knowingly retaining any permanently inactive well, cathodic protection well, or monitoring well that connect to a known pathway for pollutants from either above or below ground. The proper disposal of drilling fluids is required. Any abandoned wells must be destroyed as a condition of a new construction or reconstruction permit.

Permits to install local small water systems are enforced by the San Benito County Department of Environmental Health within the Public Health Division. Such a system is considered a supply of water for between 2 and 4 dwelling units. The system can include any type of collection, treatment, storage, or distribution facilities between those units. The County's Environmental Health Department must deem the underlying aquifer to have sufficient water quantity and quality to support that supply. Laboratory tests are required as part of the permit application to ensure water quality. Water quantity standards for each well include a sustained source capacity of 3 gallons/minute during a 24-hour period of continuous pumping or for a spring or horizonal well, a continuous yield of 1 gallons/minute between August and October.

All new wells that do not pass quality standards listed in Chapter 15.05.036 of the County Code of Ordinances must be sealed or destroyed according to the standards of Department of Water Resources Bulletin No. 74-81, unless sufficient mitigation can be done to render the water potable again and ensure that the local groundwater supply is not threatened. For all wells that were constructed before the effective date of the ordinance, well owners must apply to construct a replacement well in that location or repair the damaged well. If one of these wells cannot provide the quantity requirements in the Local Small Water Systems Ordinance, then well owner must prove to the Health Officer that there are sufficient storage facilities to provide adequate supply for domestic use. The Health Officer has the authority to inspect and carry out tests on facilities at any time.

Additionally, permits must be obtained to inject native surface water or imported water into a groundwater aquifer within county lines. This does not apply to a public agency operating a public water system. An environmental review must be done in order to determine that the water quantity or quality of the underlying aquifers are not threatened by permitted activity. The fee for the permit pays for the required environmental review document. The permit is reviewed annually for compliance.

In unincorporated areas, an applicant must get a permit to extract groundwater for sale or for use off parcel, given that the safe yield of the subbasin is not exceeded. Mining of groundwater on private property to be transported outside of county lines is prohibited.

San Joaquin County

Applicants are required to fill out and submit the Well/Pump Permit form to the San Joaquin County Environmental Health Department for the construction of a new well, replacement well, modification to an existing well, installation of a monitoring well, or putting a well out of service. A permit issued by the Environmental Health Department expires one year from the date issued, but an additional year extension may be granted by the Director if requested. Additional forms required for permitting a well in San Joaquin County, including the Well Exemption Statement and New Well Information form. The Well Exemption Statement must be completed to document the exemption criteria applicable for the new well application. Exemption criteria for a new well includes: the well is not located in a critically overdrafted basin (Tracy or Cosumnes Subbasins are not critically overdrafted), the new well owner is a *de minimis* extractor (maximum extraction of 2 AFY or less for domestic purposes only), the replacement well has the same extraction as the existing well (where the existing well must be destroyed or meet *de minimis* extractor requirements), a public agency that substantially meets or exceeds these requirements through another requirement of the law, or a city or municipal well to provide water supply solely for residents of the city or county. If the new well does not meet the exemption criteria, the New Well Information form must be submitted to the Environmental Health Department before a new well permit is issued. The collected information must be posted to the Department's website for public information.

The San Joaquin County Well Standards contains standards for well location (minimum distances from potential sources of contamination and pollution), construction or repair, well disinfection, sampling, construction and abandonment of geophysical or seismological test holes or wells, and monitoring wells. As noted in Table 2-7, special requirements for well construction in San Joaquin County include determination of water quality during construction, depth limitations, perforation specification, and sealing-off strata listed in Bulletin 74-5, which was approved by DWR. Division 11: Infrastructure Standards and Requirements, Chapter 9-1115 of the County Zoning Code states that a well permit may be approved by the Director of Environmental Health Division only if the following conditions are met: (1) the proposed well shall not be offensive, dangerous, or injurious to health, or create a nuisance; (2) the proposed water complies in all respects to the standards of the Environmental Health Division for the construction of wells; and (3) upon completion of the well, the applicant or the Well Contractor shall file a copy of a Well Drillers Report with the Environmental Health Division, where these report forms will be furnished by the

Director of Environmental Health Division or the State of California Water Resources Control Board. Policy IS-4.15 of the County General Plan states that prior to issuing building permits for new development that will rely on groundwater, the County shall require confirmation for existing wells and test wells for new wells to ensure that water quality and quantity are adequate to meet the needs of existing, proposed, and planned future development.

When a well no longer functions as originally designed, or cannot appropriately function in place of another design, or has fallen in to such a state of disuse or disrepair that it may become a source of impairment to groundwater quality, constitutes a safety hazard, or found to be abandoned, it must be destroyed under a well destruction permit. Sealing requirements, as detailed in Chapter 6.3 (Sealing Requirement) of San Joaquin County Well Standards, must be adhered to in order to prevent vertical movement of water entering the well casing and interacting with the groundwater. Under no circumstances are abandoned wells to be used for the disposal of any solid or liquid wastes. If the owner declares intention to use the well again, and the well is capable of functioning as originally designed, the well shall be maintained in such a way that: (1) the well has no defects that will impair the quality of water in the well or the water bearing formations; (2) the well is capped with a watertight seal or cover; (3) the well is marked so it may be easily seen; and (4) the area around the well is kept clear of brush and debris. After remaining out of service for five (5) years, the Director of Environmental Health Division may call the well to be properly abandoned. According to County Code, Title 5, Division 4, Chapter 3 Well Drilling Requirements, the District Health Office is authorized, after reasonable efforts to eliminate pollution, contamination, or a safety hazard, to enforce the permanent abandonment by destruction of any well that is polluted, contaminated or is located as to become polluted or contaminated or is a safety hazard. The District Health Officer is authorized to destroy any such well and recover the cost of the destruction from the owner of the property on which the well is located.

Stanislaus County

Well applicants must first fill out the Application for Well Construction or Destruction form and submit it to the Stanislaus County Department of Environmental Resources, in addition to paying the appropriate fees, before receiving a well construction or destruction permit. After receipt of the application, it is reviewed by the Department of Environmental Resources to determine whether it is subject to prohibitions in the Groundwater Ordinance against unsustainable groundwater extraction and export of water using the following criteria:

- The well is pumping from a known and definite channel;
- The well is intended to replace an existing well permitted prior to November 25, 2014 and the replacement well has no greater capacity than the well it is replacing;
- The well is located in an unincorporated area of the County;
- Wells on property served by a public water agency that is in compliance with an adopted Groundwater Management Plan or Groundwater Sustainability Plan;
- Wells intended to extract 2 AFY of groundwater or less; and
- Groundwater extraction or water export in compliance with a permit previously granted by the Department of Environmental Resources.

If the application is not exempt based on these criteria, the applicant must submit a Supplemental Application for Non-Exempt Wells with information to demonstrate that groundwater pumped from the well is being sustainably extracted without causing any of the “Undesirable Results” listed in Section 97.030 (9) of the Groundwater Ordinance. “Undesirable Results consist of 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 in groundwater storage;
- Significant and unreasonable degradation of water quality;

- Significant and unreasonable land subsidence that substantially interferes with surface land uses; and
- Surface water depletions that have significant and unreasonable adverse impacts on the beneficial uses of surface water.

A technical review is then conducted to verify whether the information submitted by the applicant demonstrates that groundwater extraction from the well will not cause, or substantially contribute to, any "Undesirable Results." If the applicant fails to demonstrate that proposed extractions will not substantially contribute to any "Undesirable Results," there is an opportunity for the applicant to submit additional data, accept mitigation measures, or amend their application. While not required, if the above steps aren't taken by the applicant an Environmental Impact Report under the California Environmental Quality Act (CEQA) is required.

As previously stated, Stanislaus County adopted a Groundwater Ordinance in November 2014 (Chapter 9.37 of the County Code, hereinafter, the "Ordinance") that codifies requirements, prohibitions, and exemptions intended to help promote sustainable groundwater extraction in unincorporated areas of the county. The Ordinance prohibits the unsustainable extraction of groundwater and makes issuing permits for new wells that are not exempt from this prohibition discretionary. Applications for non-exempt wells must include substantial evidence that they will not withdraw groundwater unsustainably. For unincorporated areas covered in an adopted GSP pursuant to SGMA, the County can require holders of permits for wells it reasonably concludes are withdrawing groundwater unsustainably to provide substantial evidence that continued operation of such wells does not constitute unsustainable extraction and has the authority to regulate future groundwater extraction.

Similar to well construction, well owners must fill out an Application for Well Construction or Destruction form prior to destroying a well. Every abandoned well must be destroyed in accordance with methods prescribed in Chapter 9.36 (Water Wells) of the Stanislaus County Code as well as DWR Bulletin 74. The County health officer has the authority to order the destruction or repair of any well that is polluted or unsafe or is so located as likely to become polluted. Well owners are required to continuously maintain any well that is out of service, so as to be safe and to prevent pollution of any aquifer. A properly maintained out-of-service well shall not be considered to be an abandoned well.

2.3.3 Water Resources Monitoring Programs

2.3.3.1 Delta-Mendota Canal Groundwater Pump-in Program Water Quality Monitoring Plan

The Pump-in Program (PIP) is an agreement between the U.S. Bureau of Reclamation (USBR), the San Luis & Delta-Mendota Water Authority, and its Member Agencies to convey up to 50,000 acre-feet of groundwater in the DMC. This is permitted through the Warren Act of 1911 which allows the USBR to issue temporary contracts to convey non-project water in federal irrigation canals, such as the DMC, in times of need. The PIP is subject to environmental commitments through the National Environmental Protection Act (NEPA), including monitoring groundwater quality, levels, and subsidence.

The program monitors conditions of private wells participating in the program in addition to in-stream measurements. Specifically, groundwater reporting includes wellhead:

- Water quality analysis (i.e. heavy metals, nitrate, TDS, radioactivity, organic chemicals, pH); and
- Depth to groundwater

If groundwater depth exceeds a specified depth and/or water quality reaches maximum limits, then PIP pumping is mandated to stop.

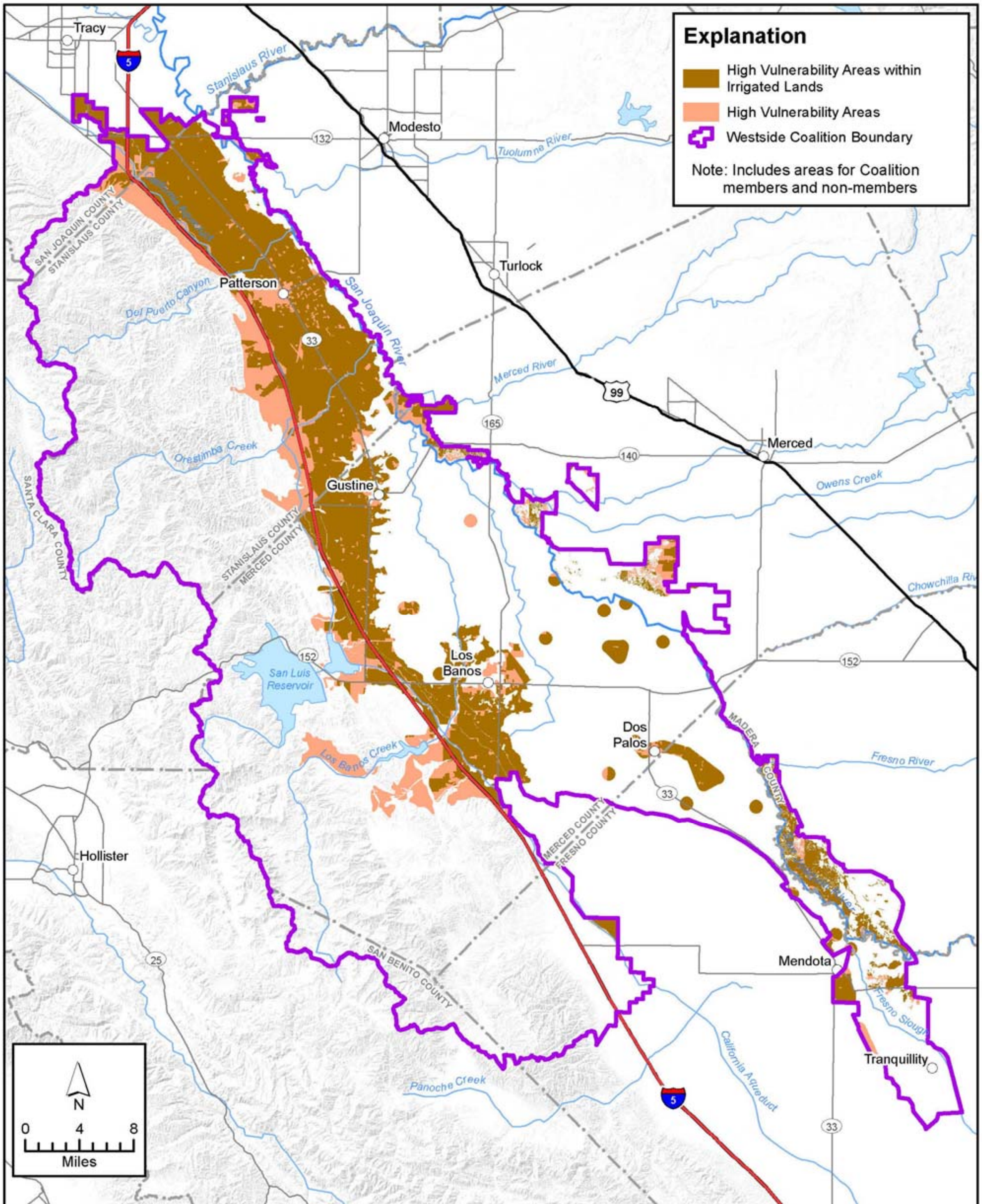
2.3.3.2 Irrigated Lands Regulatory Program (ILRP)

As part of the Irrigated Lands Regulatory Program, growers in the Delta-Mendota Subbasin (as part of the Western San Joaquin River Watershed Coalition, Grassland Drainage Area Coalition and/or Eastern San Joaquin River Watershed Coalition) participate in a Groundwater Quality Trend Monitoring (GQTM) Program, a regional shallow groundwater quality monitoring program intended to ensure that irrigated agricultural discharges do not impair access to safe and reliable drinking water. The GQTM Program under the ILRP is designed to be coordinated with other regulatory and non-regulatory monitoring programs associated with agricultural operations to minimize duplicative regulatory oversight.

As documented in the GQTM Programs associated with each Coalition, the goals of the monitoring program are to determine current water quality conditions of groundwater relevant to irrigated agriculture and to use that information, along with historical data, to evaluate the regional effects of irrigated agricultural practices. The monitoring network developed for the GQTM Program uses factors relating to the vulnerability of groundwater and prioritization of high vulnerability areas (HVAs) in focusing locations for monitoring. Figure 2-30 and Figure 2-31 show the high vulnerability areas as identified in the Northern and Central Delta-Mendota Regions. The HVAs represent areas where intrinsic physical properties make groundwater more vulnerable to influences from overlying land use activities; the prioritization of HVAs considers the relative vulnerability within the HVAs along with additional factors including existing groundwater quality conditions, land use, and other factors such as the proximity of communities reliant on groundwater.

Existing larger-capacity wells that are relatively shallow, but not completed in the zone of first-encountered groundwater, were the main candidate for inclusion as monitoring wells in the GQTM Program. These types of wells were prioritized as they are more likely to exhibit regional groundwater trends that are relevant to agricultural operations on a regional scale because of the greater potential for lateral and vertical constituent transport along longer flow paths with the increased depth. Additionally, these wells have relatively large groundwater capture zones drawing groundwater from more regional contributing areas and minimizing the degree to which selected monitoring wells reflect only localized groundwater conditions around a well. Wells selected for monitoring are shown in Figure 2-32.

Wells included in the GQTM Program are monitored for selected water quality parameters, including nitrate (as nitrogen), electrical conductivity, pH, dissolved oxygen, temperature, oxygen-reduction potential, and turbidity on an annual basis, and total dissolved solids, carbonate, bicarbonate, chloride, sulfate, boron, calcium, sodium, magnesium and potassium every five years.



Source: Western San Joaquin River Watershed Groundwater Quality Trend Monitoring Workplan, Phase I – Monitoring Design Approach, 2016

Figure 2-30. High Vulnerability Areas, Western San Joaquin River Watershed Coalition

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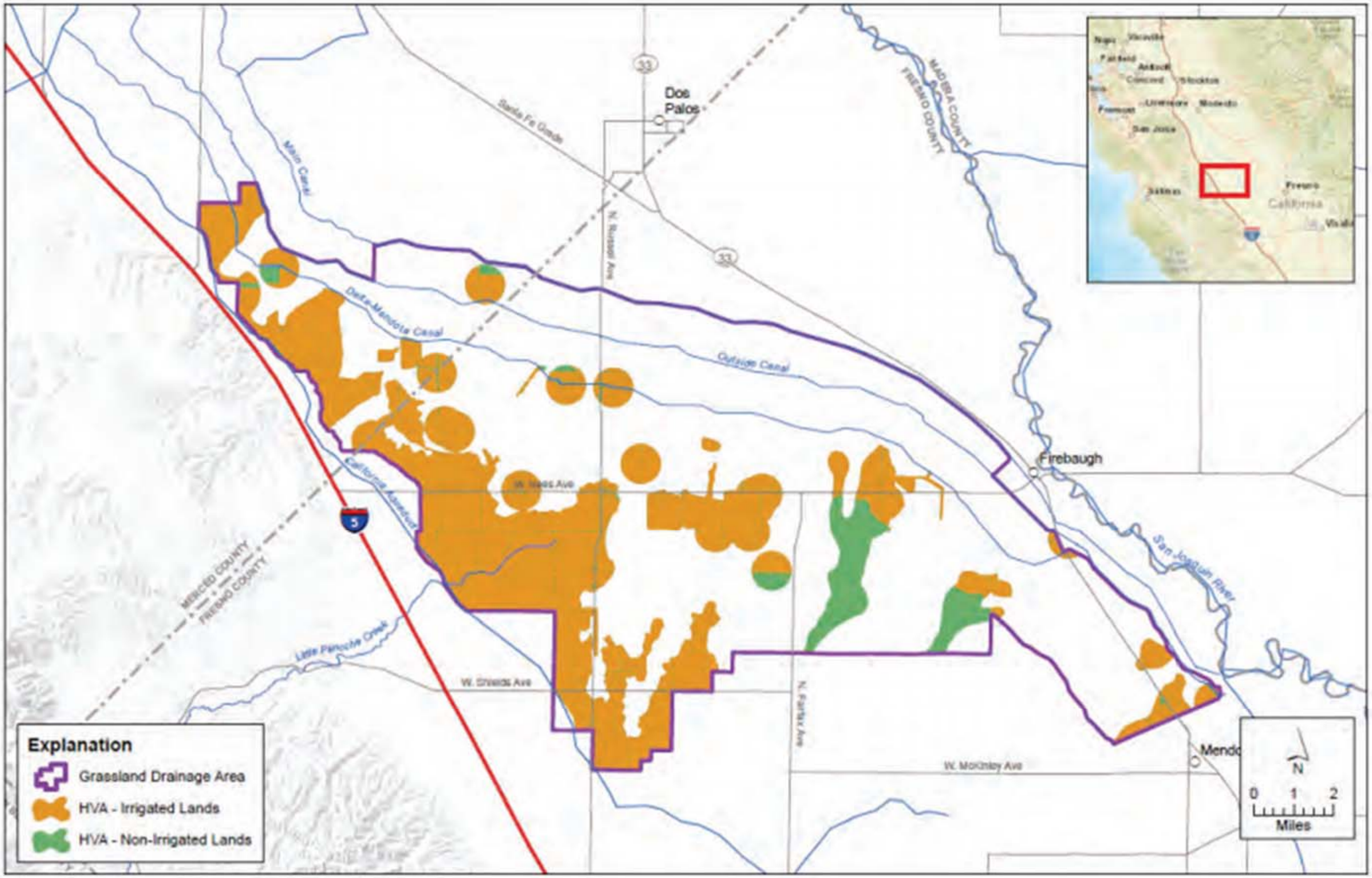

Source: Grassland Drainage Area Groundwater Quality Management Plan, 2017

Figure 2-31. High Vulnerability Areas, Grassland Drainage Area

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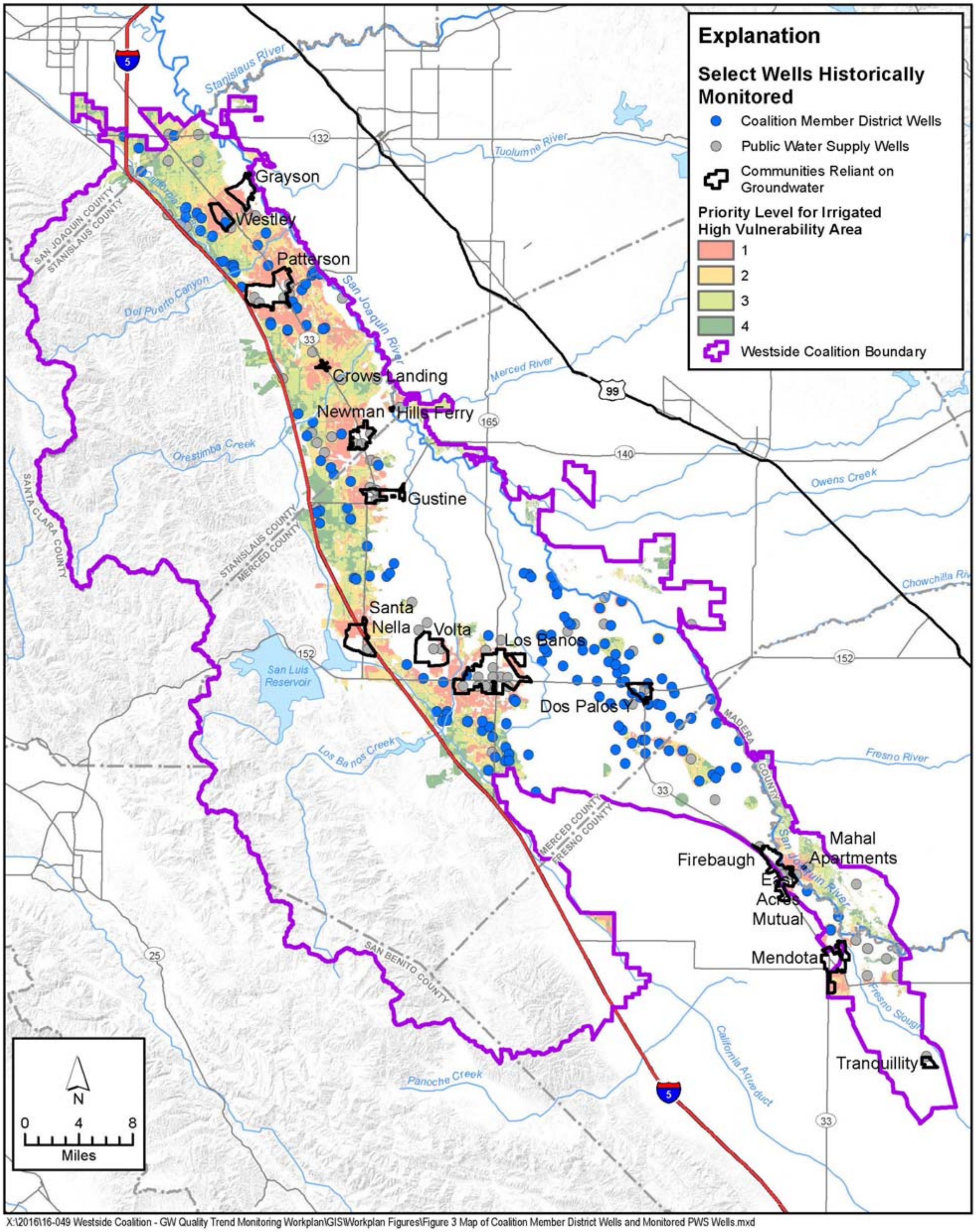

Source: Western San Joaquin River Watershed Groundwater Quality Trend Monitoring Workplan, Phase I – Monitoring Design Approach, 2016

Figure 2-32. Groundwater Quality Trend Monitoring Program Wells, Western San Joaquin River Watershed Coalition

2.3.3.3 Department of Water Resources Water Data Library (WDL)

DWR's WDL is a database that stores groundwater elevation measurements from wells in the Delta-Mendota Subbasin measured from 1930 through 2018. Data contained in the WDL is from several different monitoring entities, including DWR, Kings River Conservation District, Westlands Water District, SLDMWA, Madera-Chowchilla CASGEM Group, and USBR.

DWR's WDL includes a compendium of groundwater level and quality data. Samples are collected from a variety of well types including irrigation, stock, domestic, and some public supply wells. Wells are not regularly sampled, and most wells have only one- or two-days' worth of sampling measurements and contain large temporal gaps. Constituents most frequently monitored include dissolved chloride, sodium, calcium, boron, magnesium, and sulfate. Measurements taken include conductance, pH, total alkalinity, and hardness (more than 1,000 total samples per parameter). Additional dissolved nutrients, metals, and TDS are also sampled but have fewer sample results available (one to 1,000 samples per parameter).

2.3.3.4 GeoTracker Groundwater Ambient Monitoring and Assessment Program (GAMA)

Established in 2000, the GAMA Program monitors groundwater quality throughout the State of California. GAMA is intended to create a comprehensive groundwater monitoring program throughout California and increase public availability and access to groundwater quality and contamination information. GAMA receives data from a variety of monitoring entities including DWR, U.S. Geological Survey (USGS), and the SWRCB. For the Delta-Mendota Subbasin, DWR, the California Department of Health Services and Department of Pesticide Regulation, Environmental Defense Fund, and the USGS submit data from monitoring wells for a suite of constituents including TDS, nitrates and nitrites, arsenic, and manganese.

2.3.3.5 GeoTracker

GeoTracker is the State Water Resource Control Board's data management system for sites that impact, or have the potential to impact, water quality in California, with emphasis on groundwater. GeoTracker contains records for sites that require cleanup, such as Leaking Underground Storage Tank (LUST) Sites, Department of Defense Sites, and Cleanup Program Sites. GeoTracker also contains records for various unregulated projects as well as permitted facilities including: Irrigated Lands, Oil and Gas production, operating Permitted USTs, and Land Disposal Sites. A search of GeoTracker for the areas covered by the Northern and Central Delta-Mendota Regions did not indicate that there are any ongoing groundwater remediation activities in those Regions.

2.3.3.6 National Water Information System (NWIS)

The USGS's NWIS contains extensive water data, including manual measurements of depth to water in wells throughout California. Wells are monitored by the USGS. Most of the wells that were monitored in 2017 have been monitored since 2008, although a few have measurements dating back to 1983. Groundwater level measurements at these wells are taken approximately once per quarter.

2.3.3.7 State Water Resources Control Board Division of Drinking Water

The SWRCB's Division of Drinking Water (DDW, and formerly the Department of Health Services) monitors public water system wells for California Code of Regulations Title 22 requirements relative to levels of organic and inorganic compounds such as metals, microbial compounds and radiological analytes. Data are available for active and inactive drinking water sources, for water systems that serve the public, and wells defined as serving 15 or more connections, or more than 25 people per day for 60 or more days per year. In the Delta-Mendota Subbasin, DDW wells are monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate.

2.3.3.8 CASGEM

In 2009, the CASGEM Program began systematic, local monitoring of groundwater levels throughout the state. The intent of the program is to track and make publicly available seasonal and long-term groundwater elevation trends to use as a tool for effective groundwater management.

The Groundwater Monitoring Program (GMP) in the Delta-Mendota Subbasin is managed by the San Luis & Delta-Mendota Water Authority. The GMP characterizes the groundwater basin and outlines monitoring procedures for depth-to-water and groundwater quality. The figures below display the CASGEM network of groundwater wells by aquifer (Figure 2-33) and additional groundwater wells that voluntarily share groundwater depth data (Figure 2-34).

2.3.3.9 Department of Water Resources Groundwater Information Center Interactive Map

The Groundwater Information Center Interactive Map (GICIMA) is a database that collects and stores groundwater elevations and depth-to-water measurements. Groundwater elevations are measured biannually in the spring and fall by local monitoring agencies. Depth-to-water and groundwater elevation data is submitted to DWR for inclusion in the GICIMA by various monitoring entities around the state.

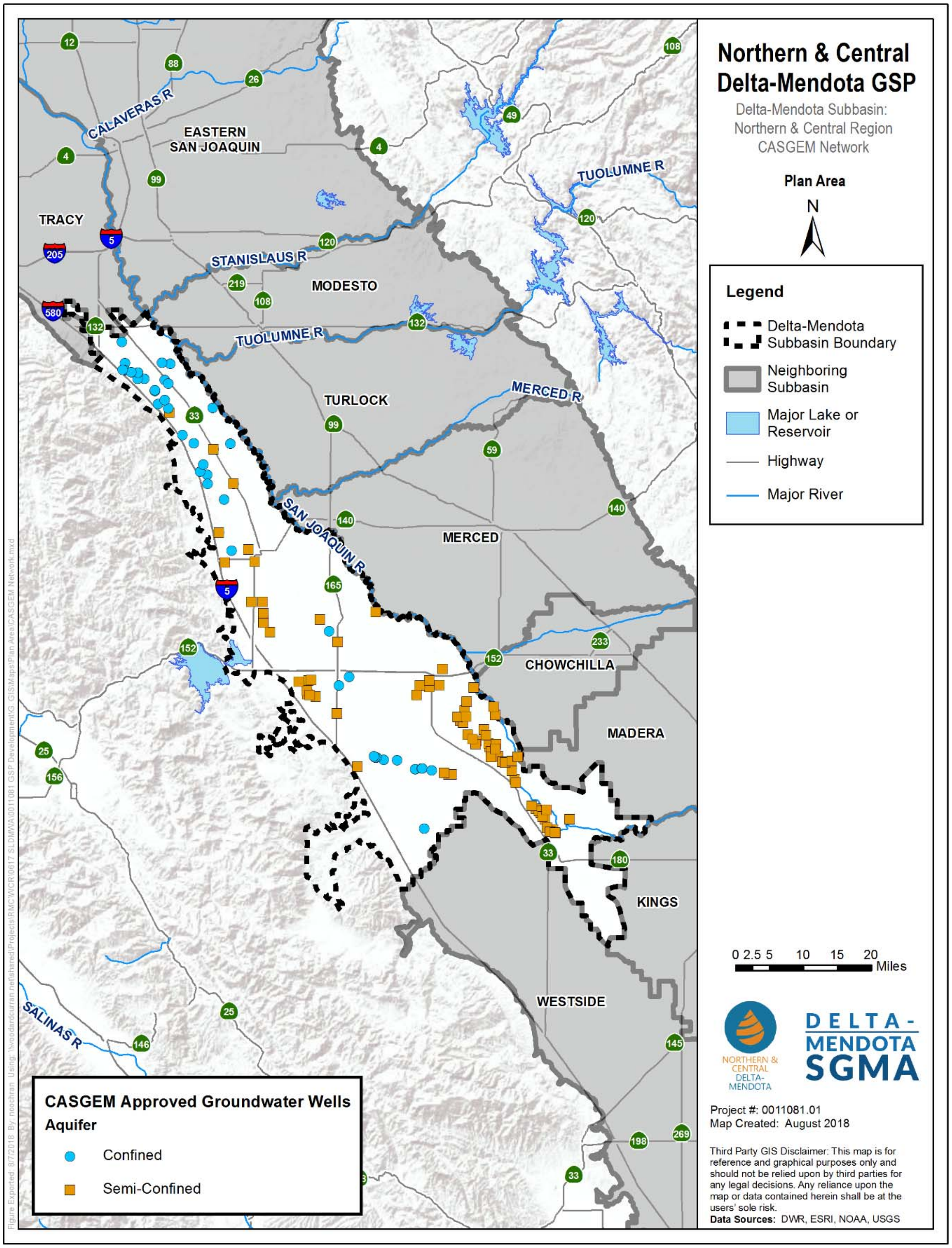

Figure 2-33. Delta-Mendota Subbasin CASGEM Groundwater Monitoring Network

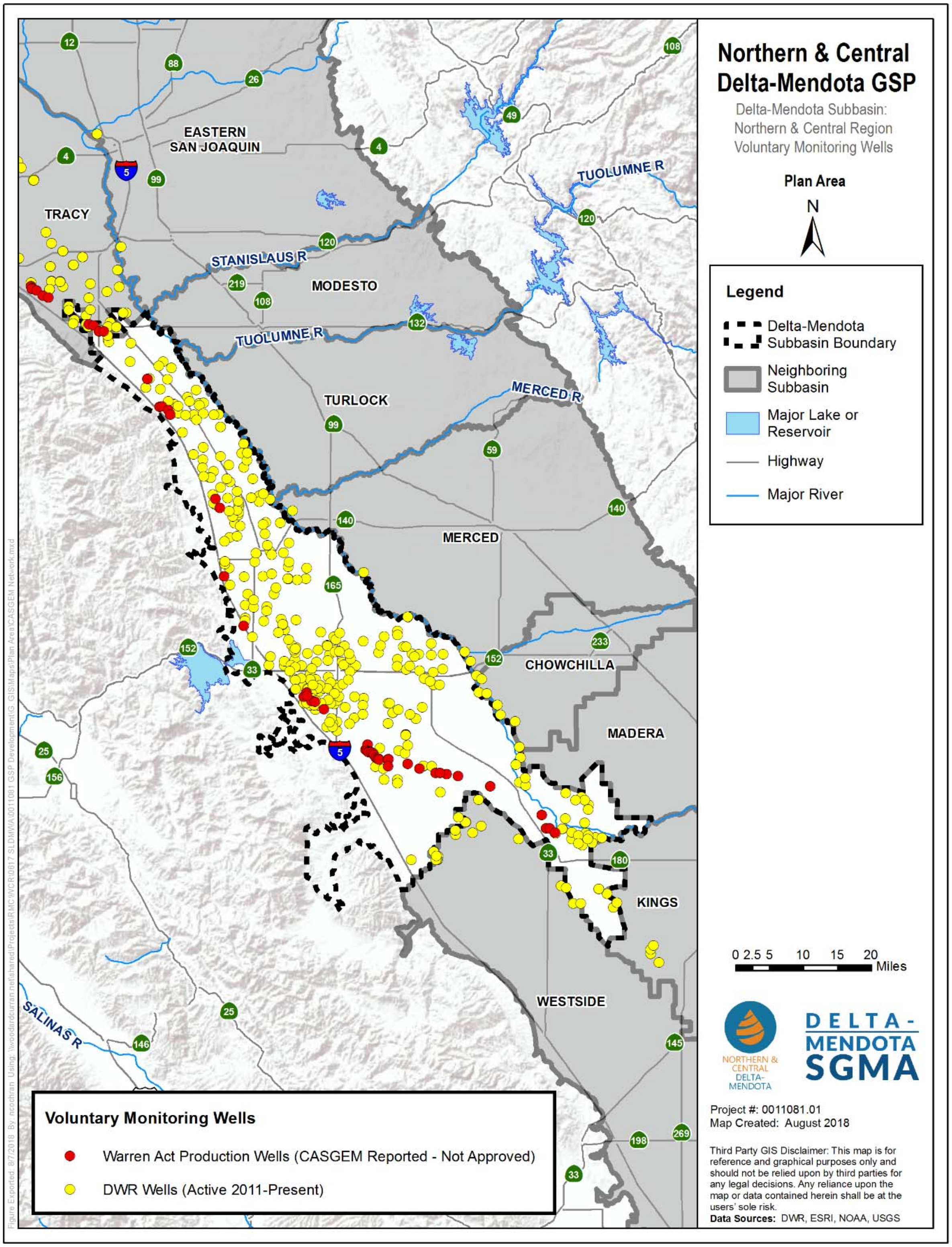

Figure 2-34. Voluntary Monitoring Wells in the Delta-Mendota Subbasin

2.3.3.10 Subsidence Monitoring

There are a variety of agencies that monitor subsidence in the San Joaquin Valley. Most of the agencies provide publicly available subsidence data that can be used by local agencies for groundwater management. Table 2-8, below, summarizes the monitoring agencies and methods.

Table 2-8. Summary of Subsidence Monitoring in the Central Valley

Agency	Subsidence Monitoring Method
DWR	• Extensometers and borehole extensometers • Surveying/Spirit Leveling
USGS	• Extensometers (National water Information System) • Interferometric Synthetic Aperture Radar (InSAR) • Surveying/Spirit Leveling
UNVACO	• Continuous Global Positioning System (CGPS) stations
NASA	• Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) (InSAR) • Gravity Recovery & Climate Experiment (GRACE)
San Joaquin River Restoration Program (SJRRP)	• Extensometers

2.3.3.10.1 DWR Surveying/Spirit Leveling

Spirit leveling is a precise way to obtain data for smaller land areas, and is commonly used along road, railroad tracks, aqueducts, and canals. DWR and the USBR have collected spirit-level measurements along the Delta-Mendota Canal and in the Central California Irrigation District since 1935.

2.3.3.10.2 USGS Extensometers (NWIS)

The USGS California network consists of 20 extensometer stations in the Central Valley with the intention of measuring subsidence. Of the 20 stations, four are located within the Delta-Mendota Subbasin: (1) The 365325120391501 station has subsidence data from 1958 through 2000 and 2009 through 2018; (2) the 364536120184301 station has subsidence data from 1966 through 1983 and 1999 through 2018; (3) the 364518120222401 station has subsidence data from 1999 through 2018; and (4) the 364518120222401 station has subsidence data from 1999 through 2018.

2.3.3.10.3 USGS InSAR

Interferometric Synthetic Aperture Radar (InSAR) takes high-density measurements over large areas by using radar signals from Earth-orbiting satellites to measure changes in land-surface altitude. USGS has records of 15 InSAR measurement points in California, three of which are within the Delta-Mendota Subbasin: the InSAR measurement point near Panoche Area, Oro Loma extensometer (12S/12E-16H2), and Panoche extensometer (14S/13E-11D6). All three InSAR measuring locations have data from 2003 to 2008.

2.3.3.10.4 University NAVSTAR Consortium (UNAVCO) CGPS

Continuous Global Positioning System (CGPS) stations have typically been constructed to monitor motions caused by plate tectonics but are widely used for other purposes, including subsidence monitoring. UNAVCO Plate Boundary Observatory (PBO) operates a network of about 1,100 CGPS and meteorology stations in the western U.S. There are six stations in the Delta-Mendota Subbasin: (1) The Mendota_CN2004 station (also referenced to as the P304 station) has subsidence data from 2004 through 2018. (2) The Los Banos_CN2005 station (also referenced to as the P303 station) has subsidence data from 2005 through 2018. (3) The Patterson_CN2005 station (also referenced as the 259 station) has subsidence data from 2005 through 2018. (4) The LilPanocheCN2004 station (also referenced as the P301 station) has subsidence data from 2004 through 2018. (5) The ArkansaCrkCN2006 station (also referenced as the P255 station) has subsidence data from 2006 through 2018. And (6) the QuintoCrk_CN2005 Station (also referenced as the P252 station) has subsidence data from 2005 through 2018.

2.3.3.10.5 NASA UAVSAR and InSAR

The National Aeronautics and Space Administration's (NASA) Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) uses an airborne radar to study a variety of parameters, including subsidence. The NASA UAVSAR and InSAR satellites measurements cover most of the Delta-Mendota Subbasin, with data gaps south of Patterson, Newman, and Gustine, east of Dos Palos, and north and south of Tranquillity. Available data for the Delta-Mendota Subbasin are limited to Spring 2015 through 2017, a 2-acre pixel grid, and measurement resolution within the range of 0.2 to 0.39 inches.

2.3.3.10.6 NASA GRACE

NASA's Gravity Recovery and Climate Experiment (GRACE) maps Earth's gravity field by making accurate measurements of the distance between two satellites, using Global Positioning System and a microwave ranging system. Among a variety of parameters, GRACE measures changes in hydrology and can be used as a subsidence measuring tool. GRACE's land water storage data is provided on a 0.5-degree global grid.

2.3.3.10.7 SJRRP Geodetic Network

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River and restore a self-sustaining Chinook salmon fishery in the river, while reducing or avoiding adverse water supply impacts from Restoration Program flows. The Program began monitoring subsidence in 2011, with the USBR surveying a network of over 70 subsidence monitoring points along the San Joaquin River and within the Delta-Mendota Subbasin in July and December of each year.

2.3.4 Implications of Existing Monitoring and Management Programs in this GSP

Several existing groundwater monitoring programs in the Northern and Central Delta-Mendota Regions will form the basis for future monitoring in these regions of the Delta-Mendota Subbasin. Specifically, appropriate monitoring stations currently being utilized for CASGEM, the Delta-Mendota Canal Groundwater Pump-in Program Water Quality Monitoring Program, the Western San Joaquin River Coalition Groundwater Quality Trend Monitoring Program and Real-time Monitoring Program will be utilized for groundwater elevation and quality monitoring programs, while appropriate existing extensometers and other subsidence monitoring stations will be utilized along with ongoing surveying programs in the Regions for subsidence monitoring. Over the long-term, the GSAs representing the Northern and Central Delta-Mendota Regions will be looking to streamline ongoing monitoring programs through coordination with the respective State and Federal agencies.

Several existing groundwater management and/or monitoring programs exist that may limit the operational flexibility of the groundwater basin. Programs with the largest impacts include the following:

USBR Delta-Mendota Canal Pump-in Program – Currently, the USBR issues five-year Warren Act Contracts to the DMC PIP Participating Districts that include additional design constraints to address their potential contribution to subsidence along the DMC. Each Warren Act Contract allows the annual introduction, conveyance, and storage of up to 10,000 AF of groundwater within federal facilities under a series of designed constraints and operating criteria, including the establishment of a static maximum depth to groundwater and Fall/Winter Median Levels, environmental protection measures, water quality, and groundwater monitoring and reporting.

The cumulative volume of groundwater introduced into the DMC under the PIP is limited to 50,000 AFY. The 50,000 AF is annually allocated by the Authority among the Participating Districts based on need. Introduction, conveyance, and storage of non-Project Water in CVP facilities is also subject to available capacity as determined by USBR. Furthermore, San Luis Water District, Panoche Water District, and Pacheco Water District require an exchange with the USBR in order to deliver a portion of the non-Project Water from the San Luis Canal. Exchanged water is used by the USBR to meet CVP demands downstream of the points of introduction and a like amount of CVP water is delivered to the respective districts participating in the exchange.

In general, constraints established and documented in the Final Environmental Assessment (EA) for the Delta-Mendota Canal Groundwater Pump-in Program Revised Design Constraints (EA-18-007) limit the volume and quality of water that can be pumped into the DMC, which may limit the ability to move water around the Delta-Mendota Subbasin to balance demands and supplies.

Irrigated Lands Regulatory Program - The Irrigated Lands Regulatory Program has been implemented by the CV-RWQCB to manage individual farm discharges to surface water and groundwater. Components of the program are specifically intended to regulate discharges to groundwater. Whenever a crop is grown, irrigated and fertilized, it is assumed that a portion of the soil amendments (specifically fertilizer) is converted to nitrate percolating to groundwater. This is intended to evaluate and manage the loading of nitrate to groundwater to minimize impacts to domestic groundwater users and the subbasin. Therefore, reductions in nitrate loading to the groundwater basin are linked to both reduced fertilizer use and/or to reduced irrigation (resulting in reduced percolation). As such, implementation of this regulation will have a net effect of reducing groundwater recharge from agricultural irrigation.

County Groundwater Use Ordinances – All of the counties in which the Delta-Mendota Subbasin lies include groundwater export limitations within their county ordinances. These ordinances will limit Subbasin operational flexibility by limiting the ability to move water around the Delta-Mendota Subbasin to balance demands and supplies.

Federal and/or State Drinking Water Standards- Federal and State drinking water standards are in place to be protective of human health, but they may limit Subbasin operational flexibility by limiting the ability to use groundwater to meet water demands without treatment. For example, naturally-occurring concentrations of hexavalent chromium exceed the State's proposed MCL of 10 parts per billion. Passage of this MCL will require the City of Patterson to treat all of its groundwater extractions prior to distribution, potentially limiting groundwater use to meet demands in this area without undue financial burden. Similar constraints may limit the ability of Delta-Mendota Subbasin to effectively use conjunctive use to meet all demands.

2.4 EXISTING AND PLANNED CONJUNCTIVE USE PROGRAMS

Conjunctive use programs in the Northern and Central Delta-Mendota Regions are currently implemented and planned by single agencies as well as through multi-agency partnerships. Maximizing the beneficial use of surface water, groundwater, and recycled water resources is of critical concern to water managers throughout the Delta-Mendota Subbasin, as urban and agricultural demands expand and as climate change continues to impact water supply availability. The following programs demonstrate efforts within the Northern and Central Delta-Mendota Regions to utilize existing water resources conjunctively and demonstrate feasibility to continue to implement conjunctive use projects in the future.

Del Puerto Water District is partnering with Central California Irrigation District on a 20-acre project to develop the Orestimba Creek Groundwater Recharge and Recovery Project, located in western Stanislaus County near the community of Newman. The proposed groundwater recharge facility near Orestimba Creek would allow the recharge of 500 AFY of surface water to the Delta-Mendota Subbasin. Existing connections to the Delta-Mendota Canal would deliver up to 500 AFY to the groundwater recharge facility and serve as a conveyance facility for deliveries during dry periods. A production well would be constructed to recover the banked water during dry periods, with the recharge water source varying from year to year. The proposed project would help provide a long-term solution by banking excess water during wet periods by diverting excess water and storing it in recharge ponds, accelerating the rate of groundwater recharge for the local aquifer. Monitoring or observation wells would be installed at key locations to monitor the rate of groundwater recharge. This data would also be used to determine the volume of water allowed to be extracted so that the rate of recharge would always exceed extraction.

Patterson Irrigation District (PID) primarily receives surface water deliveries and pumps groundwater on an as-needed basis. PID has focused its efforts on improving surface water deliveries and pumping efficiencies by recycling surface drainage, as opposed to limiting canal seepage. Deep percolation of irrigation water and distribution system losses recharge the groundwater within PID’s service area. This stored groundwater supply is available to PID and others during drought conditions, thus recharge is an important component of PID’s water management strategy.

Pacheco Water District and San Luis Water District maintain Warren Act contracts to allow pumping of groundwater meeting water quality standards into the Delta-Mendota Canal when surface water supplies are insufficient to meet demand. Pacheco Water District, San Luis Water District, and some landowners own deep wells tied into the Districts’ and private surface water distribution systems. When surface waters are insufficient to meet demand, groundwater is conjunctively used with surface water supplies.

The North Valley Regional Recycled Water Program (NVRRWP) is a large-scale conjunctive use project located primarily within San Joaquin, Stanislaus, and Merced Counties. A partnership between Del Puerto Water District, the City of Modesto, and the City of Turlock has been formed to implement the NVRRWP. Tertiary-treated recycled water from the Cities of Modesto and Turlock will be blended with water in the Delta-Mendota Canal to provide deliveries of up to 59,000 AFY to farms within Del Puerto Water District’s service area in San Joaquin, Stanislaus, and Merced Counties as well as south of the Delta Central Valley Project Improvement Act-designated Refuges. The NVRRWP meets two critical objectives: the opportunity for the Cities of Modesto and Turlock to permanently remove their wastewater discharges to the San Joaquin River, reducing exposure to increasingly stringent regulatory requirements and putting recycled water to beneficial use; and a regional solution to address water supply shortages within Del Puerto Water District’s service area.

Several GSAs in the Delta-Mendota Subbasin participate in the San Joaquin River Water Quality Improvement Project (SJRIP). The SJRIP is a project designed to reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass. Specifically, under the SJRIP, shallow groundwater that would be extracted via tile drains are diverted to acreage for reuse rather than discharged to the San Luis Drain and Mud Slough. As of 2015, approximately 5,341 acres of the project site have been planted with salt-tolerant crops and irrigated with agricultural drainwater. Most of the salt-tolerant crops (3,863 acres) are located on 4,095 acres, commonly referred to as the eastern project area because they are situated east of Russell Avenue, near the city of Firebaugh, in Fresno County, California. An additional 1,861 acres, acquired in 2008 and referred as the western project area, were planted with 1,478 acres of salt-tolerant crops.

San Benito County includes two policies that encourage the support of future conjunctive use programs in their 2035 General Plan as an important component in reaching their sustainable water supply goals. Policy PFS-3.5 and PFS-3.6 are listed in Section 2.2.1.10 above.

In addition to projects directly managing conjunctive use and underground storage, underground storage occurs throughout the Delta-Mendota Subbasin through stormwater recharge and agricultural water recharge. Stormwater collects both naturally and artificially and eventually percolates through the ground and into aquifers for beneficial use for both urban and agriculture. Recharge from agricultural water irrigation percolates into the ground and eventually into aquifers where it can be pumped again for use. Groundwater percolation also occurs through unlined irrigation ditches and canals. This natural and unmanaged recharge creates future opportunities for conjunctive use programs; however, this recharge may decline as farmers move toward more precise and water efficient irrigation methods.

2.5 PLAN ELEMENTS FROM CWC SECTION 10727.4

2.5.1 Control of Saline Water Intrusion

The Delta-Mendota Subbasin does not experience saline water intrusion; therefore, this element is not applicable to the Northern and Central Delta-Mendota Regions.

2.5.2 Wellhead Protection Areas and Recharge Areas

Wellhead Protection Areas, as defined under the Federal Wellhead Protection Program (Section 1428 of the Safe Drinking Water Act Amendments of 1986), are the surface and subsurface areas surrounding a water well or well field supply for a public water system through which contaminants are reasonably likely to move toward and reach such water or well field. The State of California's Drinking Water Source Assessment and Protection Program (DWSAP) serves as the State's Wellhead Protection Program. There are no existing local wellhead protection programs in the Northern and Central Delta-Mendota Regions; therefore, agencies within the Plan area adhere to federal, state, and county regulations governing wellhead protection.

Important sources of groundwater recharge in the Northern and Central Delta-Mendota Regions are derived from percolation of surface water (mainly from applied irrigation) as well as a small component of rainfall. Management of potential groundwater quality impacts associated with this recharge is through the Irrigated Lands Regulatory Program.

2.5.3 Migration of Contaminated Groundwater

There are several federal, state, and regional programs in place in the Northern and Central Delta-Mendota Regions to monitor for and mitigate groundwater contamination. The Central Valley Regional Water Quality Control Board, under the State Water Resources Control Board, has primary responsibility in enforcing water quality regulations within the Northern and Central Delta-Mendota Regions. The SLDMWA acts as the regional monitoring coordinator under the Groundwater Management Plans for the North and South Agencies in the Delta-Mendota Canal Service Area. As the regional monitoring coordinator, the SLDMWA has helped to better understand the hydrogeology of the Groundwater Management Areas, the vertical and lateral groundwater flow directions, and water quality based on the various groundwater monitoring activities supporting the Groundwater Management Plans. Such groundwater quality monitoring efforts have made participating agencies aware of new sources of contamination or changes in existing plumes of contamination that are occurring.

The San Joaquin County Environmental Health Department (SJCEHD) carries out the "Underground Injection Control" program with the purpose to protect public health and the environment from exposure to contaminants that may exist in shallow underground injection wells, such as dry wells, seepage pits, and sumps, that can transport contaminants to soil and groundwater. Activities include identifying, mapping, inspecting, and remediating potential or existing contaminant sources. The SJCEHD also permits and inspects well installation and destruction to minimize the potential for the wells to adversely impact groundwater. The Stanislaus County Department of Environmental Resources is also charged with protecting groundwater through the management of wells (construction and destruction), groundwater recharge, storage and recovery programs, contamination remediation and agricultural operations. Similarly, the Merced County Division of Environmental Health (MCEHD) and the Fresno County Division of Environmental Health (FCEHD) permit and inspect well installations, including the installation of appropriate well seals, and abandonments to minimize the potential for the wells to adversely impact groundwater. Additionally, San Joaquin County, Stanislaus County, Merced County, Fresno County, and SWRCB operate underground storage tank programs with the primary focus of preventing contamination of groundwater by inspecting, permitting, monitoring, repairing, installation and removal of underground storage tanks.

San Benito County Code of Ordinances, Chapter 15.05.125 specifies that San Benito County Water District (SBCWD) may delineate certain areas with poor groundwater quality. The SBCWD can prevent the mixing of water from multiple aquifers if a proposed well construction, reconstruction, or destruction is in such an area. To allow the project to proceed, SBCWD may require a report prepared by a registered geologist or civil engineer with a stratigraphic description of the site and recommendations for the location and what types of seal(s) are necessary to prevent the migration of contaminated water.

The SWRCB's DDW (former under the California Department of Public Health) regularly collects data and monitors public drinking water supplies as part of the State's Drinking Water Program. Data are maintained in a database and utilized to develop reports and source water assessments. Under the Pesticide Contamination Prevention Act of 1985, the California Department of Pesticide Regulation (DPR) maintains a Ground Water Protection Program where DPR evaluates risk and monitors for pesticide contamination in groundwater, identifies sensitive areas, and develops mitigation measures to prevent further contamination. DPR adopts regulations to protect groundwater as part of the Ground Water Protection Program.

Finally, agricultural agencies with irrigated commercial cropland not covered under an individual order are subject to the CV-RWQCB's Irrigated Lands Regulatory Program, which requires a groundwater monitoring program for specified constituents under general orders for waste discharge requirements. Agencies that participate in Watershed Coalitions are required to coordinate their participation in irrigated lands programs for the Watershed Coalition as well as RWQCB.

2.5.4 Well Abandonment and Well Destruction Programs

A summary of the well abandonment and destruction programs within the Northern and Central Delta-Mendota Regions are detailed in Section 2.3.2 (County Well Construction/Destruction Standards and Permitting).

2.5.5 Activities Implementing, Opportunities for, and Removing Impediments to Conjunctive Use or Underground Storage

Conjunctive use management is already utilized by water managers throughout the Delta-Mendota Subbasin to increase storage and resiliency in the system in the face of increasing demands and climate change. Within the Northern and Central Delta-Mendota Regions, both small and large conjunctive use projects are currently being developed at the time of GSP development. A description of conjunctive use programs within the Northern and Central Delta-Mendota Regions are discussed in Section 2.4 (Existing and Planned Conjunctive Use Programs). There are also opportunities for additional conjunctive use and underground storage projects, which can be aided with efforts to reduce impediments to such projects.

The Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area identified three primary focal points for potential conjunctive use opportunities: (1) Identify areas of local overdraft and evaluate the viability of a recharge program using direct recharge; (2) Evaluate the availability of additional surface water supplies, which could be utilized in conjunctive use programs either directly or via exchange of CVP supplies; and (3) Optimize the overall groundwater yield during dry periods through sound basin management. Conjunctive use has largely remained unmanaged throughout the Delta-Mendota Subbasin. When full surface water supplies are being received, less groundwater pumping occurs which allows for recharge through seepage and deep percolation of surface water. Whereas during dry periods, pumping increases to supplement curtailed surface water deliveries. There are many opportunities throughout the Delta-Mendota Subbasin to implement managed recharge projects and more emphasis has been placed on locating water supplies for recharge as water users experience more frequent and prolonged surface water shortages.

Cities and counties throughout the Subbasin have incorporated goals and policies into their General Plans to support conjunctive use projects. The City of Patterson completed an update to the City's General Plan in 2010 that includes new policies oriented toward implementing conjunctive use of recycled water and imported surface water supplies to augment the City's supplies through application to landscape irrigation and non-potable municipal uses providing in-lieu groundwater recharge. Fresno County's General Plan also includes policies to protect groundwater resources from contamination and overdraft by developing conjunctive use of surface water and groundwater. While local cities and counties have made efforts to remove impediments to conjunctive use and underground storage projects, there are impediments at the state and federal level causing barriers to local agencies trying to implement these types of projects.

Permitting required for direct groundwater basin augmentation is a major regulatory barrier to conjunctive use projects statewide. Active recharge of groundwater basins with surface water treated to drinking water standards typically requires obtaining Water Discharge Requirements (WDRs) for discharges to land from the State. As potable water is chlorinated, there is the potential to degrade groundwater through the introduction of chlorine and the formation of disinfection byproducts (DBP) in the subsurface. In 2012, the State adopted a state-wide General Order (Water Quality Order 2012-0010: General Waste Discharge Requirements for Aquifer Storage and Recovery Projects that Inject Drinking Water into Groundwater) that recognizes the benefits of storing treated surface water in aquifers. To obtain coverage under the General Permit, an application has to be made to the State, and includes preparation of an anti-degradation analysis. Regulatory approval is also required from the U.S. Environmental Protection Agency (EPA) for injecting water into underground aquifers. The U.S. EPA classifies aquifer storage recovery (ASR) wells as "Class V" injection wells, which are regulated through EPA's Underground Injection Control (UIC) Program. ASR wells would need to be registered as a Class V injection well through EPA's website.

In addition to regulatory barriers, legal, economic, and physical obstacles must be overcome to expand the development and implementation of conjunctive use projects statewide. Generally, in-lieu groundwater banking has not historically required permits, but under new regulations and programs to be developed under SGMA, it is unknown if this will remain true. Additionally, in some areas, the location of water available for recharge, the location of recharge facilities and the cost and engineering associated with implementing such recharge projects pose physical and economic challenges to such projects. Easing or removing these impediments would involve streamlining the regulatory process by passing additional legislation to make the process for approving and permitting conjunctive use projects easier, providing legal protections/agreements for the right to use banked water, supporting of local partnerships to increase the economy of scale, and providing funding support specifically targeted toward conjunctive use projects.

2.5.6 Measures Addressing Groundwater Contamination Cleanup, Groundwater Recharge, In-Lieu Use, Diversions to Storage, Conservation, Water Recycling, Conveyance, and Extraction Projects

Groundwater contamination cleanup activities are largely the responsibility of local agencies, such as the cities and the counties. As part of the CASGEM program, the SLDMWA has coordinated development of a basin-wide groundwater monitoring plan that includes a groundwater monitoring network approved by DWR. Historically, SLDMWA has also coordinated the development of Groundwater Management Plans for the Delta-Mendota Subbasin to address basin management and protection. The City of Patterson has included water supply planning and policy documents to increase local groundwater recharge and protect groundwater quality. Currently, Pacheco Water District and San Luis Water District as well as some local landowners own and operate deep wells to conjunctively manage surface water and groundwater. These facilities allow for the pumping and transfer of groundwater from areas of good water quality to areas where the water is needed.

All active recharge, in-lieu use, diversions to storage, and water recycling projects within the Northern and Central Delta-Mendota Regions are described in Section 2.5.5 (Activities Implementing, Opportunities for, and Removing Impediments to Conjunctive Use or Underground Storage).

Water conservation is implemented through various measure as documented in Urban Water Management Plans (UWMPs) and Agricultural Water Management Plans (AWMPs). Within the Northern and Central Delta-Mendota Regions, the City of Modesto, which serves the community of Grayson, and the City of Patterson submitted 2015 UWMPs. Within the 2015 UWMPs, Modesto and Patterson are required to address demand management measures that fall under the following categories: Water Waste Prevention Ordinances, Metering, Conservation Pricing, Public Education and Outreach, Programs to Assess and Manage Distribution System Real Losses, and Water Conservation Program Coordination and Staffing Report. The Cities are also required to demonstrate compliance with SBx7-7 (Water Conservation Act of 2009), which requires that water agencies reduce potable water demands 20% by 2020, where interim targets are reported in 2015 UWMPs.

Within the Northern and Central Delta-Mendota Regions, Patterson Irrigation District, West Stanislaus Irrigation District, and San Luis Water District submitted 2015 AWMPs. Agricultural water suppliers are required to implement and demonstrate the following efficient water management practices in their 2015 AWMPs: measure the volume of water delivered to customers and adopt a pricing structure for water customers based at least in part on quantity delivered. Additional efficiency measures are optional for agricultural water providers if they are locally cost effective and technically feasible. Patterson Irrigation District, West Stanislaus Irrigation District, and San Luis Water District all implement efficiency measures beyond what is required in the 2015 AWMPs, such as on farm evaluations.

The primary conveyance projects within the Northern and Central Delta-Mendota Regions are the Delta-Mendota Canal and California Aqueduct, which run the length of the Plan area. The Delta-Mendota Canal carries water southeasterly from the C.W. “Bill” Jones Pumping Plant to the Mendota Pool and is an essential irrigation supply as part of the San Luis Unit and the Central Valley Delta Division. Water from the Central Valley Project moved by the Delta-Mendota Canal is used for irrigation along the San Joaquin Valley and is meant to replace San Joaquin River water stored at Friant Dam. The canal is 116.5 miles long and terminates at the Mendota Pool, about 30 miles west of Fresno. Initial diversion capacity is 4,600 cubic feet per second (cfs), which gradually decreases to 3,211 cfs at the terminus. Many of the irrigation and water districts within the Northern and Central Delta-Mendota Regions purchase surface water from the Central Valley Project to offset additional water demand not met by groundwater.

The California Aqueduct is the primary conveyance structure for the State Water Project, carrying water from the Sacramento-San Joaquin Delta (Delta) to the San Joaquin Valley and Southern California. The San Luis Reservoir, which is located along the western border of the Central Delta-Mendota Region just outside the Subbasin, is a key facility jointly serving both the State Water Project and Central Valley Project. San Luis Reservoir is the largest off-stream reservoir in the United States and has a maximum capacity of up to 2 million AF (MAF) of water. The reservoir feeds water into the California Aqueduct and Delta-Mendota Canal and allows for storage of excess winter and spring flows diverted from the Delta until the water is needed by the State Water Project and Central Valley Project contractors.

The Delta-Mendota Canal Groundwater Pump-in Program is a basin-wide extraction project jointly operated by USBR and SLDMWA on behalf of the following SLDMWA Member Agencies: Banta Carbona Irrigation District, Byron-Bethany Irrigation District, Del Puerto Water District, Mercy Springs Water District, Panoche Water District, Pacheco Water District, San Luis Water District, and West Stanislaus Irrigation District. Warren Act Contracts from USBR are held by SLDMWA for the annual cumulative introduction of up to 50,000 AF of groundwater into the Delta-Mendota Canal to augment surface water deliveries from the Central Valley Project.

2.5.7 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

As mentioned in Section 2.5.6 (Measures Addressing Groundwater Contamination Cleanup, Groundwater Recharge, In-Lieu Use, Diversions to Storage, Conservation, Water Recycling, Conveyance, and Extraction Projects), within the Northern and Central Delta-Mendota Regions, 2015 AWMPs were submitted by Patterson Irrigation District, West Stanislaus Irrigation District, Panoche Water District and San Luis Water District. Documented in the 2015 AWMPs are water conservation and efficiency measures implemented by each agency that are “reasonable and economically justifiable programs to improve delivery and use of water used for agricultural purposes" (Section 10902(b)) and promote water conservation through "the reduction of the amount of water irretrievably lost to saline sinks, moisture-deficient soils, water surface evaporation, or non-crop evapotranspiration in the process of satisfying an existing beneficial use achieved either by improving the technology or method for diverting, transporting, applying, or recovering the water or by implementing of other conservation methods" (Section 10902(c)).

PID documented its adherence to BMPs for Agricultural Contractors in its 2015 AWMP. PID requires farmers to install PID-approved flow meters on new pressurized irrigation systems. The PID approval process consists of a list of specific devises or technologies to be approved, a written understanding of the obligations of the farmer/district regarding maintenance and access, and written requirements related to proper installation of the flow meters. PID also offers on-farm evaluations consisting of farm irrigation and drainage system evaluations using their mobile lab type assessments. While there has been a low level of interest for farm evaluations in the past, district staff are also readily available to landowners to answer questions regarding irrigation efficiency and provide recommendations for most efficient irrigation practices on a case by case basis. A wide array of water use and crop water use reports and information is also provided to growers, including their field water use by crop and comparison to district averages. PID maintains extensive materials in its water conservation library, which is available to staff, farmers, and the public. These materials include books and videos on water management, water measurements, soil-plant-water relationships, engineering, fertigation, etc. Tiered pricing as also been implemented by PID to discourage inefficient use.

West Stanislaus Irrigation District (WSID) documents its adherence to BMPs for Agricultural Contractors in its 2015 AWMP. WSID hosts grower seminars and short courses to promote BMPs for water quality improvement, provide information on new regulations and enforcement, provide information on available grants and resources, and other topics as determined necessary. On-farm irrigation system evaluations are coordinated through the San Luis & Delta-Mendota Water Authority and are performed to improve water use efficiency and water quality in local waterways. The District provides information about on-farm evaluation programs to customers and may offer incentives for participation.

Panoche Water District's AWMP includes an inventory of the District's water resources, location and facilities, documents GMPs used by their agricultural contractors, and outlines the District's operating rules and regulations. BMPs utilized by the District include providing timely field and crop-specific water delivery information to the local growers, providing agricultural water management educational programs and materials, and using a tiered pricing system as an incentive for increased irrigation efficiency. The Plan also includes the Westside Regional Drainage Plan, which promotes the effective management of high saline drainage water and promoting drainage reuse.

San Luis Water District currently measures water at each individual grower turnout and collects a portion of its revenue based on the quantity of water delivered to growers. The District has already implemented the following "conditional" efficient water management practices (EWMPs) identified in Water Code § 10608.48: alternative land use, recycled water use, on-farm irrigation system improvements, incentive pricing, distribution system improvements, order/delivery flexibility, supplier spill and tailwater systems, conjunctive use, automated canal controls, facilitated customer pump test and evaluations, designate a Water Conservation Coordinator, water management services to customers, and supplier pump efficiency.

2.5.8 Efforts to Develop Relationships with State and Federal Regulatory Agencies

Entities in the Northern and Central Delta-Mendota Regions, as well as throughout the Delta-Mendota Subbasin, have a long history of working with both state and federal agencies. Such state agencies include DWR, SWRCB, CV-RWQCB, and California Department of Fish and Wildlife (CDFW). Long-standing relationships on the federal side include the USBR and U.S. Fish and Wildlife Service (USFWS).

The Northern and Central Delta-Mendota Regions water managers have a long history of working with DWR through the SWP and CASGEM program. Oak Flat Water District holds a long-term water supply contract for water service from the SWP, which was executed in 1965 and deliveries beginning in 1968. Oak Flat Water District's contract Table A delivery is 5,700 AFY. Additionally, Oak Flat Water District participates in various water transfer and substitution programs through the SWP. Other entities in the Northern and Central Delta-Mendota Regions have entered into short-term contracts with DWR to use SWP conveyance structures and participate in water transfers. An exchange agreement among DWR, USBR, Del Puerto Water District, and Oak Flat Water District, executed in May 2014, approved the exchange of up to 2,000 AF of Del Puerto Water District's CVP water supplies for an equivalent amount of Oak Flat Water District's approved SWP water supplies through April 2015. Deliveries were made using Oak Flat's turnouts in the California Aqueduct. In exchange, USBR made an equivalent amount of Del Puerto Water District's CVP water supplies available to DWR at O'Neill Forebay. During 2015, a total of 19 AF was delivered to Oak Flat's turnouts under this agreement.

Water managers in the Northern and Central Delta-Mendota Regions also participate in groundwater level monitoring programs through DWR. The San Luis & Delta-Mendota Water Authority, of which many Northern and Central Delta-Mendota Regions water agencies are Member Agencies, is the CASGEM monitoring entity for the Delta-Mendota Subbasin.

Surface water rights holders within the Northern and Central Delta-Mendota Regions coordinate with the SWRCB Division of Water Rights annually to report surface water extractions. West Stanislaus Irrigation District, Patterson Irrigation District, Twin Oaks Irrigation District, and El Solyo Water District are the primary surface water rights holders in the Northern and Central Delta-Mendota Regions. West Stanislaus Irrigation District is entitled to extract up to 189,790 AFY from the San Joaquin and Tuolumne Rivers, Patterson Irrigation District holds a riparian water right on the San Joaquin River, Twin Oaks Irrigation District is entitled to 10,560 AFY from the San Joaquin River, and El Solyo Water District is entitled to 22,805 AFY from the San Joaquin River.

Through the CV-RWQCB, many Northern and Central Delta-Mendota Regions entities participate in the ILRP through the Westside San Joaquin River Watershed Coalition and Grassland Drainage Area Coalition. The ILRP was initiated in 2003 to prevent agricultural runoff from impairing surface waters, and in 2012, groundwater regulations were added to the program. Waste discharge requirements, which protect both surface water and groundwater, address irrigated agricultural discharges throughout the Central Valley. Commercial growers are required to implement management practices to protect water quality and submit farm information to either their coalition or the Central Valley Water Board. Monitoring reports, assessment reports, management plans, surface water quality data, and groundwater quality data are required to be developed and collected by coalitions and must be submitted to the CV-RWQCB.

CDFW owns and operates wildlife areas and conservation easements throughout the Delta-Mendota Subbasin (Figure 2-7). The Mendota Wildlife Area, North Grasslands Wildlife Area, Little Panoche Reservoir Wildlife Area, O'Neill Forebay Wildlife Area, Volta Wildlife Area, Los Banos Wildlife Area, and West Hilmar Wildlife Area are operated by CDFW. Entities in the Northern and Central Delta-Mendota Regions have developed similar relationships with the USFWS. San Luis National Wildlife Refuge and San Joaquin River National Wildlife Refuge are the primary federally-owned and -operated refuges in or adjoining the Northern and Central Delta-Mendota Regions. While there are no formal working relationships between local water managers and CDFW or USFWS relating to land use and water supply planning, local water managers have conducted informal discussions with representatives from CDFW and USFWS representatives regarding involvement in SGMA activities.

Water from the CVP is delivered to the following Northern and Central Delta-Mendota Regions purveyors, as available: Del Puerto Water District, West Stanislaus Irrigation District, Patterson Irrigation District, San Luis Water District, Panoche Water District, Eagle Field Water District, Oro Loma Water District, Mercy Springs Water District, Fresno Slough Water District, Tranquillity Irrigation District, and Pacheco Water District. CVP deliveries to these contractors began the early 1950s. CVP water has been a crucial water supply source throughout the Delta-Mendota Subbasin and agreements with USBR to use CVP facilities for water transfers and substitutions, such as for the North Valley Regional Recycled Water Project, are vital to maximize the beneficial use of water throughout the Delta-Mendota Subbasin.

2.5.9 Processes to Review Land Use Plans and Efforts to Coordinate with Land Use Planning Agencies to Assess Activities that Potentially Create Risk to Groundwater Quality or Quantity

Entities with land use authority in the Delta-Mendota Subbasin includes the counties, cities, and communities overlying the basin. Within the Delta-Mendota Subbasin, these same entities are either individual GSAs or part of larger GSAs participating in the development and implementation of this GSP. As such, land use planning is integrally combined with groundwater management through the implementation of this GSP.

2.5.10 Impacts on Groundwater Dependent Ecosystems

Impacts on groundwater dependent ecosystems (GDEs) have not been assessed at this time due to a lack of available information and relative data necessary to analyze impacts to GDEs, as well as location, timing, and quantity of interconnected surface waters. For more information about the identification of GDEs in the Northern and Central Delta-Mendota Regions, refer to Section 5.3.7.6 of the Basin Setting Chapter (Chapter 5) of this GSP.

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Section 3

Governance & Administration

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3. GOVERNANCE & ADMINISTRATION

This section includes information pursuant to Article 5. Plan Contents, Subarticle 1. Administrative Information, § 354.6 (Agency Information) as well as Subarticle 8. Interagency Agreements (§ 357.2 Interbasin Agreements and § 357.4 Coordination Agreements), as required by the Groundwater Sustainability Plan (GSP) Regulations. Agency Contact information for the Northern & Central Delta-Mendota Region GSP and the plan manager is included in this section. The organization and management structure, as well as the legal authority of each Groundwater Sustainability Agency (GSA) in the Northern & Central Delta-Mendota Region GSP, is detailed and accompanied by GSA boundary maps and a description of activity agreements in place for the development and implementation of the Northern & Central Delta-Mendota Region GSP. Additionally, any intra-basin and inter-basin coordination agreements are described along with their associated government structures.

3.1 AGENCY CONTACT INFORMATION

This GSP has been prepared in a cooperative manner by the following eight (8) GSAs in the Northern and Central Delta-Mendota Regions:

- Central Delta-Mendota GSA
- City of Patterson GSA
- DM-II GSA
- Northwestern Delta-Mendota GSA
- Oro Loma Water District GSA
- Patterson Irrigation District GSA
- West Stanislaus Irrigation District GSA
- Widren Water District GSA

The location and proximity of these GSAs are shown in **Figure 3-1**.

These GSAs are coordinating GSP development and implementation for the Northern and Central Delta-Mendota Regions under the following agreements:

- Central Delta-Mendota Region Sustainable Groundwater Management Act (SGMA) Services Activity Agreement and amendments
- Northern Delta-Mendota Region SGMA Services Activity Agreement and amendments

This GSP, prepared for the Northern & Central Delta-Mendota Region GSP, is one of six GSPs that have been prepared in a coordinated fashion for the Delta-Mendota Subbasin as a whole (**Figure 3-2**).

Contact information for the Northern & Central Delta-Mendota Region GSP is as follows:

Mr. Seth Harris, Plan Manager
Northern and Central Delta-Mendota Regions
842 6th Street
Los Banos, CA 93635
Phone: (209)-324-1033 / Fax (209)-833-1034
sethharris@sldmwa.org

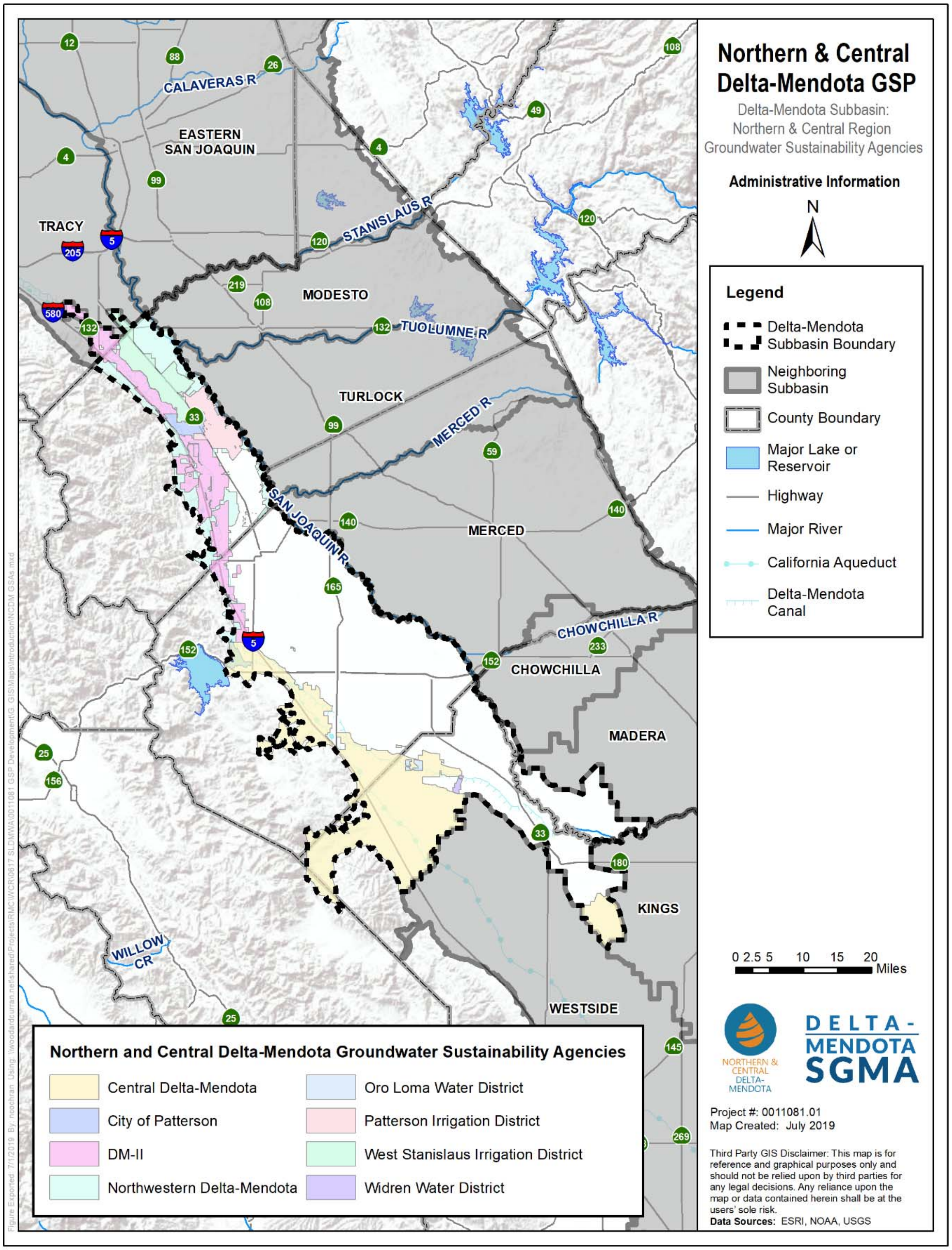

Figure 3-1. Northern and Central Delta-Mendota Regions GSA Boundaries

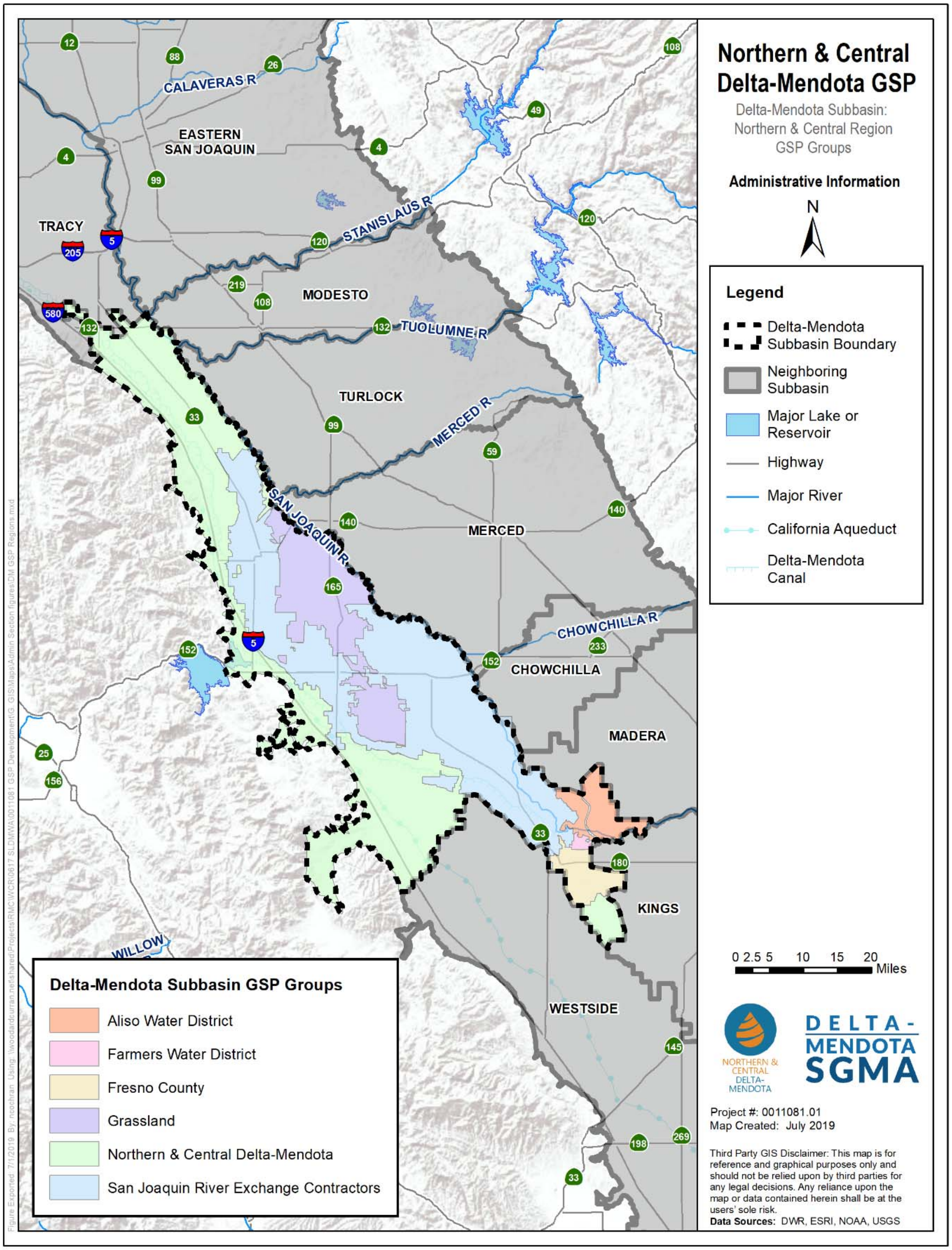

Figure 3-2. Delta-Mendota Subbasin GSP Regions

3.2 NORTHERN AND CENTRAL DELTA-MENDOTA REGIONS GROUNDWATER SUSTAINABILITY AGENCIES

The eight (8) GSAs that comprise the Northern & Central Delta-Mendota Region GSP each have their own individual organization and management structures as well as legal authority under which they operate, as described below for each GSA. Additionally, activity agreements between the GSAs comprising the Northern Delta-Mendota Region and Central Delta-Mendota Region describe how the two regions coordinate with the San Luis & Delta-Mendota Water Authority (SLDMWA or Authority) as plan administrator to prepare and implement a single GSP for their portion of the Delta-Mendota Subbasin. Persons with management authority for Plan implementation have been identified in the "Plan Manager Contact Information" section (Section 3.3.2.2, below).

3.2.1 Central Delta-Mendota GSA

The Central Delta-Mendota GSA is a Joint Powers Authority (JPA) that includes the following members: Fresno County, Merced County, Eagle Field Water District, Fresno Slough Water District, Mercy Springs Water District, Pacheco Water District, Panoche Water District, San Luis Water District, Santa Nella County Water District, and Tranquillity Irrigation District. This GSA, along with a portion of San Benito County through a Memorandum of Understanding, supports development and implementation of a GSP for the Central Delta-Mendota Region. For the purposes of this GSP, the Central Delta-Mendota GSA boundary includes the JPA and San Benito County portion of the Subbasin. **Figure 3-3** shows the boundary of the Central Delta-Mendota Region.

The Central Delta-Mendota GSA is managed by a Board of Directors where each Party to the agreement designates one person to serve on the Board of Directors as a Director and up to two persons to serve as an alternate(s) to its appointed Director to act during the absence of disqualification of the Party's director. The Director and alternate Directors serve at the pleasure of his or her applicable appointing Party. Officers of the Board of Directors for the Central Delta-Mendota GSA include the Chairman, who presides at all Board of Directors meetings; Vice Chairman, who serves in the absence of the Chairman; and Secretary, who may, but does not need to be, a member of the Board of Directors. The Central Delta-Mendota GSA also has a designated Treasurer from one of the member agencies and a Controller from the same member agency as the designated Treasurer, unless a certified public accountant has been designated as Treasurer. The Board of Directors may hire/appoint legal counsel for the GSA. In addition to, or in lieu of, hiring employees, the Central Delta-Mendota GSA may engage one or more third parties to manage any of all of the business of the Agency on terms and conditions acceptable to the Board of Directors.

The Board of Directors meetings are subject to the Brown Act and hold at least one regular meeting each year, with other regular meetings and special meetings held as necessary. Regular meetings are held at a fixed hour, date, and place. The Board of Directors Chairman may appoint, with the concurrence of the majority of the Board of Directors present, ad hoc or standing committees as may be helpful from time to time. The Secretary of the Board of Directors prepare meeting minutes and place them in the records for the GSA. A majority of the Board of Directors members constitutes a quorum of the Board of Directors. All actions of the Board of Directors must be taken by majority vote of the Board of Directors at the meeting. A special vote requires a 2/3rd approval by the Board of Directors present for the following determinations:

1. To exercise the GSA enforcement powers identified in Chapter 9 (commencing with Section 10732) of SGMA;
2. To approve initial and annual operating budgets;
3. To revise Member Contributions of the Parties;
4. To impose certain charges, which may include fees, assessments or both, to fund the cost of the Agency for complying with and as authorized by SGMA, and sustainably managing groundwater within the Central Delta-Mendota Region;
5. To adopt rules, regulations, policies, and procedures governing the adoption and implementation of the GSP for the Central Delta-Mendota Region; and

6. To adopt a GSP and any amendments.

The agreement supporting the formation and operation of the Central Delta-Mendota GSA is not intended to form a new legal entity. The common powers of the GSA include, but are not limited to, the following (as detailed in Article 5 of the Central Delta-Mendota GSA Agreement):

1. Adopting initial and annual operating budgets;
2. Accepting contributions, grants, or loans from any public or private agency or individual in the United States or any department, instrumentality, or agency thereof for the purpose of financing its activities; and
3. Investing money that is not needed for immediate necessities, as the Board of Directors determines advisable, in the same manner and upon the same conditions as other local entities in accordance with Section 53601 of the Government Code.

San Benito County is also a member agency to the Central Delta-Mendota GSA and has entered into a Memorandum of Understanding (MOU) with the Parties to the Central Delta-Mendota GSA JPA, where the MOU was entered on October 23, 2018 by all Central Delta-Mendota GSA member agencies. This MOU allows for the inclusion of an unmanaged *de minimis* area of San Benito County into the Central Delta-Mendota GSA and the Northern & Central Delta-Mendota Region GSP Group.

3.2.2 City of Patterson GSA

The City of Patterson GSA operates within its current city organization and management structure as well as legal authority, as described in the City Charter. The City of Patterson has the ability to exercise all relevant duties, powers, and responsibilities to implement the Northern & Central Delta-Mendota Region GSP. Public noticing and records regarding decisions made in support of this GSP are maintained as part of the City Councils records in accordance with City ordinances and protocols (https://www.ci.patterson.ca.us/680/Sustainable-Groundwater-Management-Act-S). Figure 3-4 shows the boundary of the City of Patterson GSA.

3.2.3 DM-II GSA

The DM-II GSA is a multi-agency GSA formed between Del Puerto Water District and Oak Flat Water District. Figure 3-5 shows the boundary of the DM-II GSA. On April 19, 2017, both parties formalized a Memorandum of Agreement (MOA) establishing the DM-II Multi-Agency GSA in the Northern Delta-Mendota Region.

The decision-making body formed for the DM-II GSA is a Steering Committee comprised of two Members and one Alternate Member appointed by each party as its Steering Committee members and one person serving as its Steering Committee alternate. The Contractual Service Areas of the GSA parties are represented by the appointed representatives, but they are not entitled to independent representation on the Steering Committee. There are no term limits for appointed Steering Committee Members and they represent each party at the pleasure of their respective governing body. There are three Steering Committee officer positions: Chairman, Vice Chairman, and Secretary.

Steering Committee meetings are subject to the Brown Act and as such, meetings are held at a regularly designated meeting time. A meeting notice and agenda is provided to all Steering Committee members and alternates, Parties, and interested parties who have requested notice and are placed on the member agency websites. Meeting minutes are taken and placed as permanent records of the GSA. All DM-II GSA parties are entitled to one vote where the majority vote rules, with the exception of Special voting that requires 2/3rd majority. Approval of the parties is required for the following actions (as detailed in Section 9.5(b) of the Memorandum of Agreement establishing the DM-II GSA):

1. Approval of a Steering-Committee-recommended budget;
2. A Party becoming obligated to pay a revised Participation Percentage under this Agreement;

3. Amendment of the Agreement, including but not limited to, for purposes of adding a new Party or the replacement of this Agreement with an alternative form of agreement;
4. Adoption of the Northern & Central Delta-Mendota Region GSP; and
5. A Party becoming obligated to take specific actions to implement SGMA.

The MOA between the DM-II GSA members is not intended to form a new legal entity. The powers of the GSA include, but are not limited to, the following (as detailed in Section 8.1 of the Memorandum of Agreement establishing the DM-II GSA):

1. Execute contracted services including, but not limited to, consultants, attorneys, accountants, and financial advisors to accomplish activities relating to GSA duties, responsibilities, and obligations;
2. Conduct all necessary research and investigations, compile appropriate reports and collect data to assist in GSP preparation, develop Coordination Agreements with other GSAs in the Subbasin, and prepare reports and assessments to allow the Parties to participate in sustainable management of the Subbasin in compliance with SGMA;
3. To cooperate, act in conjunction with, and contract with the United States, the State of California, local agencies, or other Parties for the purposes of assisting Parties with forming a multi-agency GSA and preparing, adopting, and implementing the Northern & Central Delta-Mendota Region GSP;
4. To apply for, accept, receive, and administer agreements, grants, loans, gifts, contributions, donations, or other forms of aid from any agency of the United States, State of California, or other public or private person or entity necessary or beneficial for preparing or implementing the Northern & Central Delta-Mendota Region GSP; and
5. To investigate legislation and proposed legislation, regulations and proposed California Department of Water Resources (DWR) or State Water Resources Control Board (SWRCB) actions affecting SGMA and the Delta-Mendota Subbasin and make appearances regarding such matters.

3.2.4 Northwestern Delta-Mendota GSA

The Northwestern Delta-Mendota GSA represents communities, water districts, and other entities in portions of Merced and Stanislaus Counties which are outside of other GSA boundaries but within county limits in the Delta-Mendota Subbasin. Public notices and permanent records are maintained on each of the counties' websites. Figure 3-6 shows the boundary of the Northwestern Delta-Mendota GSA.

The Northwestern Delta-Mendota GSA is formed through a Memorandum of Understanding between Merced and Stanislaus Counties, encompassing areas of non-GSA coverage within the counties. The Northwestern Delta-Mendota GSA does not have a formal agreement with other entities within its GSA boundaries. The County-default provision in SGMA (Section 10724) is used to provide coverage in the Subbasin for the "white areas" or other areas of non-GSA coverage within Merced and Stanislaus Counties. Merced and Stanislaus Counties speak and meet regularly to discuss on-going SGMA activities, and all represented areas are encouraged to participate.

3.2.5 Oro Loma Water District GSA

The Oro Loma Water District GSA operates within its current organization and management structure under its current Board of Directors, as well as its legal authority as a special district. Oro Loma Water District has the ability to exercise all relevant duties, powers, and responsibilities as a GSA to implement the Northern & Central Delta-Mendota Region GSP. Public notices and permanent records are maintained on the District's website. Figure 3-7 shows the boundary of the Oro Loma Water District GSA.

3.2.6 Patterson Irrigation District GSA

The Patterson Irrigation District GSA operates within its current organization and management structure under its current Board of Directors, as well as its legal authority as a special district. Patterson Irrigation District has the ability to exercise all relevant duties, powers, and responsibilities as a GSA to implement the Northern & Central Delta-Mendota Region GSP. Public notices and permanent records are maintained on the District's website (pattersonid.org). Figure 3-8 shows the boundary of the Patterson Irrigation District GSA.

3.2.7 West Stanislaus Irrigation District GSA

The West Stanislaus Irrigation District GSA operates within its current organization and management structure under the West Stanislaus Irrigation District Board of Directors, as well as its legal authority as a special district. West Stanislaus Irrigation District exercises all relevant duties, powers, and responsibilities as a GSA to implement the Northern & Central Delta-Mendota Region GSP. Public notices and permanent records are maintained at the District's office. Figure 3-9 shows the boundary of the West Stanislaus Irrigation District GSA.

3.2.8 Widren Water District GSA

The Widren Water District GSA operates within its current organization and management structure under its current Board of Directors, as well as legal authority to act as a special district. Widren Water District exercises all relevant duties, powers, and responsibilities as a GSA to implement the Northern & Central Delta-Mendota Region GSP. Public notices and permanent records are maintained at the District's office. Widren Water District GSA meetings are subject to the Brown Act and as such, meetings are held on a designated date and time selected by the Widren Water District Board of Directors. All meeting notices and agendas are posted in advanced at the District office and provided to Board members as well as other interested parties who have requested notice. Widren Water District is a Landowner Voting District, with votes allocated on the basis of assessed valuation. There are five seats on the Board of Directors, four of which are currently filled. Due to the small number of landowners, finding legally qualified candidates to seek Board seeks has historically been a challenge. Each Board member has one vote on matters reaching the Board. Figure 3-10 shows the boundary of the Widren Water District GSA.

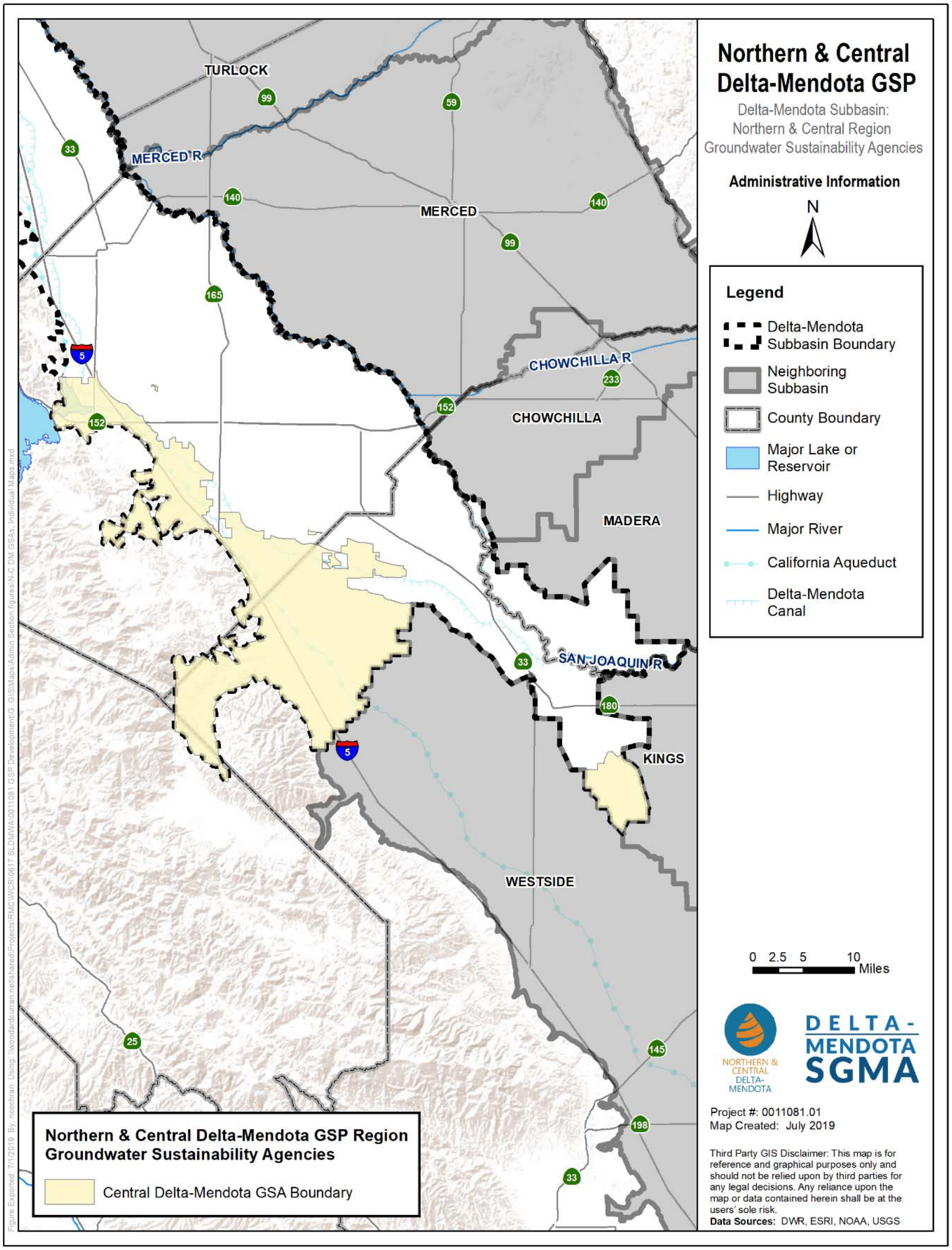

Figure 3-3. Central Delta-Mendota GSA Boundary, Central Delta-Mendota Region

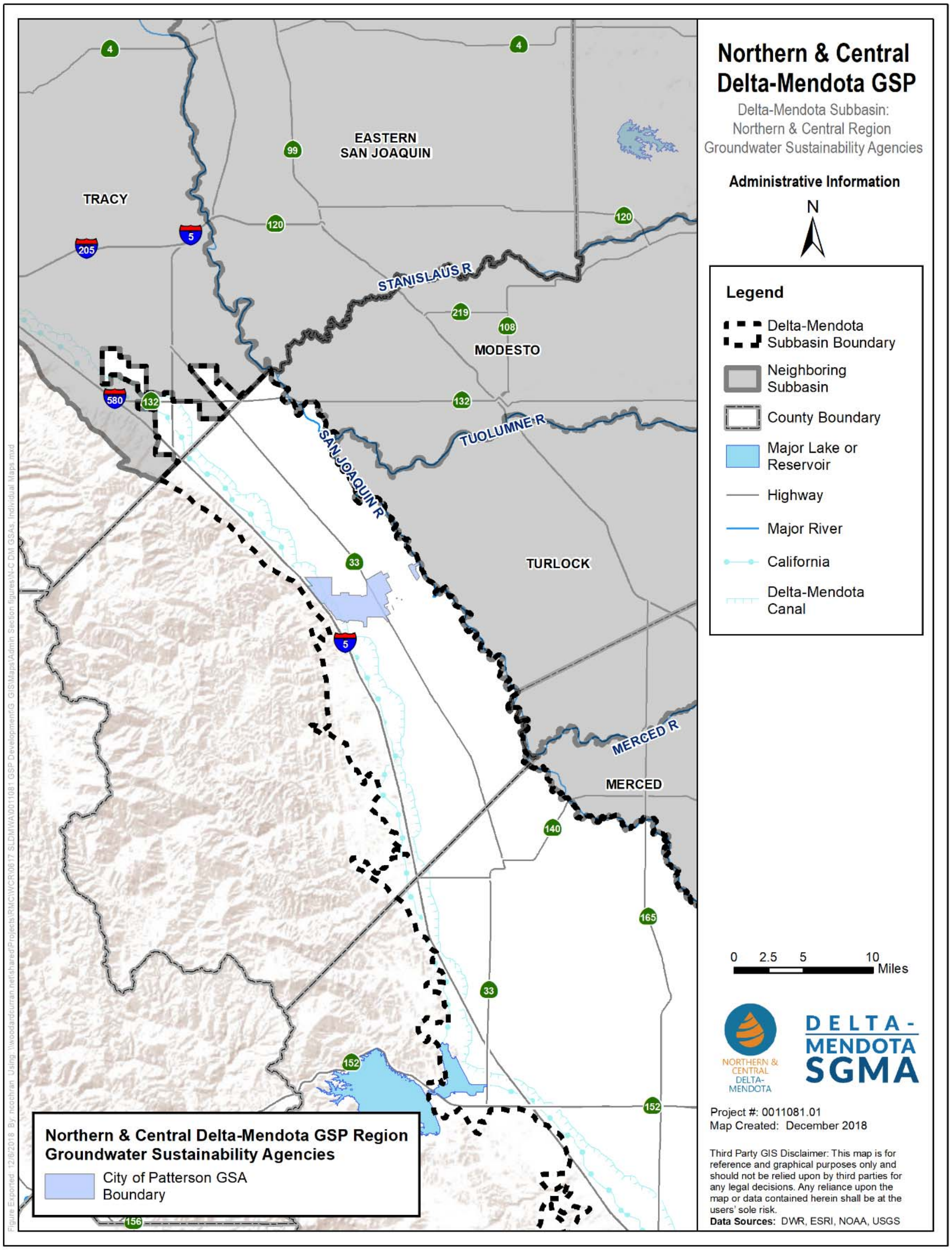

Figure 3-4. City of Patterson GSA Boundary, Northern Delta-Mendota Region

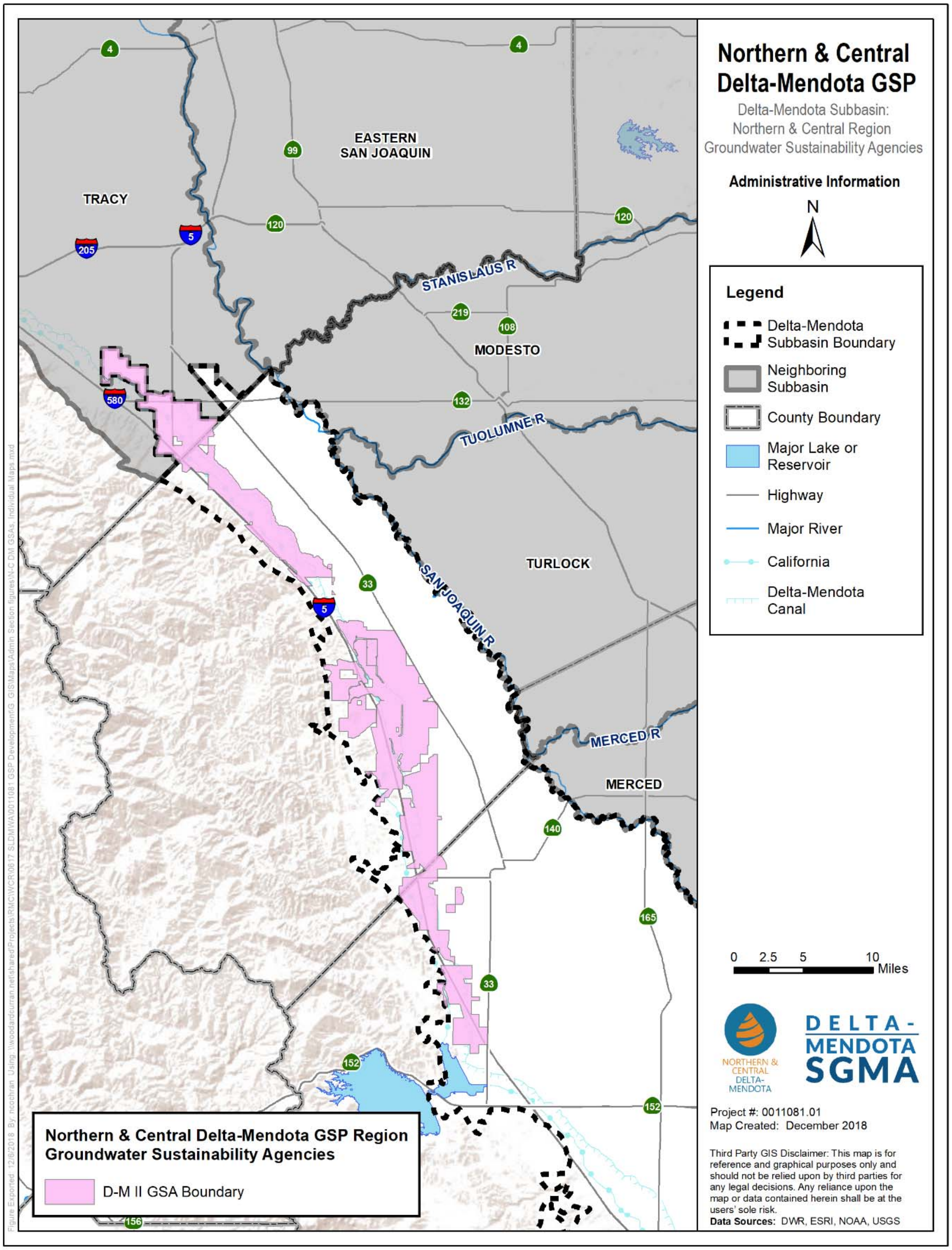

Figure 3-5. DM-II GSA Boundary, Northern Delta-Mendota Region

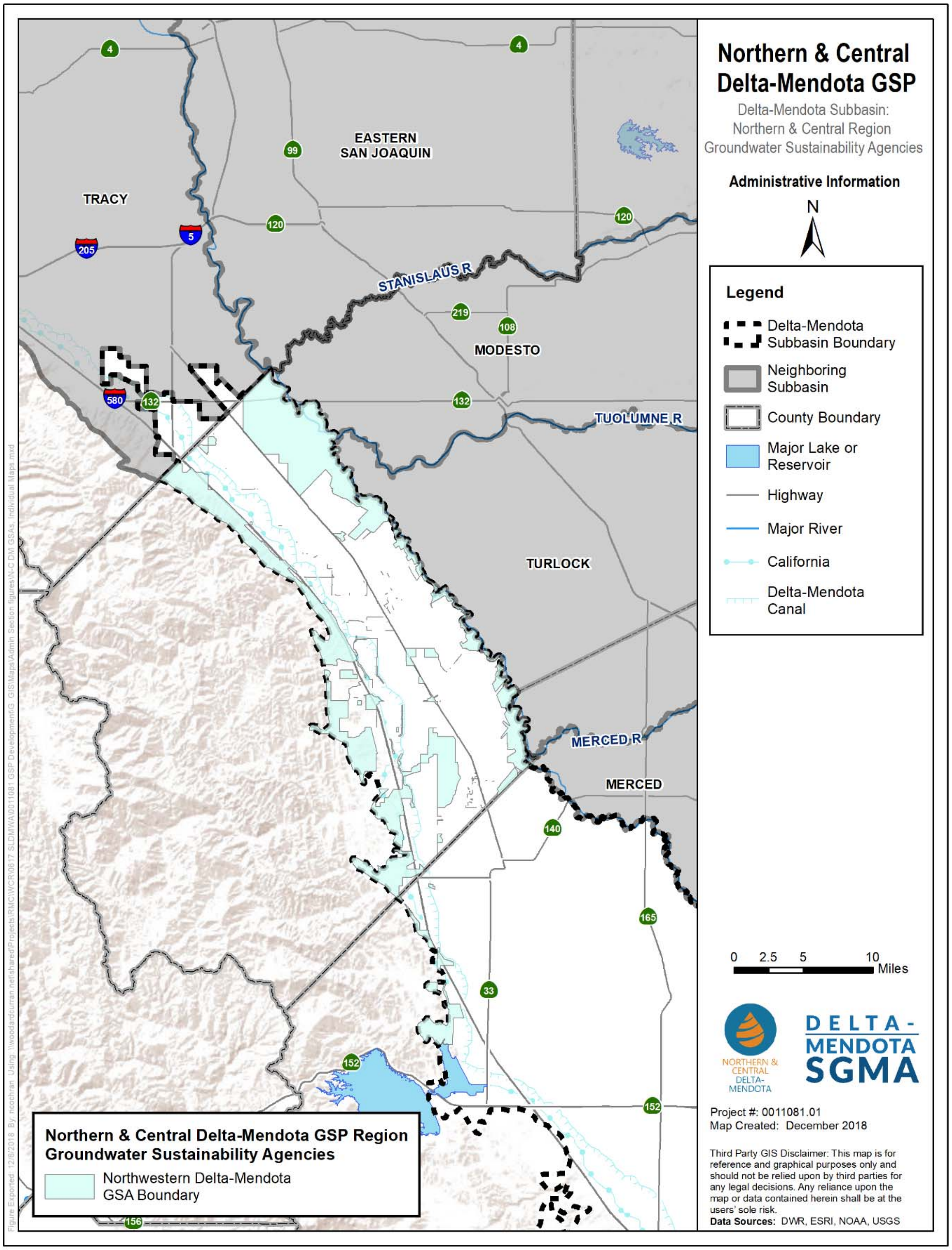

Figure 3-6. Northwestern Delta-Mendota GSA Boundary, Northern Delta-Mendota Region

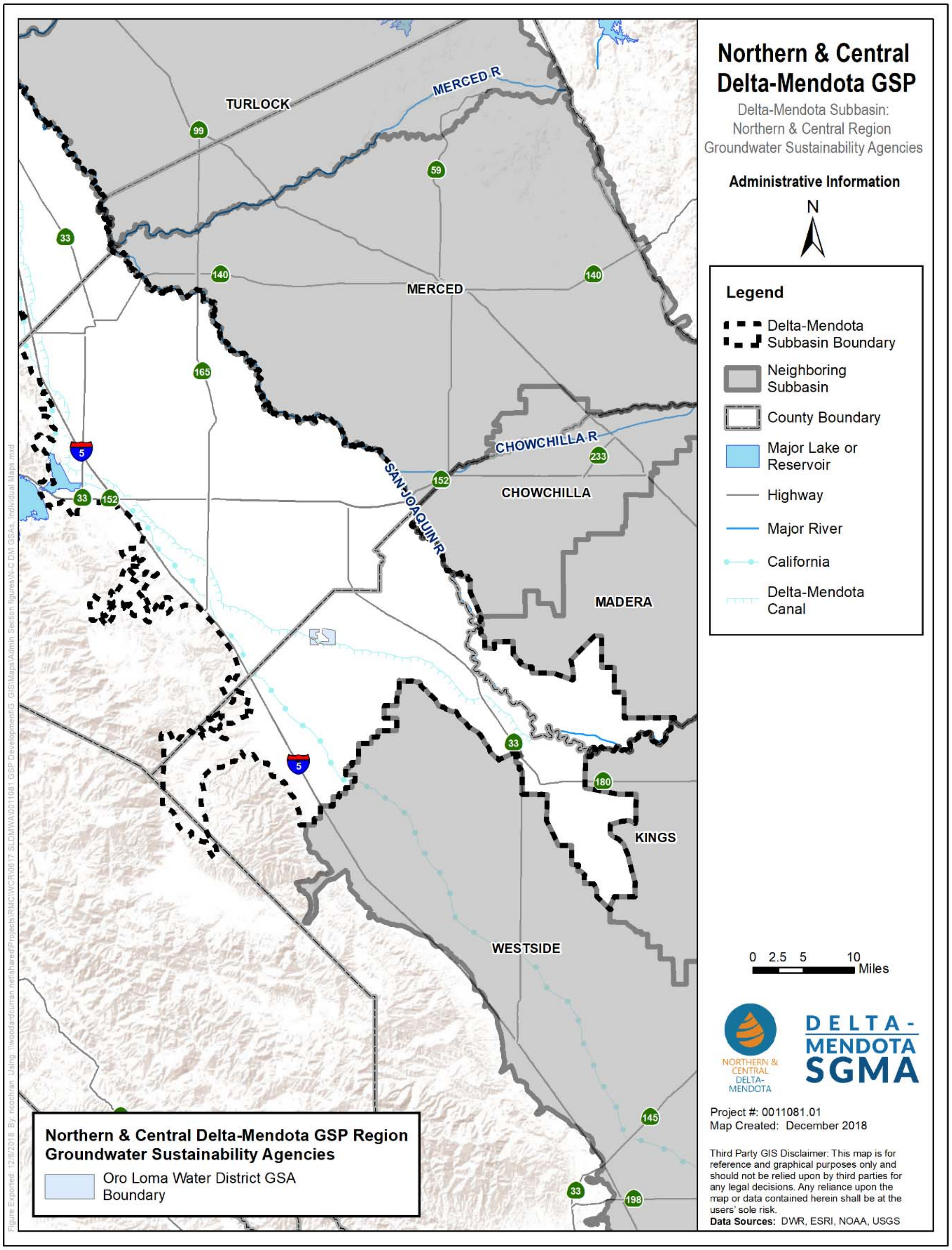

Figure 3-7. Oro Loma Water District GSA Boundary, Central Delta-Mendota Region

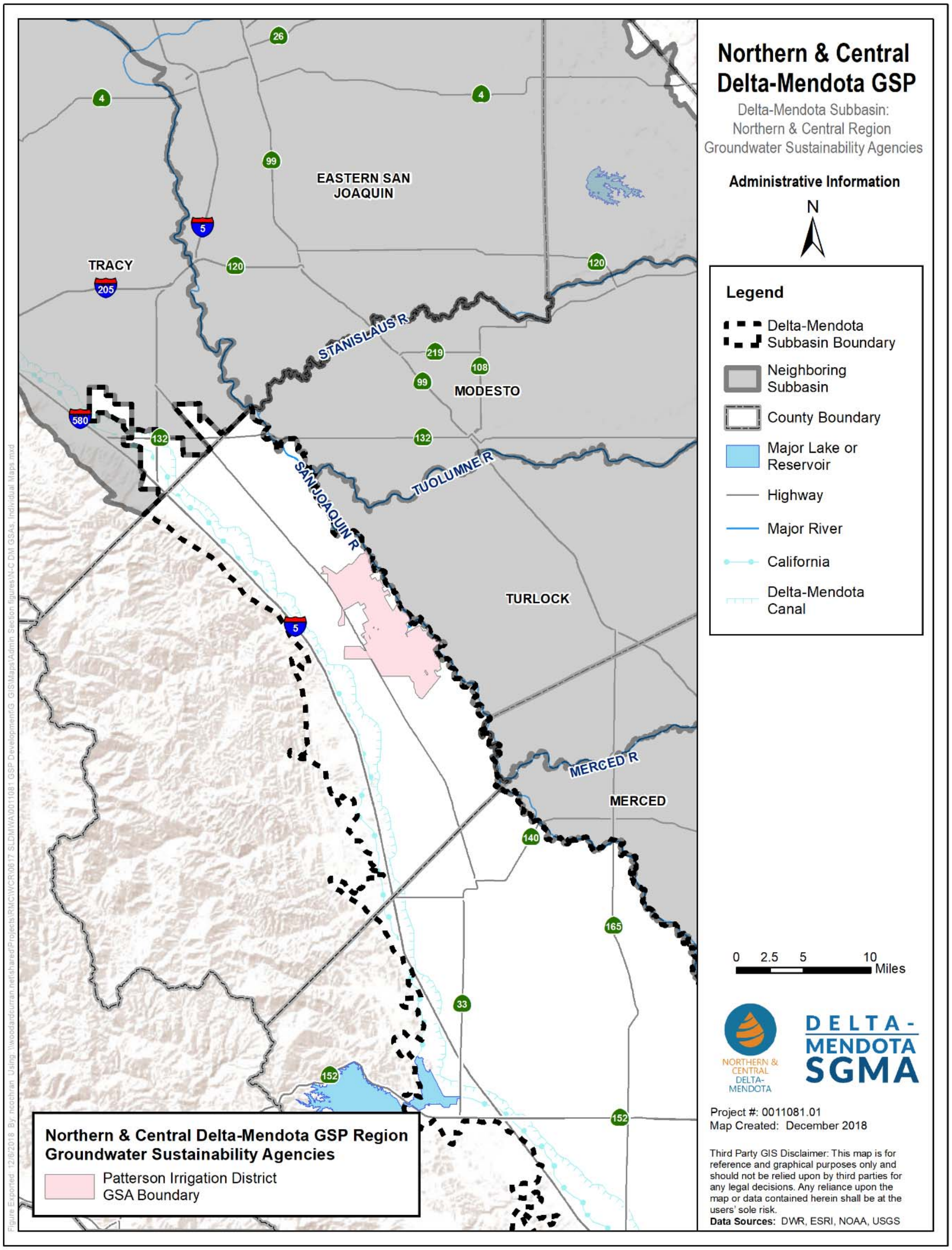

Figure 3-8. Patterson Irrigation District GSA Boundary, Northern Delta-Mendota Region

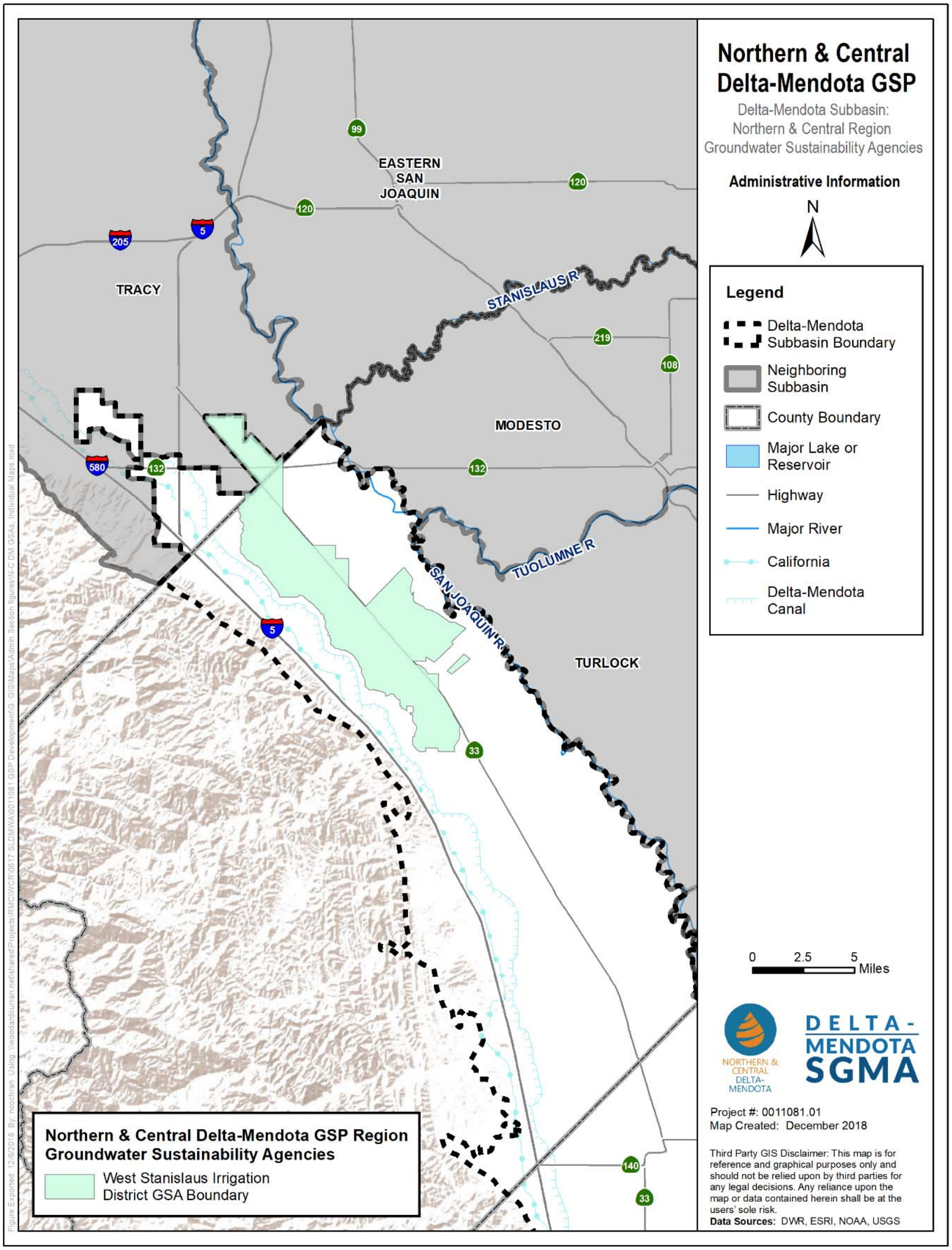

Figure 3-9. West Stanislaus Irrigation District GSA Boundary, Northern Delta-Mendota Region

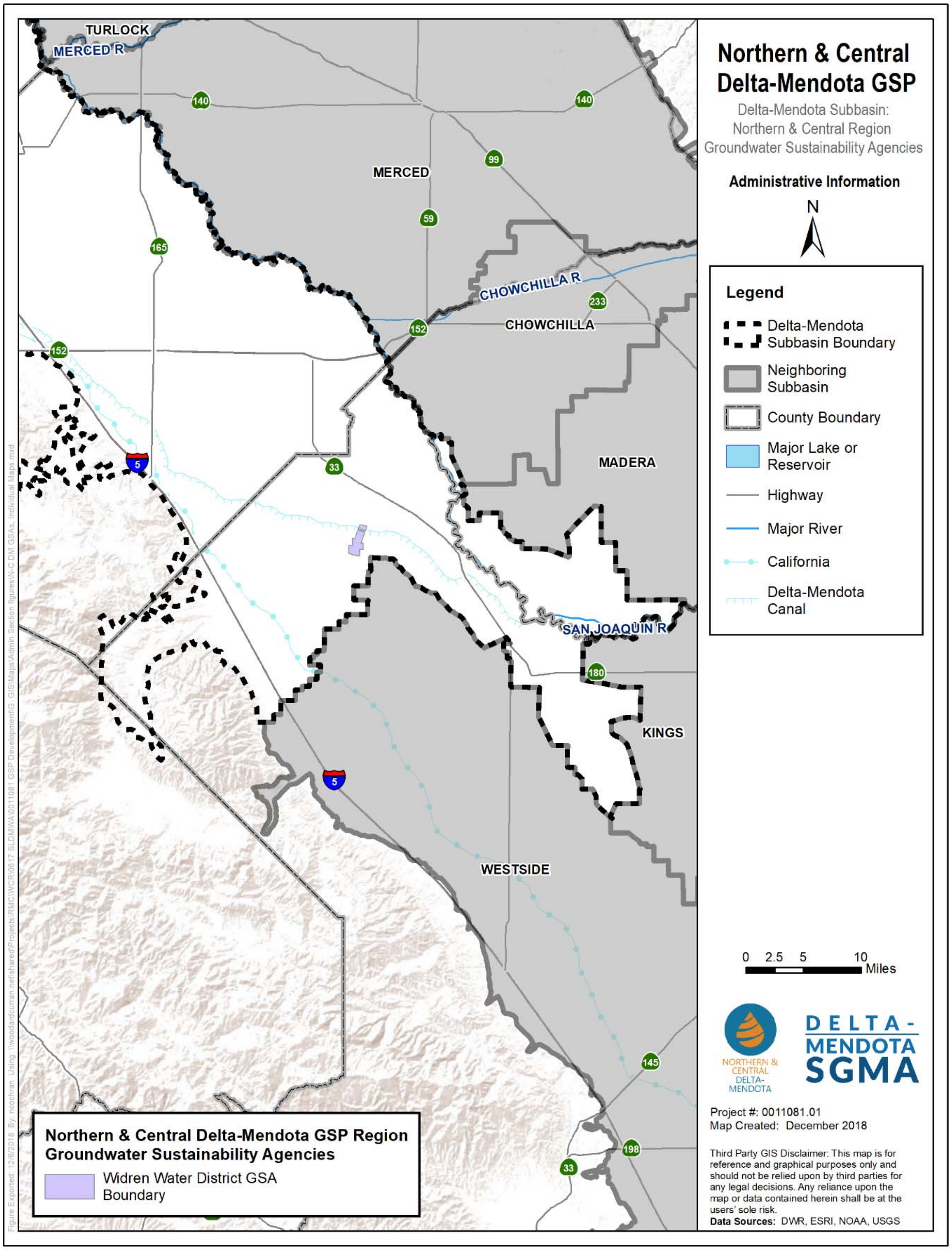

Figure 3-10. Widren Water District GSA Boundary, Central Delta-Mendota Region

3.3 GSA COORDINATION AND GOVERNANCE

The GSAs comprising the Northern and Central Delta-Mendota Regions are coordinating with each other and with other Subbasin GSAs under several agreements. These coordination agreements are described below and are included as an exhibit to this GSP.

3.3.1 Northern Delta-Mendota SGMA Services Activity Agreement

Effective February 24, 2017, Del Puerto Water District, Patterson Irrigation District, and West Stanislaus Irrigation District entered into an Activity Agreement with the SLDMWA to utilize SLDMWA's resources to assist with:

1. Procedural requirements for forming GSAs in the Northern Delta-Mendota Region that are separate and independent from SLDMWA;
2. Planning, preparation, and implementation of a GSP for or including the Northern Delta-Mendota Region; and
3. Coordination with other GSPs within the Delta-Mendota Subbasin and adjoining subbasins as required by SGMA.

A MOA was signed by the following non-Authority members within the Northern Delta-Mendota Region on April 4, 2017 to extend the same SGMA services listed above for Authority member agencies: City of Patterson, Merced County, Oak Flat Water District, and Stanislaus County.

Through the Northern Delta-Mendota SGMA Services Activity Agreement, a Management Committee has been formed with one Management Committee Member and one alternate Management Committee Member appointed by action of the governing body of each Activity Participant. There are three officer positions on the Management Committee: Chairperson, Vice-Chairperson, and Secretary. All elected officers retain their positions at the pleasure of the majority vote of the Management Committee.

Meetings of the Management Committee are called, as necessary and appropriate, by the Executive Director of SLDMWA, Assistant Executive Director of the SLDMWA (acting on the Executive Director's behalf), or the Chairman of the Management Committee. All meetings are conducted in accordance with the Brown Act (e.g. publicly noticed), both on the SLDMWA website (http://www.sldmwa.org/) and on the Northern & Central Delta-Mendota Region GSP website (http://deltamendota.org/north-central-dm-gsp.html). All actions of the Management Committee are decided by a simple majority vote, with the exception of actions detailed in Section 6.4 of the Northern Delta-Mendota Region SGMA Services Activity Agreement where a unanimous vote is required:

1. A recommendation to the Board of Directors of the Authority to a compromise or payment of any claim against the Authority arising from the Activity Agreement;
2. To submit to the Activity Participants for consideration by the GSAs covering the Northern Delta-Mendota Region any proposed Northern Delta-Mendota Region GSP;
3. To adopt a proposed initial operating budget within ninety (90) days of the execution of this Activity Agreement, and proposed annual budget by January 15 of each year or by such alternate date as may be required so that it can be incorporated into the Authority's annual budget for the fiscal year beginning on March 1 of each year;
4. To propose to set or modify the Participation Percentages of the Activity Participants from time to time;
5. To authorize the Authority to enter into agreements with consultants within the approved budgets, subject to the limitations provided in this Activity Agreement;
6. To provide recommendations to Activity Participants for consideration by their respective GSAs within the Northern Delta-Mendota Region regarding imposing fees authorized by SGMA to fund the cost of complying with SGMA, and sustainably managing groundwater within the Northern Delta-Mendota Region;

7. To propose rules, regulations, policies and procedures recommended to the Activity Participants for consideration by the respective GSAs within the Northern Delta-Mendota Region governing the adoption and implementation of a GSP as authorized by Chapter 5 of SGMA;
8. To assist the Activity Participants by investigating and reporting on legislation and proposed legislation, regulations and proposed SWRCB actions affecting SGMA and the Delta-Mendota Subbasin and making appearances regarding such matters; and
9. Any other action for which a unanimous vote is required by the terms of this Agreement.

Under the Northern Delta-Mendota SGMA Services Activity Agreement, the following activities authorized to be carried out specifically include, but are not limited to (as described in Section 4.2 of the Northern Delta-Mendota Region SGMA Services Activity Agreement):

1. Provide administrative services to the Activity Participants to assist in forming and implementing individual or multi-agency GSAs that are independent of SLDMWA;
2. Provide staff resources or to solicit and accept proposals from consultants to acquire consulting services as needed to assist multiple parties in compiling data, conducting monitoring, undertaking groundwater studies, and developing models as needed to develop and adopt the Northern Delta-Mendota Region GSP;
3. Provide funding mechanisms through budgets approved by the Management Committee, the Board of Directors, and Activity Participants to obtain necessary services for the development and implementation of the Northern Delta-Mendota Region GSP;
4. Provide accounting and billing services to collect from Activity Participants the cost of services incurred under the Activity Agreement;
5. Provide services to facilitate outreach to interested parties, as defined by SGMA, that may be required while developing and implementing any Northern Delta-Mendota Region GSAs and GSP(s);
6. Provide services to facilitate coordination among the GSAs throughout the Delta-Mendota Subbasin and neighboring subbasins to assist in the development and implementation of intra- or inter-basin Coordination Agreements required by SGMA;
7. Propose for adoption by Northern Delta-Mendota Region GSAs forms of rules, regulations, policies, and procedures governing the adoption and implementation of a GSP (as authorized by Chapter 5 of SGMA); and
8. Undertake additional activities and responsibilities requested and funded by Activity Participants acting through the Management Committee.

The authorized actions of the Management Committee include, but are not limited to (as described in Section 6.6(a) of the Northern Delta-Mendota Region SGMA Services Activity Agreement):

1. Setting policy or practices for the Activity Agreement;
2. Making budget recommendations in conjunction with the Executive Director and/or the Assistant Executive Director of the Authority or any Authority staff or consultant designated to manage the Activity Agreement;
3. Determining the recommended basis for calculation of the Participation Percentages for each fiscal year, and the timing required for payments of obligations;
4. Employing consultants and otherwise authorizing expenditure of Activity Agreement funds within the parameters of the budget approved by the Authority;
5. Developing and implementing guidelines, rules or regulations; and
6. Other actions deemed reasonably necessary or convenient to the purposes of the Activity Agreement.

3.3.2 Central Delta-Mendota SGMA Services Activity Agreement

Effective February 15, 2017, Eagle Field Water District, Mercy Springs Water District, Oro Loma Water District, Pacheco Water District, Panoche Water District, San Luis Water District, Tranquillity Irrigation District, and Fresno Slough Water District entered into an Activity Agreement with SLDMWA to utilize the resources of SLDMWA to assist with:

1. The formation of a multi-agency groundwater sustainability agency in the Central Delta-Mendota Region of the Delta-Mendota Subbasin that is separate and independent from the Authority;
2. Planning, preparation, and assistance with implementation of a groundwater sustainability plan for the Central Delta-Mendota Region; and
3. Coordination with other GSPs within the Delta-Mendota Subbasin or neighboring subbasins as required by SGMA.

A MOA was signed by the following non-Authority members within the Central Delta-Mendota Region on March 7, 2017 to extend the same SGMA services listed above for Authority member agencies: Fresno County, Merced County, Santa Nella County Water District, and Widren Water District.

Through the Central Delta-Mendota SGMA Services Activity Agreement, a Management Committee has been formed with one Management Committee Member and one alternate Management Committee Member appointed by action of the governing body of the Activity Participant. There are three officer positions on the Management Committee: Chairperson, Vice-Chairperson, and Secretary. All elected officers will retain their positions at the pleasure of the majority vote of the Management Committee.

Meetings of the Management Committee are called as necessary and appropriate by the Executive Director of SLDMWA, Assistant Executive Director of the SLDMWA (acting on the Executive Director's behalf), or the Chairman of the Management Committee. All meetings are conducted in accordance with the Brown Act (e.g. are publicly noticed) both on the SLDMWA website (http://www.sldmwa.org/) and on the Northern & Central Delta-Mendota Region GSP website (http://deltamendota.org/north-central-dm-gsp.html). All actions of the Management Committee are decided by a 3/4 vote, with the exception of actions detailed in Section 6.4 of the Central Delta-Mendota Region SGMA Services Activity Agreement where a unanimous vote is required:

1. A recommendation to the Board of Directors of the Authority to a compromise or payment of any claim against the Authority arising from the Activity Agreement;
2. To submit to the Activity Participants for consideration by the GSAs covering the Central Delta-Mendota Region any proposed Central Delta-Mendota Region GSP; and
3. Any other action for which a unanimous vote is required by the terms of this Agreement.

The following actions shall require a two-thirds (2/3) vote of a quorum of the Management Committee:

1. To adopt a proposed initial operating budget within ninety (90) days of the execution of this Activity Agreement, and proposed annual budget by January 15 of each year or by such alternate date as may be required so that it can be incorporated into the Authority's annual budget for the fiscal year beginning on March 1 of each year;
2. To propose to set or modify the Participation Percentages of the Activity Participants from time to time;
3. To authorize the Authority to enter into agreements with consultants within the approved budgets, subject to the limitations provided in this Activity Agreement;
4. To provide recommendations to Activity Participants for consideration by a single GSA or the Central Delta-Mendota GSA regarding imposing fees authorized by SGMA to fund the cost of complying with SGMA, and sustainably managing groundwater within the Central Delta-Mendota Region;

5. To propose rules, regulations, policies and procedures recommended to the Activity Participants for consideration by a single agency GSA or the Central Delta-Mendota GSA governing the adoption and implementation of a GSP as authorized by Chapter 5 of SGMA; and
6. To assist the Activity Participants by investigating and reporting to the Management Committee on legislation and proposed legislation, regulations and proposed SWRCB actions affecting SGMA and the Delta-Mendota Subbasin and making appearances regarding such matters.

Under the Central Delta-Mendota SGMA Services Activity Agreement, the following activities authorized to be carried out specifically include, but are not limited to (as described in Section 4.2 of the Central Delta-Mendota Region SGMA Services Activity Agreement):

1. Provide administrative services to assist Activity Participants who are forming and implementing a multi-agency GSA;
2. Provide staff resources or to solicit and accept proposals from consultants to acquire consulting services as needed to assist multiple parties in compiling data, conducting monitoring, undertaking groundwater studies, and developing models as needed to develop and adopt the Central Delta-Mendota Region GSP;
3. Provide funding mechanisms, through budgets approved by the Management Committee, the Board of Directors, and the Activity Participants, to obtain services necessary for the development and implementation of the Central Delta-Mendota GSP;
4. Provide accounting and billing services to collect from the Activity Participants the costs of services incurred under the Activity Agreement;
5. Provide services to facilitation outreach to interested parties, as defined by SGMA, that may be required for the development and implementation of the Central Delta-Mendota GSA or Central Delta-Mendota Region GSP;
6. Provide services to facilitate coordination among the GSAs in the Central Delta-Mendota Region, GSAs throughout the Delta-Mendota Subbasins, and GSAs in neighboring subbasins to assist in the development or implementation of intra- and inter-basin Coordination Agreements required by SGMA;
7. Propose the adoption of rules, regulations, policies, and procedures by the Central Delta-Mendota Region GSAs for governing the adoption and implementation of a GSP (as authorized by Chapter 5 of SGMA); and
8. Undertake additional activities and responsibilities requested and funded by the Activity Participants acting through the Management Committee.

The authorized actions of the Management Committee include, but are not limited to (as described in Section 6.6(a) of the Central Delta-Mendota Region SGMA Services Activity Agreement):

1. Setting policy or practices for the Activity Agreement;
2. Making budget recommendations in conjunction with the Executive Director and/or the Assistant Executive Director of the Authority or any Authority staff or consultant designated to manage the Activity Agreement;
3. Determining the recommended basis for calculation of the Participation Percentages for each fiscal year, and the timing required for payments of obligations;
4. Employing consultants and otherwise authorizing expenditure of Activity Agreement funds within the parameters of the budget approved by the Authority;
5. Developing and implementing guidelines, rules or regulations; and
6. Other actions deemed to be reasonably necessary or convenient to the purposes of the Activity Agreement.

3.3.3 Delta-Mendota Subbasin

This section includes a description of intra-basin coordination agreements, which are required where there are more than one GSP to be implemented in a groundwater basin, and inter-basin coordination agreements, which are optional agreements between neighboring groundwater subbasins, pursuant to Article 8. Interagency Agreements, § 357.4. Coordination Agreements and § 357.2 Interbasin Agreements.

3.3.3.1 Intra-Basin Coordination

The Delta-Mendota Subbasin Coordination Agreement (Coordination Agreement), effective as of December 12, 2018, has been signed by all participating agencies in the Delta-Mendota Subbasin. The purpose of the Agreement, including technical reports to be developed after the initial execution of this Agreement, is to comply with SGMA requirements and to ensure that the multiple GSPs within the Subbasin are developed and implemented utilizing the same methodologies and assumptions, that the elements of the GSPs are appropriately coordinated to support sustainable subbasin management, and to ultimately set forth the information necessary to show how the multiple GSPs in the Subbasin will achieve the sustainability goal as determined for the Subbasin in compliance with SGMA and its associated regulations.

A key goal of basin-wide coordination is to ensure that the Subbasin GSPs utilize the same data and methodologies during their plan development and that elements of the Plans necessary to achieve the sustainability goal for the basin are based upon consistent interpretations of the basin setting, as required by SGMA and associated regulations. This Coordination Agreement defines how the coordination efforts will be achieved and documented, and also sets out the process for identifying the Plan Manager. It is the intent that the Coordination Agreement become part of each individual GSP within the Delta-Mendota Subbasin.

The Coordination Agreement for the Delta-Mendota Subbasin covers the following topics:

1. Purpose of the Agreement, including:
    a. Compliance with SGMA and
    b. Description of Criteria and Function;
2. General Guidelines, including:
    a. Responsibilities of the Parties and
    b. Adjudicated or Alternative Plans in the Subbasin;
3. Role of SLDMWA, including:
    a. Agreement to Serve,
    b. Reimbursement of SLDMWA, and
    c. Termination of SLDMWA's Services;
4. Responsibilities for Key Functions, including:
    a. Coordination Committee,
    b. Coordination Committee Officers,
    c. Coordination Committee Authorized Action and Limitations,
    d. Subcommittees and Workgroups,
    e. Coordination Committee Meetings, and
    f. Voting by Coordination Committee;
5. Approval by Individual Parties;
6. Exchange of Data and Information, including:
    a. Exchange of Information and
    b. Procedure for Exchange of Information;

7. Methodologies and Assumptions, including:
    a. SGMA Coordination Agreements,
    b. Pre-GSP Coordination, and
    c. Technical Memoranda Required;
8. Monitoring Network
9. Coordinated Water Budget
10. Coordinated Data Management System
11. Adoption and Use of the Coordination Agreement, including:
    a. Coordination of GSPs and
    b. GSP and Coordination Agreement Submission;
12. Modification and Termination of the Coordination Agreement, including:
    a. Modification or Amendment of Exhibit "A" (Groundwater Sustainability Plan Groups including Participation Percentages),
    b. Modification or Amendment of Coordination Agreement, and
    c. Amendment for Compliance with Law;
13. Withdrawal, Term, and Termination;
14. Procedures for Resolving Conflicts;
15. General Provisions, including:
    a. Authority of Signers,
    b. Governing Law,
    c. Severability,
    d. Counterparts, and
    e. Good Faith; and
16. Signatories of all Parties

Department Point of Contact

The point of contact for the Delta-Mendota Subbasin is:

Christopher Olvera
Department of Water Resources
Christopher.Olvera@water.ca.gov
(559) 230-3373

Agency Responsibilities

In meeting the terms of the Coordination Agreement, all Parties (meaning the Delta-Mendota Subbasin GSAs) agree to work collaboratively to meet the objectives of SGMA and the Coordination Agreement. Each Party to the Agreement is a GSA and acknowledges that it is bound by the terms of this Coordination Agreement as an individual party.

The Parties have established a Coordination Committee to provide a forum to accomplish the coordination obligations of SGMA, where the Coordination Committee operates in full compliance with the Brown Act. The Coordination Committee is composed of a Chairperson and Vice Chairperson, Secretary, Plan Manager, and a GSP Group Representative and Alternate Representative for each of the six GSP groups. The Chairperson and Vice Chairperson are rotated annually among GSP Groups in alphabetical order. The Secretary assumes primary responsibility for Brown Act compliance. The GSP Group Representatives, who are identified in Table 3-1, are selected by each respective GSP Group at the discretion of the respective GSP Group, and such appointments are effective upon providing written notice to the Secretary and to each Group Contact. The Coordination Committee recognizes each GSP Group Representative and GSP Group Alternate Representative until the Group Contact provides written notice of removal and replacement to the Secretary and to every other Group Contact. Each GSP Group or GSP Subgroup is required to promptly fill any vacancy created by the removal of its Representative or Alternate Representative so that each GSP Group has the number of validly designated representatives.

Each GSP Group Representative is entitled to one vote at the Coordination Committee, where the Alternate Representative is authorized to vote in the absence of the GSP Group Representative. The unanimous vote of the GSP Representatives from all GSP Groups and vote of a majority of a quorum is required on all items upon which the Coordination Committee is authorized to act. Voting procedures to address a lack of unanimity take place upon a majority vote of a quorum of the Coordination Committee and include: straw polls, provisional voting, and delay of voting (see Section 5.6.3 – *Voting Procedures to Address Lack of Unanimity* of the Coordination Agreement). Where the law or the Coordination Agreement require separate written approval by each of the Parties, such approval is evidenced in writing by providing the resolution, Motion, or Minutes of their respective Board of Directors to the Secretary of the Coordination Committee. Minutes of the Coordinate Committee are kept and prepared by the Secretary's appointee and maintained by the Secretary as Coordination Agreement records and are available to the Parties and the public upon request. Meeting agenda and minutes are posted on the Delta-Mendota website (www.deltamendota.org).

The Coordination Committee may appoint subcommittees, workgroups, and otherwise direct staff made available by the Parties. Subcommittees or workgroups may include qualified individuals possessing the knowledge and expertise to advance the goals of the Coordination Agreement on the topics being addressed by the subcommittee, whether or not such individuals are GSP Group Representatives or Alternate Representatives. Tasks assigned to subcommittees, workgroups, or staff made available by the Parties may include developing technical data, supporting information, and/or recommendations on specialized matters to the Coordination Committee. One GSP Group Representative or Alternate Representative is required to vote on behalf of the GSP Group at the subcommittee level. If no GSP Group Representative or Alternate Representative is present, one individual working on a subcommittee on behalf of the Parties in a GSP Group votes on behalf of the GSP Group. Subcommittees report voting results and provide information to the Coordination Committee but are not entitled to make determinations or decisions that are binding on the Parties.

The Coordination Committee is authorized to act upon the following items:

1. The Coordination Committee reviews, and consistent with the requirements of SGMA, approves the Technical Memoranda that compose the Common Chapter (see *Coordinated Data and Methodology*);
2. The Coordination Committee is responsible for ongoing review and updating of the Technical Memoranda as needed; assuring submittal of annual reports; providing five-year assessments and recommending any needed revisions to the Coordination Agreement; and providing review and assistance with coordinated projects and programs, once the GSPs have been submitted to and approved by DWR;
3. The Coordination Committee reviews and approves work plans, and in accordance with the budgetary requirements of the respective Parties, approves annual estimated of Coordinated Plan Expenses presented by the Secretary and any updates to such estimates provided that such estimates or updates with supporting documentation are circulated to all Parties for comment at least thirty (30) days in advance of the meeting at which the Coordination Committee will consider approval of the annual estimate;
4. The Coordination Committee is authorized to approve changes to Exhibit "A" (Groundwater Sustainability Plan Groups including Participation Percentages) to the Agreement and to recommend amendments to terms of the Agreement;
5. The Coordination Committee may assign work to subcommittees and workgroups as needed, provide guidance and feedback and ensure that subcommittees and workgroups prepare work products in a timely manner;
6. The Coordination Committee directs the Plan Manager in the performance of its duties under SGMA; and
7. The Coordination Committee provides direction to its Officers concerning other administrative and ministerial issues necessary for the fulfillment of the above-enumerated tasks.

Additional information regarding the roles, responsibilities, and duties of the Coordination Committee can be found in Section 5 – *Responsibilities for Key Functions* of the Coordination Agreement.

Exchange of Information

Timely exchange of information is a critical aspect of GSP coordination. All parties to the Coordination Agreement have agreed to exchange public and non-privileged information through collaboration and/or informal requests made at the Coordination Committee level or through subcommittees designated by the Coordination Committee. To the extent it is necessary to make a written request for information to another Party, each Party designates a representative to respond to information requests and provides the name and contact information of the designee to the Coordination Committee. Requests may be communicated in writing and transmitted in person or by mail, facsimile machine, or other electronic means to the appropriate representative as named in the Coordination Agreement. The designated representative is required to respond in a reasonably timely manner. Nothing in the Agreement shall be construed to prohibit any Party from voluntarily exchanging information with any other Party by any other mechanism separate from the Coordination Committee.

The Parties agree that each GSP Group shall provide the data required to develop the Subbasin-wide coordinated water budget but, unless required by law, will not be required to provide individual well or parcel-level information in order to preserve confidentiality of individuals to the extent authorized by law, including but not limited to Water Code Section 10730.8, subdivision (b). To the extent that a court order, subpoena, or the California Public Records Act is applicable to a party, the Party in responding to a request made pursuant to that Act for release of information exchanged from another Party shall notify each other Party in writing of its proposed release of information in order to provide the other Parties with the opportunity to seek a court order preventing such release of information.

Dispute Resolution

Procedures for conflict resolution have been established within the Coordination Agreement. In the event that a dispute arises among Parties as it relates to the Coordination Agreement, the disputing Party or Parties are to provide written notice of the basis of the dispute to the other Parties within thirty (30) calendar days of the discovery of the events giving rise to the dispute. Within thirty (30) days after such written notice, all interested Parties are to meet and confer in good faith to informally resolve the dispute. All disputes that are not resolved informally shall be settled by arbitration. In such an event, within ten (10) days following the failed informal proceedings, each interested Party is to nominate and circulate to all other interested Parties the name of one arbitrator. Within ten (10) days following the nominations, the interested Parties are to rank their top three among all nominated arbitrators, awarding three points to the top choice, two points to the second choice, and one point to the third choice and zero points to all others. Each interested Party will then forward its tally to the Secretary, who tabulates the points and notifies the interested Parties of the arbitrator with the highest cumulative score, who shall be the selected arbitrator. The Secretary may also develop procedures for approval by the Parties for selection of an arbitrator in the case of tie votes or in order to replace the selected arbitrator in the event such arbitrator declines to act. The arbitration is be administered in accordance with the procedures set forth in the California Code of Civil Procedure, Section 1280, *et seq.*, and of any state or local rules then in effect for arbitration pursuant to said section. Upon completion of arbitration, if the controversy has not been resolved, any Party may exercise all rights to bring legal action relating to the controversy.

Coordinated Data and Methodology

Pursuant to SGMA, the Coordination Agreement ensures that the individual GSPs utilize the same data and methodologies for developing assumptions used to determine: 1) groundwater elevation; 2) groundwater extraction data; 3) surface water supply; 4) total water use; 5) changes in groundwater storage; 6) water budgets; and 7) sustainable yield. The Parties have agreed to develop agreed-upon methodologies and assumptions for the aforementioned items prior to or concurrent with the individual development of GSPs. This development is facilitated through the Coordination Committee's delegation to a subcommittee or workgroup of the technical staff provided by some or all of the Parties. The basis upon which the methodologies and assumptions have been developed includes existing data/information, best management practices, and/or best modeled or projected data available and may include consultation with DWR as appropriate.

The data and methodologies for assumptions described in Water Code Section 10727.6 and Title 23, California Code of Regulations, Section 357.4 to prepare coordinated plans are set forth in Technical Memoranda prepared by the Coordination Committee for each of the following elements: Monitoring Network, Coordinated Water Budget, Coordinated Data Management System, and Adoption and Use of the Coordination Agreement. The Technical Memoranda have been subject to the unanimous approval of the Coordination Committee and once approved, have been attached to and incorporated by reference into the Coordination Agreement without formal amendment of the Coordination Agreement being required. The Parties have agreed that they will not submit this Coordination Agreement to DWR until the Technical Memoranda described herein have been added to the Coordination Agreement. The Technical Memoranda created pursuant to this Agreement are to be utilized by the Parties during the development and implementation of their individual GSPs in order to assure coordination of the GSPs is in compliance with SGMA. The Technical Memoranda have been included as an appendix to this GSP as a part of the Common Chapter (Appendix B).

Plan Implementation and Submittal

Under the Coordination Agreement, the Parties have agreed to submit their respective GSPs to DWR through the Coordination Committee and Plan Manager, in accordance with all applicable requirements. Subject to the subsequent attachment of the Technical Memoranda as appendices to the Common Chapter, the Parties intend that the described Coordination Agreement fulfill the requirements of providing an explanation of how the GSPs implemented together satisfy the requirements of SGMA for the entire Subbasin. The Coordination Agreement does not otherwise affect each Party's responsibility to implement the terms of its respective GSP in accordance with SGMA. Rather, this Coordination Agreement is the mechanism through which the Parties will coordinate their respective GSPs to the extent necessary to ensure that such GSP coordination complies with SGMA.

Each Party is responsible for ensuring that its own GSP complies with the statutory requirements of SGMA, including but not limited to the filing deadline. The Parties to this Coordination Agreement intend that their individual GSPs be coordinated together in order to satisfy the requirements of SGMA and to be in substantial compliance with the California Code of Regulations. The collective GSPs will satisfy the requirements of Water Code Sections 10727.2 and 10727.4 by providing a description of the physical setting and characteristics of the separate aquifer systems within the Subbasin, the measurable objectives for each such GSP, interim milestones, and monitoring protocols that together provide a detailed description of how the Subbasin as a whole will be sustainably managed.

The Parties agree to submit their respective GSPs to DWR through the Coordination Committee and Plan Manager, in accordance with all applicable requirements. The Coordination Committee is responsible for assuring submittal of annual reports and providing five-year assessments recommending any needed revisions to the Coordination Agreement.

Coordinated Data Management System

The Delta-Mendota Subbasin GSAs have developed and will maintain a coordinated Data Management System that is capable of storing and reporting information relevant to the reporting requirements and/or implementation of the GSPs and monitoring network of the Subbasin.

The Parties have also developed and will maintain separate Data Management Systems. Each separate Data Management System developed for each GSP will store information related to implementation of each individual GSP, monitoring network data and monitoring sites requirements, and water budget data requirements. Each system will be capable of reporting all pertinent information to the Coordination Committee. After providing the Coordination Committee with data from the individual GSPs, the Coordination Committee will ensure the data are stored and managed in a coordinated manner throughout the Subbasin and reported to DWR on an annual basis.

Adjudicated Areas and Alternative Plans

There are no adjudicated areas within the Delta-Mendota Subbasin, and no Alternative Plans have been submitted by the local agencies within the Subbasin.

Legal Bindings of the Delta-Mendota Subbasin Coordination Agreement

The Coordination Agreement, as contained herein, is reflected in the same manner and form as in the other five Subbasin GSPs. All parties understand that the Delta-Mendota Subbasin Coordination Agreement is part of the GSPs for all participating all Subbasin GSAs and will be a primary mechanism by which the six Subbasin GSPs will be implemented in a coordinated fashion. Further, all parties to the Coordination Agreement understand that DWR will evaluate the agreement for compliance with the procedural and technical requirements of GSP Regulations § 357.4 (Coordination Agreement) to ensure that the agreement is binding on all parties and that provisions of the agreement are sufficient to address any disputes between or among parties to the agreement.

The Coordination Agreement will be reviewed as part of the five-year assessment and revised as necessary, dated, and signed by all parties.

3.3.3.2 Inter-basin Agreements

SLDMWA, on behalf of the Northern and Central Delta-Mendota Regions, executed an inter-basin data sharing agreement with Westlands Water District in April 2018. The purpose of the agreement is to establish a set of common assumptions on groundwater conditions on either side of the boundary between Westland Water District's service area and the Delta-Mendota Subbasin to be used for the development of GPSs in support of implementation of SGMA. In this agreement, SLDMWA and Westlands Water District agree to provide each other with recorded, measured, estimated, and/or simulated modeling data located within five (5) miles of the boundary between Westlands Water District and the Delta-Mendota Subbasin. A list of data types to be shared between those in agreement can be found in Appendix A *Coordination Agreements*.

Data provided under this agreement are understood to be shared with consultants, other stakeholders in the respective basins (Delta-Mendota Subbasin and Westside Subbasin), and that the information will be made public through the development of the respective Parties' (meaning SLDMWA and Westlands Water District) GSPs and the supporting documentation of the GSPs. Other than publishing information for those purposes, neither Party will disclose the other Party's information to any third party, except if the other Party determines, at its sole discretion, the disclosure is required by law. Each Party may review preliminary results before publishing the information.

3.3.4 Governance Structure

3.3.4.1 Northern & Central Delta-Mendota Region GSP Governance Structure

The Northern and Central Delta-Mendota Regions GSAs adopted and executed SGMA Services Activity Agreements between themselves and the San Luis & Delta-Mendota Water Authority on February 24, 2017 and February 15, 2017, respectively; in addition to MOAs by non-Authority members on April 4, 2017 and March 7, 2017, respectively. The Agreements have since been amended several times. Figure 3-11 shows the governance structure of the Northern & Central Delta-Mendota Region GSP. The individual GSAs within the Northern & Central Delta-Mendota Region GSP are participating in the Northern & Central Delta-Mendota Region GSP through either an Activity Agreement or a Memorandum of Agreement with SLDMWA. The Northern Delta-Mendota Management Committee and Central Delta-Mendota Management Committee were developed to represent the Northern and Central Delta-Mendota Regions on the Delta-Mendota Subbasin Coordination Committee with one voting member each.

3.3.4.2 Delta-Mendota Subbasin SGMA Governance Structure

The GSAs within the Delta-Mendota Subbasin have adopted and executed a Coordination Agreement on December 12, 2018 to comply with the SGMA requirement that multiple GSAs within a given subbasin must coordinate when developing and implementing their GSPs (see Inter-Agency Coordination subsection above for more information). Additionally, a Cost Share Agreement was signed and executed by the same parties on December 12, 2018. Figure 3-12 shows the SGMA governance structure within the Delta-Mendota Subbasin. In addition to the two members appointed to represent each the Northern & Central Delta-Mendota Region GSP and the San Joaquin River Exchange Contractors Water Authority (SJRECWA) GSP Region on the Delta-Mendota Subbasin Coordination Committee as voting members, the Grassland Water District GSP Region, Farmers Water District GSP Region, Fresno County Management Areas A & B GSP Region, and Aliso Water District GSP Region all have appointed one voting member each for a total of eight voting members.

Two working groups were formed under the auspices of the Delta-Mendota Subbasin Coordination Committee: the Technical Working Group and the Communications Working Group. Representatives of each GSP region participate on each working group.

<u>Plan Manager Contact Information</u>

The initial Plan Manager for the Northern & Central Delta-Mendota Region GSP is Seth Harris, Water Resources Coordinator for SLDMWA. The ultimate plan manager for the Northern & Central Delta-Mendota Region GSP has yet to be determined but will be a representative from the SLDMWA. In the meantime, Mr. Harris can be contacted at:

Seth Harris
Initial Plan Manager and SGMA Coordinator for Northern & Central Delta-Mendota Region GSP
842 6th Street
Los Banos, CA 93635
Phone: (209)-324-1033 / Fax (209)-833-1034
sethharris@sldmwa.org

Additionally, contact information is provided for all members and alternative members for the Northern Delta-Mendota Region Management Committee and Central Delta-Mendota Region Management Committee in Table 3-2 and Table 3-3, respectively.

Table 3-1. Delta-Mendota Subbasin Coordination Committee Members

GSP		GSA	Agency	Coordination Committee Members	
				Primary	Alternate
Northern & Central Delta-Mendota Region GSP	Northern Delta Mendota Region Management Committee	Patterson Irrigation District GSA	Patterson Irrigation District	Vince Lucchesi	Walt Ward
			Twin Oaks Irrigation District		
		West Stanislaus Irrigation District GSA	West Stanislaus Irrigation District		
		DM-II GSA	Del Puerto Water District		
			Oak Flat Water District		
		City of Patterson GSA	City of Patterson		
		Northwestern Delta-Mendota GSA	Merced County		
			Fresno County		
	Central Delta-Mendota Region Management Committee	Central Delta-Mendota GSA	San Luis Water District	Ben Fenters	Lacey Kiriakou
			Panoche Water District		
			Tranquillity Irrigation District		
			Fresno Slough Water District		
			Eagle Field Water District		
			Pacheco Water District		
			Santa Nella County Water District		
			Mercy Springs Water District		
			Merced County		

GSP	GSA	Agency	Coordination Committee Members	
			Primary	Alternate
		Fresno County		
	Widren Water District GSA	Widren Water District		
	Oro Loma Water District GSA	Oro Loma Water District		
San Joaquin River Exchange Contractors Water Authority GSP	San Joaquin River Exchange Contractors Water Authority GSA	Central California Irrigation District	Jarrett Martin, Chris White	Alejandro Paolini, John Wiersma
		Columbia Canal Company		
		Firebaugh Canal Water District		
		San Luis Canal Company		
	Turner Island Water District-2 GSA	Turner Island Water District		
	City of Mendota GSA	City of Mendota		
	City of Firebaugh GSA	City of Firebaugh		
	City of Los Banos GSA	City of Los Banos		
	City of Dos Palos GSA	City of Dos Palos		
	City of Gustine GSA	City of Gustine		
	City of Newman GSA	City of Newman		
	Madera County GSA	Madera County		
	Merced County Delta-Mendota GSA	Merced County		
Grassland GSP	Grassland GSA	Grassland Water District	Ric Ortega	Ken Swanson
		Grassland Resource Conservation District		

GSP	GSA	Agency	Coordination Committee Members	
			Primary	Alternate
	Merced County Delta-Mendota GSA	Merced County		
Farmers Water District GSP	Farmers Water District GSA	Farmers Water District	Jim Stilwell	Don Peracchi
Fresno County GSP	Fresno County - Management Area A	Fresno County	Buddy Mendes	Glenn Allen or Augustine Ramirez
	Fresno County - Management Area B	Fresno County		
Aliso Water District GSP	Aliso Water District GSA	Aliso Water District	Joe Hopkins	Board Secretary (Ross Franson)

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Table 3-2. Northern Delta-Mendota Region Management Committee Contact Information

GSA	Agency	Member	Member Phone Number	Member E-mail	Alternate Member	Alternate Member Phone Number	Alternate Member E-mail
Patterson Irrigation District GSA	Patterson Irrigation District Twin Oaks Irrigation District[1]	Vince Lucchesi	(209)-892-6233	vlucchesi@pattersonid.org	Steve Trinta	(209)-892-6233	
West Stanislaus Irrigation District GSA	West Stanislaus Irrigation District	Bobby Pierce (Chairperson)	(209)-894-3091	bobby.pierce@weststanislausid.org	Jeanne Zolezzi	(209)-472-7700	jzolezzi@herumcrabtree.com
DM-II GSA	Del Puerto Water District	Anthea Hansen	(209)-892-4470	ahansen@delpuertowd.org	Adam Scheuber	(209)-985-2186	ascheuber@delpuertowd.org
	Oak Flat Water District	John Beltran	(209)-837-4331	john@beltranfarms.com	Anthea Hansen	(209)-892-4470	ahansen@delpuertowd.org
City of Patterson GSA	City of Patterson	Maria Encinas	(209)-895-8061	mencinas@ci.patterson.ca.us	Fernando Ulloa	(209)-895-8073	fulloa@ci.patterson.ca.us
Northwestern Delta-Mendota GSA	Merced County	Lacey Kiriakou	(209)-385-7654	lkiriakou@countyofmerced.com	Steve Maxey	(209)-385-7654	smaxey@countyofmerced.com
	Stanislaus County	Walt Ward	(209)-535-6710	wward@envres.org	Jamie Eggers	(209)-525-6768	jaggers@envres.org

[1] Twin Oaks Irrigation District is not a member of the Northern Delta-Mendota Region Management Committee but is represented by Patterson Irrigation District through a Memorandum of Understanding (MOU) forming the Patterson Irrigation District GSA.

Table 3-3. Central Delta-Mendota Region Management Committee Contact Information

GSA	Agency	Member	Member Phone Number	Member E-mail	Alternate Member	Alternate Member Phone Number	Alternate Member E-mail
Central Delta-Mendota GSA	San Luis Water District	Mike Wood	(559)-269-6992	mwood@reagan.com	Ben Fenters	(209)-605-0435	bfenters@slwd.net
	Panoche Water District	Joe McGahan	(209)-364-6136	jmcgahan@summerseng.com	Micahel Linneman		-
	Tranquillity Water District	Jerry Silveira			Danny Wade	(559)-698-7225	danny@trqid.com
	Fresno Slough Water District	Matthew Hurley			Liz Reeves	(559)-698-7225	liz@trqid.com
	Eagle Field Water District	John Bennett			Randall Miles	(209)-364-6149	rhm@jfbri.com
	Pacheco Water District	Aaron Barcellos (Chairperson)	(209)-826-2636	aaron@abarag.com	Juan Cadena	(209)-364-6136	jcadena@panochewd.org
	Santa Nella County Water District	Amy Montgomery (Secretary)	(209)-826-0920	amontgomery@sncwd.com	Jeff Black		-
	Mercy Springs Water District	Brad Gleason	(209)-364-6136		Juan Cadena	(209)-364-6136	jcadena@panochewd.org
	Merced County	Lacey Kiriakou	(209)-385-7654	lkiriakou@countyofmerced.com	Steve Maxey	(209)-385-7654	smaxey@countyofmerced.com
	Fresno County	Augustine Ramirez	(559)-600-4234	auramirex@co.fresno.ca.us	Glenn Allen	(559)-600-9672	glallen@fresnocountyca.gov
Widren Water District GSA	Widren Water District	Damian Aragona	(209)-826-0342	damian@jpprop.org	Jean Sagouspe	(209)-826-0342	jean@jpprop.org
Oro Loma Water District GSA	Oro Loma Water District	Ryan Stager		rstager@olaughlinparis.com	Valerie Kincaid	(916)-559-5498	vkincaid@olaughlinparis.com

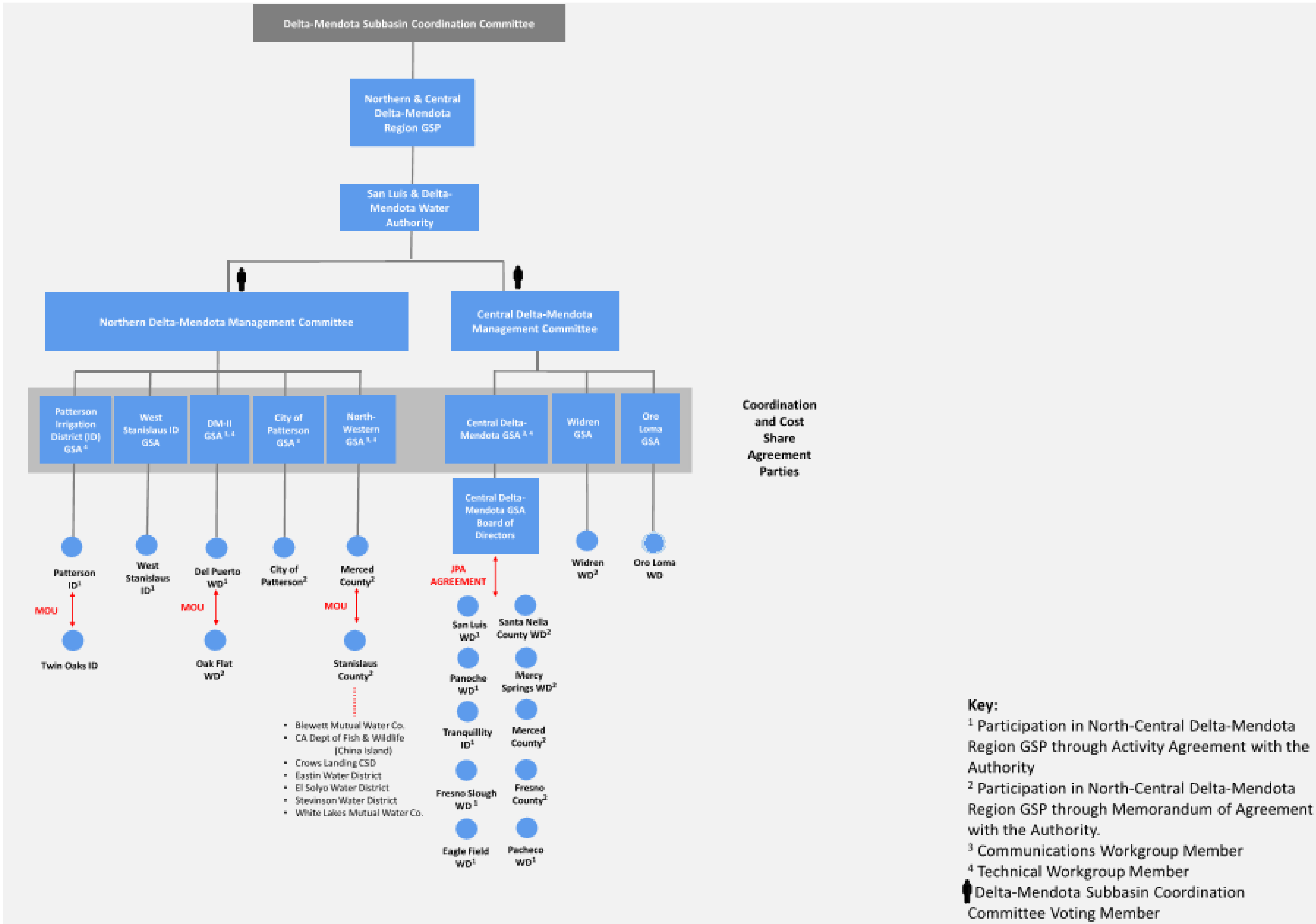

Figure 3-11. Governance Structure of the Northern & Central Delta-Mendota Region GSP

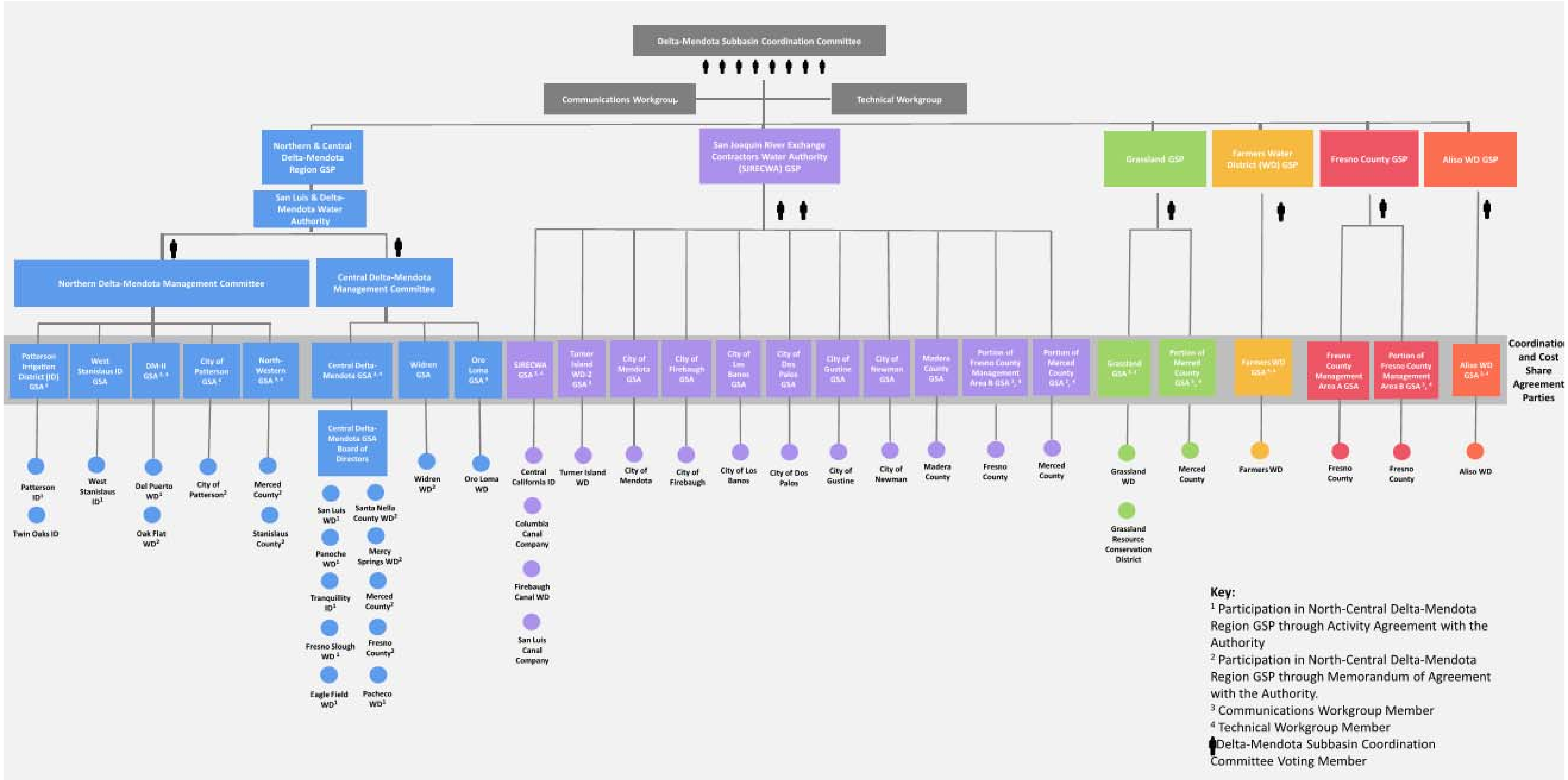

Figure 3-12. Governance Structure of the Delta-Mendota Subbasin

Section 4

Outreach & Communication

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4. OUTREACH AND COMMUNICATION

This section includes information pursuant to Article 5. Plan Contents, Subarticle 1. Administrative Information, §354.10 (Notice and Communication), as required by the Groundwater Sustainability Plan (GSP) Emergency Regulations. Details related to the Northern & Central Delta-Mendota Region GSP public noticing and outreach efforts during the GSP development process are included in this section. Documents used during these efforts are included in Appendices B and C. Northern & Central Delta-Mendota Region GSP outreach, as well as coordinated intra-basin and inter-basin outreach and communication efforts, are both described herein.

4.1 DESCRIPTION OF BENEFICIAL USES AND USERS IN PLAN AREA

As defined by California Water Code §13050(f), beneficial uses of the waters of the State include, but are not limited to, the following:

- Domestic, municipal, agricultural, and industrial supply;
- Power generation;
- Recreation;
- Aesthetic enjoyment;
- Navigation; and
- Preservation and enhancement of fish, wildlife, and other aquatic resources and preserves.

Sustainable Groundwater Management Act (SGMA) regulations require consideration of all beneficial uses and users of groundwater within the Subbasin during development of a GSP. As such, beneficial users in the Northern and Central Delta-Mendota Regions were identified for consideration in the Plan Area. This list of beneficial use categories and stakeholder groups, presented in Table 4-1, was used to identify stakeholders and invite both stakeholders and the public to engage and consult during GSP development. The beneficial uses and user stakeholder groups listed in Table 4-1 were identified according to the best available information at the time of GSP development. Efforts to further refine the list of beneficial uses and users stakeholder groups will be made prior to the first GSP update in 2025.

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Table 4-1. Beneficial Uses and User Stakeholder Groups

Beneficial Use	Stakeholder Groups	

General Public	• Urban water providers
	  o City of Modesto
	  o City of Patterson
	  o Grayson Community Services District
	  o Santa Nella County Water District
	  o Volta Community Services District
	  o Westley Community Services District
	  o Tranquillity Irrigation District
	• Domestic Well Owners
	  o There are many domestic wells overlying the Basin. Most of these well owners are *de minimis* users as defined by SGMA.
	• Federal and State Lands
	  o Agencies
	    ▪ U.S. Bureau of Reclamation
	    ▪ U.S. Bureau of Land Management
	    ▪ California Department of Water Resources
	    ▪ California State Water Resources Control Board
	  o Facilities
	    ▪ San Luis Reservoir
	    ▪ California Aqueduct
	    ▪ Delta-Mendota Canal
	    ▪ West Stanislaus Irrigation District Conveyance Facilities
	    ▪ Patterson Irrigation District Conveyance Facilities
		• Agricultural Users and Groups
		  o Patterson Irrigation District
		  o Tranquillity Irrigation District
		  o Twin Oaks Irrigation District
		  o West Stanislaus Irrigation District
		  o Del Puerto Water District
		  o Eagle Field Water District
		  o Eastin Water District
		  o El Solyo Water District
		  o Whitelake Mutual Water Company
		  o Fresno Slough Water District
		  o Mercy Springs Water District
		  o Oak Flat Water District
		  o Oro Loma Water District
		  o Pacheco Water District
		  o Panoche Water District
		  o San Luis Water District
		  o Widren Water District
		  o Agricultural Council of California
		  o California Farm Bureau Federation
		  o California Farm Water Coalition
		• Counties
		  o Fresno County
		  o Merced County
		  o San Joaquin County
		  o San Benito County
		  o Stanislaus County; Stanislaus County Housing Authority
		• Industrial Supply
		  o Aggregate mining
		  o Food processing
		  o Manufacturing
		• Business Groups/Interests
		  o Self-Help Enterprises
		  o BizFed
		• Tribes (None known)

Power Generation	• Power Plants
	  o Almond 2 Power Plant
	  o Malaga Power Plant
	  o Midway Peaking Project
	  o Panoche Energy Center
	  o Walnut Energy Center
		• Hydropower
		  o O'Neil
		  o San Luis Bypass
		  o Wolfsen Bypass

Recreation	• Agencies
	  o Army Corp of Engineers
	  o California Department of Parks and Recreation
		• Recreation Areas
		  o San Luis Reservoir Recreation Area
		  o Los Banos Creek State Recreation Area

Aesthetic Enjoyment	• *See* Recreation and Preservation *sections*	
Navigation	• San Joaquin River	

Preservation and enhancement of fish, wildlife, and other aquatic resources and preserves	• Agencies
	  o U.S. Department of Fish and Wildlife
	  o California Department of Fish and Wildlife
	  o California Department of Parks and Recreation
	  o California State Water Resources Control Board
	• Environmental Groups
	  o The Nature Conservancy
	  o The Audubon Society
		• Ecosystem Uses
		  o Creeks
		    ▪ Crow Creek
		    ▪ Del Puerto Creek
		    ▪ Ingram Creek
		    ▪ Hospital Creek
		    ▪ Garzas Creek
		    ▪ Little Panoche Creek
		    ▪ Los Banos Creek
		    ▪ Orestimba Creek
		    ▪ Panoche Creek
		    ▪ Quinto Creek
		    ▪ Salado Creek
		    ▪ Little Salado Creek
		    ▪ Salt Creek
		  o Rivers
		    ▪ San Joaquin River
		    ▪ Kings River
		    ▪ Fresno Slough
		  o Refuges
		    ▪ San Joaquin River National Wildlife Refuge
		    ▪ San Luis National Wildlife Refuge
		  o Groundwater Dependent Ecosystems

4.2 PLAN DEVELOPMENT

4.2.1 Decision-making Process

As one of six GSPs being prepared for the Delta-Mendota Subbasin, the Northern & Central Delta-Mendota Region GSP development required decision making at both the GSP- and subbasin-level. Decisions relating to critical GSP components, such as water balance methodology, sustainability indicators, and groundwater dependent ecosystem (GDE) identification and impacts were coordinated through a multi-step process before being finalized first at the GSP-level and then at the subbasin-level. This process is outlined below where differences in the GSP and Subbasin decision-making processes are identified as necessary:

1. The project team develops the initial recommendation
2. The initial recommendation is presented to the Groundwater Sustainability Agencies (GSAs) via the Northern and Central Delta-Mendota Technical Advisory Committee and Northern and Central Delta-Mendota Regional Management Committees at the GSP-level, and to the Delta-Mendota Subbasin Communication and Technical Working Groups and Delta-Mendota Subbasin Coordination Committee at the subbasin-level
3. Feedback from the Northern and Central Delta-Mendota Technical Advisory Committee and Northern and Central Delta-Mendota Regional Management Committees at the GSP-level, and Delta-Mendota Subbasin Working Groups and Delta-Mendota Subbasin Coordination Committee at the subbasin-level are incorporated into the recommendation
4. Step 2 and 3 are repeated as needed
5. The agreed-upon recommendation is presented at a public workshop
6. Feedback from stakeholders is incorporated into the recommendation as appropriate
7. The recommendation is documented in the appropriate GSP section and Subbasin Common Chapter
8. Completed GSP or Common Chapter sections are circulated to the GSAs in the Plan Area or Delta-Mendota Subbasin GSP Working Groups and Coordination Committee for comment
9. Comments on the recommended approach/section are incorporated into the appropriate document(s)
10. The GSP or Common Chapter section is posted online for public review and comment
11. Public comments are collected and documented

As detailed above, the decision-making process includes multiple points for both internal (GSA members) and external (public) stakeholders to contribute to the GSP development. Participation in this process was encouraged through stakeholder outreach, communications, and public workshops conducted throughout GSP development.

4.2.2 Comments Received Regarding the Plan

During the GSP development phase, the Northern & Central Delta-Mendota Region GSP Group posted draft chapters of its Plan to its website (website information provided in Section 4.3.4) for 30 days to allow for public review and comment. Upon the release of each chapter, notice was provided to the stakeholder list and an announcement was placed on the GSP website. Comments received on the Public Draft GSP chapters have been compiled and are included in Appendix C of this GSP.

4.3 OUTREACH

4.3.1 Noticing

In accordance with GSP Emergency Regulations §357.2(a), the Northern & Central Delta-Mendota Region GSP Group submitted notice to the California Department of Water Resources (DWR) stating the intent to develop a GSP. This notice was submitted to DWR on January 5, 2018, a copy of which is included in Appendix G.

Following the initial notice submitted to DWR, the Northern & Central Delta-Mendota Region GSP Group has provided public notices related to major project junctions and milestones. The methods used to circulate these notices are detailed further in Section 4.3.4 and additional details regarding the stakeholder distribution list is included in the next section.

Finally, upon completion of the GSP, notice was provided to the counties and cities within the Northern and Central Delta-Mendota Regions regarding Plan adoption. This notice was distributed on September 9, 2019, a copy of which is included in Appendix G.

4.3.1.1 GSP Stakeholder List

At the project outset, stakeholder interest was solicited and a contact list was developed to facilitate distribution of project information and notices. The initial stakeholder list included, but was not limited to, representatives from the following groups:

- Public agencies in the Northern and Central Delta-Mendota Regions, other GSAs in the Delta-Mendota Subbasin and adjoining subbasins, including state agencies such as the California Department of Fish and Wildlife
- Farm bureaus and agricultural groups in the Northern and Central Delta-Mendota Regions, in other GSP Regions of the Delta-Mendota Subbasin and adjoining subbasins
- Non-governmental organizations (NGOs) representing environmental interests such as The Audubon Society and The Nature Conservancy
- Private companies and citizens with prior engagement in related planning projects (such as the Integrated Regional Water Management Planning [IRWMP] process)

This stakeholder list was updated throughout the project lifecycle, with new interested parties signing up at public meetings, via email, or through the GSP website. The final stakeholder contact list includes over 500 parties and is included in Appendix C.

4.3.2 Opportunities for Public Engagement

Throughout the GSP development process, stakeholders, and the public were encouraged to engage with the GSP development team. Through use of the stakeholder list and other noticing strategies (detailed in Section 4.3.4), the Northern & Central Delta-Mendota Region GSP Group invited interested parties to join in deliberation, dialogue, and discussions related to the development of the GSP. The primary opportunity for engagement with the GSP team came during the subbasin-wide public workshops, but additional targeted meetings and events were held as well as direct communications via website-based communications links, email and letters. Public input gathered during the engagement events was documented for consideration during GSP development, with formal comments presented in Error! Reference source not found.. The following sections describe the opportunities for public engagement.

4.3.2.1 Public Workshops

The Northern & Central Delta-Mendota Region GSP Group, in coordination with the other five (5) GSP groups in the Delta-Mendota Subbasin, organized and participated in a series of four sets of public workshops throughout the GSP development process. The sets of public workshops were held approximately once a quarter from the initial GSP development kickoff (May 2018) to final content development (May 2019) and were held at multiple locations around the Subbasin (typically with workshops held in the northern, central, and southern portions of the Subbasin). Recognizing the potential limits of the public's schedule, a minimum of three meetings per workshop set (e.g. three meetings were held in the May 2018 set) were organized to provide multiple opportunities for stakeholder engagement. A summary of the topics, dates, and locations of the sets of public workshops is included in Table 4-2. Methods used to notify the public of the workshops are discussed in Section 4.3.4 and presentation materials and meeting sign in sheets from the public meetings are included in Appendices B and C.

Table 4-2. Delta-Mendota Subbasin Public Workshops

Meeting Date		Meeting Location	Topics
Spring 2018	May 14	Los Banos: *San Luis & Delta-Mendota Water Authority Office*	SGMA overview, Opportunities to get involved and engage with the project team
	May 16	Patterson: *Hammon Senior Center*	
	May 17	Mendota: *Mendota Branch Library*	
Fall 2018	October 22	Firebaugh: *Firebaugh Middle School Multi-Purpose Room*	Data Collection, HCM, Groundwater Models
	October 24	Los Banos: *College Greens Building*	
	October 25	Patterson: *Hammon Senior Center*	
Winter 2019	February 19	Los Banos: *College Greens Building*	Current and Future Water Budgets, Sustainability Criteria, Projects and Management Action
	February 20	Patterson: *Patterson City Hall*	
Spring 2019	May 20	Patterson: *Patterson City Hall*	Projected Water Budget, Sustainable Yield, Monitoring Network, Projects and Management Actions
	May 21	Los Banos: *College Greens Building*	
	May 22	Santa Nella: Romero Elementary School Multi-Purpose Room	
	May 23	Mendota: *Mendota Branch Library*	

4.3.2.2 Special Environmental Considerations

Given the scope of the GSP and the requirements to consider all users of groundwater (including local ecosystems), the Northern & Central Delta-Mendota Region GSP Group, along with other GSP Groups in the Delta-Mendota Subbasin, sought consultation with NGOs representing environmental interests and natural resources-focused state agencies early in the GSP development process. As discussed in Section 4.3.1.1, representatives from organizations representing environmental interests and state agencies were included on the initial stakeholder list and received all project updates and notices, as well as invitations to attend and participate at the public workshops and regularly scheduled committee and workgroup meetings. In addition, representatives from environmental NGOs (from the Audubon Society and The Nature Conservancy) and state agencies (from the California Department of Fish and Wildlife) were invited to participate at GSP development meetings and special workshops.

In addition to the public workshops listed in **Section 4.3.2.1**, two special workshops were held with The Nature Conservancy to review groundwater dependent ecosystem identification and coverage and sustainable management criteria in the GSP. The first workshop (August 24, 2018) was held in conjunction with all GSP groups in the Delta-Mendota Subbasin, while the second meeting (April 29, 2019) was planned and held by the Northern & Central Delta-Mendota Region GSP Group for more targeted discussions. Materials from those special workshops are included in **Appendix C**.

4.3.2.3 Other Opportunities for Public Engagement

In addition to the public workshops described previously, individual GSAs in the Northern & Central Delta-Mendota Region GSP Group planned and held additional, targeted public engagement activities for their communities and stakeholders. Engagement activities conducted by the Northern and Central Delta-Mendota Regions' GSAs started shortly after SGMA legislation was passed. The following is a list of the types of other outreach efforts undertaken by the Northern and Central Delta-Mendota Regions GSAs:

- Presentations and discussions at local club meetings
- Presentations and discussions at local public agency events including, but not limited to, Board of Directors, City Council, Landowner, Grower, and Town Hall meetings
- Local SGMA workshops
- Combined outreach with IRWM outreach efforts
- Requests received via the dmsgma@sldmwa.org email address by interested parties to be added to meeting distribution lists, where interested parties who were not able to attend meetings in person were able to attend and participate via teleconference

In total, the Northern and Central Delta-Mendota Regions' GSAs conducted over 200 additional outreach activities. A log of outreach activities conducted by the various GSA groups is included in **Appendix C**.

4.3.3 Outreach to Diverse Social, Cultural, and Economic Areas of the Population

The Northern and Central Delta-Mendota Regions include a diversity of community types, including many non-native non-English (predominantly Spanish) speakers and disadvantaged communities. In order to reach as much of the population as possible, the following best practices were implemented to increase project visibility and opportunities for engagement:

- All outreach materials (including meeting flyers, fact sheets, frequently asked questions [FAQs], and videos) were translated and made available in Spanish
- Spanish-speaking interpreters were available at public meetings
- Public meetings were held in disadvantaged communities to provide easier access to the GSP process
- Meetings were held both in the late afternoon and the evening to avoid conflicts with work schedules and provide the greatest flexibility for attendance

Further, the Northern & Central Delta-Mendota Region GSP Group coordinated with other community development and planning efforts in the region to reach a greater audience. These efforts include:

- Self-Help Enterprises (SHE), a local community development organization focused on working with low-income families and communities, helped the GSP Group reach a greater number of members of the disadvantaged communities identified within the Plan area.

- SGMA information and materials were incorporated into efforts related to the IRWM Disadvantaged Community Involvement Program (DACIP) and into applicable IRWM documents (including the East Stanislaus, Merced, and Westside-San Joaquin IRWM Regions)

4.3.4 Methods for Disseminating Information

The Northern & Central Delta-Mendota Region GSP Group utilized a variety of communication methods to inform the public and its stakeholders about progress in developing the GSP and information regarding opportunities to engage in the process. The primary methods of communication are discussed below.

4.3.4.1 Informational Documents

As part of the public outreach campaign, the Northern & Central Delta-Mendota Region GSP Group developed a series of informational flyers, brochures, FAQ sheets, and other handouts to educate the public about SGMA and the GSP development process. These documents were made available at public meetings and other events and posted on the GSP website. Copies of the informational documents are included in Appendix C.

4.3.4.2 Website

Following the submittal of the notice of the intent to develop a GSP, the Northern & Central Delta-Mendota GSP Group developed a website to serve as a primary means of posting and archiving GSP activities for public access and notice. The GSP website (http://deltamendota.org/learn-more/northern-central-delta-mendota-gsp/) was developed in conjunction with the website for the Delta-Mendota Subbasin as a whole (http://deltamendota.org/).

This website includes five key components. First, the website hosts a variety of SGMA informational material for stakeholders interested in learning more about SGMA and the GSP, including links to DWR informational websites as well as FAQs about the Delta-Mendota Subbasin, Northern and Central Delta-Mendota Regions, and GSAs. Second, the GSP website was used to post information about upcoming public workshops and to house materials from previous public events. Third, the website hosts monthly newsletters documenting progress on the GSP effort. Fourth, the website included a link to sign up for the stakeholder distribution list. Finally, the website was used to share agenda and meeting minutes from various committee meetings held during GSP development and to post public drafts of GSP chapters and to solicit feedback.

4.3.4.3 Email List

As discussed in Section 4.3.1.1, a stakeholder list was developed and updated throughout GSP development. The email list was used to provide announcements related to GSP events and actions, such as upcoming public workshops or the posting of new public draft GSP chapters for comment. The final stakeholder contact list is included in Appendix C.

4.3.4.4 Newsletters

Monthly newsletters were prepared to provide stakeholders with a brief update regarding recent GSP development actions and upcoming milestones. The newsletters were developed in collaboration with the five (5) other GSP groups in the Delta-Mendota Subbasin. The newsletters were posted to GSP group websites as well as sent via email to the stakeholder list.

4.3.4.5 Public Workshops

Public workshops served as the primary method for disseminating information and directly involving the public in the GSP development process. The four sets of public workshops (listed in Table 4-2) provided stakeholders with a chance to engage with the GSP project team and other stakeholders. Stakeholders were provided with an overview of SGMA and GSP milestones and the status of the GSP development while being given an opportunity to provide feedback on the work being presented.

4.3.4.6 Other Outreach Efforts

In addition to the use of the GSP website, emails, newsletters, and public workshops, the Northern and Central Delta-Mendota Regions' GSAs planned additional, targeted public information campaigns. The following is a list of the types of other outreach efforts undertaken by the Northern and Central Delta-Mendota Regions' GSAs:

- Inclusion of SGMA materials with IRWM outreach efforts
- GSA newsletter
- Flyer posting in public utility and government buildings
- Inclusion of flyers in utility bills
- Meetings with farmers in irrigation districts

A log of outreach activities conducted by the various GSAs is included in Appendix C.

Section 5

Basin Setting

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5. BASIN SETTING

5.1 OVERVIEW

The Basin Setting chapter to the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan (GSP) contains information about the physical setting and hydrogeologic characteristics of the Northern and Central Delta-Mendota Regions, as well as current condition of the basin and anticipated future conditions. The basin setting serves as a basis for defining and assessing reasonable sustainable management criteria and projects and management actions. This chapter includes four main sections that are pursuant to the GSP Emergency Regulations Article 5. Plan Contents, Subarticle 2. Basin Setting (§ 354.12 – 354.20):

- Hydrogeologic Conceptual Model (HCM) – The HCM section (Section 5.2) provides the geologic and hydrogeologic information needed to understand how water moves throughout the Plan area and the Delta-Mendota Subbasin. This section includes information about geological formations, aquifers, structural features, and topography.
- Groundwater Conditions – The Groundwater Conditions section (Section 5.3) describes historical groundwater conditions in the Plan area, including data from January 1, 2015 to recent conditions. Groundwater trends, groundwater levels, hydrographs, contour maps, estimated change in groundwater storage, groundwater quality issues, land subsidence, and interconnected surface water systems over historical conditions through present day are presented in this section.
- Water Budget – The Water Budget section (Section 5.4) describes the data used to develop the required historic water budget, current water budget, and projected water budgets. This section also discusses the methods used in developing estimates for each water budget scenario. Sustainable yield is also described in this section.
- Management Areas – The Management Area section (Section 5.5) describes the management areas established to facilitate implementation of the GSP and how setting different sustainable management criteria than the Plan area avoids undesirable results and aids in achieving sustainability in the Subbasin by 2040.

5.2 HYDROGEOLOGIC CONCEPTUAL MODEL

This section describes the hydrogeologic conceptual model (HCM) for the Delta-Mendota Subbasin primarily as a whole based on technical studies and qualified maps that characterize the physical components and interaction of the surface water and groundwater systems, pursuant to Article 5 Plan Contents, Subarticle 2 Basin Setting, § 354.14 Hydrogeologic Conceptual Model of the Groundwater Sustainability Plan (GSP) Emergency Regulations. The physical description of the Delta-Mendota Subbasin included in this section is based on information originally published in the *Western San Joaquin River Watershed Groundwater Quality Assessment Report* (GAR) (Luhdorff & Scalmanini, 2015), *Grassland Drainage Area Groundwater Quality Assessment Report* (Luhdorff & Scalmanini, 2016), and *Groundwater Overdraft in the Delta-Mendota Subbasin* (Schmidt, 2015).

The Northern and Central Delta-Mendota Regions generally include the northern quarter of the Subbasin, the western margin of the central portion of the Subbasin (including the larger portion of the Subbasin near the southwestern boundary and within San Benito County), and the southern tip of the Subbasin (in the Tranquillity area). Due to the disperse nature of the areas covered by this GSP, the HCM presented below has been prepared predominantly on a Subbasin level.

5.2.1 Regional Geologic and Structural Setting

The Delta-Mendota Subbasin is located in the northwestern portion of the San Joaquin Valley Groundwater Basin within the southern portion of the Central Valley (Figure 5-1). The San Joaquin Valley is a structural trough up to 200 miles long and 70 miles wide filled with up to 32,000 feet of marine and continental sediments deposited during periodic inundation by the Pacific Ocean and by erosion of the surrounding Sierra Nevada and Coast Range mountains, respectively (DWR, 2006). Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough. This depositional axis is slightly west of the series of rivers, lakes, sloughs, and marshes which mark the current and historic axis of surface drainage in the San Joaquin Valley.

The Delta-Mendota Subbasin (California Department of Water Resources [DWR] Basin No. 5-22.07) is bounded on the west by the tertiary and older marine sediments of the Coast Ranges, on the north generally by the San Joaquin-Stanislaus County line, on the east generally by the San Joaquin River and Fresno Slough, and on the south by the Tranquillity Irrigation District boundary near the community of San Joaquin. Surface waters culminate from the Fresno, Merced, Tuolumne, and Stanislaus Rivers into the San Joaquin River, which drains toward the Sacramento-San Joaquin Delta.

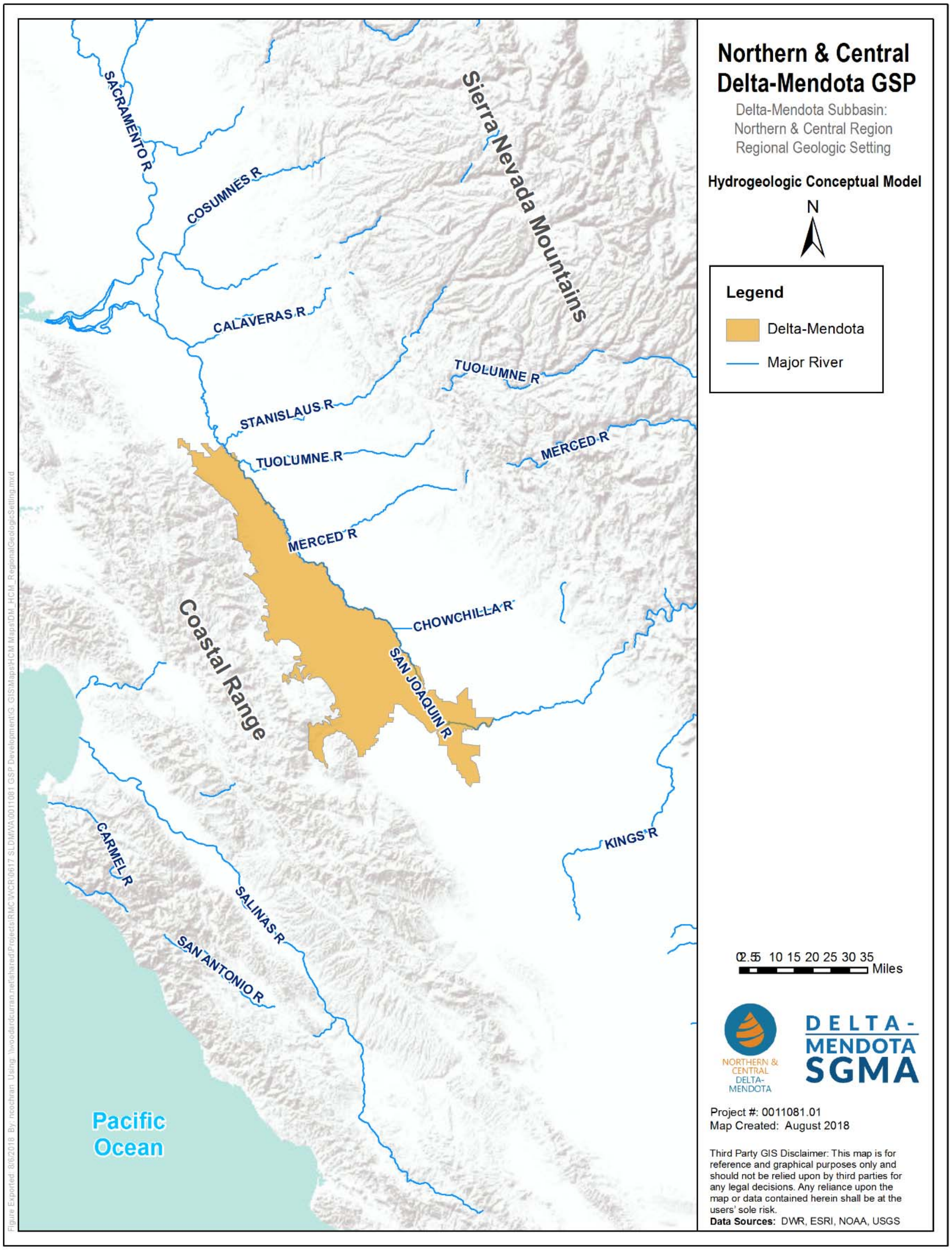

Figure 5-1. Regional Geologic Setting, Delta-Mendota Subbasin

5.2.2 Geologic History

Approximately three million years ago, tectonic movement of the Oceanic and Continental plates associated with the San Andreas Fault system gave rise to the Coast Range which sealed off the Central Valley from the Pacific Ocean (LSCE, 2015). As this occurred, the floor of the San Joaquin Valley began to transition from a marine depositional environment to a freshwater system with ancestral rivers bringing alluvium to saltwater bodies (Mendenhall et al., 1916). The Coast Ranges on the western side of the San Joaquin Valley consist mostly of complexly folded and faulted consolidated marine and non-marine sedimentary and crystalline rocks ranging from Jurassic to Tertiary age (Figure 5-2), dipping eastward and overlying the basement complex in the region (Croft, 1972; Hotchkiss and Balding, 1971). The Central Valley Floor within the Delta-Mendota Subbasin consists of Tertiary and Quaternary-aged alluvial and basin fill deposits (Figure 5-2 and Figure 5-3). The fill deposits mapped throughout much of the valley extend vertically for thousands of feet, and the texture of sediments varies in the east-west direction across the valley. Coalescing alluvial fans have formed along the sides of the valley created by the continuous shifting of distributary stream channels over time. This process has led to the development of thick fans of generally coarse texture along the margins of the valley and a generally fining texture towards the axis of the valley (Faunt et al., 2009 and 2010).

Deposits of Coast Range and Sierra Nevada sources interfinger within the Delta-Mendota Subbasin. Steeper fan surfaces, with slopes as high as 80 feet per mile, exist proximal to the Coast Range, whereas more distal fan surfaces consist of more gentle slopes of 20 feet per mile (Hotchkiss and Balding, 1971). In contrast to the east side of the valley, the more irregular and ephemeral streams on the western side of the valley floor have less energy and transport smaller volumes of sediment resulting in less developed alluvial features, including alluvial fans, which are less extensive, although steeper, than alluvial fan features on the east side of the valley (Bertoldi et al., 1991). Lacustrine and floodplain deposits also exist closer to the valley axis as thick silt and clay layers. Lakes present during the Pleistocene epoch in parts of the San Joaquin Valley deposited great thicknesses of clay sediments.

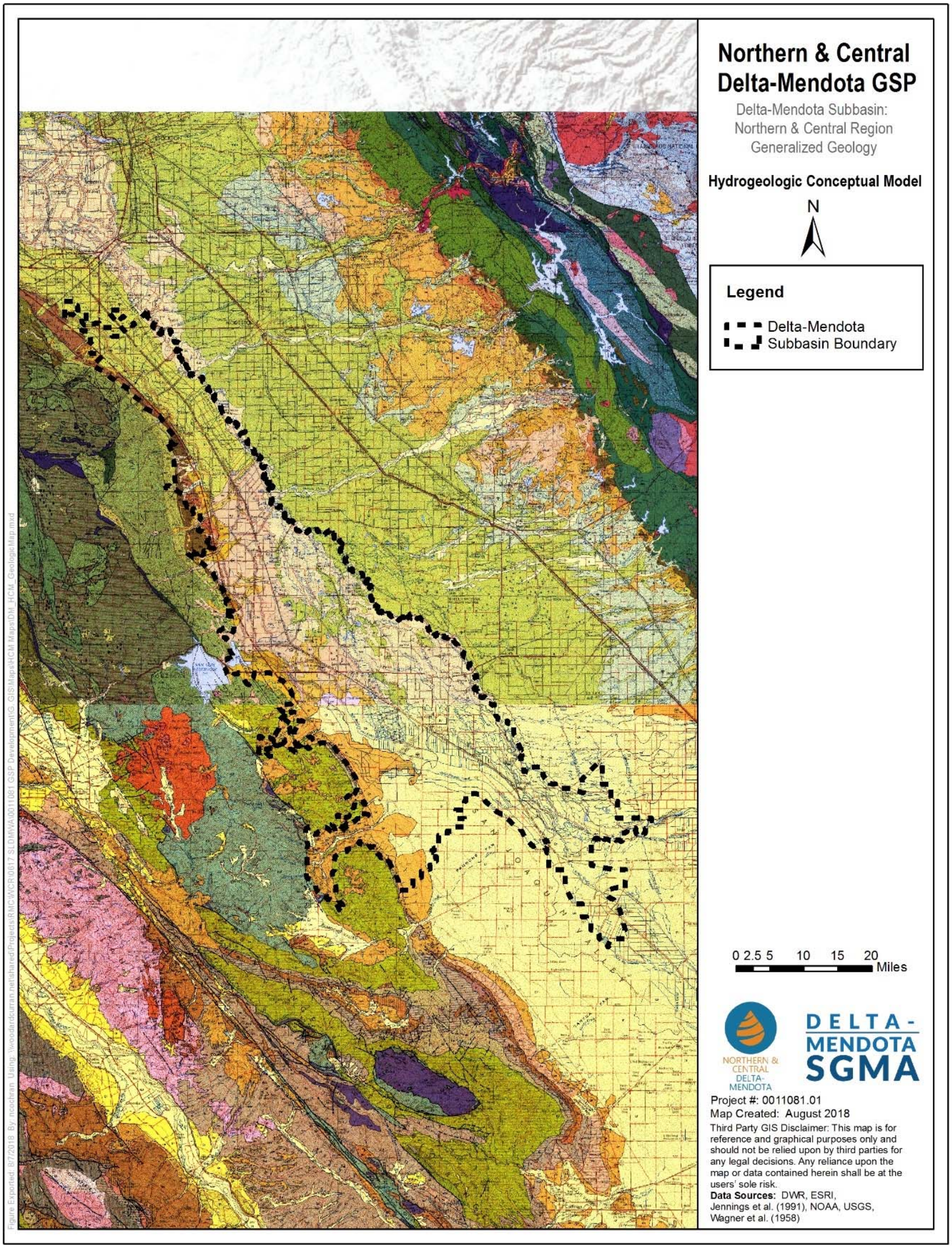

Figure 5-2. Geologic Map, Delta-Mendota Subbasin

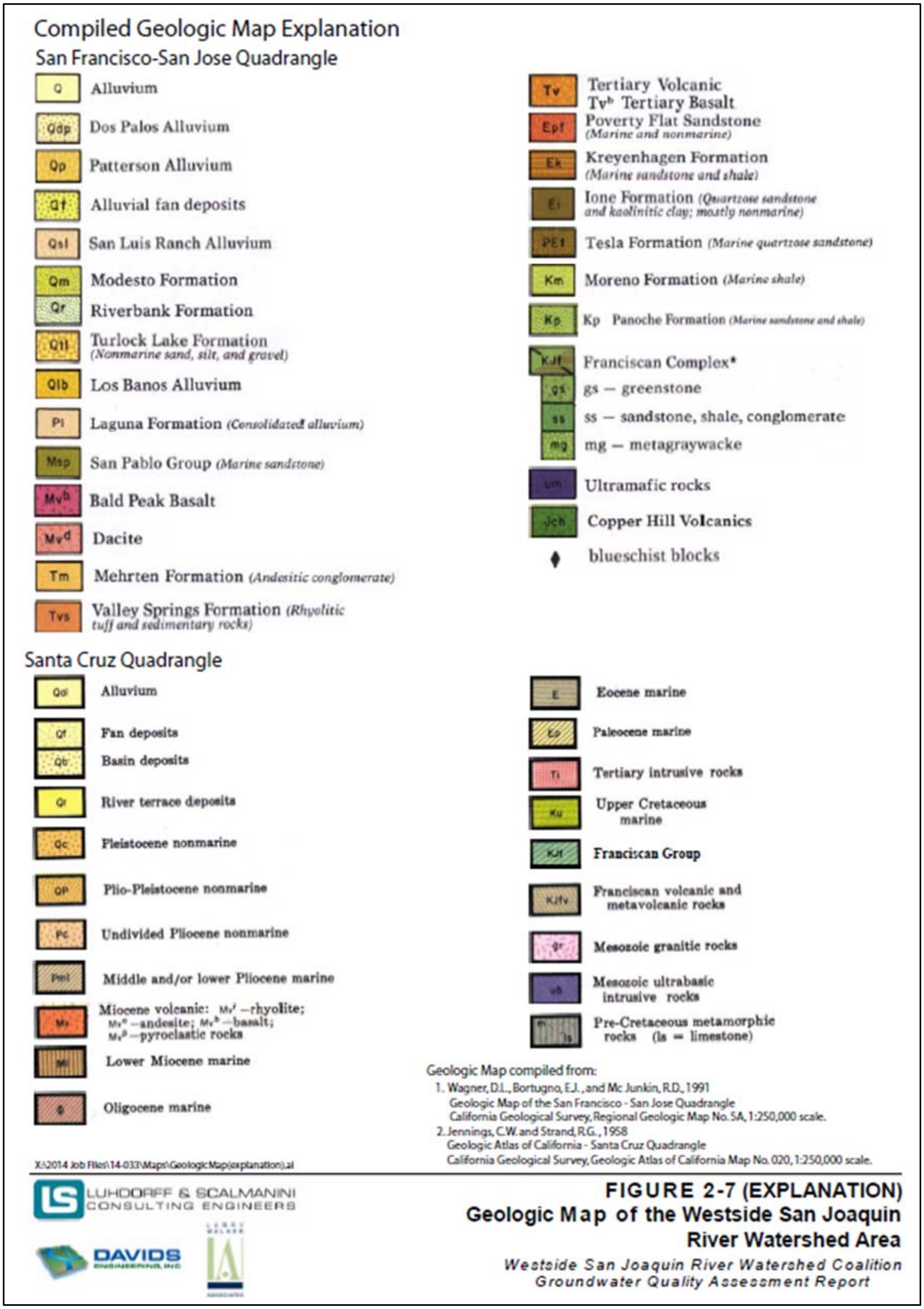

Figure 5-2. Geologic Map, Delta-Mendota Subbasin (continued)

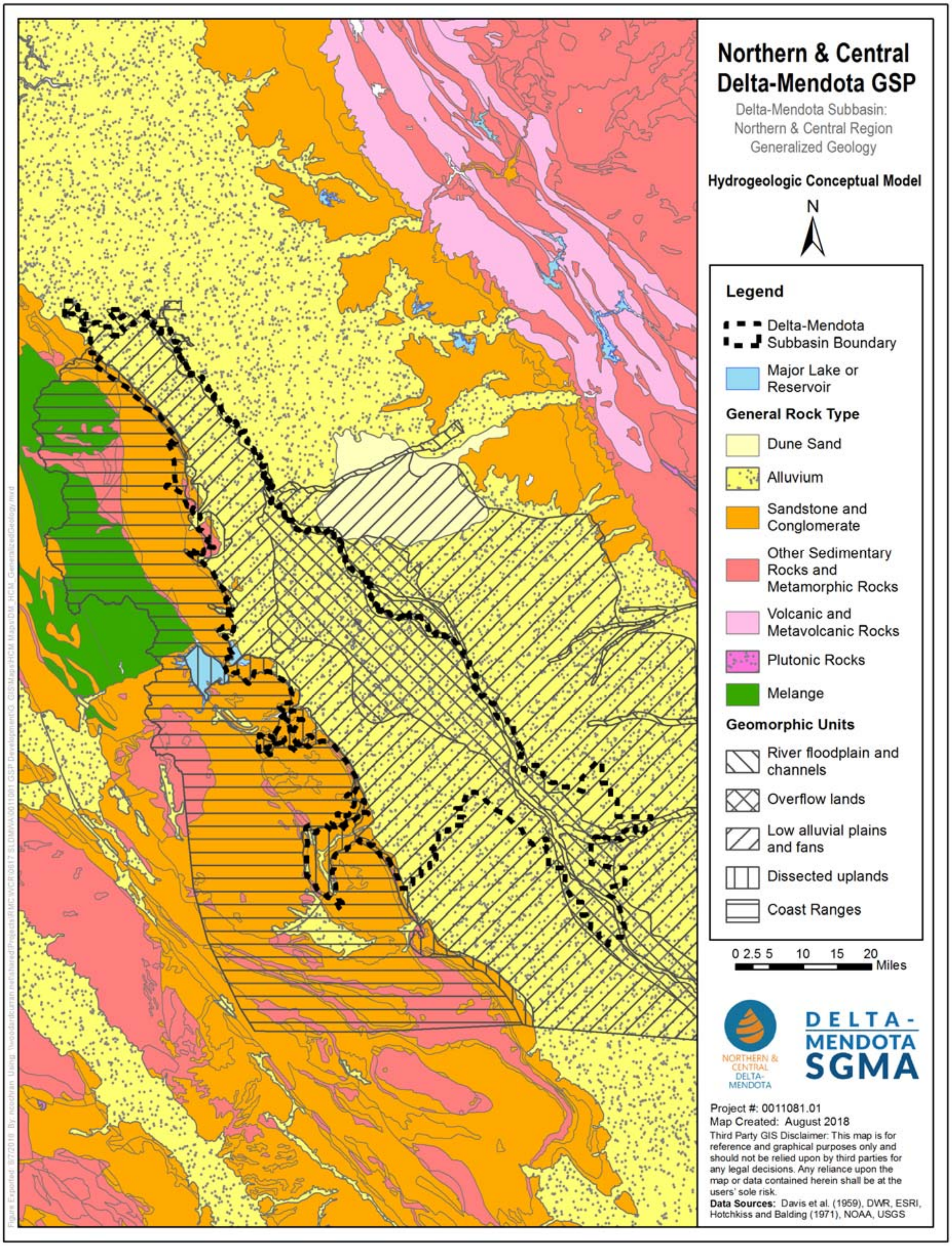

Figure 5-3. Generalized Geology, Delta-Mendota Subbasin

5.2.3 Geologic Formations and Stratigraphy

Distinct geomorphic units exist within the Delta-Mendota Subbasin, defining areas of unique hydrogeologic environments. The geomorphic units are mapped and described by Hotchkiss and Balding (1971) and Davis et al. (1959) and are shown in Figure 5-3. The two primary geomorphic units within the Central Valley Floor area of the Delta-Mendota Subbasin include the overflow lands geomorphic unit and the alluvial fans and plains geomorphic unit. Overflow lands are defined as areas of relatively poorly draining soils with a shallow water table. The overflow lands geomorphic unit is located in the southeastern portion of the Subbasin and is dominated by finer-grained floodplain deposits that are the result of historical episodic flooding of this low-land area. This has formed poorly draining soils with generally low hydraulic conductivity characteristics. In contrast, the alluvial fans and plains geomorphic unit is characterized by relatively better drainage conditions, with sediments comprised of coalescing and somewhat coarser-grained alluvial fan materials deposited by higher-energy streams flowing out of the Coast Range (Hotchkiss and Balding, 1971). The alluvial fans and plains geomorphic unit covers much of the Delta-Mendota Subbasin along the western margins of the Central Valley Floor at the base of the Coast Range.

The primary groundwater bearing units within the Delta-Mendota Subbasin consist of Tertiary and Quaternary-aged unconsolidated continental deposits and older alluvium of the Tulare Formation. Subsurface hydrogeologic materials covering the Central Valley Floor consist of lenticular and generally poorly sorted clay, silt, sand, and gravel that make up the alluvium and Tulare Formation. These deposits are thickest along the axis of the valley with thinning along the margins towards the Coast Range mountains (DWR, 2003; Hotchkiss and Balding, 1971). A zone of very shallow groundwater, generally within 25 feet of the ground surface, exists throughout large areas of the Subbasin, with considerable amounts (greater than 50 percent) of farmland in the area estimated to have very shallow depths to groundwater of less than 10 feet (Hotchkiss and Balding, 1971). Many of these areas are naturally swampy lands adjacent to the San Joaquin River.

The Tulare Formation extends to several thousand feet deep and to the base of freshwater throughout most of the area and consists of interfingered sediments ranging in texture from clay to gravel of both Sierra Nevadan and Coast Range origin. The formation is composed of beds, lenses, and tongues of clay, sand, and gravel that have been alternatively deposited in oxidizing and reducing environments (Hotchkiss and Balding, 1971). Terrace deposits of Pleistocene age lie up to several feet higher than present streambeds and are comprised of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss and Balding, 1971). The water table generally lies below the bottom of the terrace deposits; however, the relatively large grain size of the terrace deposits suggests their value as possible recharge sites. Alluvium is composed of interbedded, poorly to well-sorted clay, silt, sand, and gravel and is divided based on its degree of dissection and soil formation. The flood-basin deposits are generally composed of light-to-dark brown and gray clay, silt, sand, and organic material with locally high concentrations of salt and alkali. Stream channel deposits of coarse sand and gravel are also included.

The Tulare Formation also includes the Corcoran Clay (E-Clay) member, a diatomaceous clay or silty clay of lake bed origin which is a prominent aquitard in the San Joaquin Valley, separating the upper zone from the lower zone and distinguishing the semi-confined Upper Aquifer from the confined Lower Aquifer (Hotchkiss and Balding, 1971). However, the depth and thickness of the Corcoran Clay are variable within the Central Valley Floor, and it is not present in peripheral areas (outside the Central Valley Floor) of the Subbasin. Within the Upper Aquifer, additional clay layers exist within the upper zone and also provide varying degrees of confinement, including other clay members of the Tulare Formation and layers of white clay identified by Hotchkiss and Balding (1971). These clays are variable in extent and thickness, but the white clay is noted to be as much as 100 feet thick in areas providing very effective confinement of underlying zones (Croft, 1972; Hotchkiss and Balding, 1971). The Tulare Formation is hydrologically the most important geologic formation in the Delta-Mendota Subbasin because it contains most of the fresh water-bearing deposits. Most of the natural recharge that occurs in the Subbasin is in the alluvial fan apex areas along Coast Range stream channels (Hotchkiss and Balding, 1971).

5.2.4 Faults and Structural Features

The valley floor portion of the Delta-Mendota Subbasin contains no major faults and is fairly geologically inactive. There are few faults along the western boundary of the Subbasin within the Coast Range mountains, but they are not known to inhibit groundwater flow or impact water conveyance infrastructure (Figure 5-4).

5.2.5 Basin Boundaries

The Delta-Mendota Subbasin is defined by both geological and jurisdictional boundaries. The Delta-Mendota Subbasin borders all subbasins within the San Joaquin Valley Groundwater Basin with the exception of the Cosumnes Subbasin (Figure 5-5). The following subsections describe the lateral boundaries of the Subbasin, boundaries with neighboring subbasins, and the definable bottom of the Delta-Mendota Subbasin.

5.2.5.1 Lateral Boundaries

The Delta-Mendota Subbasin is geologically and topographically bounded to the west by the Tertiary and older marine sediments of the Coast Ranges, and to the east generally by the San Joaquin River. The northern, central, and southern portion of the eastern boundary are dictated by jurisdictional boundaries of water purveyors within the Delta-Mendota Subbasin.

The northern boundary (from west to east) of the Delta-Mendota Subbasin begins on the west by following the Stanislaus County/San Joaquin County line, then deviates to the north to encapsulate all of the Del Puerto Water District before returning back to the Stanislaus County/San Joaquin County line. The boundary continues east, and then deviates north again to encapsulate all of the West Stanislaus Irrigation District before returning back to the Stanislaus County/San Joaquin County line. The boundary continues to follow the Stanislaus County/San Joaquin County line east until it intersects with the San Joaquin River.

The southern boundary of the Subbasin (from east to west) matches the northerly boundaries of the Westlands Water District legal jurisdictional boundary as last revised in 2006. The boundary then proceeds west along the southernmost boundary of San Luis Water District. The boundary projects westward from this alignment until intersecting the Delta-Mendota Subbasin western boundary delineated by the extent of the Tertiary and older marine sediments.

The eastern boundary (from north to south) follows the San Joaquin River to within Township 11S, where it jogs eastward along the northern boundary of Columbia Canal Company. From there, the boundary continues along the eastern boundary of Columbia Canal Company until intersecting the northern boundary of the Aliso Water District. The boundary then heads east following the northern and then eastern boundary of the Aliso Water District until intersecting the Madera County/Fresno County line. The boundary then heads westerly following the Madera County/Fresno County line to the eastern boundary of the Farmers Water District. The boundary then continues southerly along the eastern boundary of the Farmers Water District and then southerly along the section line to the intersection with the railway lines. The boundary then heads east along the railway line until intersecting with the western boundary of the Mid-Valley Water District. The boundary then heads south along the western boundary of the Mid-Valley Water District to the intersection with the northern boundary of Reclamation District 1606. From there, the boundary heads west and then south following the boundary of Reclamation District 1606 and James Irrigation District until its intersection with the Westlands Water District boundary.

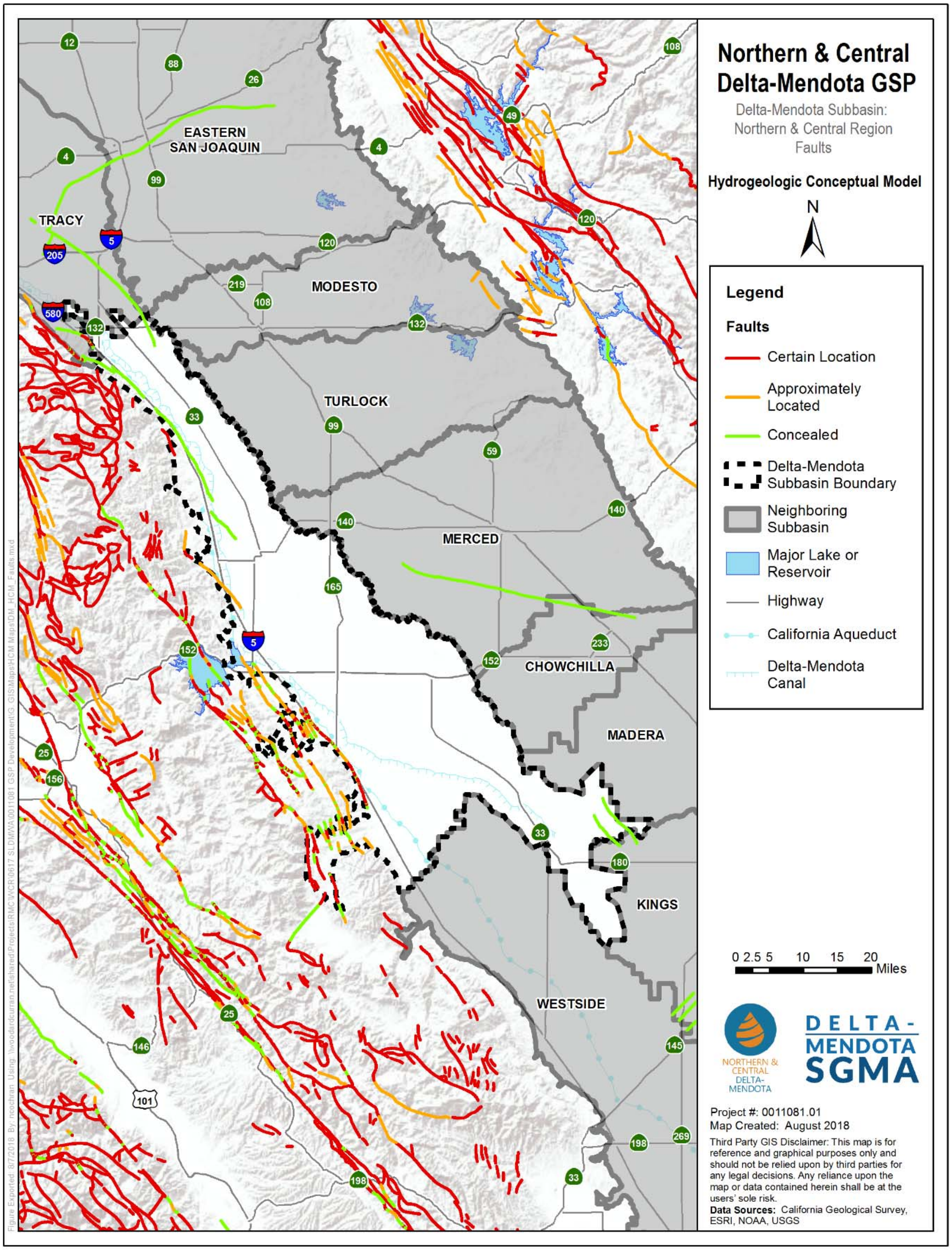

Figure 5-4. Faults, Delta-Mendota Subbasin

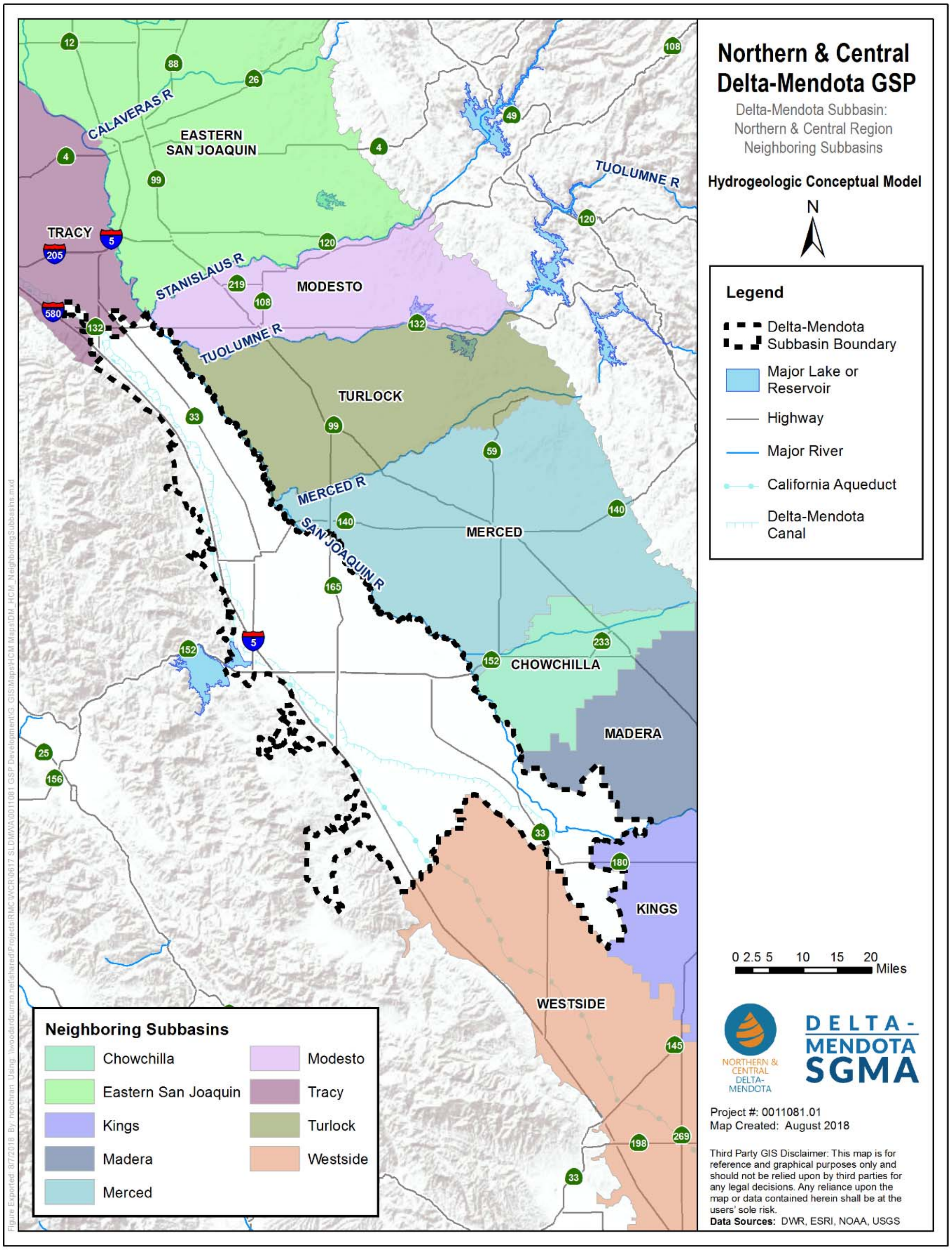

Figure 5-5. Neighboring Subbasins, San Joaquin Valley Groundwater Basin

5.2.5.2 Definable Bottom of Basin

In the San Joaquin Valley, the bottom of the Delta-Mendota Subbasin is typically defined as the interface of saline water of marine origin within the uppermost beds of the San Joaquin Formation. The San Joaquin Formation is characterized by blue and green fine-grained rocks and principally composed of fine-grained silty sands, silt, and clay (Foss and Blaisdell 1968). The San Joaquin Formation is predominantly marine in origin and is considered late Pliocene and possibly early Pleistocene in age. This formation is the upper shaley part of the Pliocene sequence. The top of the San Joaquin Formation is generally encountered around -2,000 feet above mean sea level throughout the Delta-Mendota Subbasin. For the purposes of this GSP, the base of freshwater is defined by a total dissolved solids (TDS) concentration of 3,000 micromhos per centimeter at 25 °C (or about 2,000 mg/L), as presented by Page (1973).

5.2.6 Principal Aquifers and Aquitards

DWR's Groundwater Glossary defines an aquifer as "a body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells, and springs". There are two primary aquifers within the Delta-Mendota Subbasin: a semi-confined aquifer above the Corcoran Clay and a confined aquifer below the Corcoran Clay, with the Corcoran Clay acting as the principal aquitard within the Delta-Mendota Subbasin. Figure 5-6 shows the locations of the representative cross-sections for the Northern & Central Delta-Mendota Region GSP Plan area, where Figure 5-7 through Figure 5-16 show the hydrostratigraphy of the representative cross-sections.

While the two-aquifer system described above is generally true across the Delta-Mendota Subbasin, there are portions of the basin where the Corcoran Clay does not exist (predominantly along the western margin of the Subbasin) and hydrogeology is generally controlled by localized interfingering clays, and/or where local hydrostratigraphy results in shallow groundwater conditions that differ, to some extent, from that seen in the Subbasin as a whole. Additionally, in the southern portion of the Subbasin in the Mendota and Tranquillity areas, there are A and C Clay layers in addition to the Corcoran Clay that inhibit groundwater flow. However, while there are localized complexities throughout the Subbasin, the Corcoran Clay (or E Clay) extends through much of the Delta-Mendota Subbasin generally creating a two-aquifer system.

5.2.6.1 Principal Aquifers

In the Delta-Mendota Subbasin, there are two primary aquifers composed of alluvial deposits separated by the Corcoran Clay (Schmidt, 2015): a semi-confined Upper Aquifer zone (generally the ground surface to the top of the Corcoran Clay), and a confined Lower Aquifer zone starting at the bottom of the Corcoran Clay to the base of fresh water. However, as previously described, the localized presence of the A and C Clay layers in the southern portion of the Subbasin, the absence of the Corcoran Clay at the western margin of the Subbasin and/or local hydrostratigraphy result in differing shallow groundwater conditions and/or perched groundwater conditions in some portions of the Subbasin. To this end, in addition the descriptions of the two principal aquifers in the Delta-Mendota Subbasin, a description of 'Very Shallow Unconfined Groundwater' is also provided for those portions of the basin where such conditions are present.

<u>Upper Aquifer</u>

The Upper Aquifer is represented by materials extending from the upper groundwater table to the top of the Corcoran Clay. The Upper Aquifer includes shallow geologic units of younger and older alluvium and upper parts of the Tulare Formation. Sediments within the upper Tulare Formation have variable sources and subdivision of units can be distinguished between eastern and western sourced materials. Alluvial fan materials above the Corcoran Clay in the Delta-Mendota Subbasin are generally more extensive than older alluvial fan deposits within the Tulare Formation below the Corcoran Clay. As shown in Figure 5-17 by the depth to the top of the Corcoran Clay, the Upper Aquifer extends to depths ranging between approximately 150 feet and greater than 350 feet. Other notable mapped clay units also exist within the upper part of the Tulare Formation in the Delta-Mendota Subbasin, including the A and C Clay members of the Tulare Formation and a white clay mapped by Hotchkiss and Balding (1971).

The A and C Clay occur near the Mendota and Tranquillity areas in the southeastern portion of the Delta-Mendota Subbasin. The mapped extent and elevation of the A and C Clay layers, as presented by Croft (1972) and Hotchkiss and Balding (1971), are shown in Figure 5-19 indicating areas where considerable barriers to vertical groundwater movement within the Upper Aquifer are known to exist. As shown in Figure 5-19, the extent and thickness of both the A and C Clays are somewhat uncertain, although they have been mapped to exist in the general area of Mendota. The A Clay occurs at elevations ranging from about 100 to 160 feet above mean sea level, corresponding to depths of generally between 100 and 200 feet below the ground surface. The deeper C Clay exists at correspondingly lower elevations from between 20 to 100 feet above mean sea level (Figure 5-19).

A traceable continuous white clay layer, mapped by Hotchkiss and Balding (1971), exists within the northern part of the Delta-Mendota Subbasin in the vicinity and north of Patterson. This layer ranges in thickness from 30 to 60 feet at depths between 100 and 200 feet below grade and is an effective confining layer in many areas. Although not explicitly mapped, less extensive and unmapped clay units within the Upper Aquifer also exist in other parts of the Subbasin.

<u>Lower Aquifer</u>

The Lower Aquifer is the portion of the Tulare Formation that is confined beneath the Corcoran Clay, extending downward to the underlying San Joaquin Formation and the interface of saline water of marine origin within its uppermost beds. The Lower Aquifer is generally characterized by groundwater that tends to be dominantly sodium-sulfate type, which is often of better quality than the Upper Aquifer (Davis et al., 1957; Hotchkiss and Balding, 1971). Exceptions to this quality do exist in the Subbasin, particularly in the southwestern portion of the Subbasin. Because of its relatively shallow depth within the Delta-Mendota Subbasin and lower salinity in areas when compared to other groundwater resources, the Lower Aquifer is heavily utilized as a source of groundwater for agricultural and drinking water uses within the Subbasin, where groundwater is beyond suitable for these uses in some areas.

The base of the Lower Aquifer generally decreases from south to north, changing in depth from about 1,100 to 1,200 feet deep in the south to about 600 feet to the north. Depth to the top of the Corcoran Clay ranges from less than 100 feet on the west near Interstate 5 (I-5) to more than 500 feet in the area near Tranquillity. The Corcoran Clay pinches out or is above the water level near the California Aqueduct in the western part of the Subbasin, where the Upper and Lower Aquifers merge into interfingered layers of sand, gravel, and clay.

<u>Corcoran Clay</u>

The Corcoran Clay, as a regional aquitard, is a notable hydrogeologic feature throughout most of the Delta-Mendota Subbasin, impeding vertical flow between the Upper and Lower Aquifers. The Corcoran Clay is present at varying depths across most of the Central Valley floor (Figure 5-17 and Figure 5-18). The depths to the top of the Corcoran Clay ranges between approximately 150 and 500 feet below the ground surface throughout most of the Subbasin, with a general spatial pattern of deepening to the south and east. In the far southeastern area of the Subbasin, in the vicinity of Mendota and Tranquillity, the top of the Corcoran Clay is at depths of greater than 350 feet (Figure 5-17). The thickness of the Corcoran Clay, which likely influences the degree of hydraulic separation between the Upper and Lower Aquifers, is greater than 50 feet across most of the Delta-Mendota Subbasin with thicknesses of more than 75 feet in central Subbasin areas in the vicinity of Los Banos and Dos Palos, and 140 feet in the eastern portions of the Subbasin. The Corcoran Clay appears thinner in areas north of Patterson, between Patterson and Gustine, and also in the vicinity of Tranquillity to the south (Figure 5-18). Along the westernmost portions of the Delta-Mendota Subbasin, the Corcoran Clay layer is generally non-existent or is exists as Corcoran-equivalent clays (clays existing at the same approximate depth but not part of the mapped aquitard) (Figure 5-17 and Figure 5-18).

Very Shallow Unconfined Groundwater

Floodplain deposits along the eastern side of the Subbasin, and the associated poorly-drained soils, cause naturally percolating water and applied irrigation water to build up in the very shallow zone. Shallow groundwater stagnation (where soils remain saturated within about 5 feet of the land surface) can increase salt accumulation in shallow soils and groundwater resulting from evaporation occurring directly from the water table (Corwin, 2012). The increased presence of the fine-grained floodplain deposits towards the Central Valley axis on the eastern side of the Delta-Mendota Subbasin results in low-permeability shallow soils that restrict the percolation of water, creating very shallow groundwater commonly within 25 feet of the ground surface. The combined effect of the many very shallow fine-grained lenses impeding vertical flow, especially in the distal fan and floodplain areas closer to the valley axis, can be great and represent a more substantial barrier to vertical movement of water (Bertoldi et al., 1991).

Tile drains are typically used in the eastern and southern portions of the Delta-Mendota Subbasin within the zone of Very Shallow Water (0 to 15 feet below ground surface) to manage impacts of shallow groundwater on the root zone. If groundwater within the semi-confined Upper Aquifer rises into the Very Shallow Water zone, tile drains can intercept and route such groundwater to sump pumps for removal via surface drainage networks. Further, it should be noted that some tile drains are likely within perched water zones that are not connected to the principal aquifers. Because of the generally shallow nature and high salinity, very shallow groundwater is not used to provide a major supply of water for agricultural or drinking uses within the Subbasin, although some projects are being developed to reuse this water on more salt-tolerant crops.

5.2.6.2 Aquifer Properties

The following subsections include discussion of generalized aquifer properties within the Delta-Mendota Subbasin. These include hydraulic conductivity, transmissivity, specific yield and specific storage.

DWR defines hydraulic conductivity as the "measure of a rock or sediment's ability to transmit water" and transmissivity as the "aquifer's ability to transmit groundwater through its entire saturated thickness" (DWR, 2003). High hydraulic conductivity values correlate with areas of transmissive groundwater conditions with transmissivity generally equaling hydraulic conductivity times the saturated thickness of the formation. Storage of water within the aquifer system can be quantified in terms of the specific yield for unconfined groundwater flow and the storage coefficient for confined flow, respectively (Faunt et al., 2009). Specific yield represents gravity-driven dewatering of shallow, unconfined sediments at a declining water table, but also accommodates a rising water table. The specific yield is dimensionless and represents the volume of water released from or taken into storage per unit head change per unit area of the water table. Specific yield is a function of porosity and specific retention of the sediments in the zone of water-table fluctuation.

Where the aquifer system is confined, storage change is governed by the storage coefficient, which is the product of the thickness of the confined-flow system and its specific storage. The specific storage is the sum of two component specific storages – the fluid (water) specific storage and the matrix (skeletal) specific storage, which are governed by the compressibilities of the water and skeleton, respectively (Jacob, 1940). Specific storage has units of 1 over length and represents the volume of water released from or taken into storage in a confined flow system per unit change in head per unit volume of the confined flow system (Faunt et al., 2009). Therefore, the storage coefficient of a confined flow system is dimensionless and, similar to specific yield, represents the volume of water released from or taken into storage per unit head change.

5.2.6.2.1 Hydraulic Conductivity

Figure 5-20 shows the saturated C-horizon vertical hydraulic conductivity of surficial soils within the Delta-Mendota Subbasin based on the National Resource Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO). Soil survey data for counties within the Subbasin were combined using the weighted harmonic mean of these representative layers to depict the saturated hydraulic conductivity of the C-horizon for each soil map unit. The soil profile represented by these data is variable but commonly extends to a depth of 6 or more feet.

Floodplain deposits are evident as soils with relatively low hydraulic conductivity (less than 0.5 feet per day [ft/day]) blanketing much of the Central Valley Floor, although localized areas of soils with higher hydraulic conductivity are present in association with modern and ancient surface waterways and alluvial fan features (Figure 5-20). Coarse soils of distributary alluvial fan sediments deposited by Del Puerto Creek, Orestimba Creek, and Little Panoche Creek, in addition to other ephemeral northeasterly creek flows off the Coast Ranges, are notably apparent as areas of soils of high hydraulic conductivity located along active and inactive stream channels extending eastward from the fan apex areas along the Valley Floor margins to the current alignment of the San Joaquin River in the valley axis. Additionally, soils in areas adjacent to the active channel of the San Joaquin River also exhibit high hydraulic conductivities, including values of greater than 4 ft/day which are particularly apparent in an area north of Mendota. Soils of similarly high hydraulic conductivity trending as linear features in a general northwest-southeast alignment to the north of Dos Palos and Los Banos are likely the result of historical depositional processes and paleochannels associated with the San Joaquin River (Figure 5-20). In areas peripheral to the Central Valley floor, soils tend to be characterized by relatively low hydraulic conductivity, although soils of somewhat higher hydraulic conductivity associated with distinct geologic units are mapped across much of the peripheral area to the west of Patterson and Gustine and also in localized bands associated with surface water courses.

5.2.6.2.2 Transmissivity

Transmissivity varies greatly above the Corcoran Clay, within the Corcoran Clay, and below the Corcoran Clay within the Delta-Mendota Subbasin, with transmissivities in the confined Lower Aquifer generally being larger than those in the semi-confined Upper Aquifer. Based on testing conducted at multiple locations within both the Upper and Lower Aquifers of the Delta-Mendota Subbasin, average transmissivities in the Subbasin are approximately 109,000 gallons per day per square foot (gpd/ft^2) (SJRECWA, 2018).

5.2.6.2.3 Specific Yield

DWR defines specific yield as the “amount of water that would drain freely from rocks or sediments due to gravity and describes the proportion of groundwater that could actually be available for extraction” (DWR, 2003). Specific yield is a measurement specific to unconfined aquifers.

The estimated specific yield of the Delta-Mendota Subbasin is 0.118 (DWR, 2006). Within the southern portion of the Delta-Mendota Subbasin, specific yield ranges from 0.2 to 0.3 (Beltiz et al., 1993). Specific yield estimates for the Delta-Mendota Subbasin are fairly limited in literature since the Upper Aquifer above the Corcoran Clay is semi-confined and the Lower Aquifer below the Corcoran Clay is confined. Therefore, specific yield values only characterize the shallow, unconfined groundwater within the Subbasin.

5.2.6.2.4 Specific Storage

Values for specific storage were extracted from the Central Valley Hydrologic Model 2 (CVHM2), which is currently under development by the United States Geological Survey (USGS) and includes refinements for the Delta-Mendota Subbasin. Specific storage varies above, within, and below the Corcoran Clay with CVMH2. Above the Corcoran Clay, specific storage ranges from 1.34×10^{-6} to 6.46×10^{-2} meters^{-1} (m^{-1}) with average values ranging from 6.16×10^{-3} to 1.97×10^{-2} m^{-1}. Specific storage within the Corcoran Clay is considerably smaller than above the Corcoran Clay, ranging between 1.41×10^{-6} and 2.35×10^{-6} m^{-1} and average values between 1.96×10^{-6} and 2.02×10^{-6} m^{-1}. Below the Corcoran Clay, specific storage is comparable to within the Corcoran Clay with overall ranges the same as within the Corcoran Clay and average values ranging from 1.86×10^{-6} to 2.01×10^{-6} m^{-1}. Therefore, specific storage is greatest within the semi-confined aquifer overlying the Corcoran Clay layer, with considerably smaller specific storage values with the low permeability Corcoran Clay and confined aquifer underlying the Corcoran Clay layer.

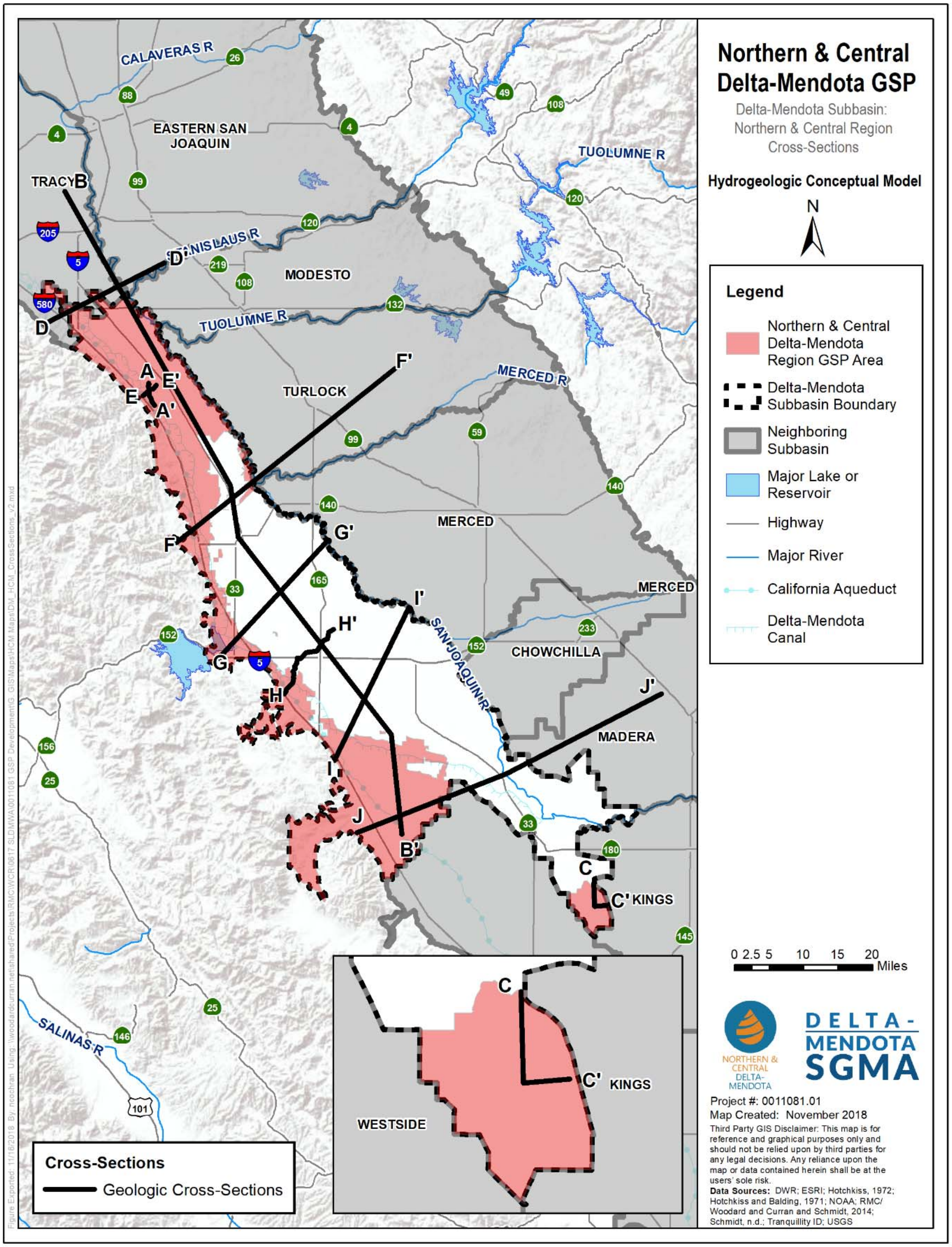

Figure 5-6. Representative Cross-Sections, Northern & Central Delta-Mendota Region GSP

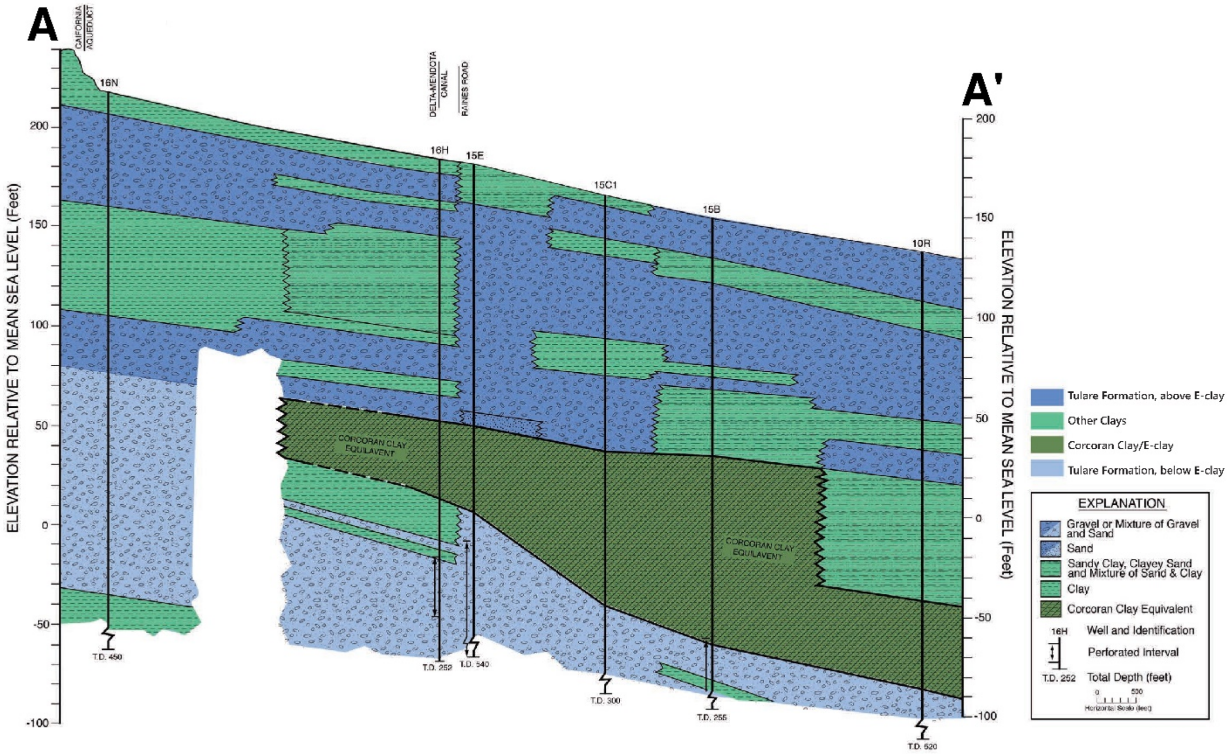

Figure 5-7. Cross-Section A-A' (RMC/W&C and Schmidt, 2014)

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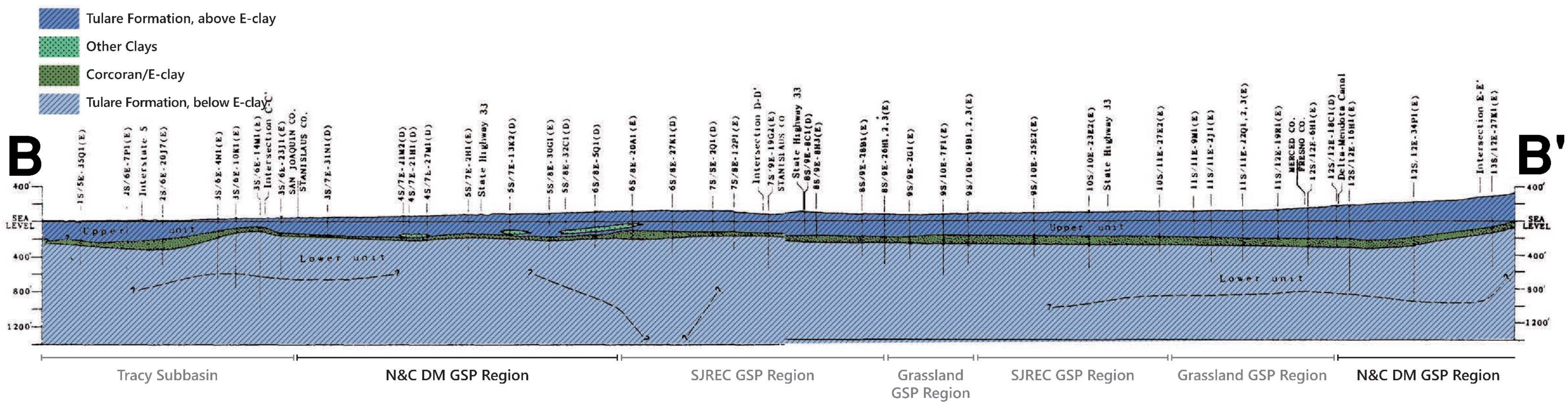

Figure 5-8. Cross-Section B-B' (Hotchkiss, 1972)

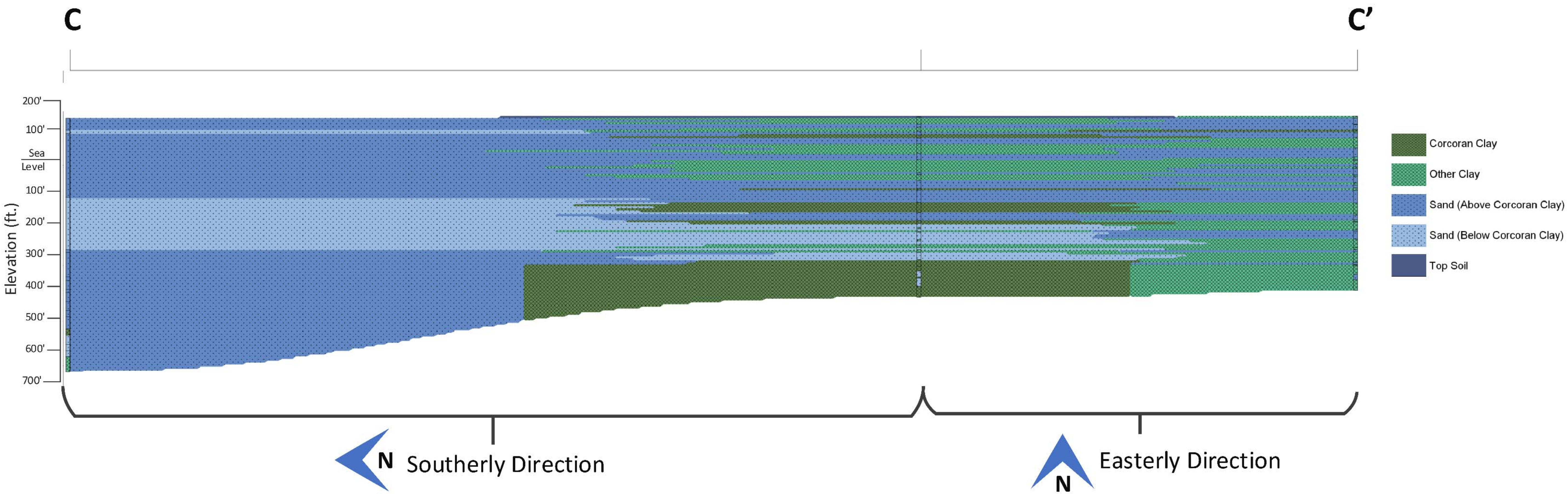

Figure 5-9. Cross-Section C-C' (Tranquillity ID, 1994 and 2000 and LSCE, 2011)

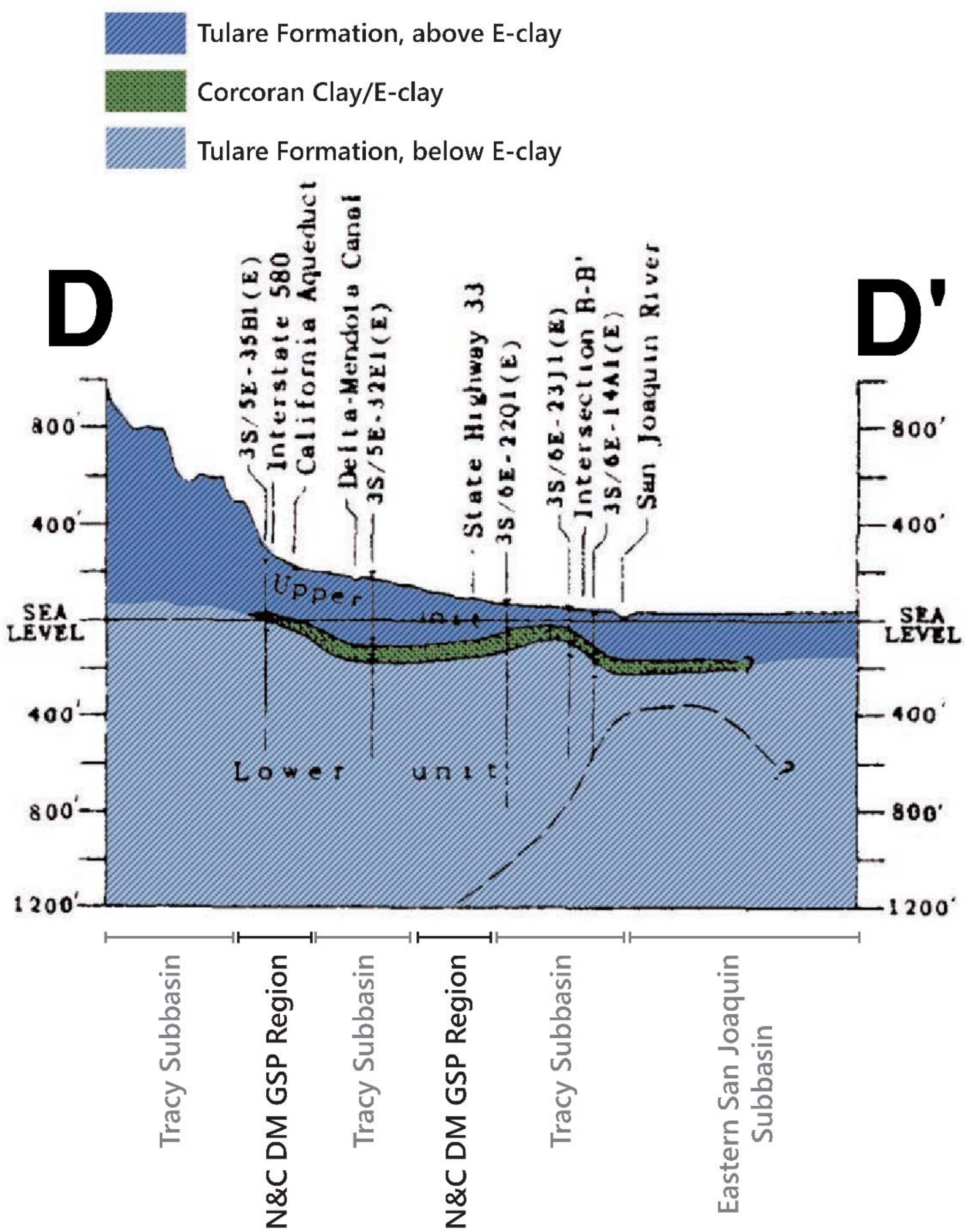

Figure 5-10. Cross-Section D-D' (Hotchkiss, 1972)

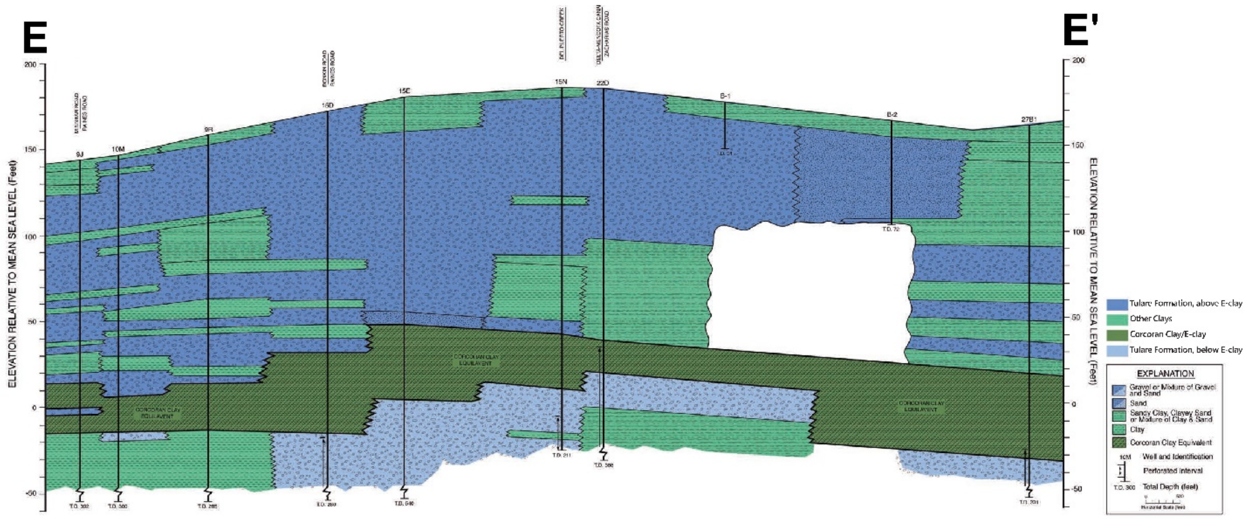

Figure 5-11. Cross-Section E-E' (RMC/W&C and Schmidt, 2014)

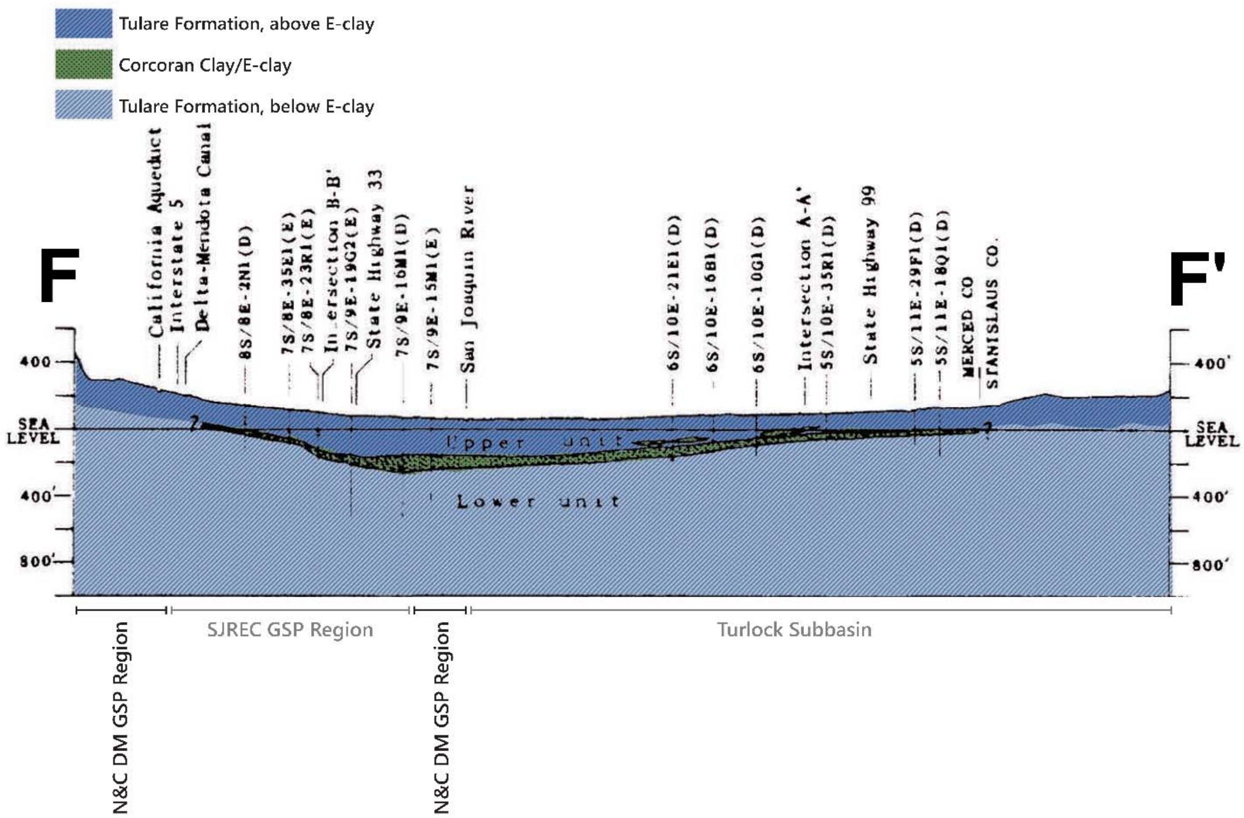

Figure 5-12. Cross-Section F-F' (Hotchkiss, 1972)

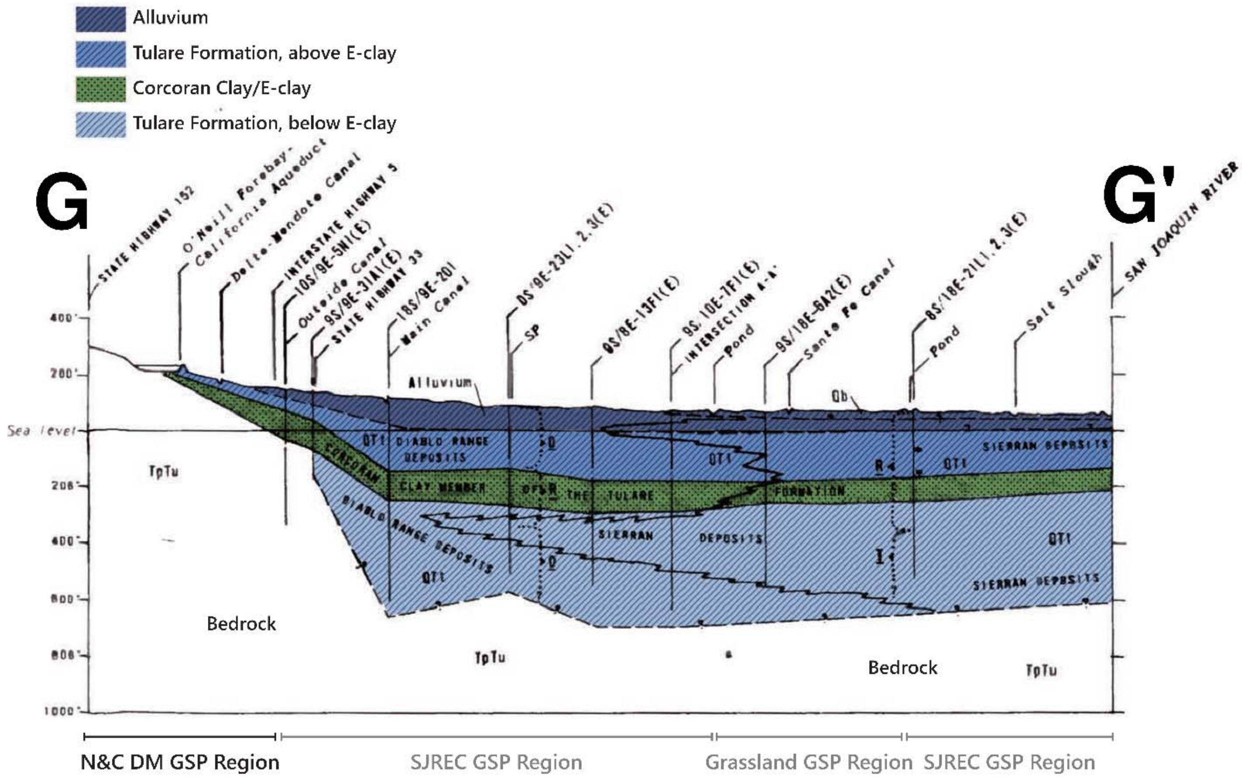

Figure 5-13. Cross-Section G-G’ (Hotchkiss & Balding, 1971)

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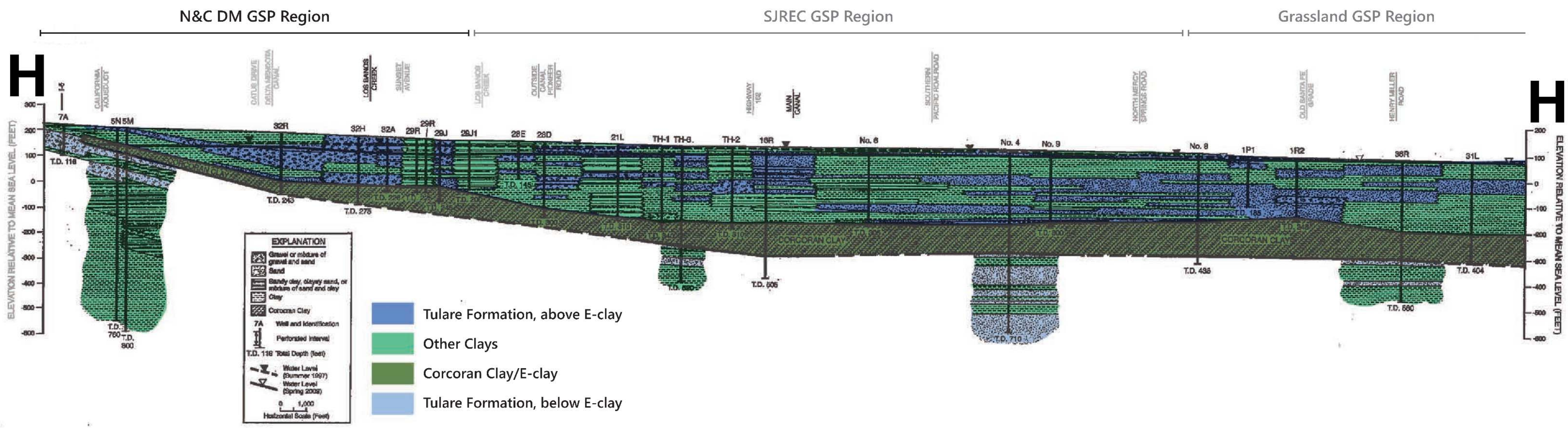

Figure 5-14. Cross-Section H-H' (Schmidt, 2018)

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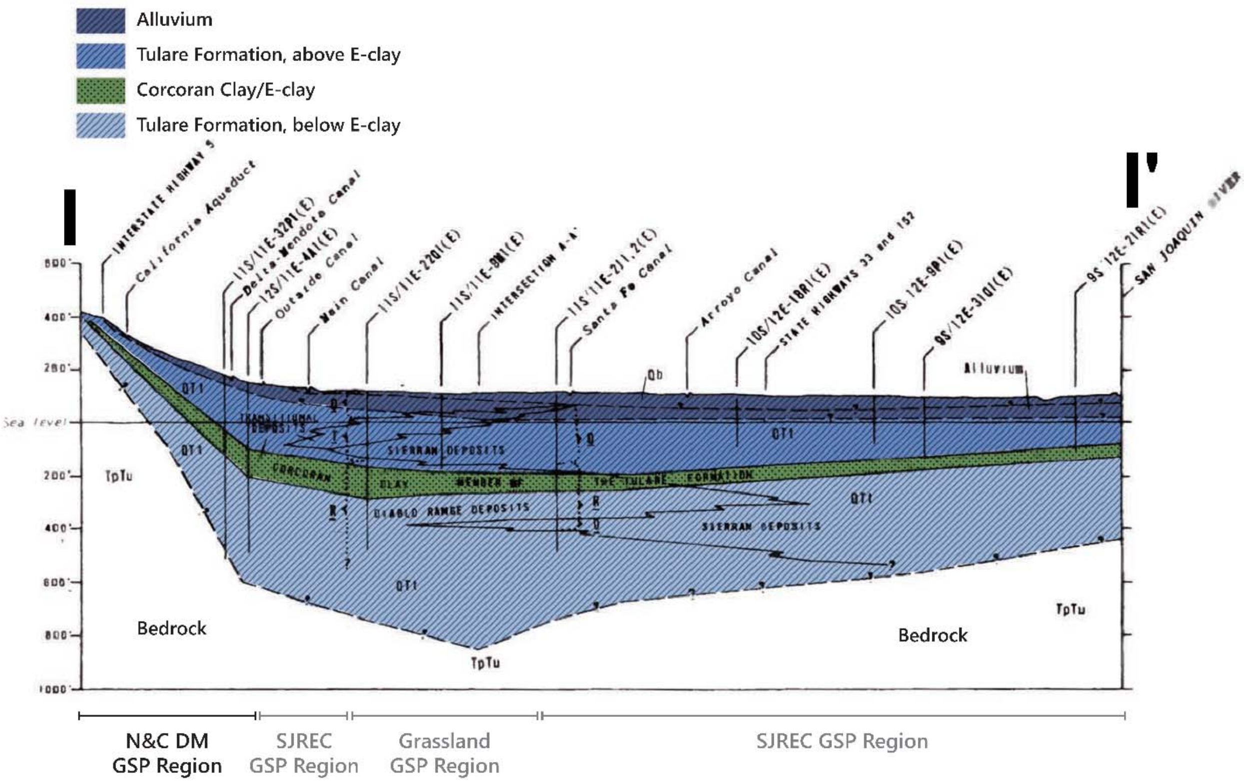


Figure 5-15. Cross-Section I-I’ (Hotchkiss & Balding, 1971)

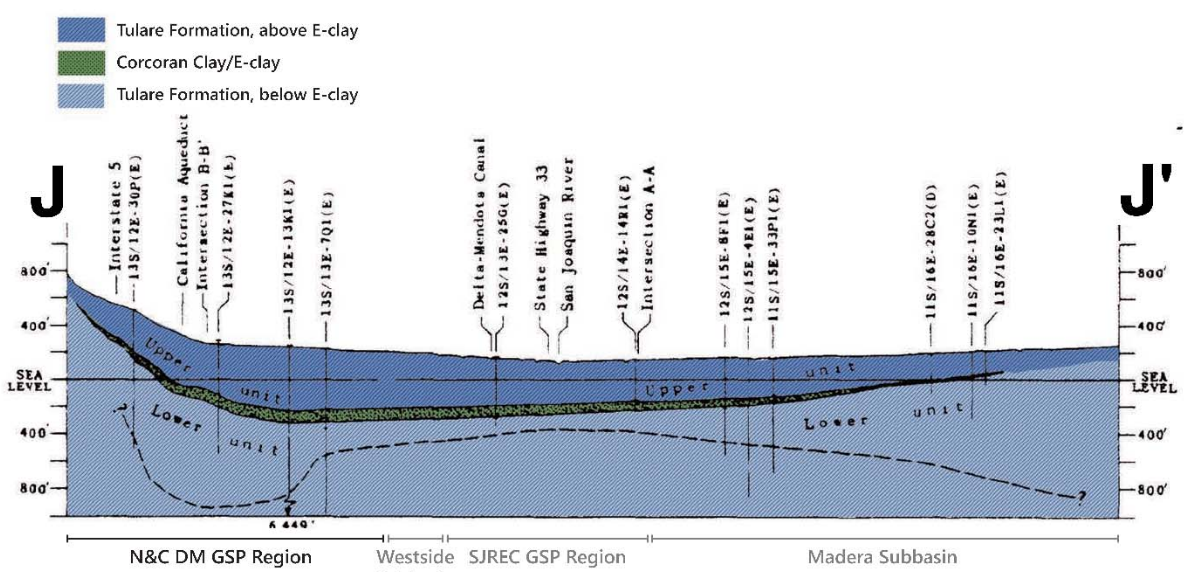


Figure 5-16. Cross-Section J-J’ (Hotchkiss, 1972)

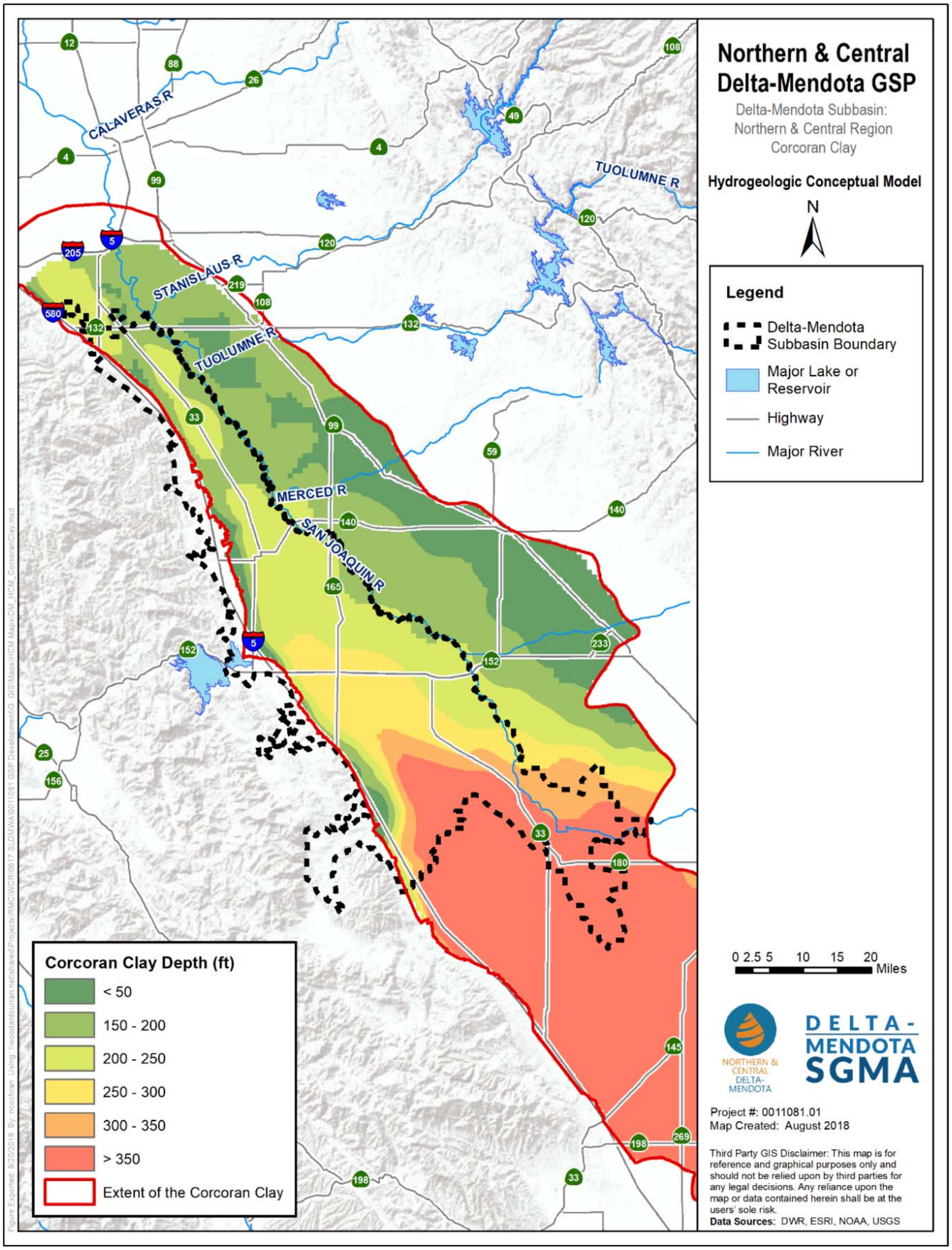


Figure 5-17. Depth to Corcoran Clay, Delta-Mendota Subbasin

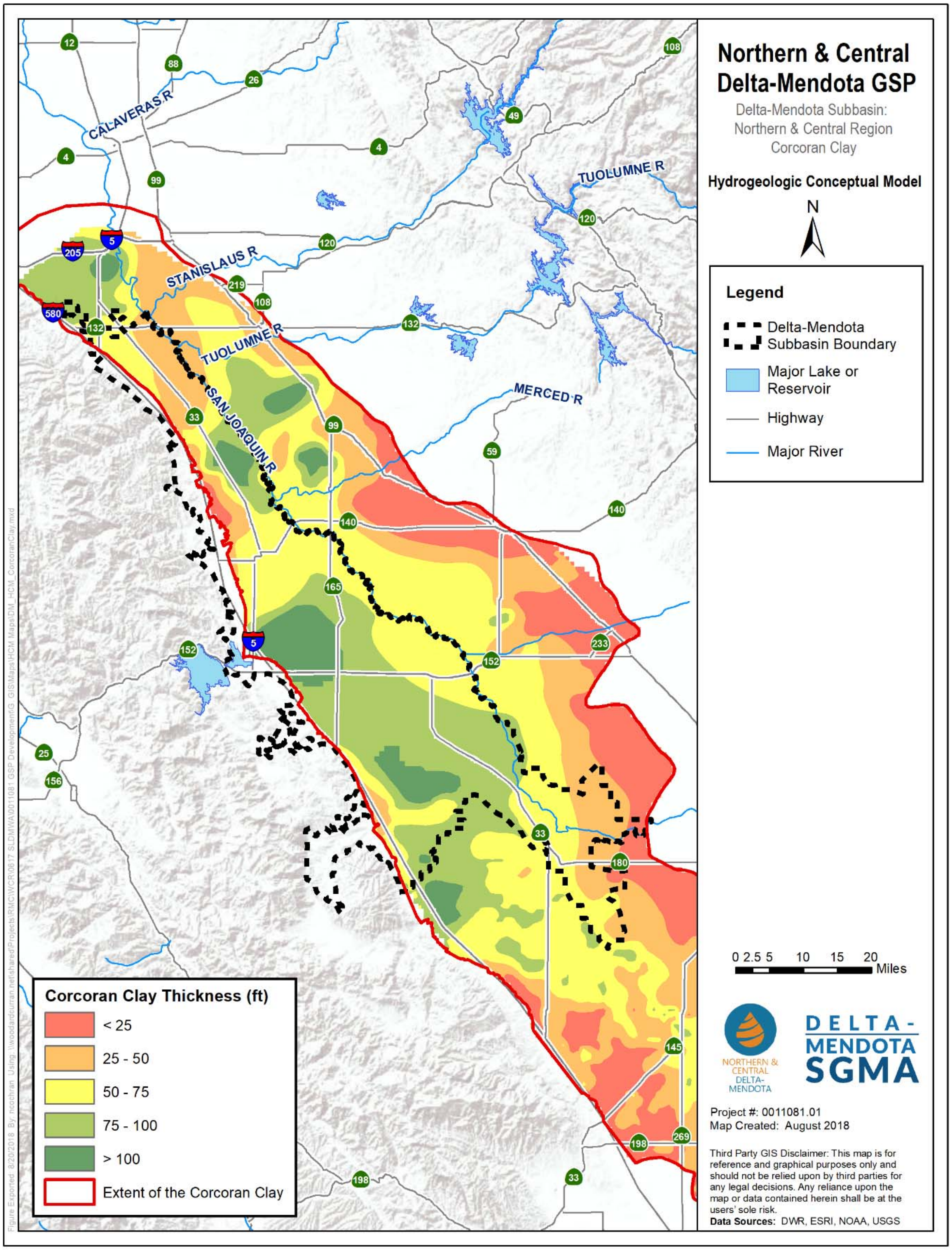


Figure 5-18. Thickness of Corcoran Clay, Delta-Mendota Subbasin

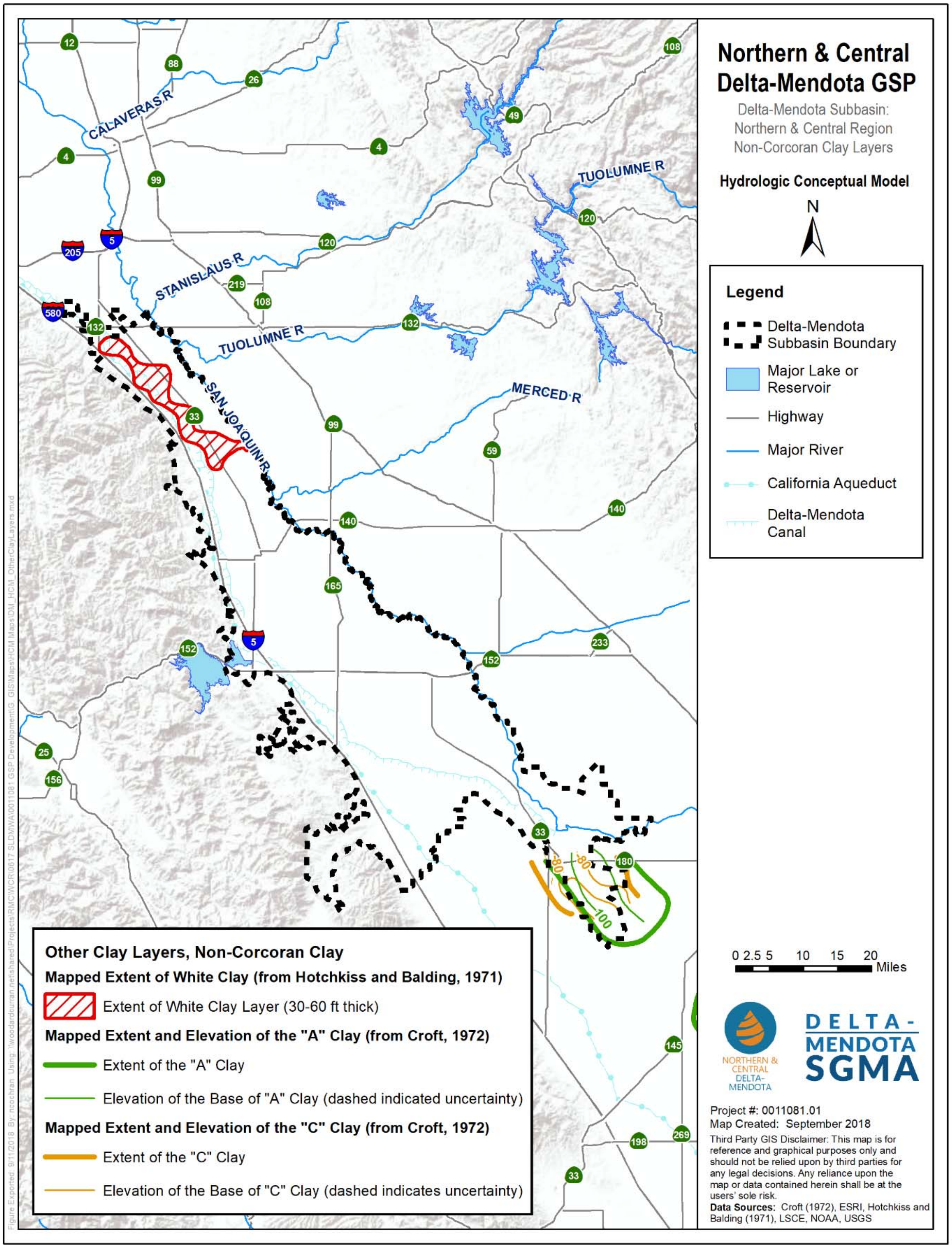


Figure 5-19. Non-Corcoran Clay Layers, Delta-Mendota Subbasin

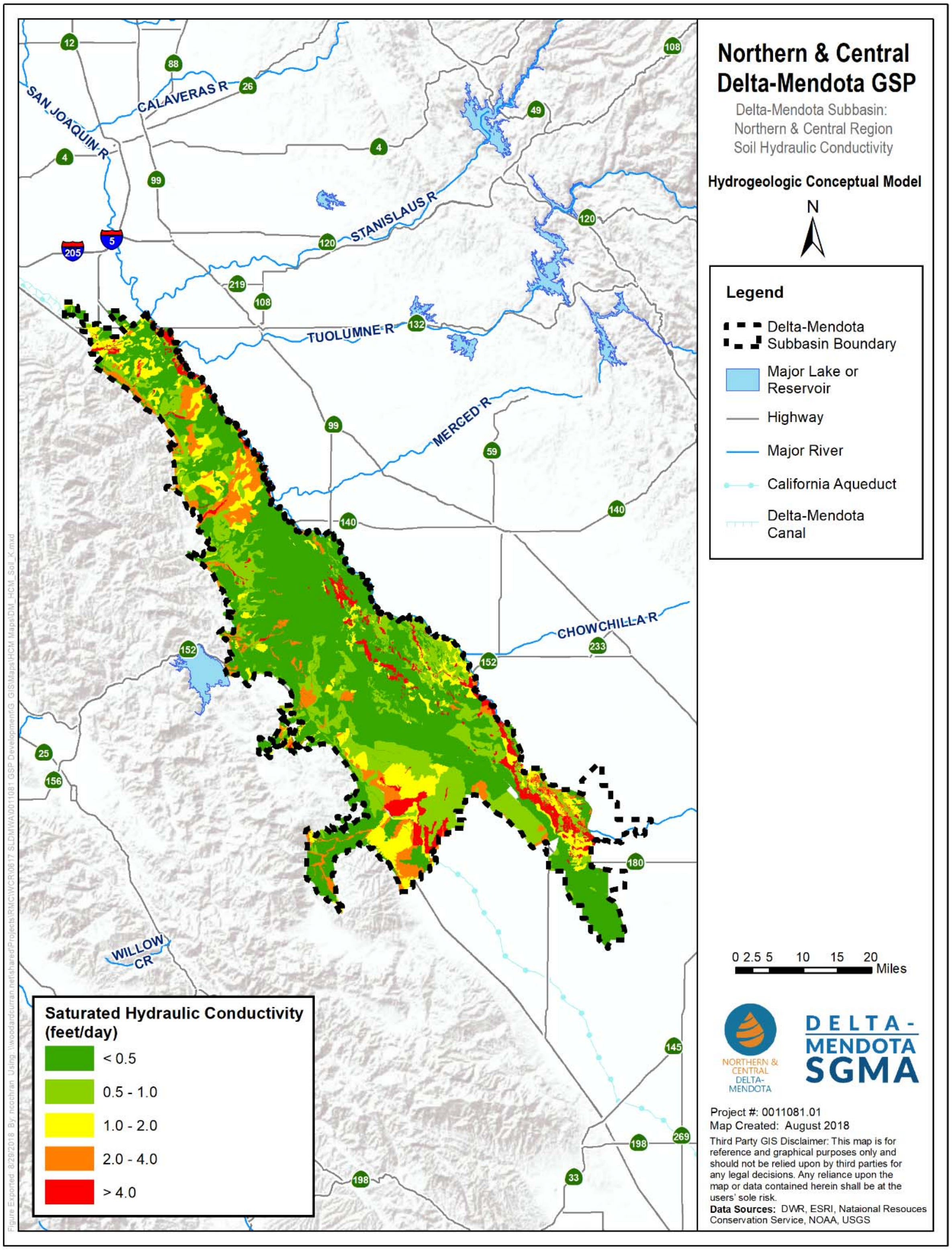


Figure 5-20. Soil Hydraulic Conductivity, Delta-Mendota Subbasin

5.2.7 Structural Properties and Restricted Groundwater Flow

Under natural (pre-development) conditions, the prevailing groundwater flow within the Upper and Lower Aquifer systems of the western San Joaquin Valley was predominantly in a generally northeasterly direction from the Coast Range towards and parallel to the San Joaquin River and the Sacramento-San Joaquin Delta (LSCE, 2015; Hotchkiss and Balding, 1971; Schmidt, 2015). Historically, numerous flowing artesian wells within the Lower Aquifer existed throughout the Delta-Mendota Subbasin (Mendenhall et al., 1916) and the pressure gradient for groundwater flow was upward from the Lower Aquifer to the Upper Aquifer. These flowing artesian conditions have disappeared in many areas as a result of increased development of groundwater resources within the Tulare Formation, changing the vertical flow gradient between groundwater zones (Hotchkiss and Balding, 1971). Additionally, the Delta-Mendota Subbasin has experienced periods of considerable decline in groundwater levels during which hydraulic heads decreased considerably in some areas due to heavy pumping (Bertoldi et al., 1991).

Despite the presence of local pumping depressions within parts of the Subbasin, the prevailing northeastward flow direction for groundwater within the region has remained (AECOM, 2011; DWR, 2010; Hotchkiss and Balding, 1971). Groundwater flows outward from the Delta-Mendota Subbasin, except along the western margin where there is some recharge from local streams and canal seepage (Schmidt, 2015). Within the Upper Aquifer, there are similar groundwater flow directions in most of the Subbasin with groundwater outflow to the northeast or towards the San Joaquin River in much of the Subbasin during wet and dry periods. One exception is in the Orestimba Creek area west of Newman where groundwater flows to the west during drought conditions and east during wet periods. Calculations based on aquifer transmissivity indicate the net groundwater outflow in the Upper Aquifer has been about three times greater during drought periods than during normal periods (Schmidt, 1997a and 1997b).

Within the Lower Aquifer, there is a groundwater divide in the area between Mendota and the point near the San Joaquin River in the Turner Island area, northeast of Los Banos. Groundwater southwest of this divide generally flows southwest toward Panoche Water District. Groundwater northeast of this divide flows to the northeast into Madera and Merced Counties. Net groundwater outflow in the Lower Aquifer under drought conditions has been about two and a half times greater than for normal conditions (Schmidt, 1997a and 1997b). Based on current and historical groundwater elevation maps, groundwater barriers do not appear to exist in the Delta-Mendota Subbasin (DWR, 2006).

The combined effect of pumping below the Corcoran Clay and increased leakage from the Very Shallow zone to the Upper Aquifer has developed a generally downward flow gradient in the Tulare Formation which changes with variable pumping and irrigation over time (Bertoldi et al., 1991). Periods of great groundwater level declines have also resulted in inelastic compaction of fine-grained materials in some locations, particularly between Los Banos and Mendota, potentially resulting in considerable decreases (between 1.5 and 6 times) in permeability of clay members within the Tulare Formation, including the Corcoran Clay (Bertoldi et al., 1991). However, the number of wells penetrating the Corcoran Clay may be enabling vertical hydraulic communication across the Corcoran Clay aquitard and other clay layers (Davis et al., 1959; Davis et al., 1964).

5.2.8 Water Quality

Groundwater in the Delta-Mendota Subbasin is characterized by mixed sulfate to bicarbonate water types in the northern and central portion of the Subbasin, with areas of sodium chloride and sodium sulfate waters in the central and southern portions (DWR, 2003). TDS values range from 400 to 1,600 mg/L in the northern portion, and 730 to 6,000 mg/L in the southern portion of the Delta-Mendota Subbasin (Hotchkiss and Balding, 1971). The Department of Health Services (DHS), which monitors Title 22 water quality standards, reports TDS values in 44 public supply wells in the Subbasin ranging in value from 210 to 1,750 mg/L, with an average value of 770 mg/L. Shallow, saline groundwater also occurs within about 10 feet of the ground surface over a large portion of the Delta-Mendota Subbasin. There are also localized areas of high iron, fluoride, nitrate, selenium, and boron in the Delta-Mendota Subbasin (Hotchkiss and Balding, 1971).

5.2.8.1 Historic Water Quality

Alluvial sediments derived from west-side streams are composed of material derived from serpentine, shale, and sandstone parent rock, which results in soil and groundwater types entirely different from those on the east side of the San Joaquin Valley (LSCE, 2015). In contrast with the siliceous mineralogy of the alluvial sands and gravels on the eastern side of the Central Valley that are derived from the Sierra granitic rocks (which are coarser and more resistant to chemical dissolution), the sulfate and carbonate shales and sandstones of Coast Range sediments on the western side are more susceptible to dissolution processes. Some soils and sediments within the western San Joaquin Valley that are derived from marine rocks of the Coast Range have notably high concentrations of naturally-occurring nitrogen, with particularly higher nitrate concentrations in younger alluvial sediments (Strathouse and Sposito, 1980; Sullivan et al., 1979). These naturally-occurring nitrogen sources may contribute to nitrate concentrations in groundwater within the Delta-Mendota Subbasin, although it is not well known where this may occur and to what degree. Naturally-high concentrations of TDS in groundwater are known to have existed historically within parts of the Subbasin due to the geochemistry of the Coast Range rocks, the resulting naturally-high TDS of recharge derived from Coast Range streams, the dissolvable materials within the alluvial fan complexes, and the naturally-poor draining conditions which tend to concentrate salts in the system. The chemical quality of waters in the Coast Range streams can be closely correlated with the geologic units within their respective catchments. Groundwater flows discharging from these marine and non-marine rocks into streams introduce a variety of dissolved constituents, resulting in variable groundwater types. The water quality and chemical makeup in westside streams can be highly saline, especially in more northern streams, including Corral Hollow and Del Puerto Creeks, where historical baseflow TDS concentrations have typically exceeded 1,000 milligrams per liter (mg/L) with measured concentrations as high as 1,790 mg/L (Hotchkiss and Balding, 1971). This is in contrast with TDS concentrations typically below 175 mg/L in streams draining from the Sierras. The contribution of water associated with these Coast Range sediments has resulted in naturally high salinity in groundwater within and around the Delta-Mendota Subbasin, which has been recognized as early as the 1900s (Mendenhall et al., 1916). Groundwater in some areas within the immediate vicinity of the San Joaquin River is influenced by lower-salinity surface water discharging from the east side of the San Joaquin Valley Groundwater Basin (Davis et al., 1957).

Areas of historical high saline groundwater documented by Mendenhall *et al*. (1916) indicate somewhat high TDS concentrations approaching or greater than 1,000 mg/L in wells sampled throughout many parts of the Delta-Mendota Subbasin. Areas of locally higher TDS concentrations (1,500-2,400 mg/L) have existed between Mendota and Los Banos; whereas the trend in deeper groundwater (average well depth of 450 feet) south of Mendota indicates slightly lower historical salinity conditions, but still somewhat high with an average TDS concentration of greater than 1,000 mg/L. In the northern part of the Subbasin, north of Gustine, the average historical TDS concentration of wells was also relatively high (930 mg/L). Historically low TDS concentrations (<500 mg/L) existed in groundwater from wells with an average depth of 209 feet in the central Subbasin area between Los Banos and Gustine.

The general chemical composition of groundwater in the Subbasin is variable based on location and depth. Groundwater within the Upper Aquifer is largely characterized as transitional type with less area characterized as predominantly of chloride, bicarbonate, and sulfate water types. Transitional water types, in which no single anion represents more than 50 percent of the reactive anions, occurs in many different combinations with greatly ranging TDS concentrations. Chloride type waters occur generally in grasslands areas east of Gustine and around Dos Palos, with sodium chloride water present in northern areas near Tracy and also extending south from Dos Palos. These waters also exhibit greatly varying salinity with typical TDS concentrations, ranging from less than 500 mg/L to greater than 10,000 mg/L and of high sodium makeup (50-75 percent of cations present) (Hotchkiss and Balding, 1971). Areas of bicarbonate groundwater within the Upper Aquifer of relatively lower TDS concentrations are directly associated with intermittent streams of the Coast Range near Del Puerto, Orestimba, San Luis, and Los Banos Creeks. Sulfate water in the central and southern Subbasin areas has TDS concentrations decreasing from west (1,200 mg/L) to east (700 mg/L) towards the San Joaquin River, similar to the bicarbonate water areas, although areas of sulfate water south of Dos Palos have much higher TDS concentrations (1,900 to 86,500 mg/L) (Hotchkiss and Balding, 1971).

Groundwater in the Lower Aquifer below the Corcoran Clay is also spatially variable, consisting of mostly transitional sulfate waters in the northern part of the Delta-Mendota Subbasin to more sodium-rich water further south in the grasslands areas. In the northern part of the Delta-Mendota Subbasin, the Lower Aquifer exhibits relatively lower TDS concentrations, ranging from 400 to 1,600 mg/L, with a sulfate-chloride type makeup near the valley margin trending to sulfate-bicarbonate type near the valley axis. Farther south, TDS concentrations in the Lower Aquifer increase with values ranging as high as 6,000 mg/L of high sodium content (Hotchkiss and Balding, 1971).

Natural conditions of groundwater salinity exist throughout the Upper and Lower Aquifers as a result of the contribution of salts from recharge off the Coast Range mountains. Surface water and groundwater flowing over and through Coast Range sediments of marine origin have dissolved naturally-occurring salts, contributing to the historical and current presence of salinity in groundwater within the Delta-Mendota Subbasin. In addition to natural salinity contributed from the Coast Range sediments, a number of other mechanisms are believed to further contribute to increased salinity in the groundwater in the region. Poorly draining soil conditions are extensive within the southern and eastern areas of the Subbasin, extending from the vicinity of Tranquillity to near Gustine, and these types of soil, combined with a shallow water table, contribute to a build-up of soil salinity.

5.2.8.2 Recent Groundwater Quality

Primary constituents of concern within the Delta-Mendota Subbasin are nitrates, TDS, and pesticides. In the Grassland Drainage Area and southern portions of the Subbasin, both selenium and boron are naturally occurring and are managed to mitigate impacts to irrigated agriculture. The maximum detected concentrations, as well as recent (about 2000 to 2014) concentrations, of these constituents are discussed in the following subsections (LSCE, 2015 and LSCE, 2016).

5.2.8.2.1 Nitrate Concentrations

The maximum nitrate (as N) concentrations observed in all wells throughout the Delta-Mendota Subbasin are depicted in Figure 5-21. The majority of wells have maximum concentrations below 5 mg/L; however, several areas exist with a greater density of wells with maximum concentrations exceeding the primary maximum contaminant level (MCL) of 10 mg/L (as N), especially in the area immediately south of Los Banos and trending northwest along Highway 33 to north of Patterson. Historical and current land use in this area consists mainly of alfalfa, almonds, cotton, corn, and tomatoes. There are a few wells around Dos Palos and southward toward Tranquillity with maximum nitrate concentrations exceeding the MCL, but most concentrations are non-detect. Figure 5-22 shows the most recent nitrate concentrations (for a period of around 2000 to 2014) in all the wells in the Subbasin. The overall picture illustrated by the nitrate data in Figure 5-22 is very similar, though slightly improving, to that seen in Figure 5-21 for maximum nitrate concentrations.

<u>Above Corcoran Clay</u>

Figure 5-23 depicts maximum nitrate concentrations above the Corcoran Clay. Available data are limited for shallow wells above the Corcoran Clay, though the majority of the nitrate concentrations are below the nitrate (as N) MCL of 10 mg/L. The few wells that do exceed the MCL do not have a consistent spatial pattern, except in the southern central portion of the Subbasin where the majority of the drainage water in very shallow wells has maximum concentrations exceeding the MCL of 10 mg/L. Compared to shallow wells (typically less than 50 feet deep), deeper wells in the Upper Aquifer (ranging in depth from 50 feet to the top of the Corcoran Clay) have more wells with maximum nitrate concentrations exceeding the MCL. The majority of these exceedances extend from south of Los Banos northwestward to north of Patterson. Wells around Dos Palos and southeast of Tranquillity tend to have lower concentrations of nitrate, typically less than 2.5 mg/L. Similar spatial patterns are evident in shallow wells presenting the most recent nitrate concentrations, although several wells near Los Banos and Patterson indicate recently improved nitrate concentrations (Figure 5-24). The most recent nitrate concentrations in shallow Upper Aquifer wells are lower at many sample locations in the area northeast and east of Los Banos. The most recent nitrate concentrations in deeper wells throughout the Upper Aquifer show the same pattern as the maximum concentrations; however, a fewer number of these wells have concentrations exceeding 10 mg/L.

Tile drains located predominantly in the southern portion of the Subbasin are designed to capture applied water that percolates below the root zone and to drain the water table in areas where it is perched or very shallow. Consequently, it is expected that water sampled from tile drains and from very shallow wells (less than 15 feet) would exhibit higher concentrations of nitrate resulting from land use practices. The most recent nitrate concentrations in deeper wells appear to be slightly improved relative to the maximum concentrations as fewer wells show most recent values above 10 mg/L compared to the maximum nitrate concentrations. Nevertheless, the spatial patterns in the most recent nitrate concentrations shown in Figure 5-24 are similar to the maximum concentrations evident in Figure 5-23.

Below Corcoran Clay

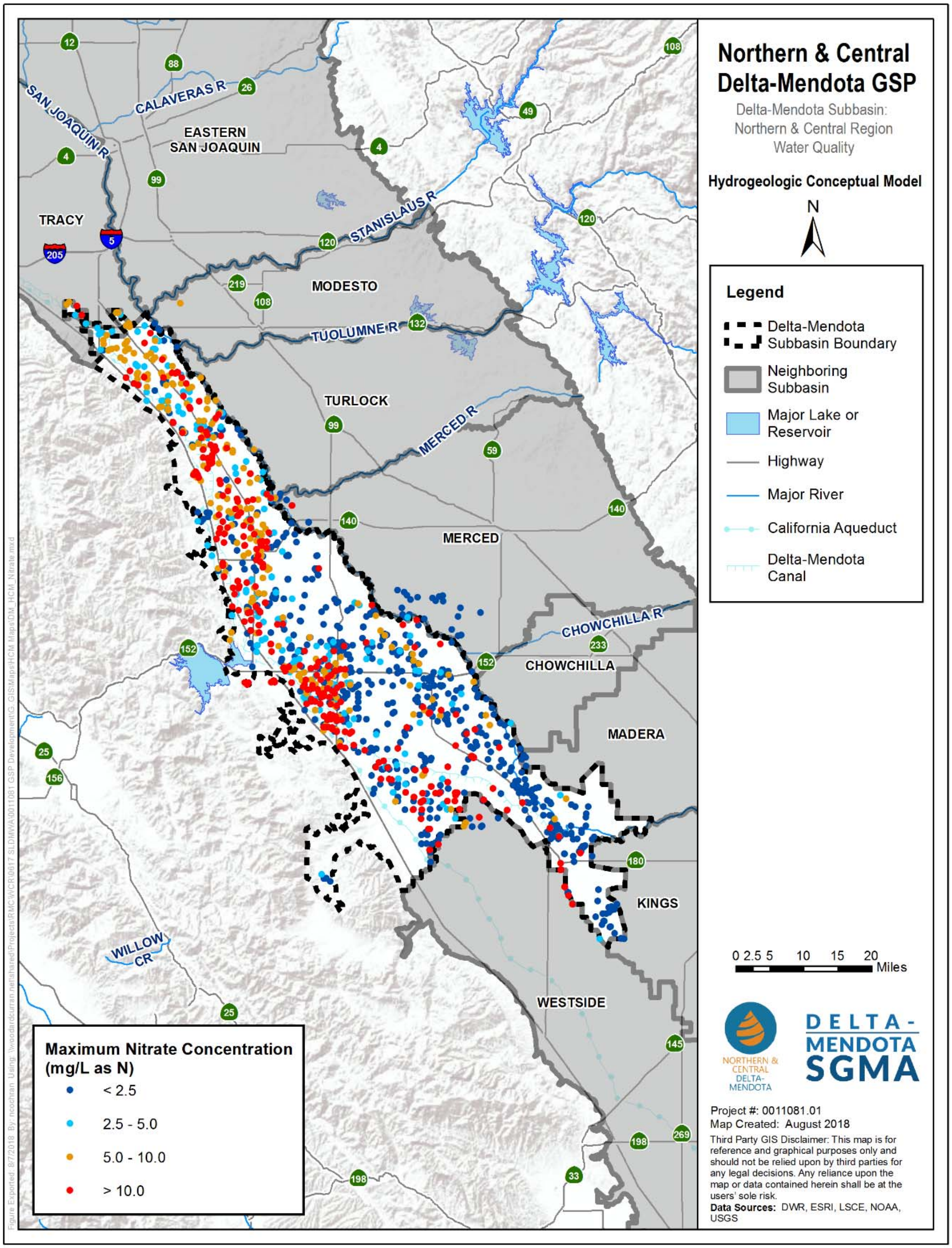
Fewer data are available relating to nitrate concentrations below the Corcoran Clay as compared to above the Corcoran Clay, primarily because most irrigation wells in the Subbasin (from which the predominance of data are available) are completed in the Upper Aquifer. Figure 5-25 displays the maximum nitrate concentrations in wells interpreted to be in the Lower Aquifer and shows the lack of data southwest of Los Banos. As is evident in Figure 5-25, most wells in the Lower Aquifer, from Gustine to north of Patterson and west of Highway 33, have a maximum nitrate (as N) concentration above 5 mg/L. However, in the most recent nitrate data, a fewer number of the Lower Aquifer wells have concentrations exceeding 10 mg/L (Figure 5-26). Limited and scattered wells south of Gustine show a maximum nitrate concentration of less than 5 mg/L. Clusters of higher nitrate concentrations in the Lower Aquifer are generally concentrated in areas where the Corcoran Clay is either thin or non-existent as seen in Figure 5-25, most notably to the west and northwest of Gustine.

Composite Wells

As seen in Figure 5-27, the maximum nitrate concentrations in the composite wells (wells screened both above and below the Corcoran Clay) are mostly above 5 mg/L nitrate as N. The maximum nitrate concentration data in composite wells are similar to the most recent data (Figure 5-28), with a few wells with recent results showing improved nitrate concentrations.

Wells of Unknown Depth

Many of the wells for which nitrate data are available could not be classified into a depth category (above or below the Corcoran Clay) because of the lack of information relating to well construction and type. The spatial distribution of nitrate concentrations in these wells of unknown depth is shown in Figure 5-29 and Figure 5-30. The majority of these wells have maximum nitrate as N concentrations below 5 mg/L, although a greater density of wells with maximum nitrate concentrations exceeding 10 mg/L can be seen in the area south of Los Banos (Figure 5-29) and extending northwest along Highway 33 to north of Patterson. This area also exhibits elevated nitrate concentrations in both the Upper and Lower Aquifers (Figure 5-23 through Figure 5-26). Other wells exceeding 10 mg/L are more sparsely distributed in the area between Dos Palos and Tranquillity.



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-21. Maximum Nitrate Concentrations, All Wells

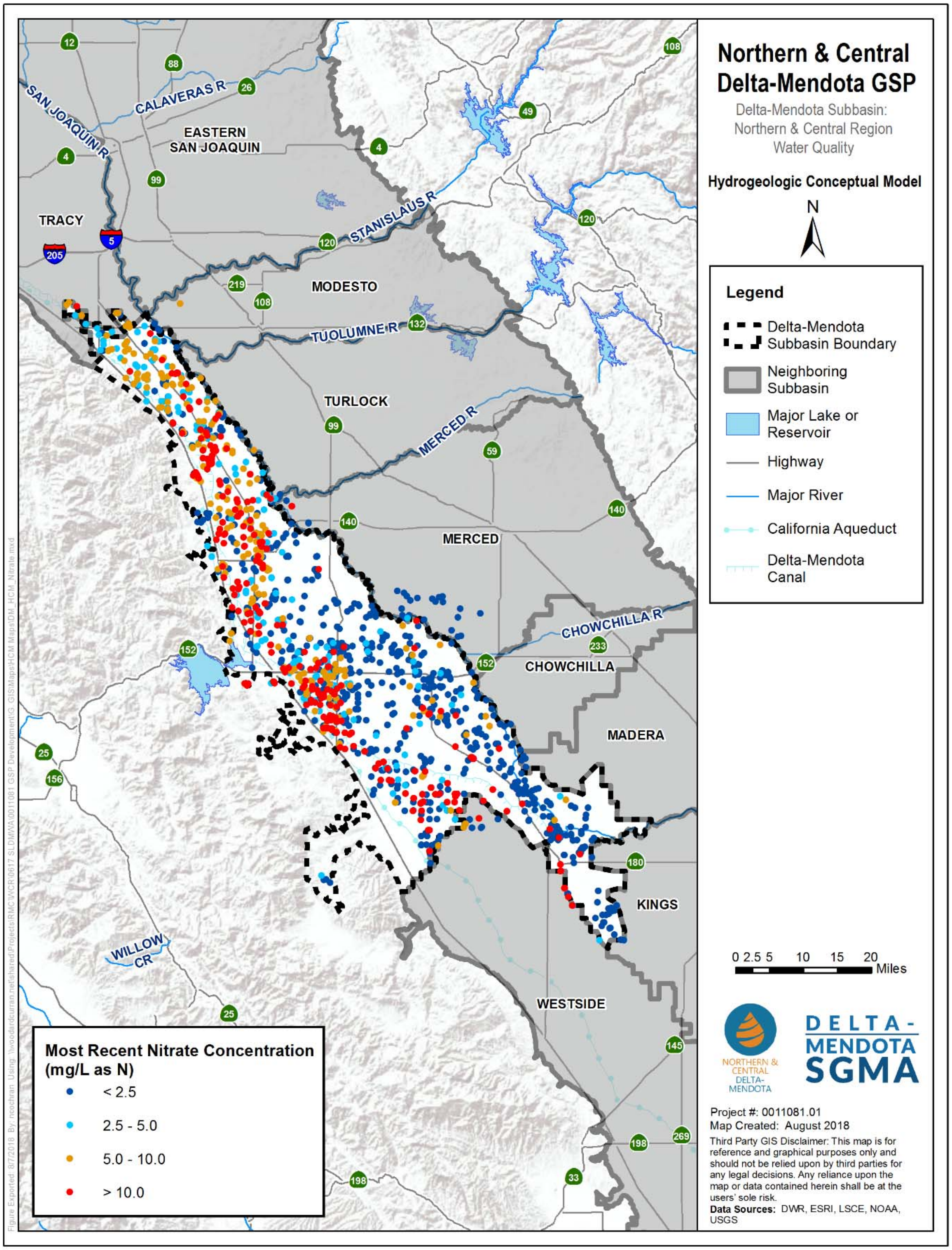
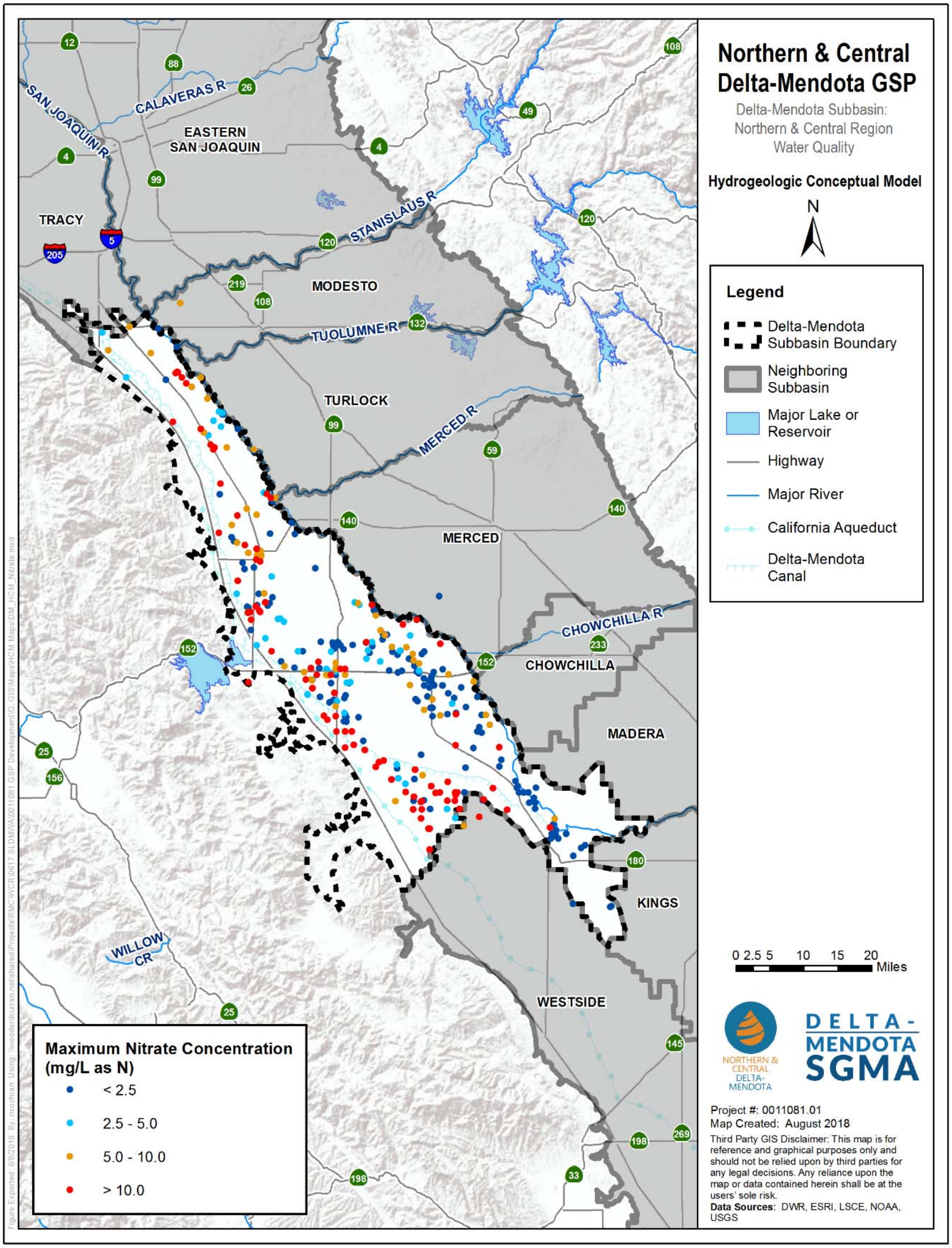


Figure 5-22. Most Recent (2000-2014) Nitrate Concentrations, All Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-23. Maximum Nitrate Concentrations, Above Corcoran Clay

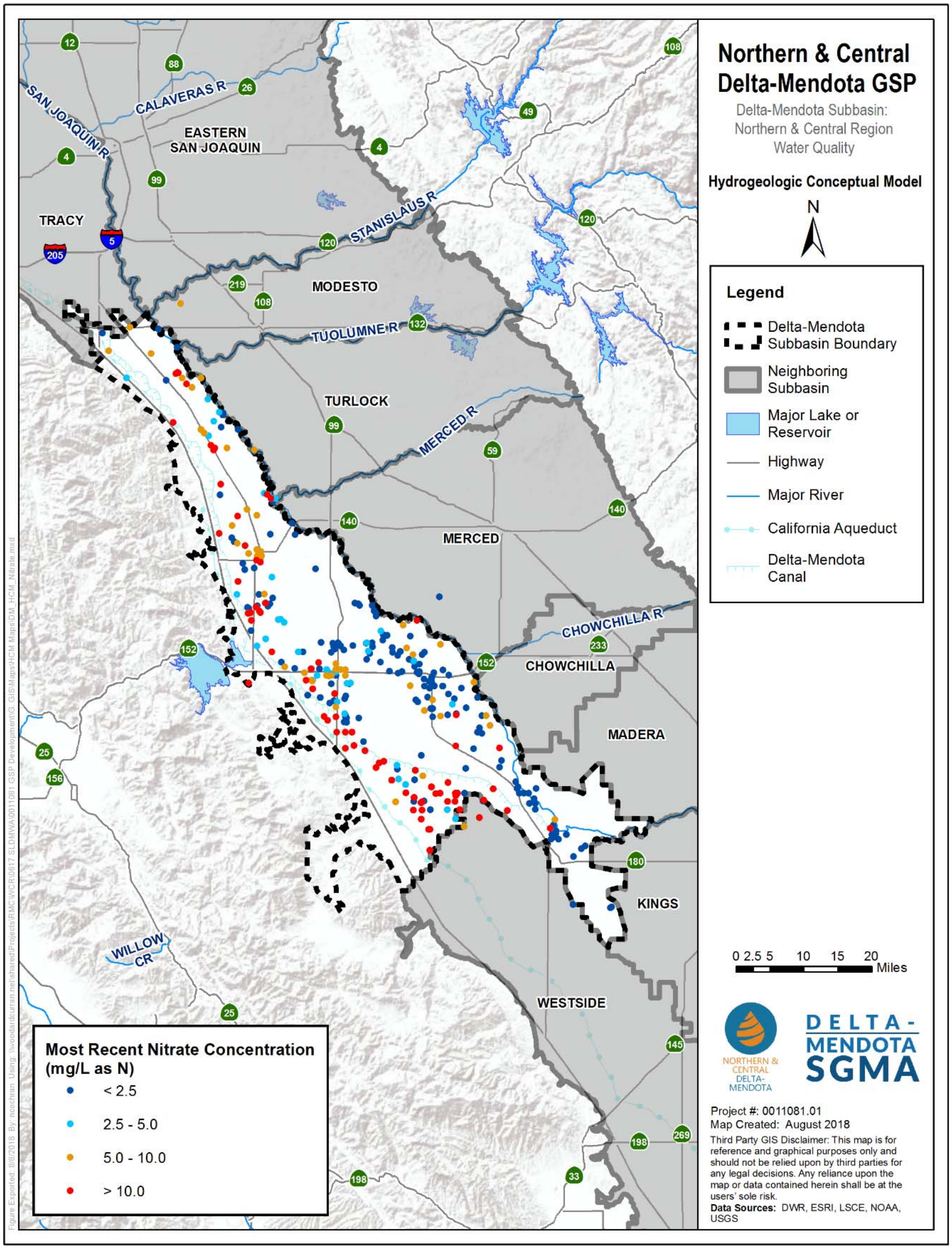
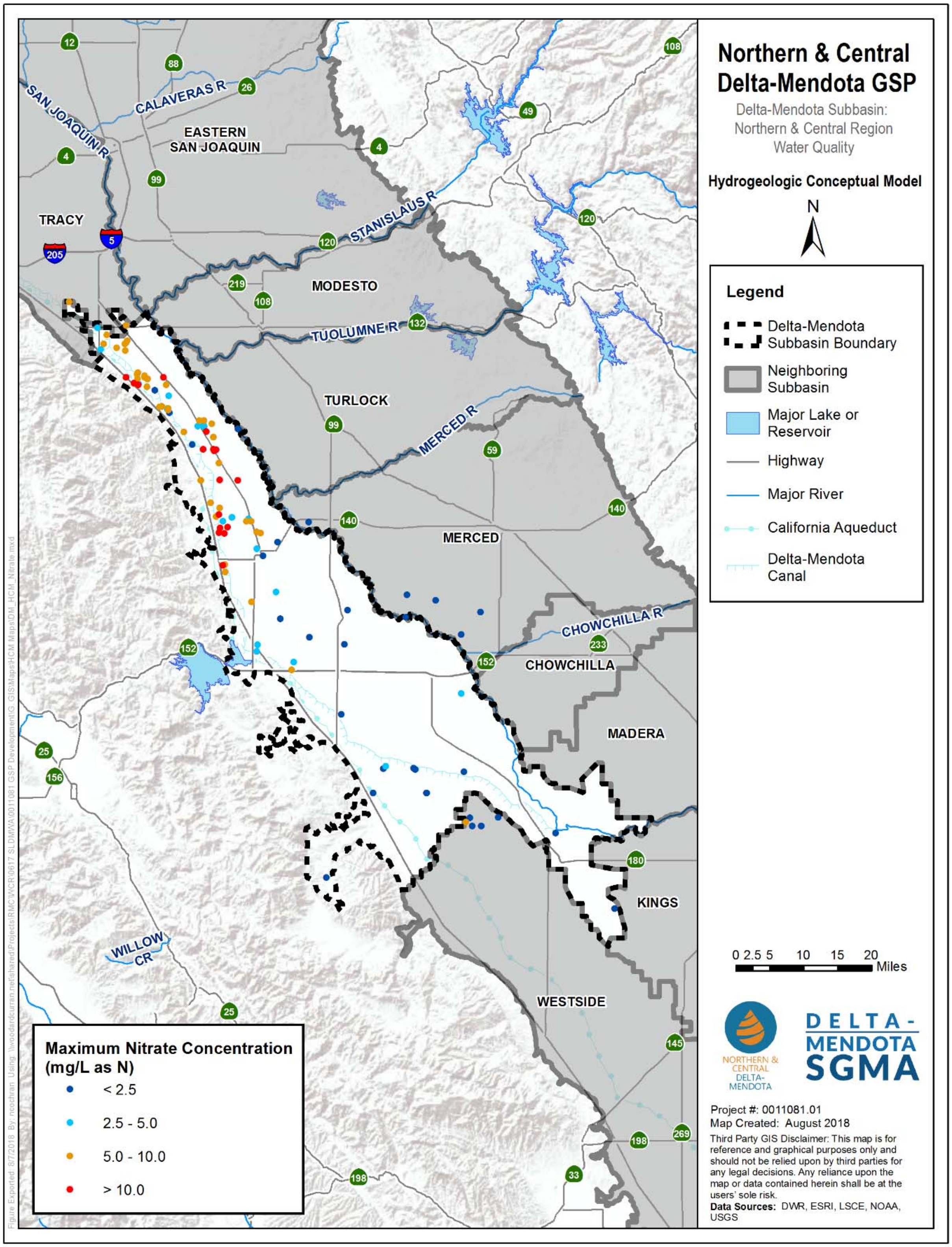


Figure 5-24. Most Recent (2000-2014) Nitrate Concentrations, Above Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-25. Maximum Nitrate Concentrations, Below Corcoran Clay

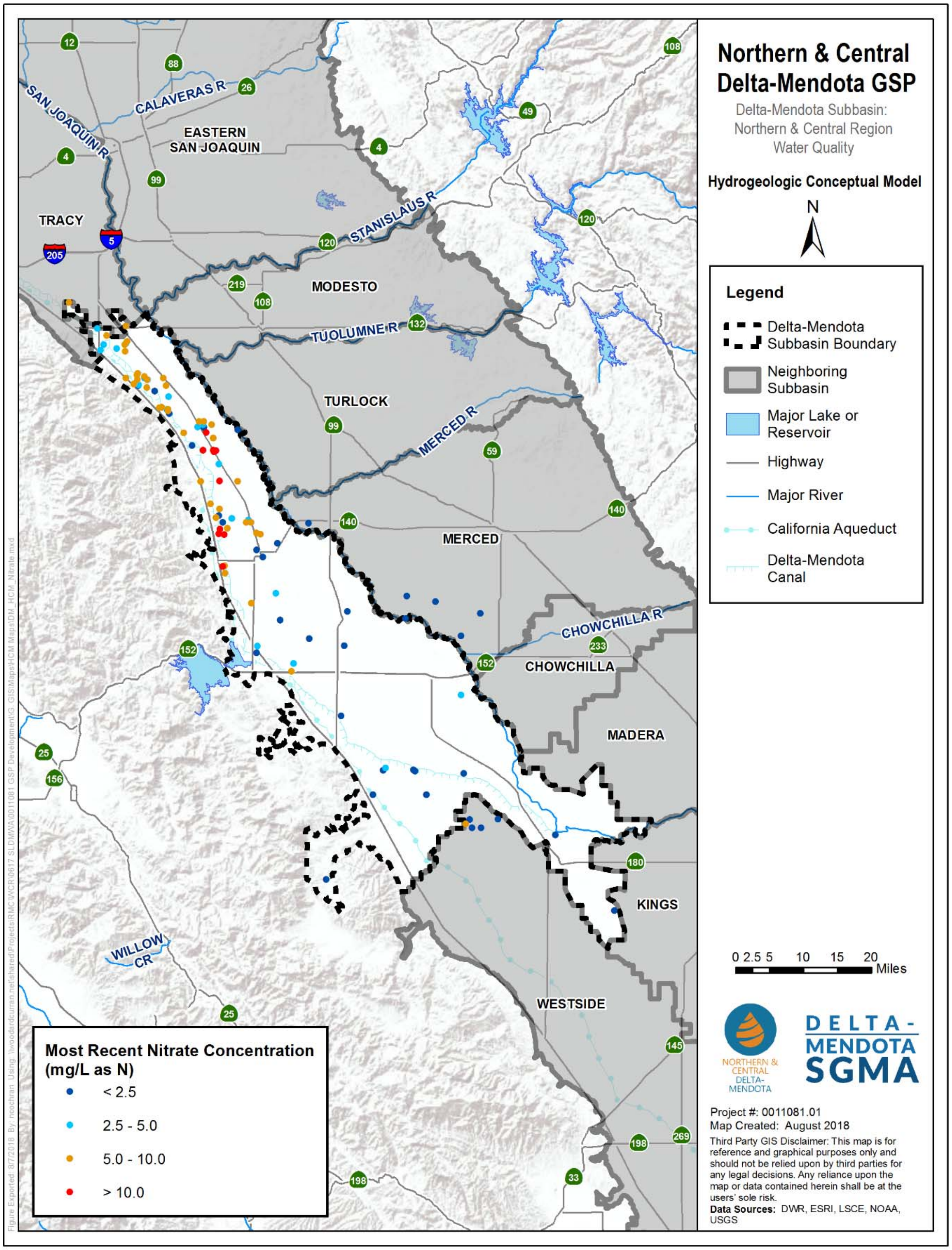
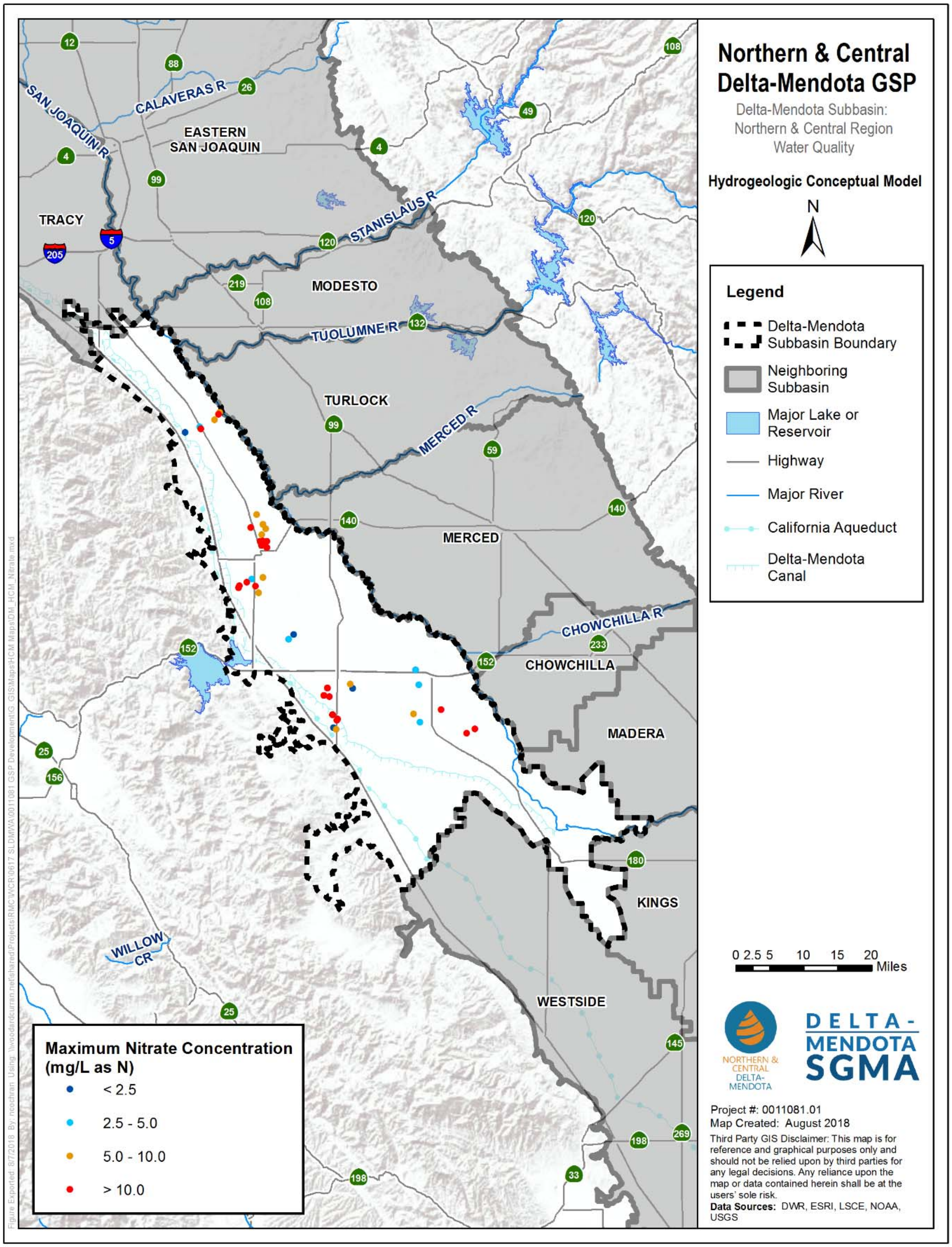


Figure 5-26. Most Recent (2000-2014) Nitrate Concentrations, Below Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-27. Maximum Nitrate Concentrations, Composite Wells

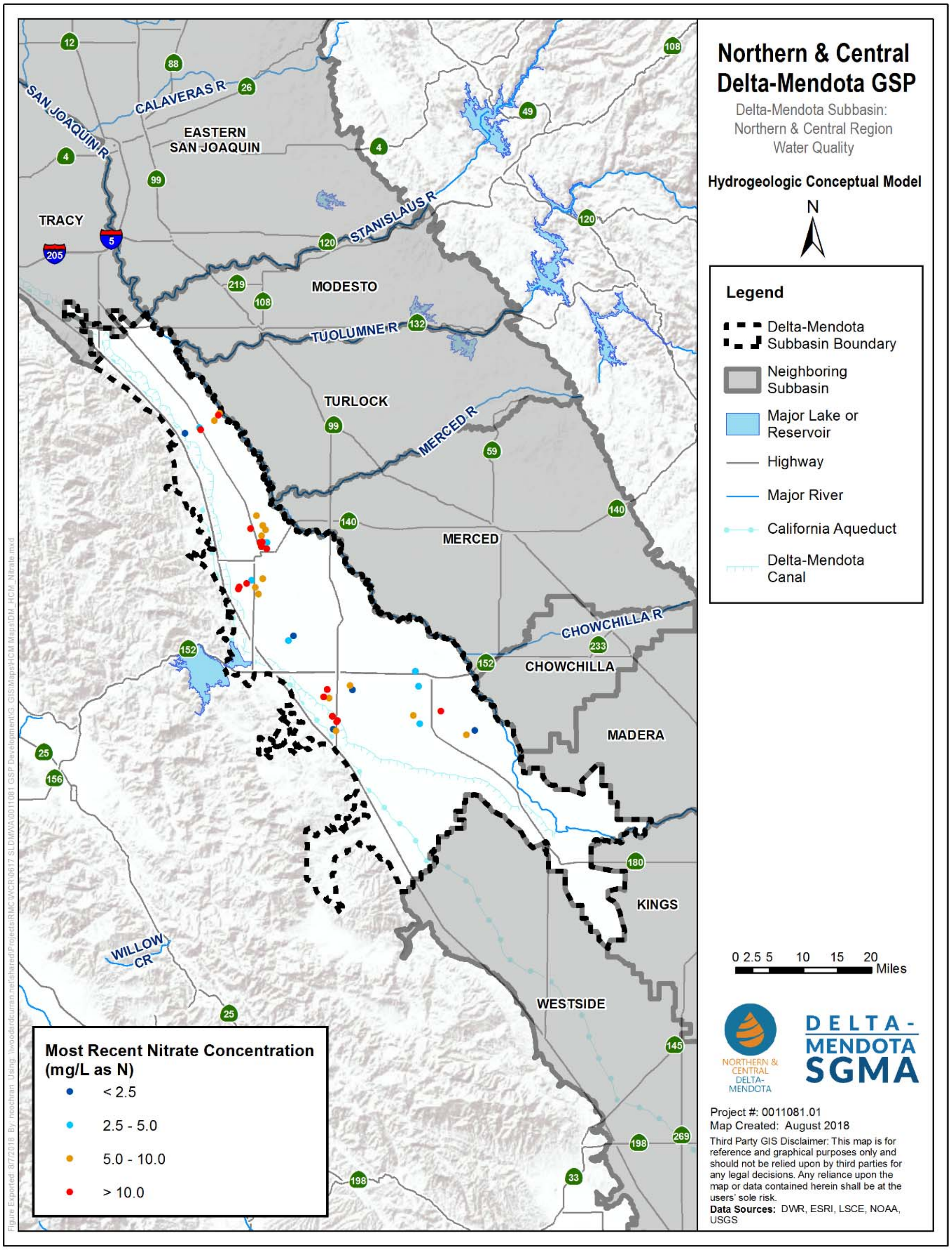
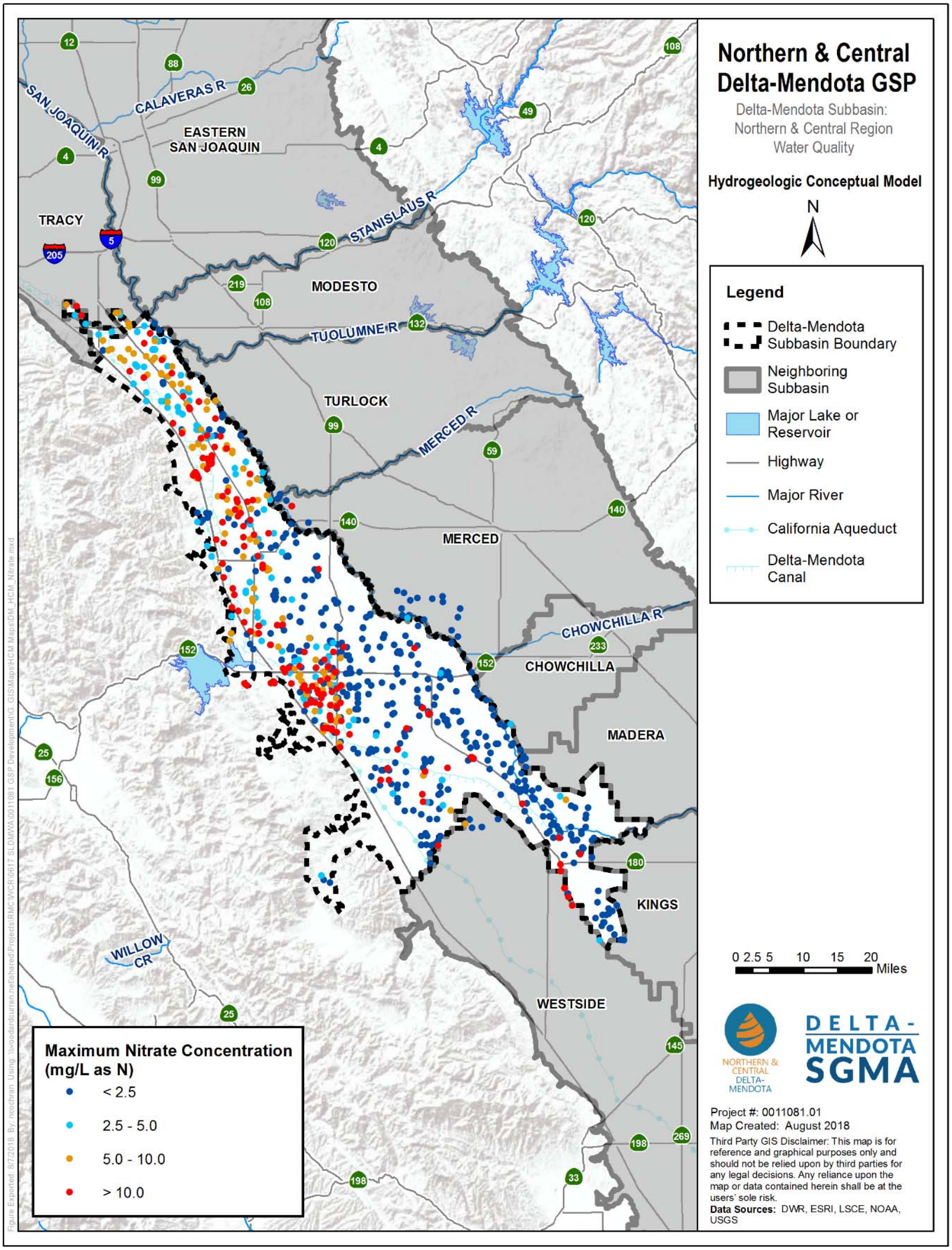


Figure 5-28. Most Recent (2000-2014) Nitrate Concentrations, Composite Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-29. Maximum Nitrate Concentrations, Wells of Unknown Depth

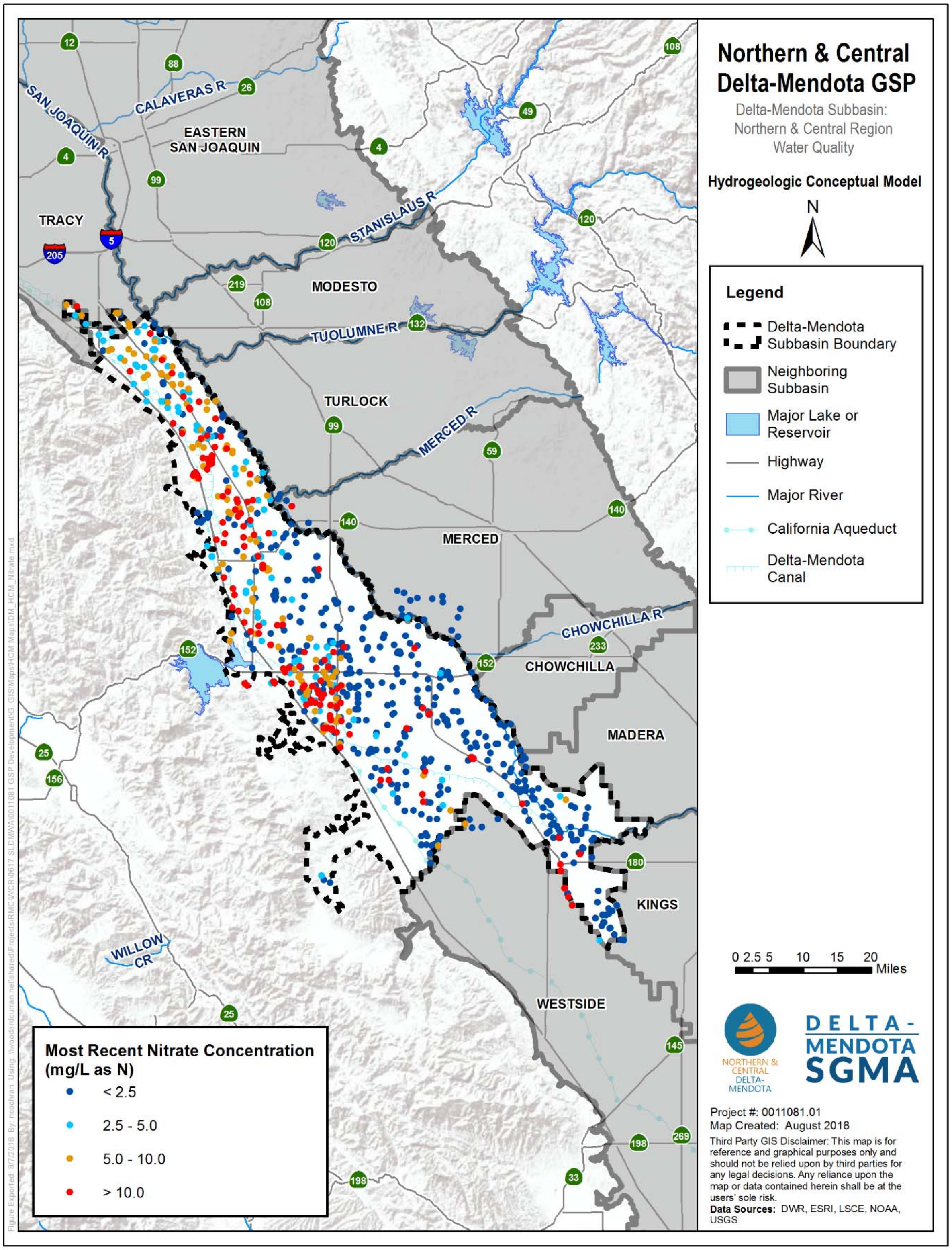


Figure 5-30. Most Recent (2000-2014) Nitrate Concentrations, Wells of Unknown Depth

5.2.8.2.2 TDS Concentrations

Figure 5-31 through Figure 5-40 present the maximum and most recent (for the period around 2000-2014) TDS concentrations in wells within the Delta-Mendota Subbasin and indicate the general salinity of groundwater. The concentration of TDS in drinking water is regulated as a Secondary Drinking Water Standard and the standards are established for aesthetic reasons such as taste, odor, and color and not based on public health concerns. TDS concentrations in groundwater, as shown in Figure 5-31 through Figure 5-40, are symbolized by five classes related to the Secondary MCL (SMCL): less than 500 mg/L, a concentration which is equivalent to the recommended SMCL; 500 to 1,000 mg/L (1,000 mg/L is equivalent to the upper level of the SMCL); 1,000 to 1,500 mg/L; 1,500 to 3,000 mg/L, equivalent and greater than the short-term level of the SMCL; and greater than 3,000 mg/L. The spatial distribution of available TDS data is similar in density to the nitrate data.

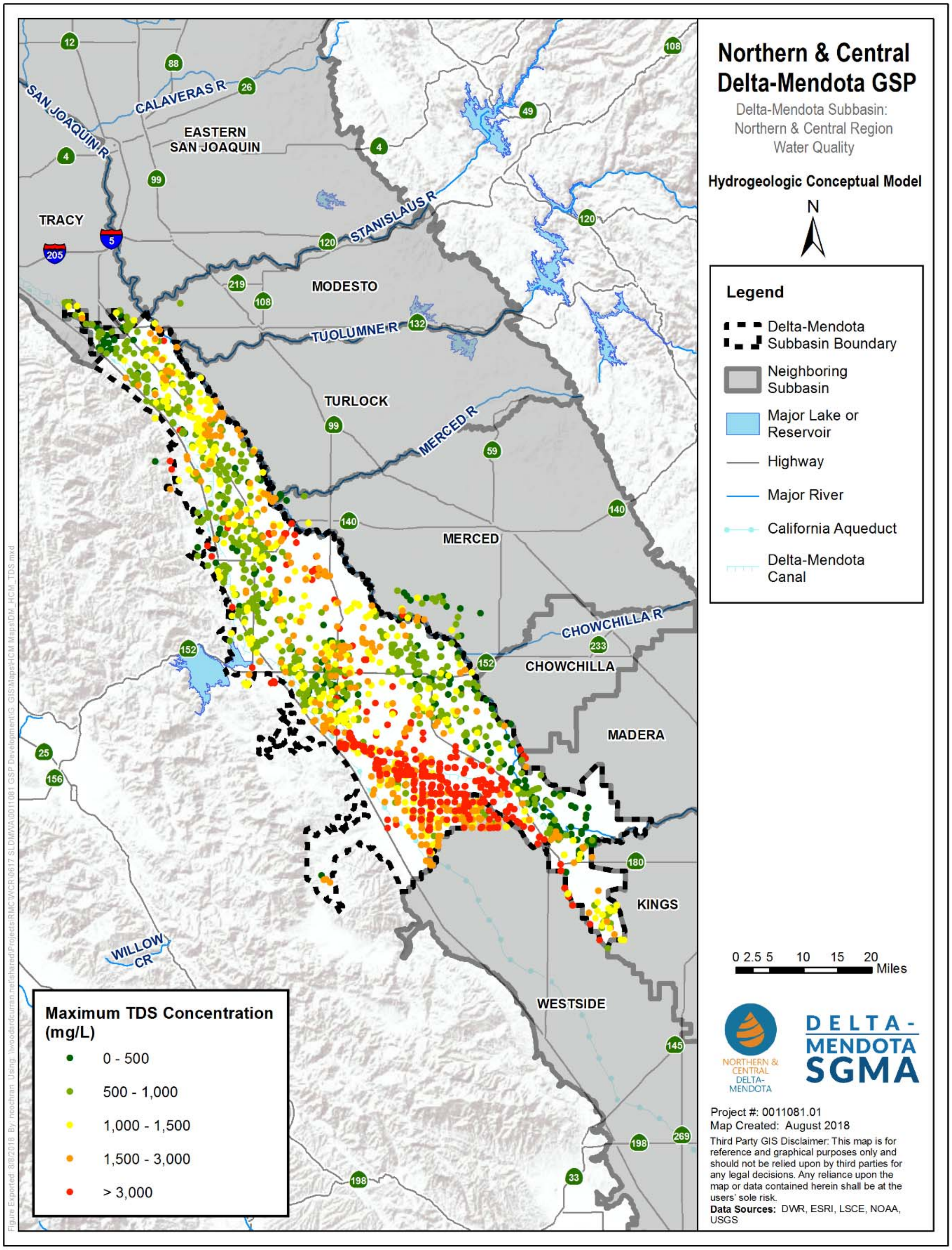
The majority of wells within Delta-Mendota Subbasin have maximum TDS concentrations below 1,000 mg/L, and a general spatial pattern of lower TDS from north of Dos Palos to Mendota is evident in Figure 5-31 and Figure 5-32. An apparent higher density of wells with TDS concentrations greater than 1,500 mg/L is evident in wells from south and southwest of Dos Palos, northwestward to north of Patterson (Figure 5-31). The most recent TDS concentrations (Figure 5-32) are generally below 1,500 mg/L indicating a slight improvement in some wells since the maximum TDS sample was taken.

Above Corcoran Clay

The majority of shallow wells in the Delta-Mendota Subbasin have TDS concentrations that are below 1,500 mg/L and are located near Los Banos and east of Dos Palos (Figure 5-33). Shallow wells with TDS concentrations above 1,500 mg/L are scattered between the area south of Dos Palos to north of Patterson. The most recent TDS concentration data show a similar pattern (Figure 5-34) with a few shallow wells near Los Banos with improving TDS concentrations. No TDS data for shallow wells are available for the Mendota and Tranquillity area. Higher TDS concentrations (greater than 1,500 mg/L) in deeper wells above the Corcoran Clay are observed in the area south of Los Banos and to the north and along the San Joaquin River where poor drainage conditions may exist. TDS concentrations in the remaining Subbasin are largely below 1,500 mg/L (Figure 5-33). The most recent data (Figure 5-34) show very similar patterns as the maximum concentration data with some wells showing improved TDS concentrations.

The majority of very shallow wells (<50 feet in depth) in the southern-central portion of the Subbasin have concentrations exceeding 3,000 mg/L (Figure 5-33). Wells to the south of W. Nees Avenue and east of N. Fairfax Avenue have relatively lower TDS values concentrated. There is a lack of data for very shallow wells in the proximity of the California Aqueduct. A clear trend of decreased TDS values can be seen when comparing the most recent TDS concentrations with the historical maximum values for very shallow wells (Figure 5-34). The area with the greatest number of wells with decreased TDS values is the area bounded by the Delta-Mendota Canal, Merced-Fresno County line, and W. Nees Avenue. For shallow wells, there is a gap in data to the north of the Delta-Mendota Canal (Figure 5-33). A clear trend of increasing TDS values to the east is evident in Figure 5-33 with a majority of the wells located to the east of N. Russell Avenue exceeding 3,000 mg/L. This is in contrast with a considerably high number of wells to the west of N. Russell Avenue having concentrations below 1,000 mg/L.

TDS concentrations seem to be improving in shallow wells (Figure 5-33 and Figure 5-34). Specifically, the most prevalent reductions in TDS concentrations can be observed in the area enclosed by the Delta-Mendota Canal, Merced-Fresno County line, W. Nees Avenue and N. Russell Avenue. TDS data for wells deeper in the Upper Aquifer are sparse (Figure 5-33 and Figure 5-34); all available data points exceed 1,000 mg/L.



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-31. Maximum TDS Concentrations, All Wells

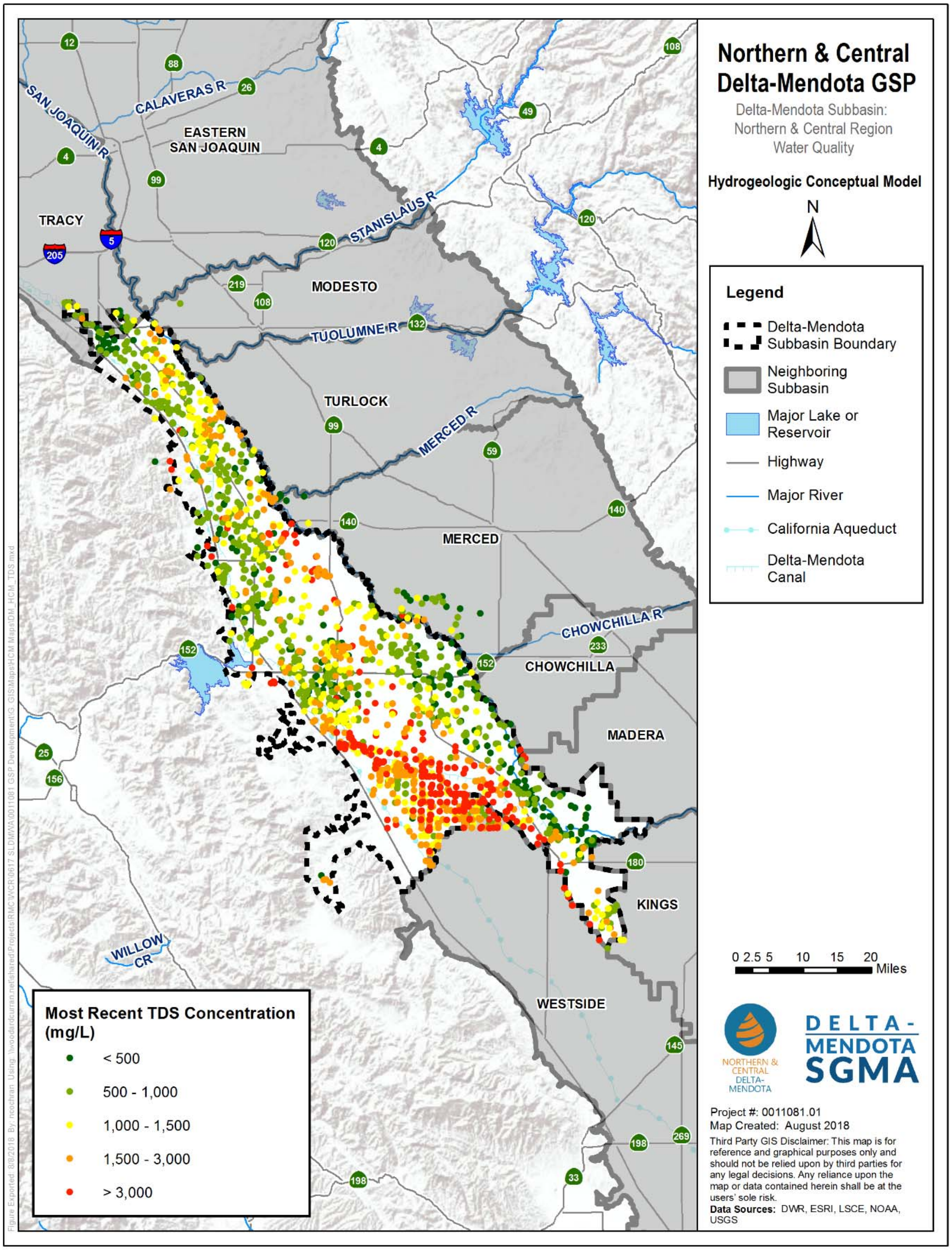
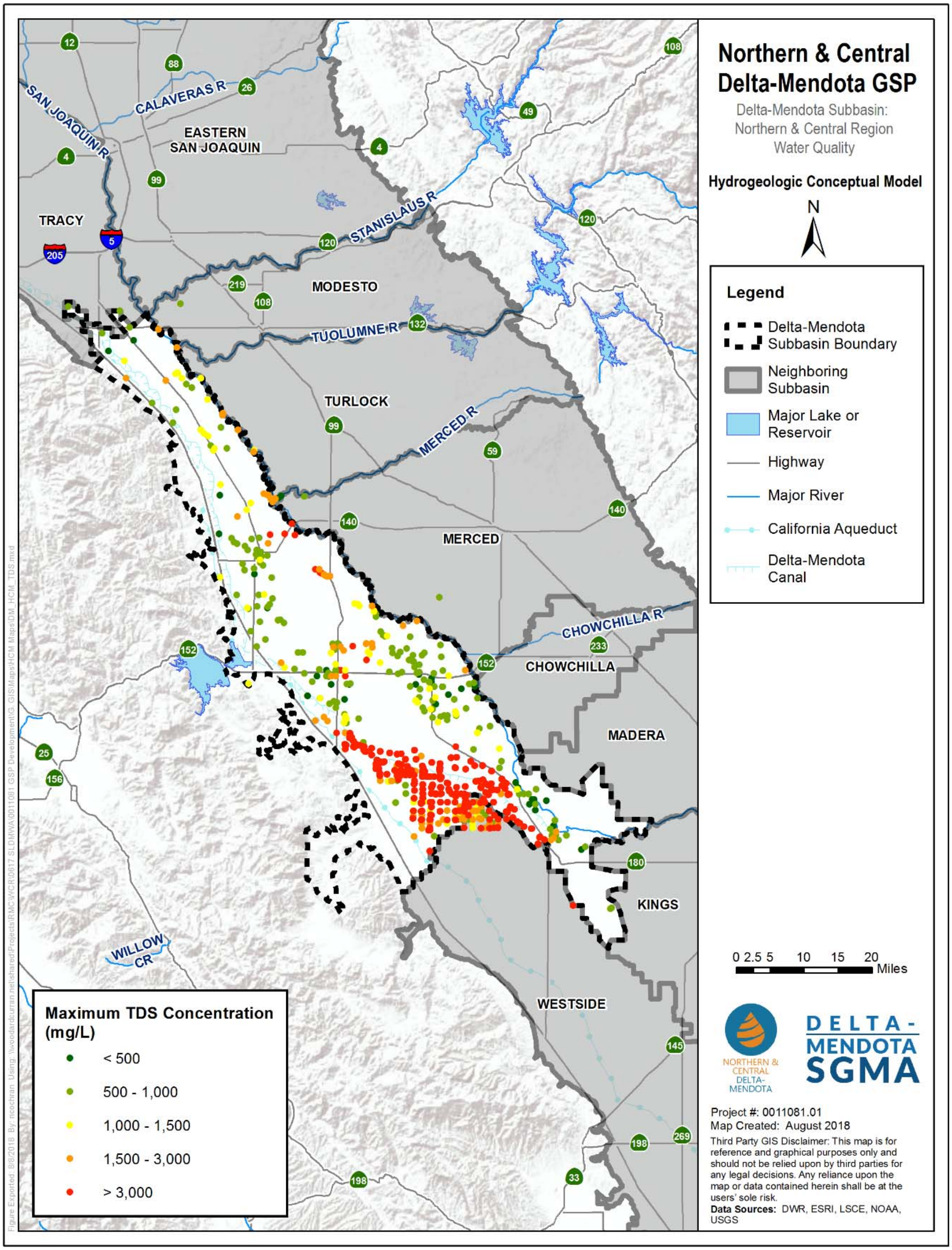


Figure 5-32. Most Recent (2000-2014) TDS Concentrations, All Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-33. Maximum TDS Concentrations, Above Corcoran Clay

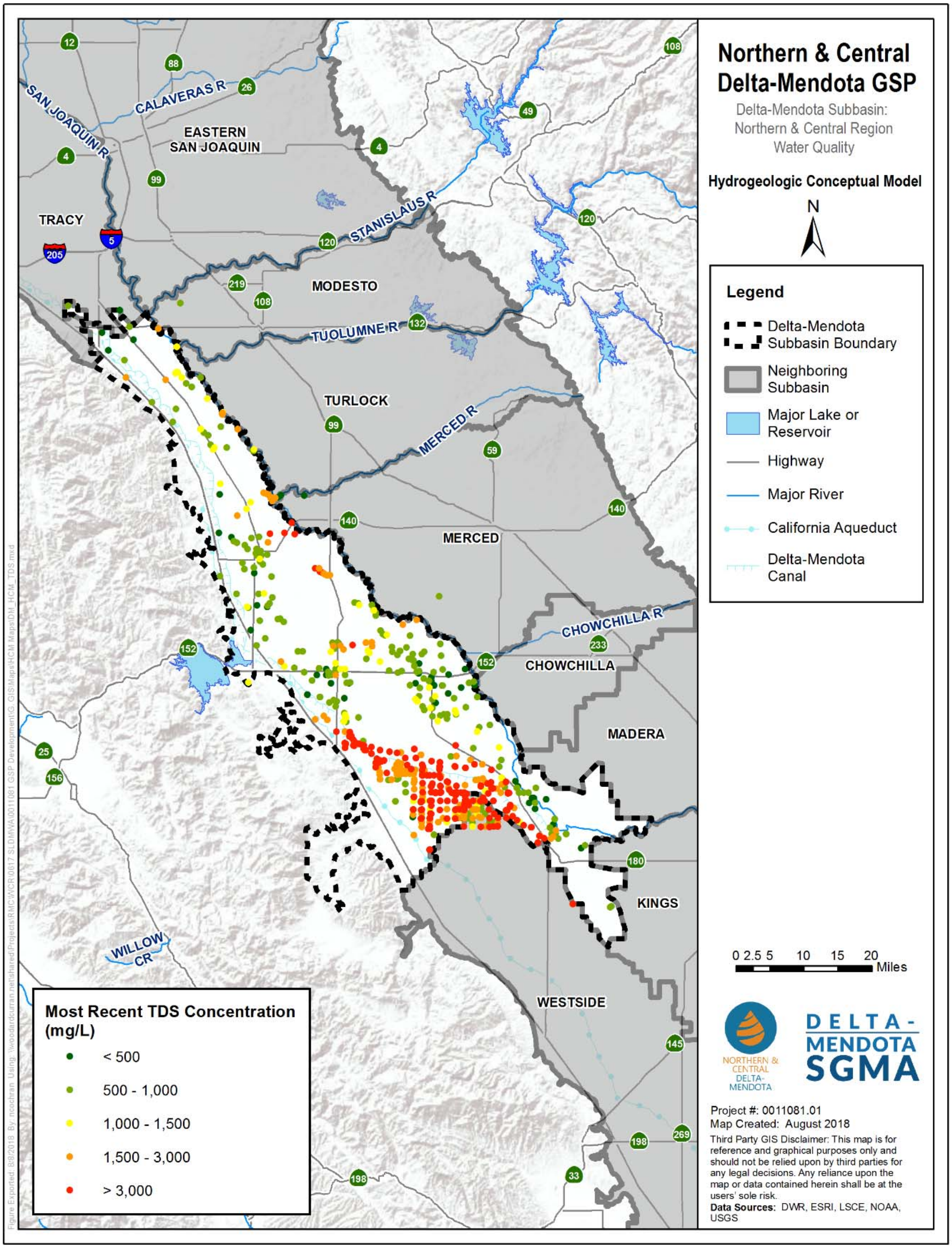


Figure 5-34. Most Recent (2000-2014) TDS Concentrations, Above Corcoran Clay

Below Corcoran Clay

As seen in Figure 5-35 and Figure 5-36, TDS concentration data for wells below the Corcoran Clay are limited compared to above the Corcoran Clay well data and are notably scarce between Los Banos and Tranquillity. However, TDS concentrations north of Los Banos indicate overall lower salinity in the Lower Aquifer than is evident in the Upper Aquifer. A majority of the wells in the Lower Aquifer show maximum TDS concentrations below 1,500 mg/L with maximum TDS concentrations below 1,000 mg/L in most wells along the northwestern edge of the Delta-Mendota Subbasin (Figure 5-35). A few wells with TDS concentrations above 1,500 mg/L are scattered between Los Banos and north of Patterson. The most recent data (Figure 5-36) highlight the same patterns evident in the maximum concentration data. Few TDS concentration data exist southeast of Los Banos for the Lower Aquifer, although the minimally available data suggest deeper TDS concentrations in these areas are mostly less than 1,500 mg/L.

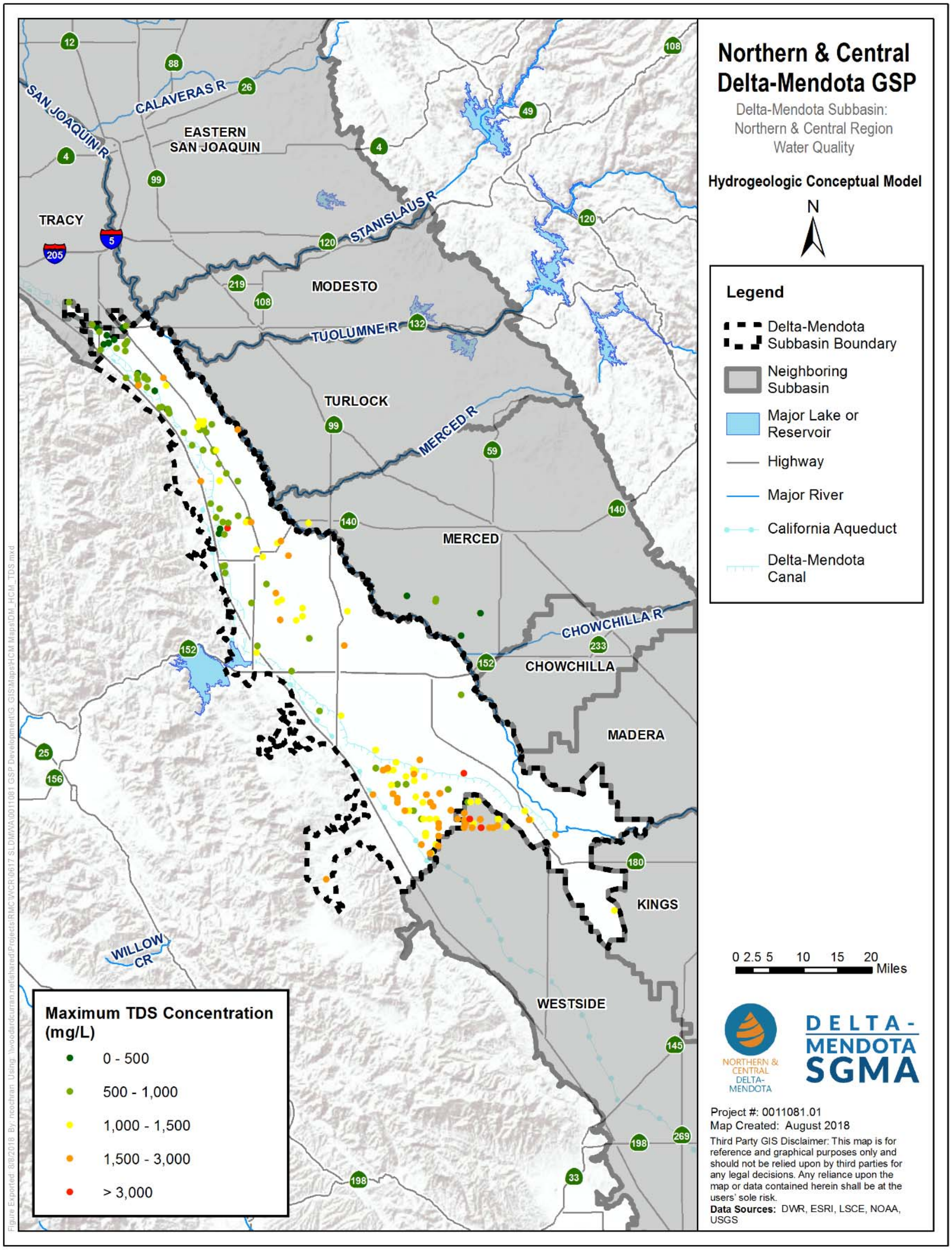
In the south-central portion of the Subbasin, the majority of data points from the Lower Aquifer exceed 1,000 mg/L (Figure 5-35). Wells with data are dispersed throughout this portion of the Subbasin with very little data available north of the Delta-Mendota Canal. A similar data distribution is seen in Figure 5-36 with very little data available north of the Delta-Mendota Canal. Most recent TDS concentrations also reflect historic maximums with most samples exceeding 1,000 mg/L.

Composite Wells

Figure 5-37 depicts maximum TDS concentration data for composite wells screened both above and below the Corcoran Clay, whereas Figure 5-38 presents the most recent concentration data for composite wells. Very few TDS concentrations are available for the composite well category, but most results are below 1,500 mg/L.

Wells of Unknown Depth

As shown in Figure 5-39 and Figure 5-40, much TDS concentration data exist for wells of unknown depth. These figures show a similar pattern to the Upper Aquifer TDS Concentration maps (Figure 5-33 and Figure 5-34) with the exception of a band of wells that exceed 1,500 mg/L south of Dos Palos and also south of Mendota that may be related to the saline front originating in the Coast Range. Several areas with higher densities of wells with lower TDS concentrations can be seen in Figure 5-39 and Figure 5-40. The area north of Dos Palos, and also the area between Dos Palos and Mendota, have a particularly high density of wells of unknown depth with lower TDS concentrations that are mostly less than 1,000 mg/L.



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-35. Maximum TDS Concentrations, Below Corcoran Clay

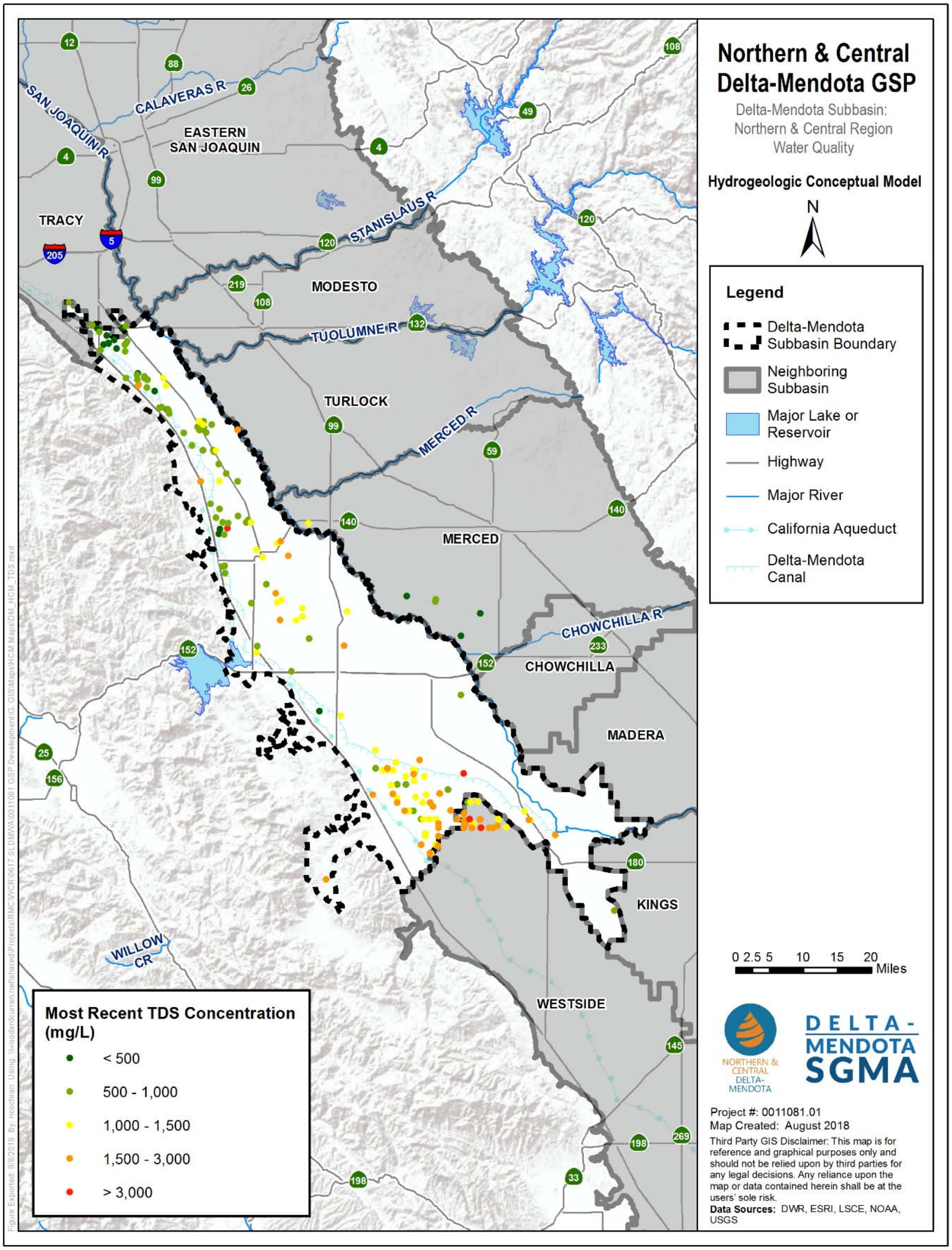
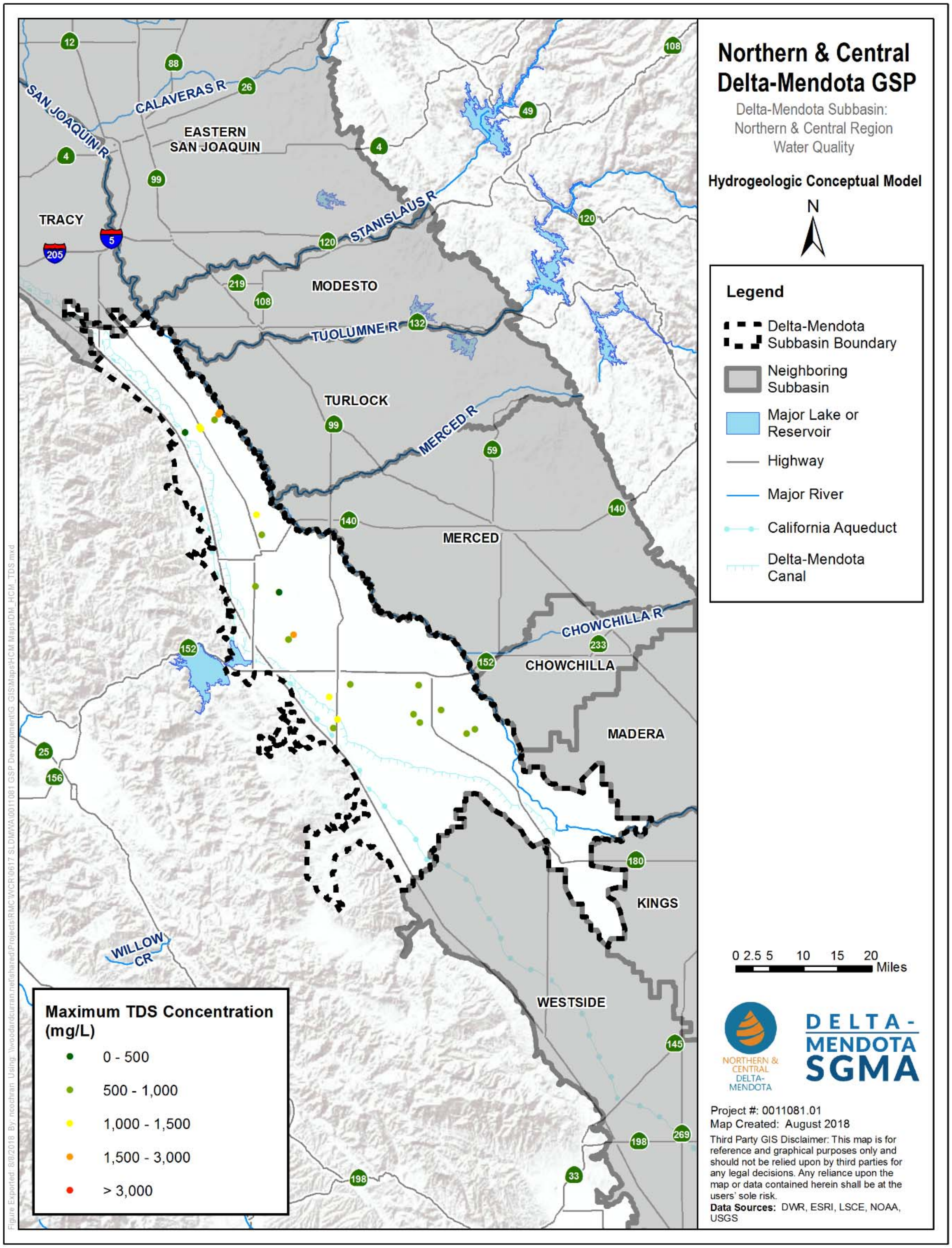


Figure 5-36. Most Recent (2000-2014) TDS Concentrations, Below Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-37. Maximum TDS Concentrations, Composite Wells

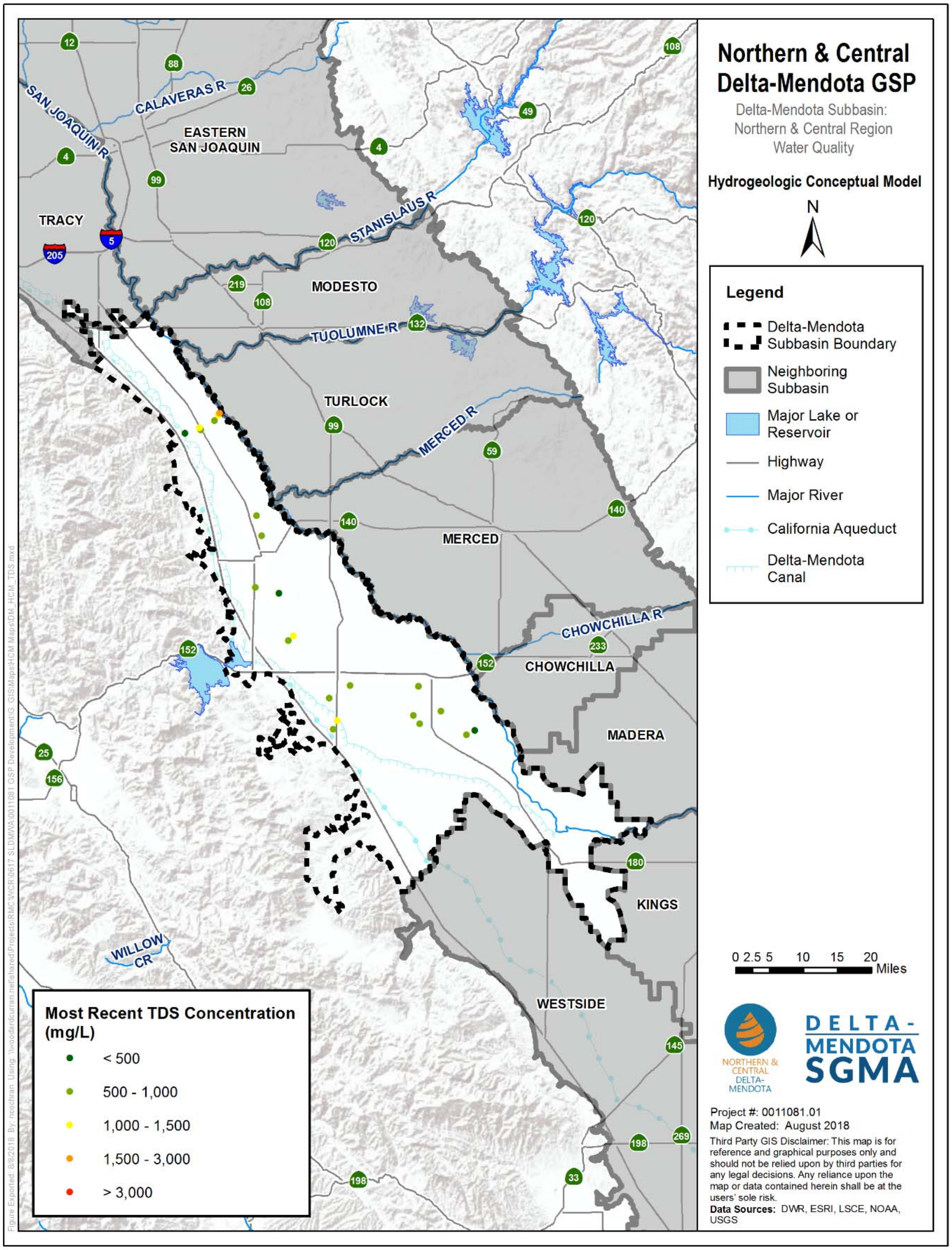
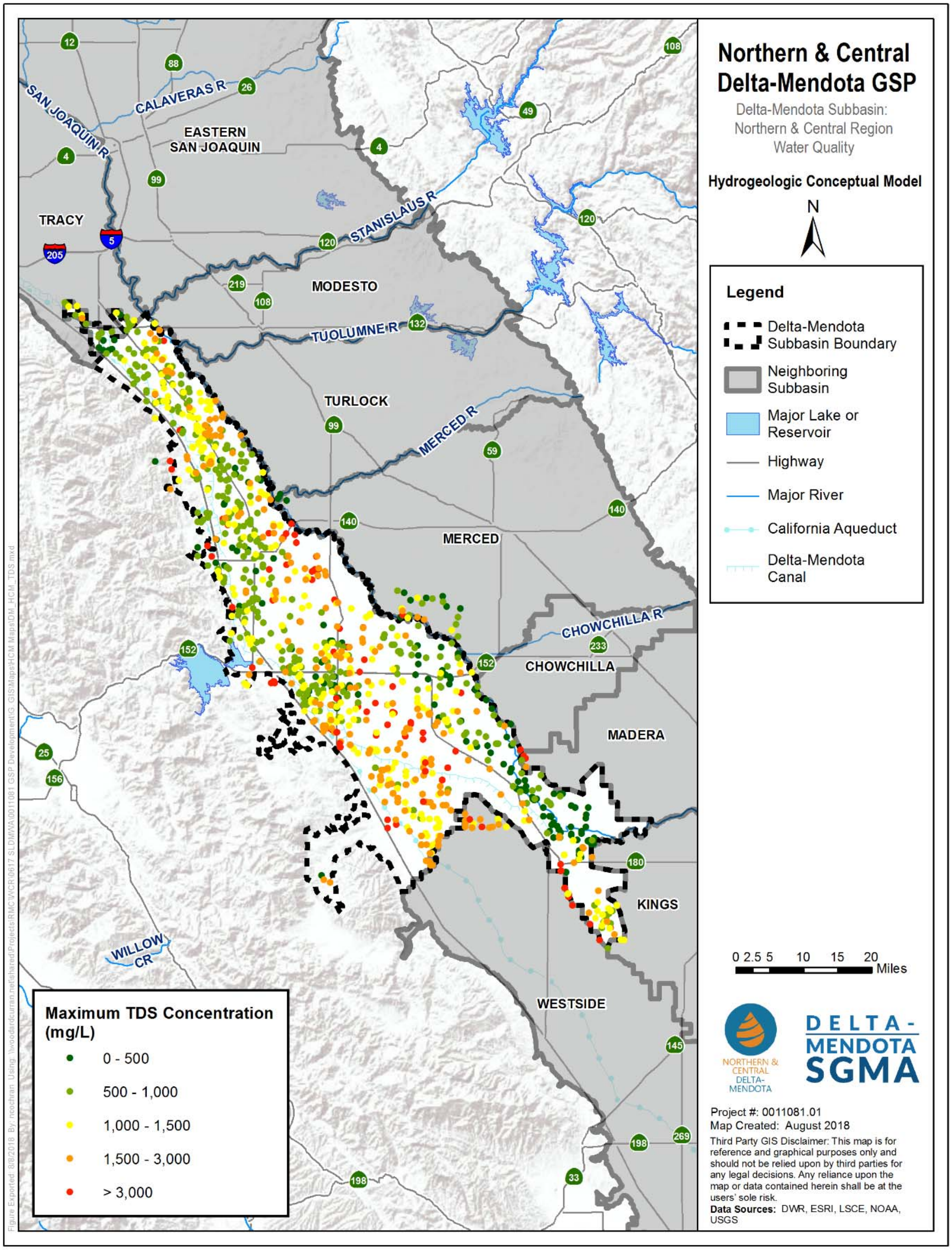


Figure 5-38. Most Recent (2000-2014) TDS Concentrations, Composite Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-39. Maximum TDS Concentrations, Wells of Unknown Depth

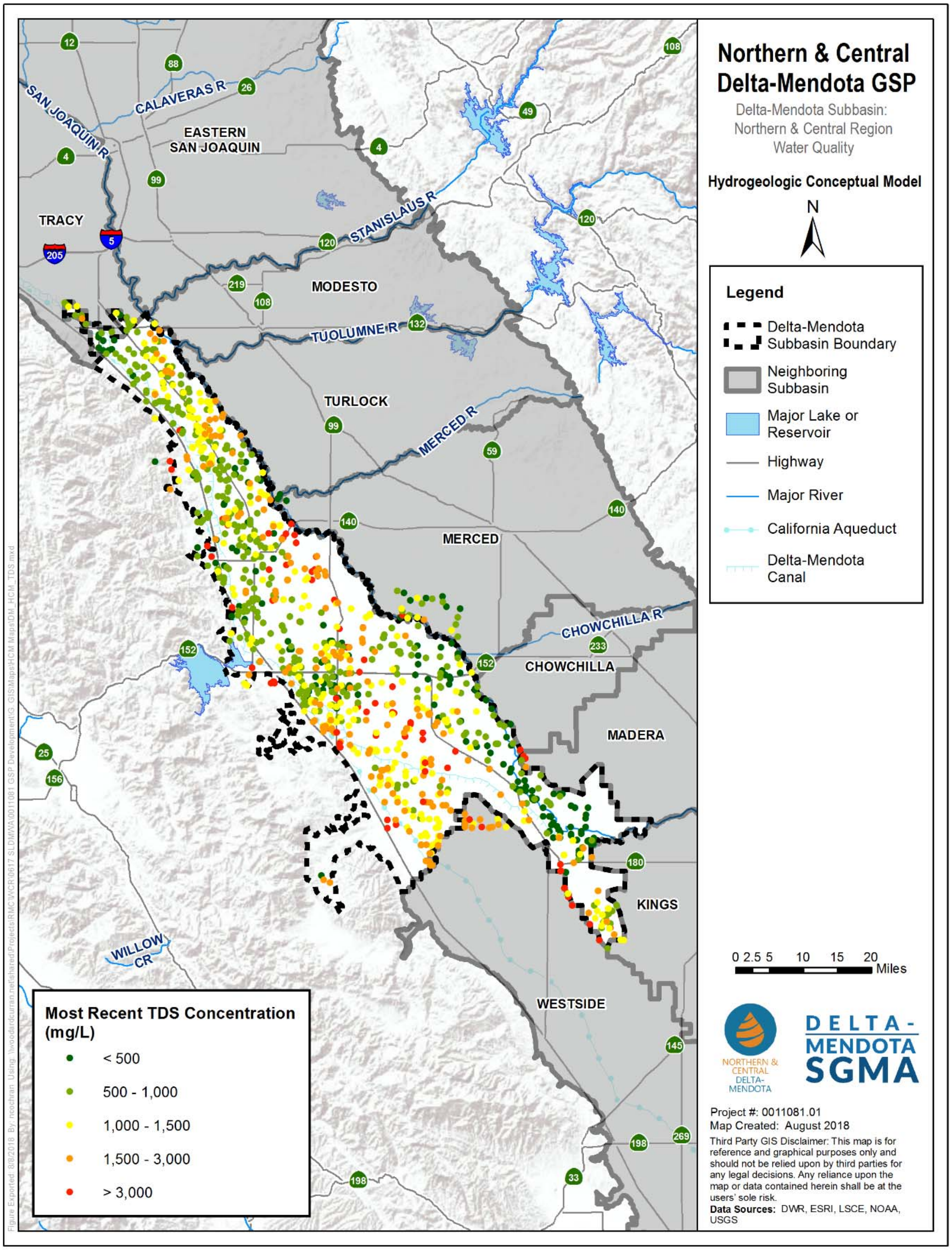


Figure 5-40. Most Recent (2000-2014) TDS Concentrations, Wells of Unknown Depth

5.2.8.2.3 Pesticides

Pesticide concentration data for the Delta-Mendota Subbasin are limited to data obtained from the California Department of Pesticide Regulation (DPR), as originally presented in Luhdorff & Scalmanini Consulting Engineers (LSCE) (2015) and LSCE (2016). Pesticide data available from DPR are for wells, but locations are only provided at the spatial resolution of the Public Land Survey System (PLSS) section in which the well is located and well depths are not reported or available for most wells. Figure 5-41 shows the locations of sections where wells have been sampled for pesticides and where pesticide test results are reported by DPR and include sections that may only be partially within the Subbasin. Because well locations are not provided with these pesticide data, it is possible that wells in sections that are only partly within the subbasin actually fall outside of the Subbasin.

Sections with detected concentrations of pesticides exceeding levels provided in the State Water Resources Control Board (SWRCB) Water Quality Goals Online Database are symbolized red in Figure 5-41; sections where pesticide detections have occurred at concentrations below the identified exceedance threshold are symbolized as orange, and green sections signify areas where pesticides were not detected. Figure 5-41 shows all available pesticide sample data from DPR within the Delta-Mendota Subbasin. Table 5-1 summarizes pesticides that have been detected in wells that are in sections that overlap with the Subbasin completely or partially, as reported in the DPR database. The threshold values used as a basis for identifying pesticide exceedances are also included in Table 5-1. The thresholds used to define pesticide exceedances were based first on a California Primary MCL; otherwise, the California Notification (action) Level and U.S. Environmental Protection Agency (EPA) Health and Water Quality advisory concentrations were used for comparison, as available.

Data for a total of 475 wells (in 258 PLSS sections) tested for pesticides in the study area were available from DPR. Of the 475 wells tested, eight unique wells had detectable concentrations of a pesticide (Table 5-1). As shown in Table 5-1, 486 instances of pesticide detections were recorded within the Delta-Mendota Subbasin; however, some wells had detectable concentrations of multiple pesticides. Of the 258 sections that had wells tested, 62 sections had wells with detectable concentrations of a pesticide and 6 sections had wells with exceedances. As shown in Figure 5-41, a higher density of pesticide detections and exceedances has occurred in the northern part of the Delta-Mendota Subbasin, from south of Gustine to north of Patterson.

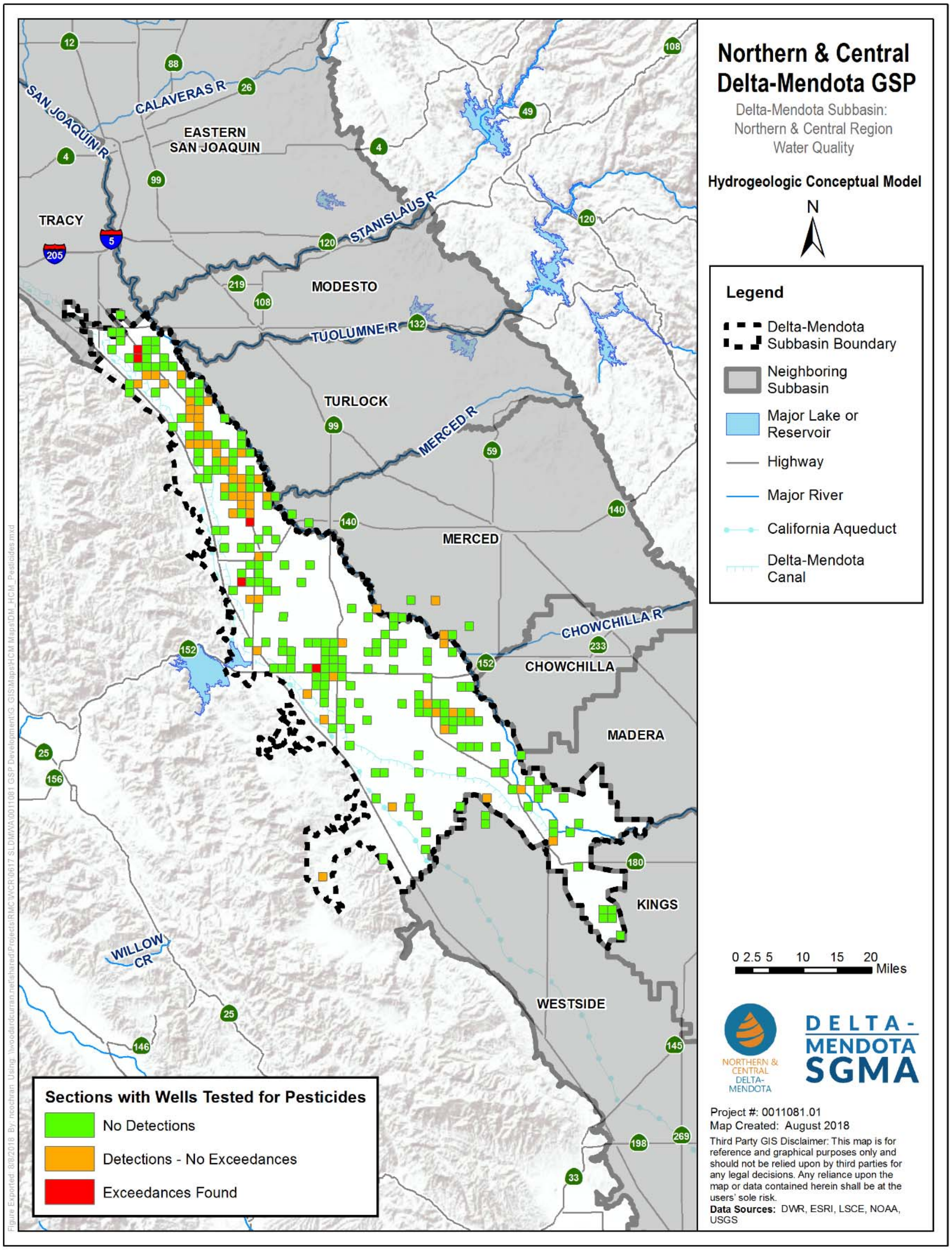


Figure 5-41. Pesticide Detections and Exceedances by Section

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Table 5-1. Summary of Pesticide Detections and Exceedances

Pesticide	Wells Sampled	Wells with Detection	Number of Sample Detections	Wells with Exceedance	Sections Sampled	Sections with Detection	Sections with Exceedance	Concentration in Samples with Detections (µg/L) Average	Minimum	Maximum	Exceedance Threshold[1] (µg/L)	Basis for Exceedance Threshold[1]
1,2-Dichloropropane (Propylene Dichloride)	204	1	1	0	129	1	0	0.039	0.039	0.039	5	
2,6-Diethylaniline	45	1	1	0	34	1	0	0.005	0.005	0.005	-	-
2-Hydroxycyclohexyl Hexazinone	8	1	1	0	6	1	0	0.126	0.126	0.126	-	-
3,4-Dichloro Aniline	45	5	5	0	34	4	0	0.048	0.004	0.215	-	-
3,5-Dichloro Aniline	40	1	1	0	30	1	0	0.004	0.004	0.004	-	-
ACET (Deisopropylatrazine)	68	1	1	0	46	1	0	0.052	0.052	0.052	-	-
Alachlor ESA	40	18	23	0	28	11	0	0.53	0.05	1.38	4	WI DNR PAL
Alachlor OXA	36	1	2	0	24	1	0	0.051	0.05	0.051	-	-
Atrazine	314	10	14	0	189	8	0	0.063	0.006	0.2	1	CA Primary MCL
Carbon Disulfide	64	3	3	0	43	3	0	0.373	0.03	1.06	160	California State Notification (Action) Level
Chlorthal-Dimethyl	52	1	1	0	40	1	0	0.004	0.004	0.004	-	-
DBCP (Dibromochloropropane)	214	15	292	2	123	10	2	0.234	0.005	10.1	0.2	CA Primary MCL
Deethyl-Atrazine (DEA)	113	11	11	0	80	9	0	0.012	0.005	0.028	-	-
Diaminochlorotriazine (DACT)	60	1	1	0	38	1	0	0.091	0.091	0.091	-	-
Diuron	165	7	17	0	104	7	0	0.204	0.07	0.73	2	U.S. EPA Health Advisory Cancer[2]
EPTC	57	5	5	0	43	5	0	0.03	0.008	0.074	40	MN HBV (Chronic)
Ethylene Dibromide	158	3	6	3	98	3	3	0.266	0.08	0.48	0.05	CA Primary MCL
Hexazinone	148	10	11	0	94	9	0	0.047	0.009	0.094	-	-

Pesticide	Wells Sampled	Wells with Detection	Number of Sample Detections	Wells with Exceedance	Sections Sampled	Sections with Detection	Sections with Exceedance	Concentration in Samples with Detections (µg/L) Average	Minimum	Maximum	Exceedance Threshold[1] (µg/L)	Basis for Exceedance Threshold[1]
Metalaxyl	47	2	2	0	36	1	0	0.035	0.015	0.054	-	-
Metolachlor	133	4	4	0	73	2	0	0.024	0.013	0.045	44	U.S. EPA Water Quality Advisory Concentration[3]
Metolachlor ESA	36	25	31	0	24	17	0	2.928	0.05	24	-	-
Metolachlor OXA	36	11	15	0	24	8	0	0.473	0.05	2.65	-	-
Molinate	114	3	3	0	59	3	0	0.01	0.007	0.01	20	CA Primary MCL
Prometon	236	8	8	0	157	8	0	4.413	0.021	13.4	-	-
Prometryn	217	2	2	0	136	2	0	0.004	0.001	0.006	-	-
Simazine	309	22	24	1	183	19	1	0.59	0.004	6.8	4	CA Primary MCL
Tebuthiuron	60	1	1	0	48	1	0	0.011	0.011	0.011	-	-

"-" No threshold established or identified

1. Source of threshold: California Environmental Protection Agency, State Water Resources Control Board, Compilation of Water Quality Goals (https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/)
2. U.S. EPA Health Advisory, Cancer Risk Level. Likely to be carcinogenic to humans.
3. National Recommended Ambient Water Quality Criteria to protect human health from consumption of water and aquatic organisms, cancer risk level

Reference: *Western San Joaquin River Watershed Groundwater Quality Assessment Report* (LSCE, 2015).and *Grassland Drainage Area Groundwater Quality Assessment Report* (LSCE, 2016)

5.2.8.2.4 Selenium and Boron

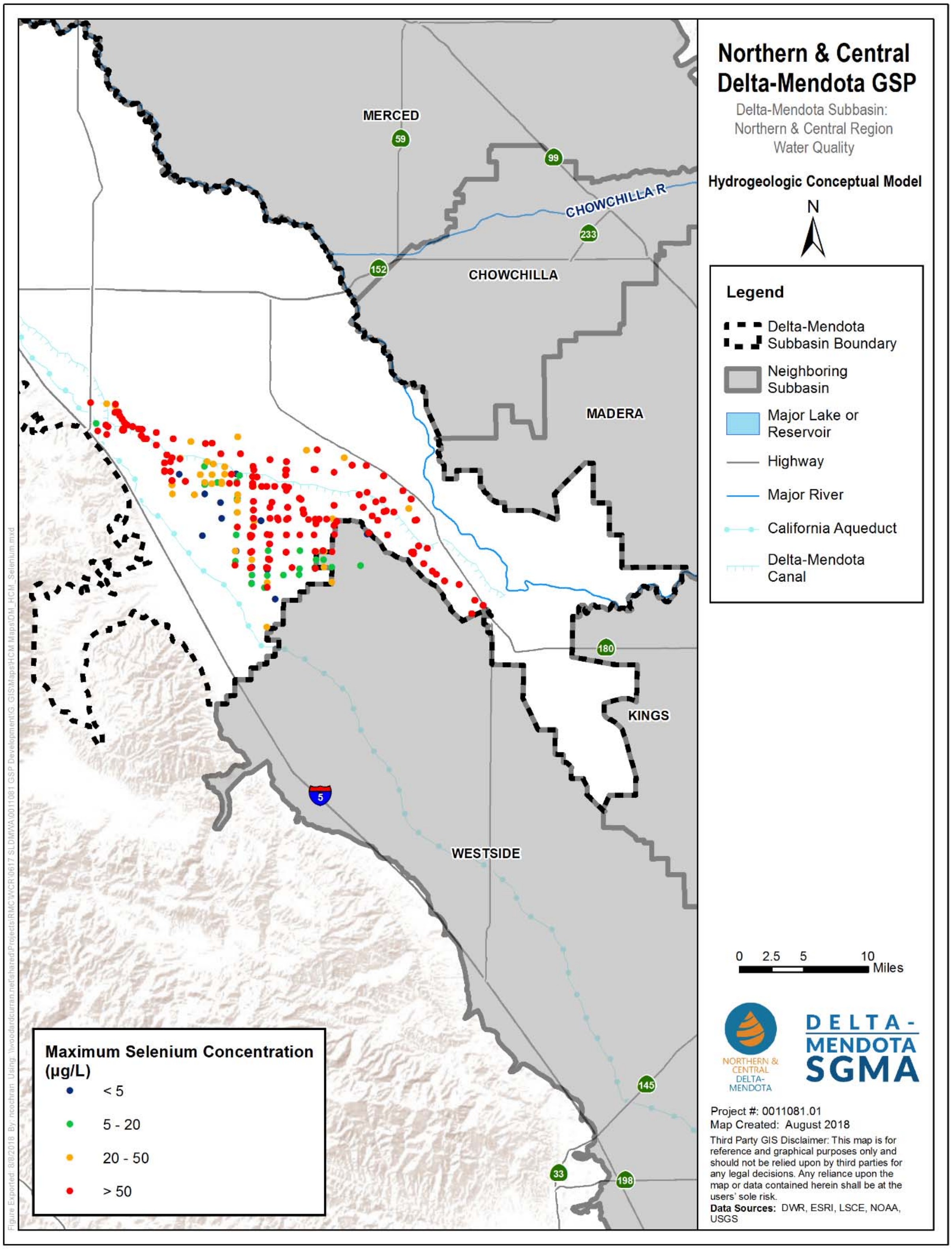
Although both selenium and boron are naturally occurring in the Delta-Mendota Subbasin and are not necessarily a product of impacts from irrigated agriculture, understanding the patterns and trends of their concentrations in groundwater within the Subbasin is helpful for the management of irrigated agriculture, particularly as it relates to sources of selenium in drainage water and boron concentrations in groundwater used for irrigation. Selenium is a natural element commonly found in soils and also occurring in groundwater. High selenium concentrations in groundwater and drainage water, especially in the southern portion of the Subbasin, have been a persistent issue. Selenium is an essential nutrient for humans; however, high concentrations can present health concerns. Selenium has a Primary MCL for drinking water of 50 micrograms per liter (µg/L) and a California Public Health Goal of 30 µg/L. Selenium can be toxic for aquatic wildlife at considerably lower levels and selenium concentrations in discharges of drainage water to surface waterways regulated under the Grassland Bypass Project Water Discharge Requirements (WDRs) have thresholds below the MCL and Public Health Goal.

Boron has no drinking water MCL, although it has a California Action Level of 1.0 mg/L and an agricultural goal of 0.7 mg/L. Many agricultural crops are sensitive to high boron concentrations and its presence in groundwater is a consideration for use of groundwater for irrigation purposes.

Figure 5-42 through Figure 5-57 depict the historical maximum and most recent concentrations (about 2000 to 2014) for selenium and boron in the southern portion of the Delta-Mendota Subbasin, the portion of the subbasin where these constituents are of key concern. These figures are also divided by primary aquifer for each of the constituents. The units for selenium concentrations displayed on the figures are in micrograms per liter (µg/L) whereas boron concentrations are presented in milligrams per liter (mg/L).

Figure 5-42 highlights the maximum concentrations of selenium observed historically within the southern portion of the Subbasin. The majority of the datapoints show maximum historical concentrations exceeding the MCL of 50 µg/L, but an improvement is evident in the most recent concentrations of selenium in Figure 5-43. Although most locations exhibit concentrations above 50 µg/L, some pockets of lower selenium concentrations exist, most notably in the area to the northwest of the W. Nees Avenue and N. Russell Avenue intersection where concentrations are below 20 µg/L.

Historical maximum concentration data for boron above and below the Corcoran Clay is shown in Figure 5-50, and the most recent data are presented in Figure 5-51. Most of these data show historical boron concentrations above 2 mg/L, a level which is considerably above the agricultural goal of 0.7 mg/L.



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-42. Maximum Selenium Concentrations, All Wells

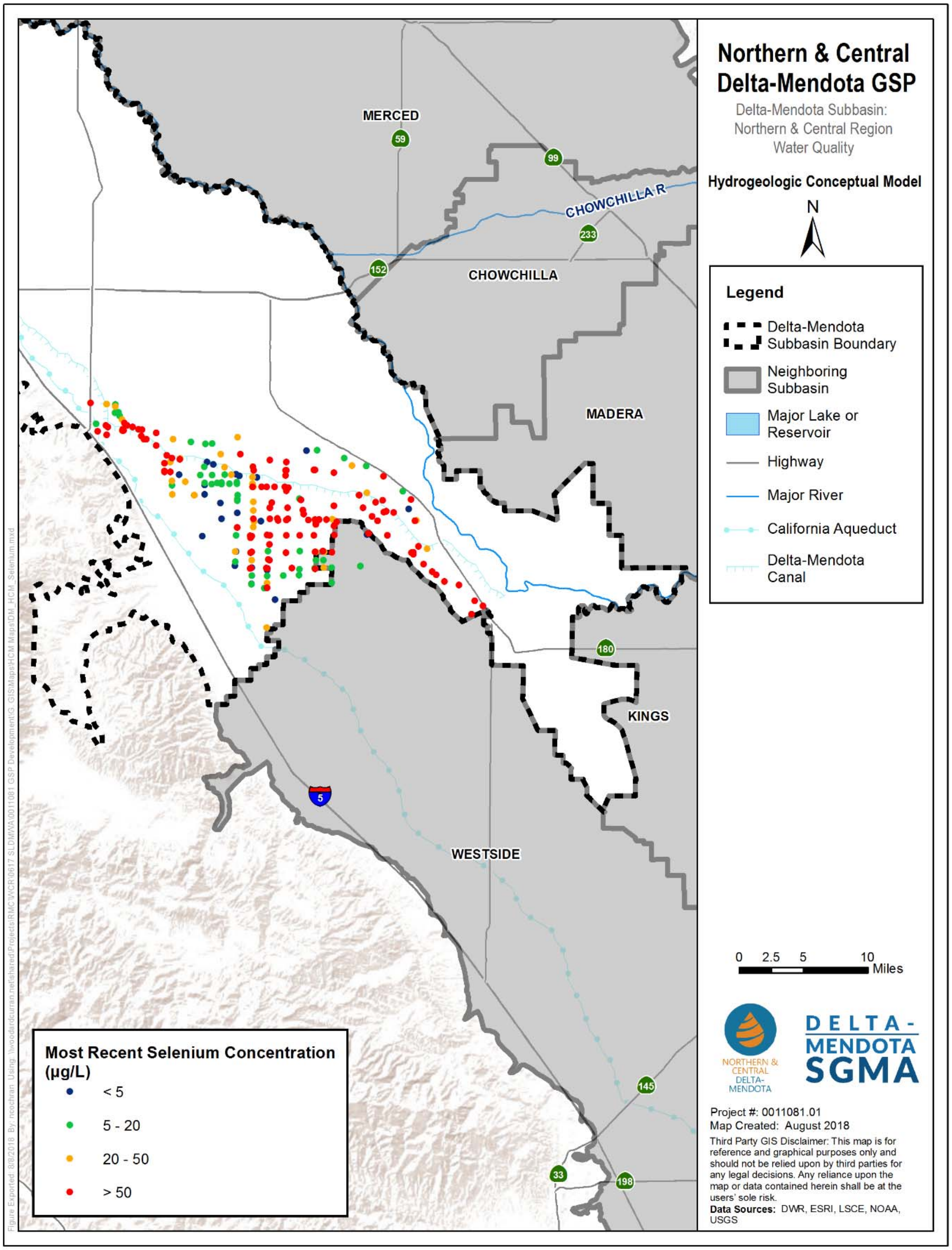
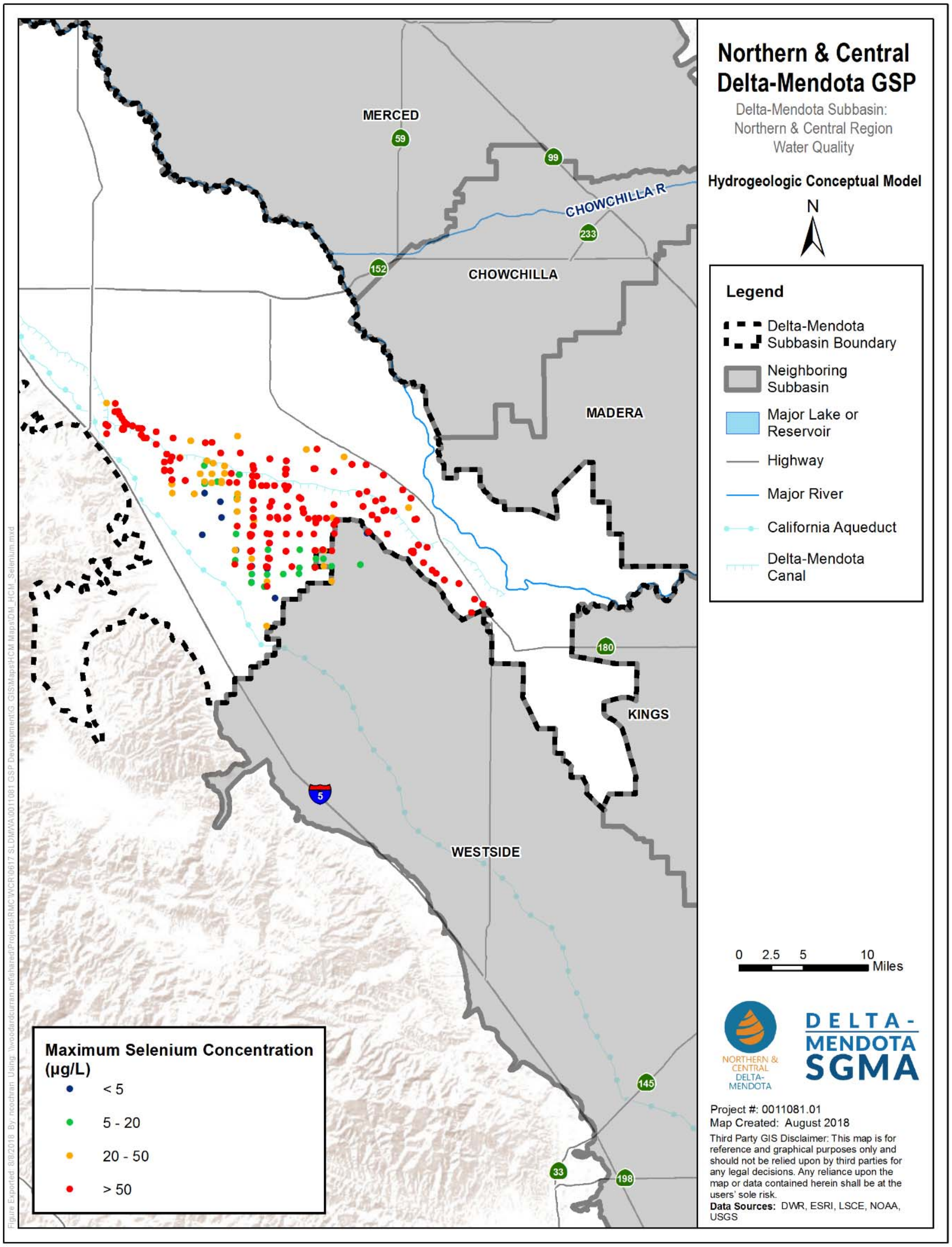


Figure 5-43. Most Recent (2000-2014) Selenium Concentrations, All Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-44. Maximum Selenium Concentrations, Above Corcoran Clay

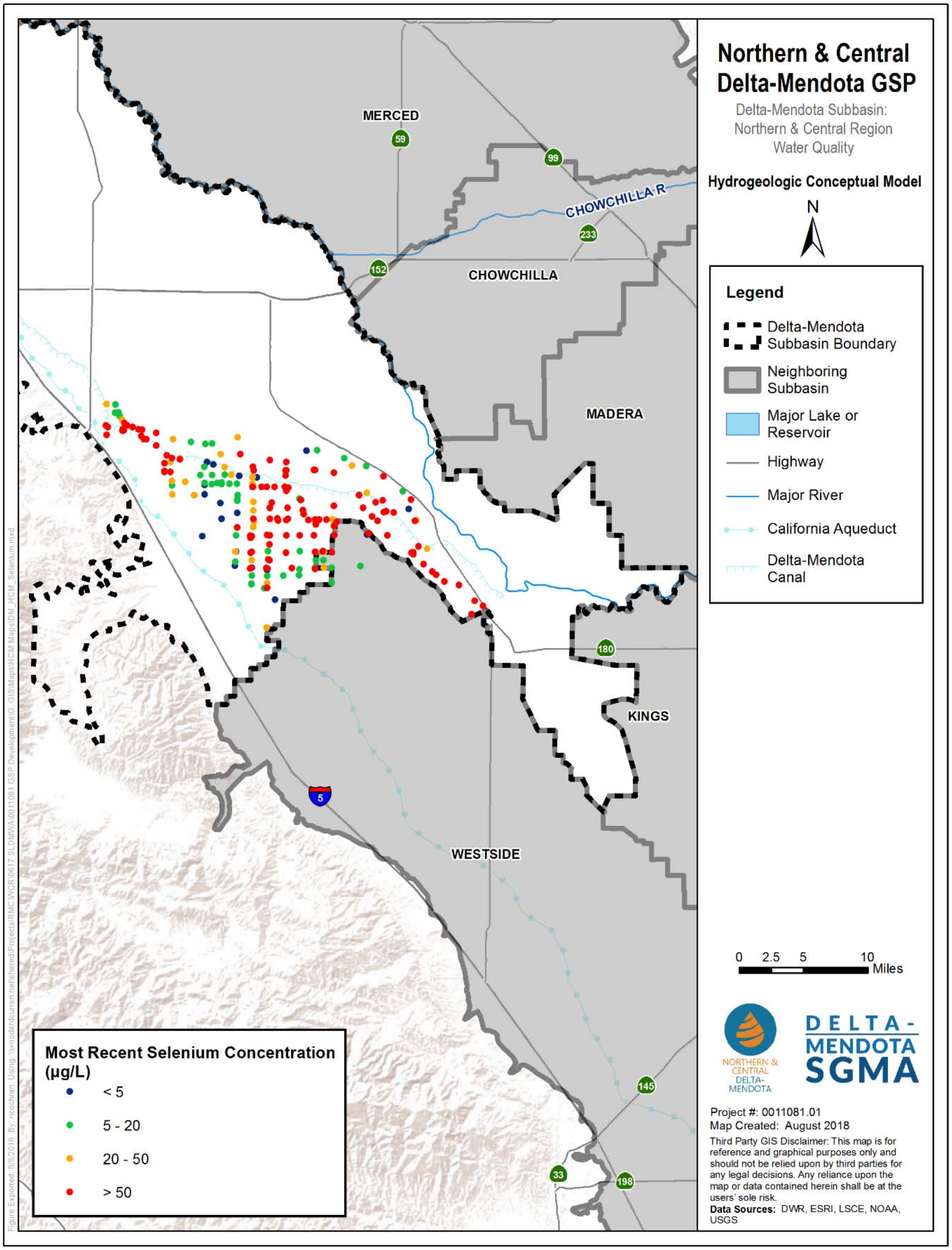
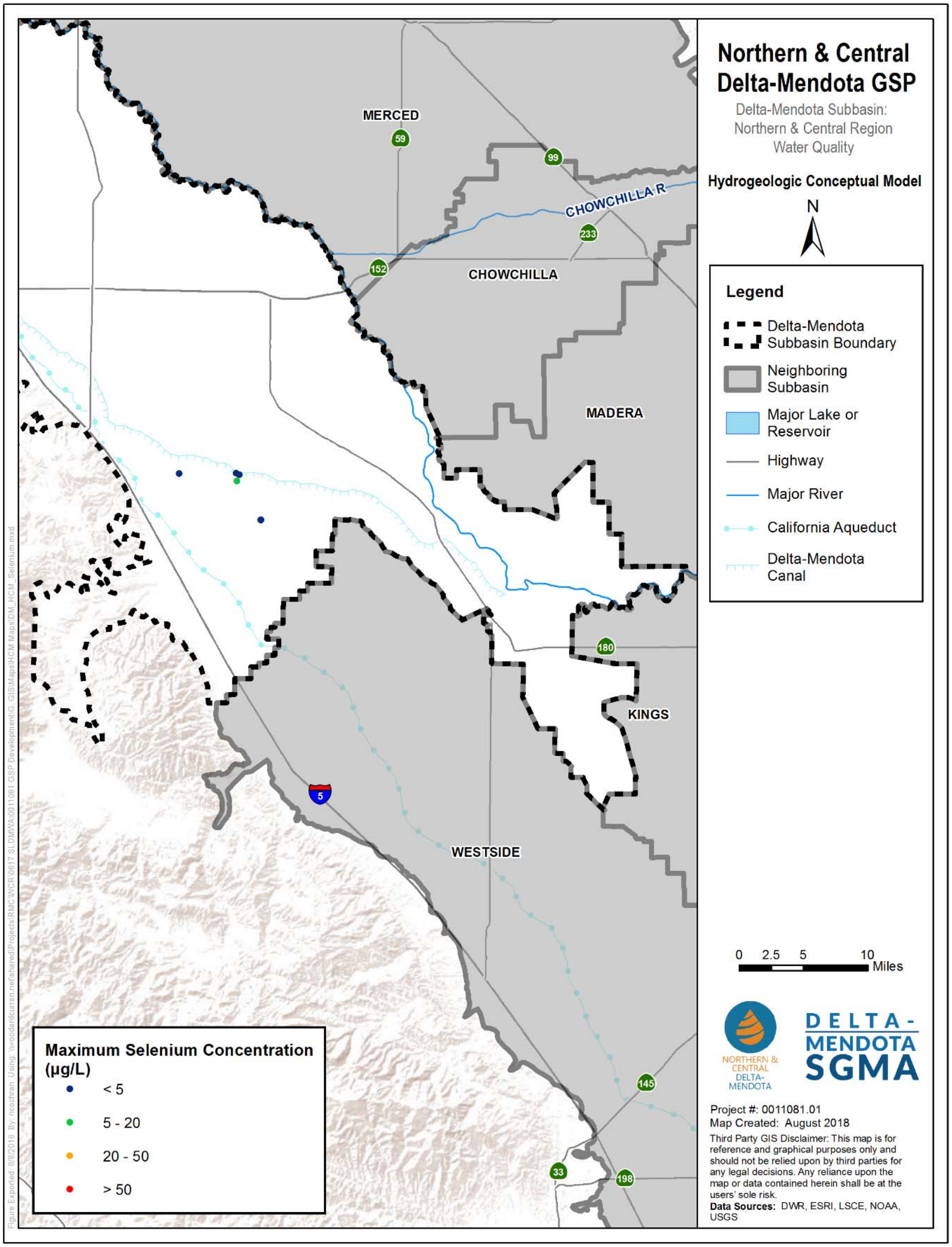


Figure 5-45. Most Recent (2000-2014) Selenium Concentrations, Above Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-46. Maximum Selenium Concentrations, Below Corcoran Clay

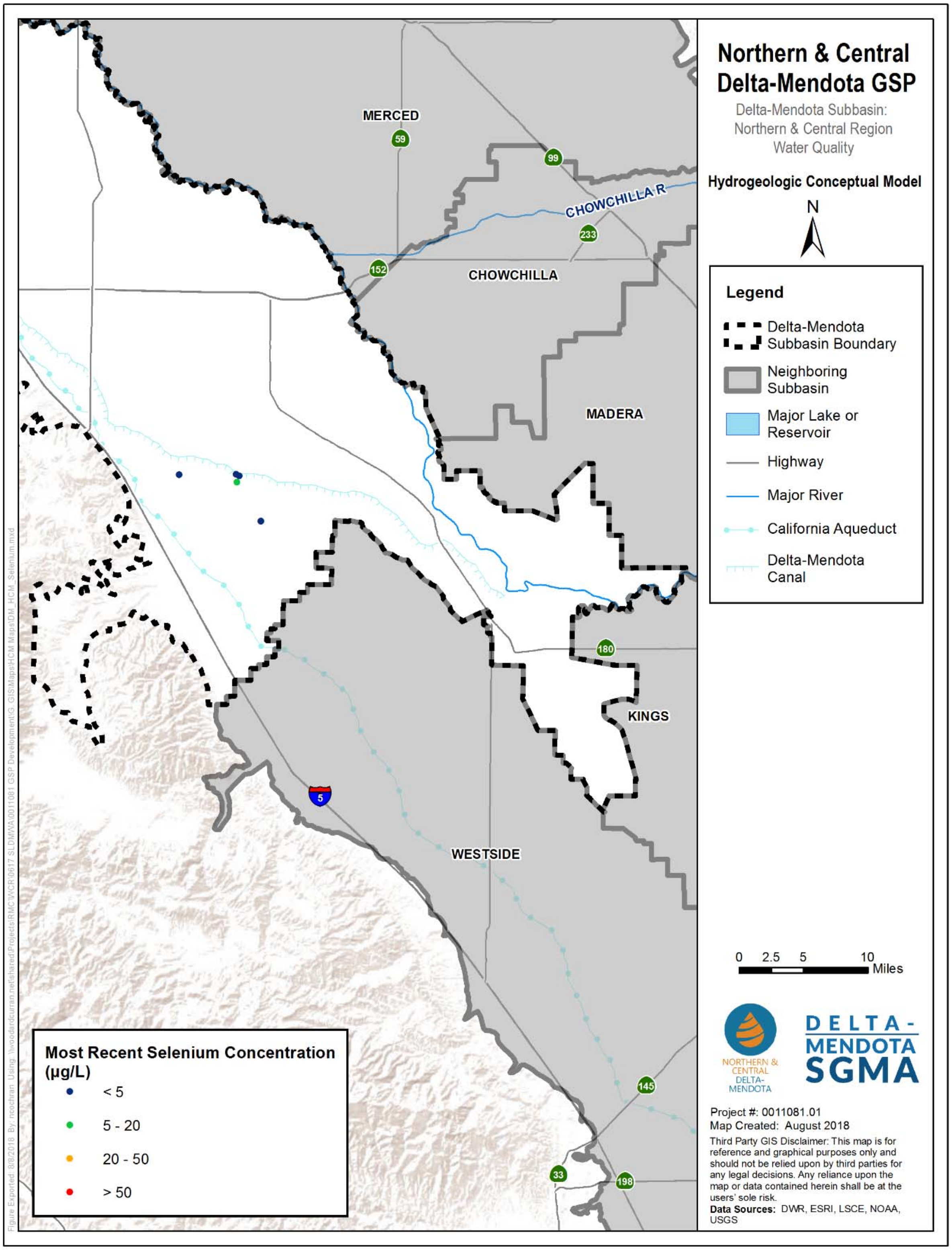
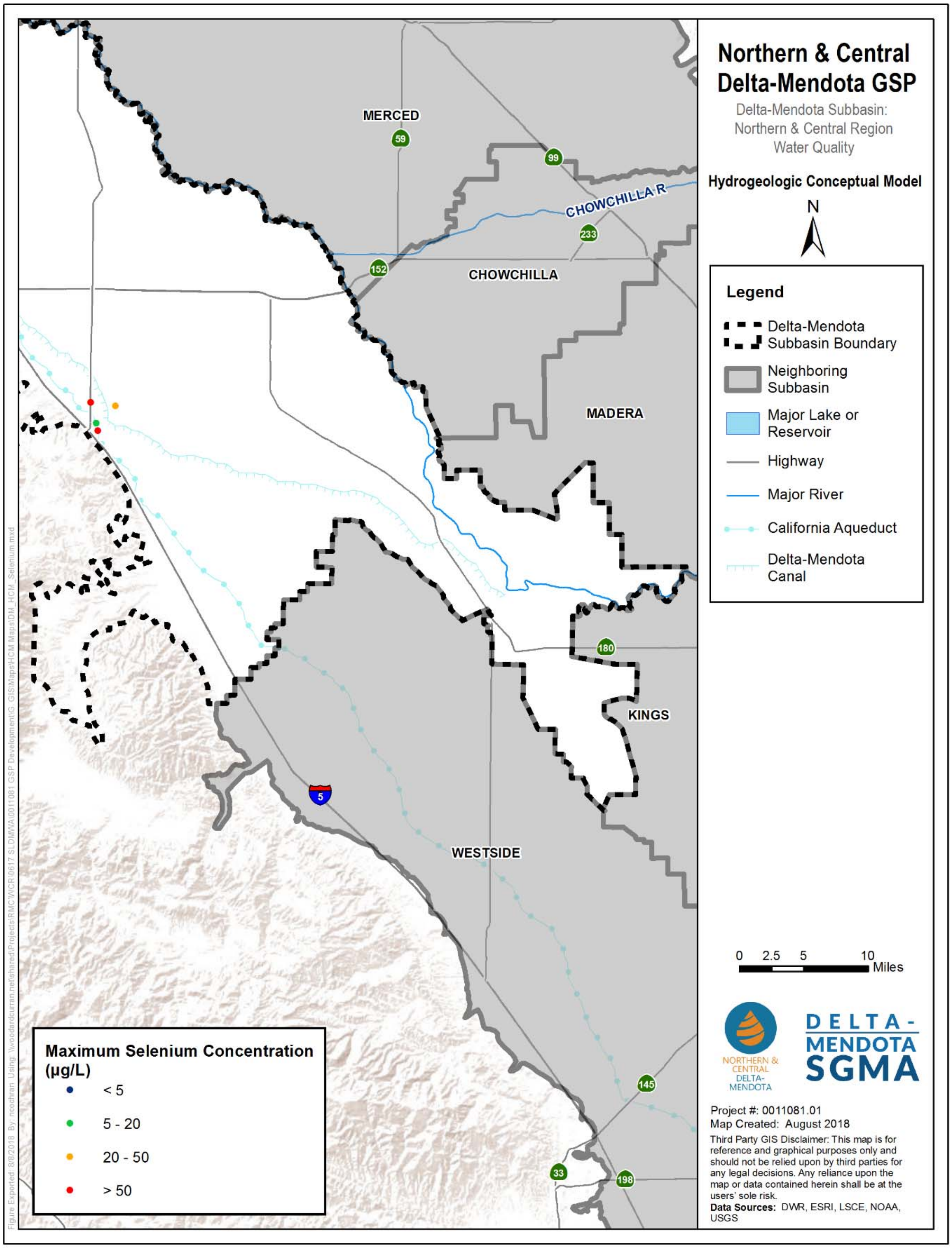


Figure 5-47. Most Recent (2000-2014) Selenium Concentrations, Below Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-48. Maximum Selenium Concentrations, Wells of Unknown Depth

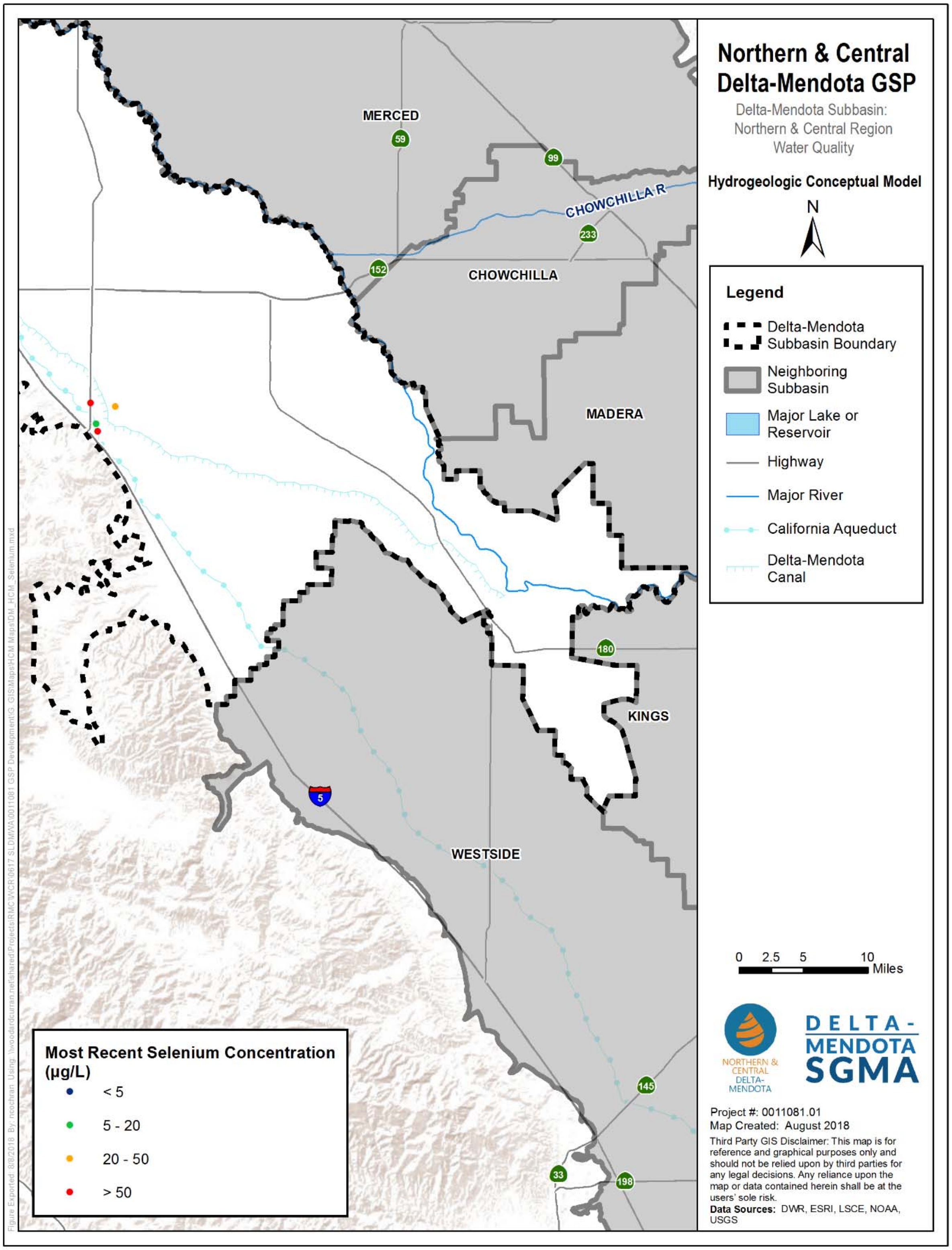
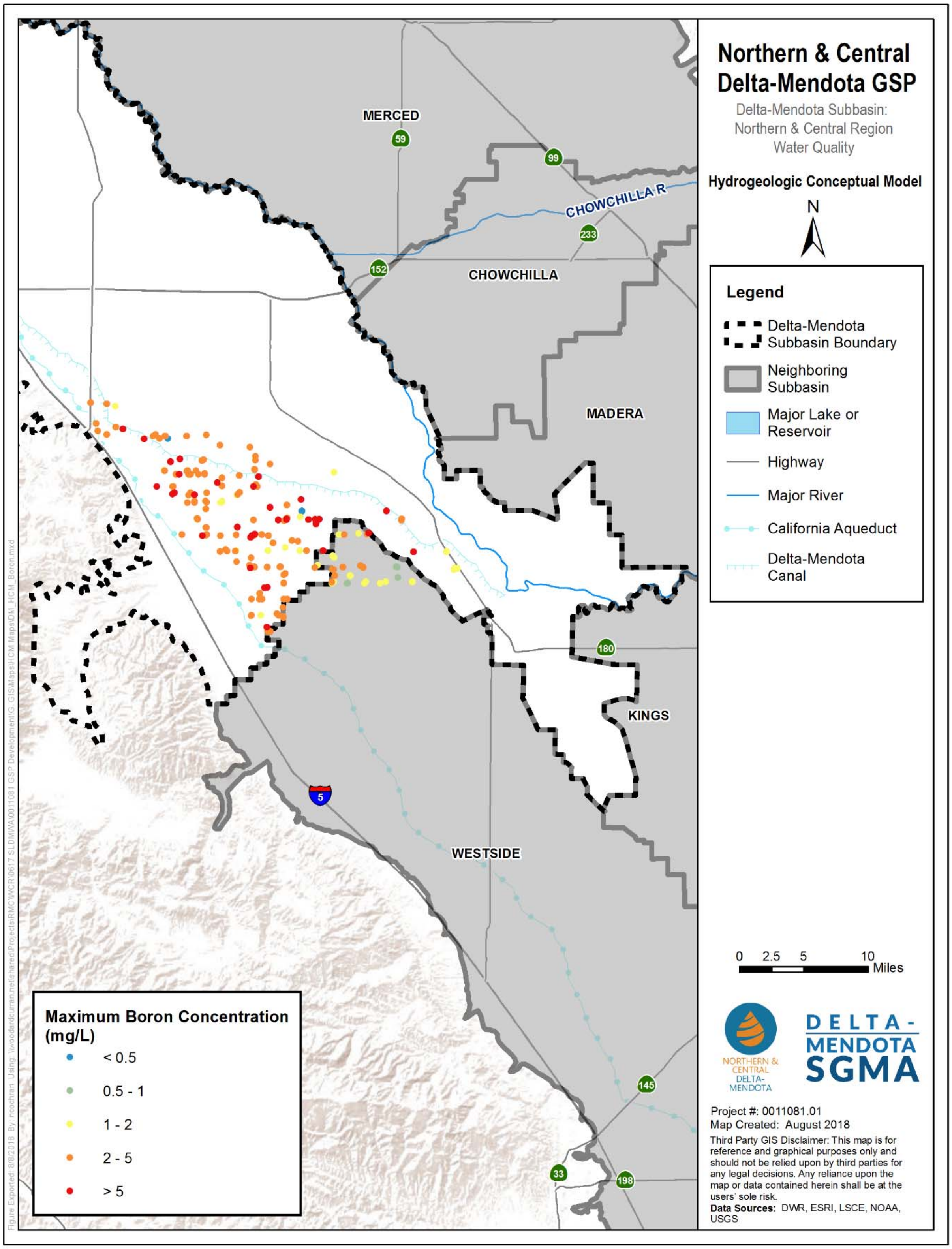


Figure 5-49. Most Recent (2000-2014) Selenium Concentrations, Wells of Unknown Depth



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-50. Maximum Boron Concentrations, All Wells

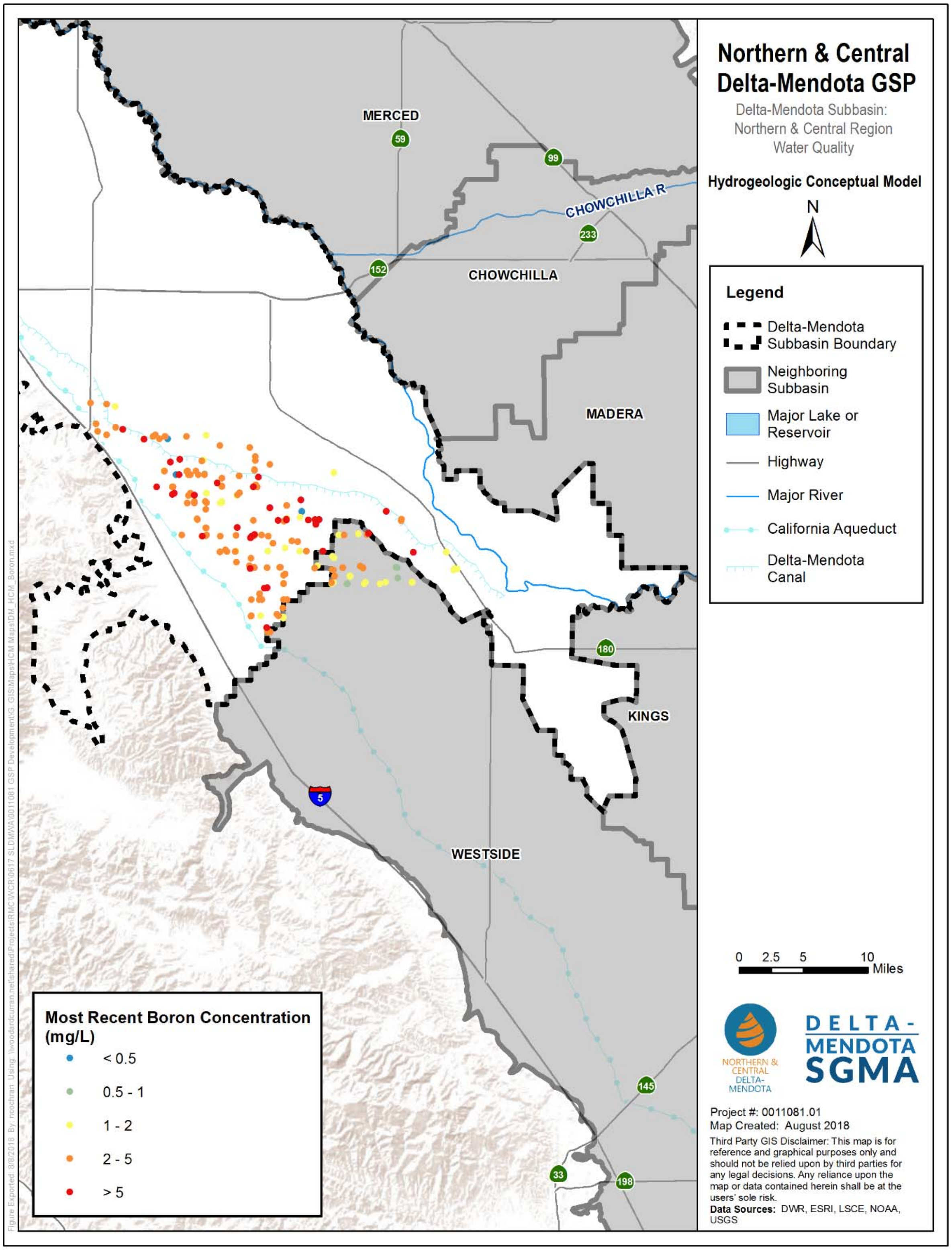
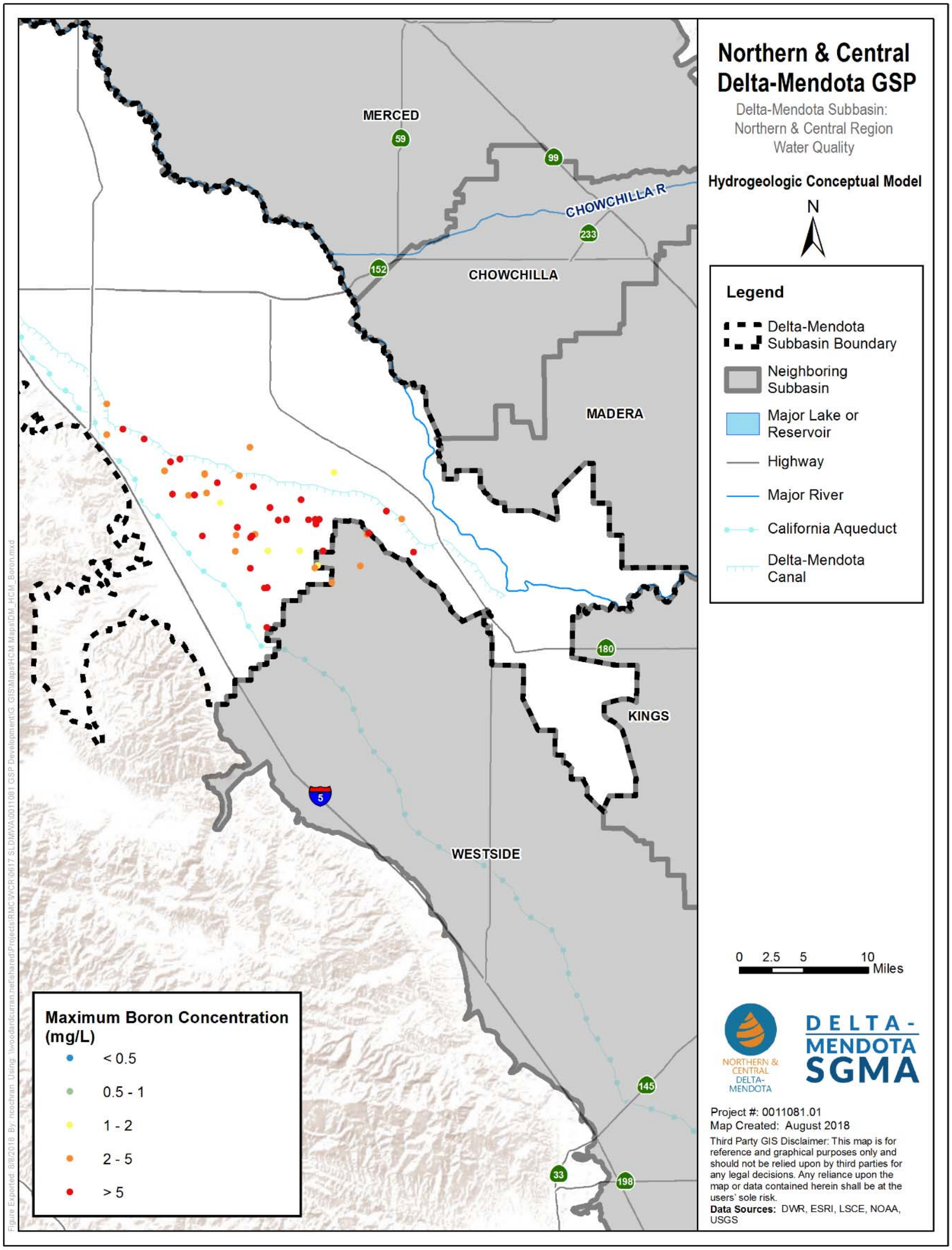


Figure 5-51. Most Recent (2000-2014) Boron Concentrations, All Wells



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-52. Maximum Boron Concentrations, Above Corcoran Clay

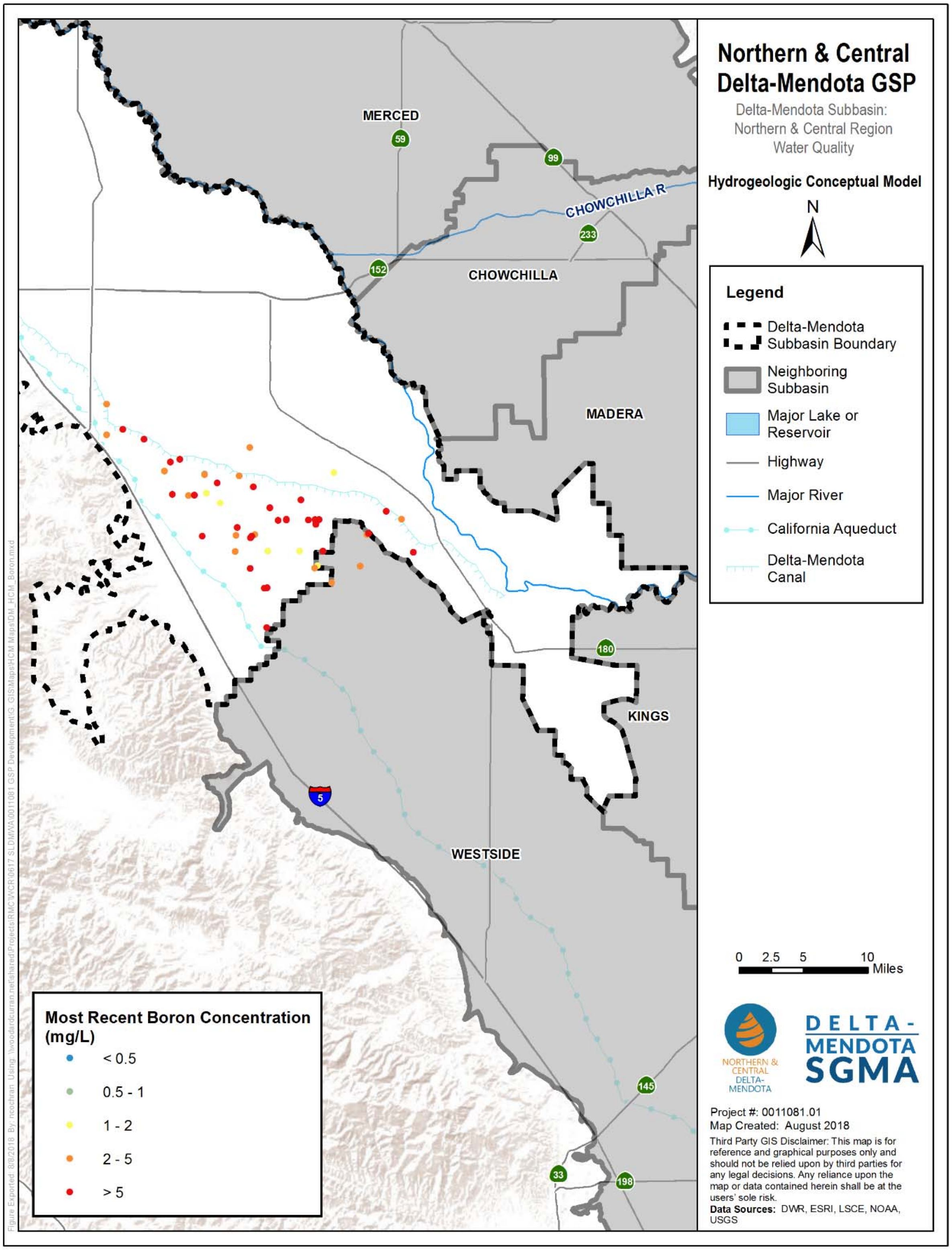
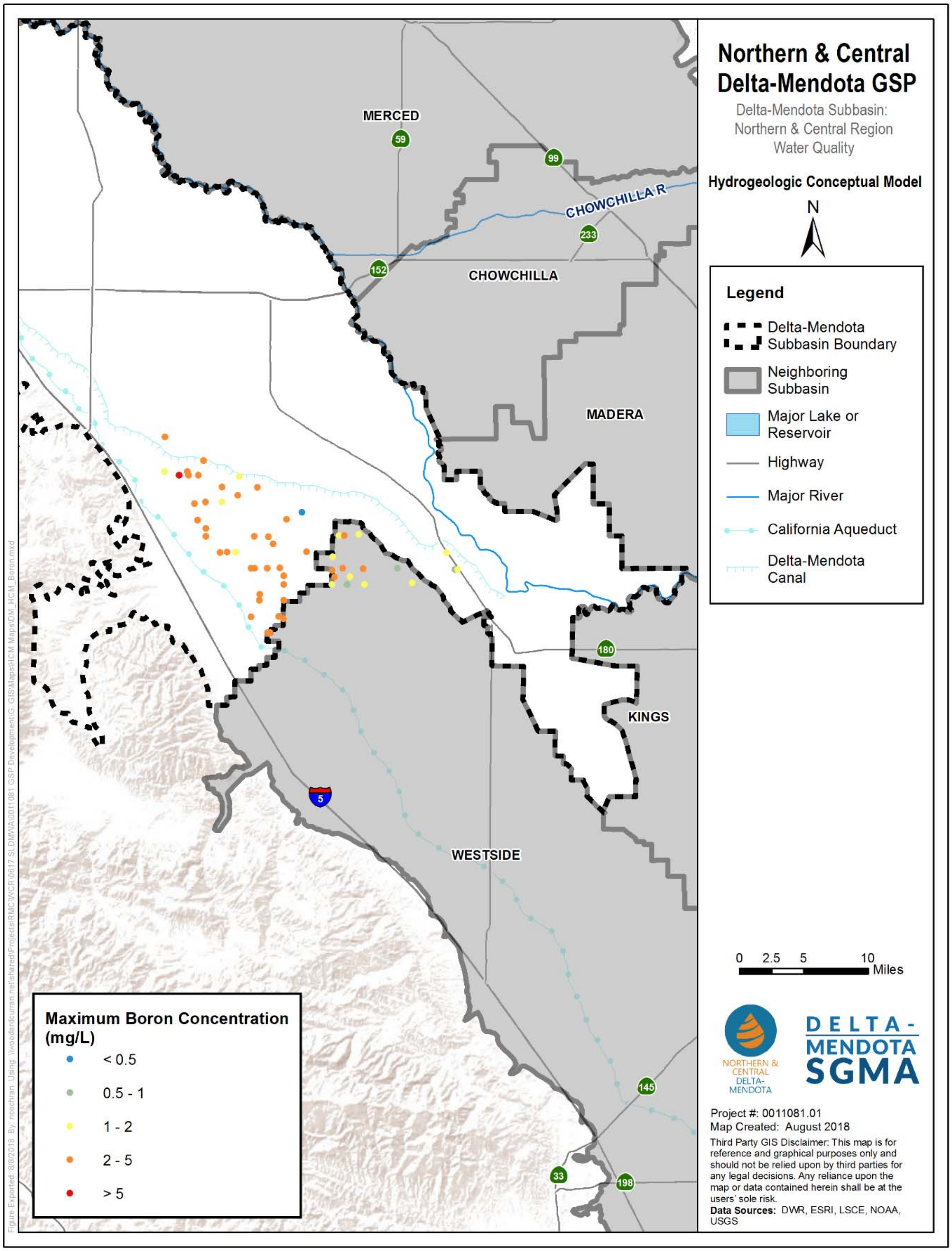


Figure 5-53. Most Recent (2000-2014) Boron Concentrations, Above Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-54. Maximum Boron Concentrations, Below Corcoran Clay

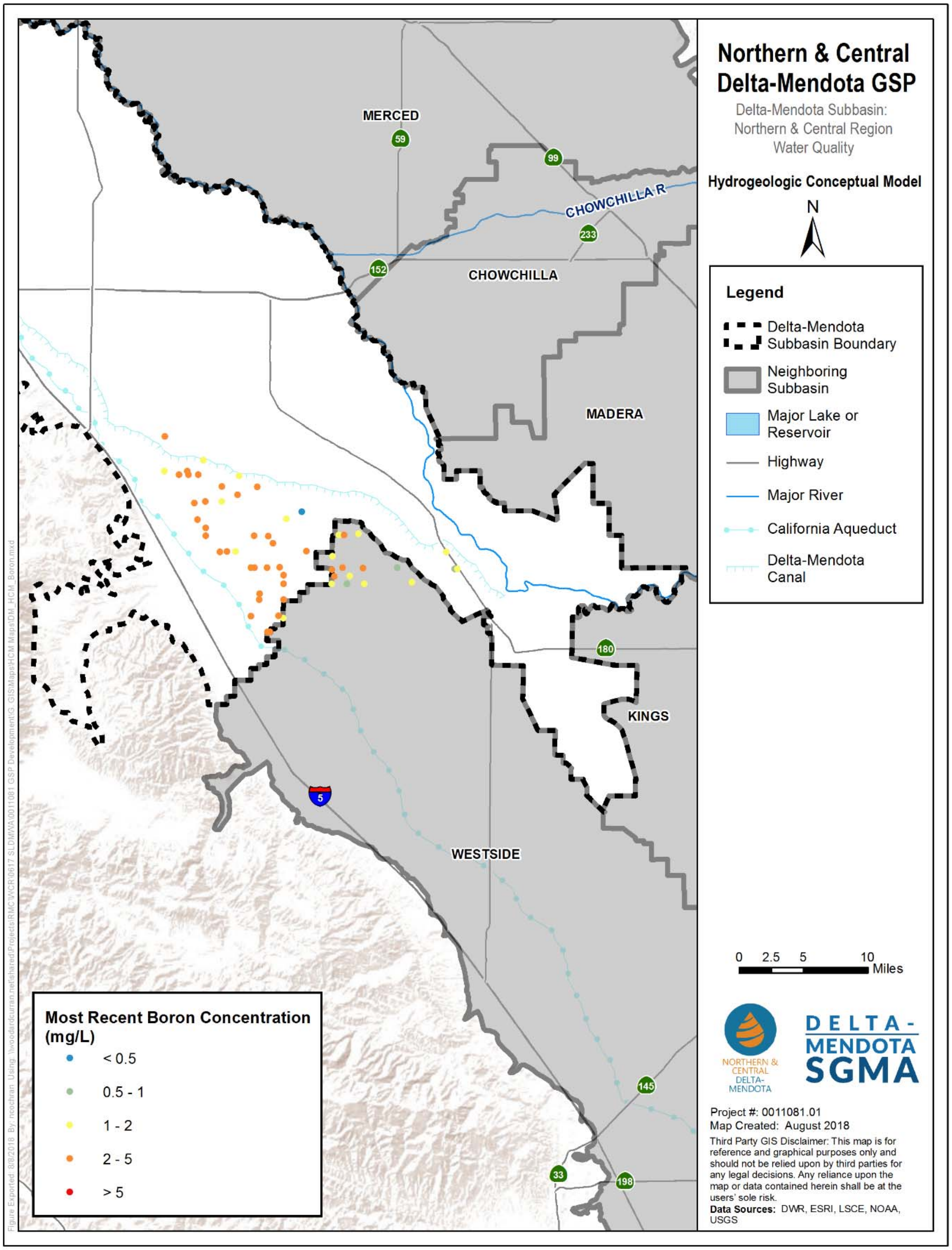
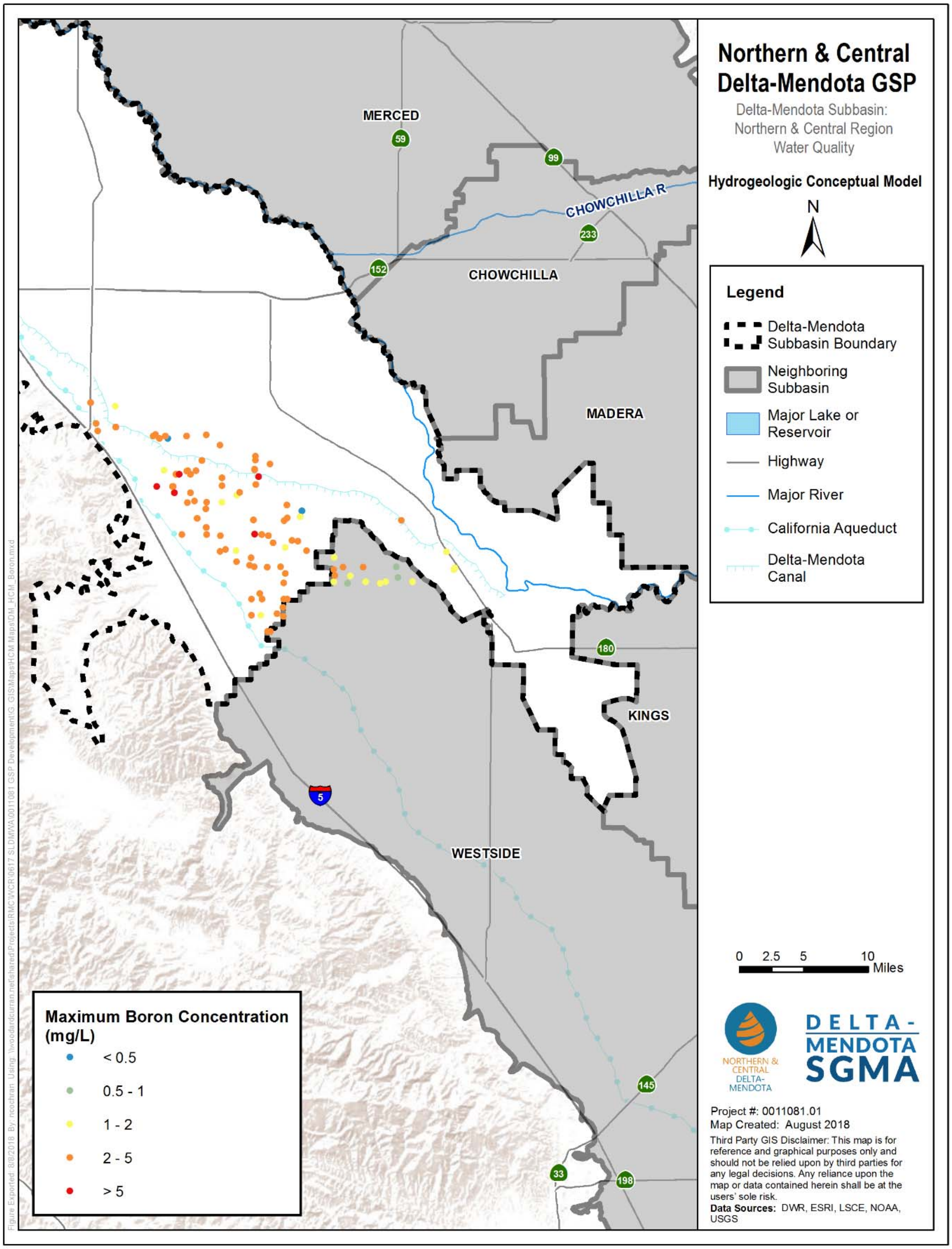


Figure 5-55. Most Recent (2000-2014) Boron Concentrations, Below Corcoran Clay



Note: Maximum concentrations are based on all data collected to date for the identified wells.

Figure 5-56. Maximum Boron Concentrations, Wells of Unknown Depth

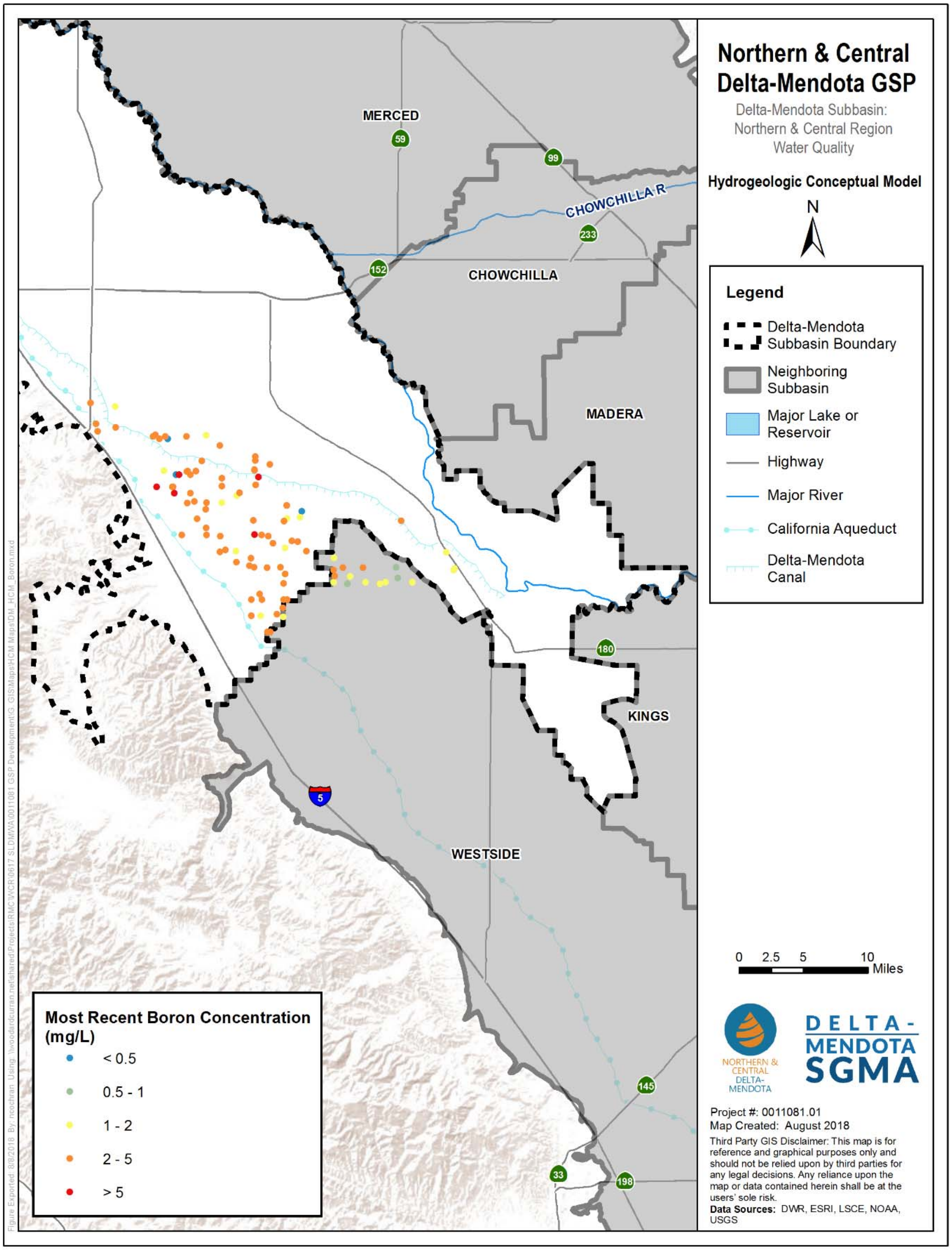


Figure 5-57. Most Recent (2000-2014) Boron Concentrations, Wells of Unknown Depth

5.2.8.3 Aquifer Use

The Delta-Mendota Subbasin is located in the San Joaquin Valley, one of the most agriculturally productive regions in California and the United States. Groundwater is one of the primary sources of water supply for agricultural uses within the Subbasin and is typically used to offset demands not met by surface water from the San Joaquin River, Central Valley Project and State Water Project. Groundwater is also the sole source of supply for many communities and cities throughout the Delta-Mendota Subbasin.

In general, most irrigation wells and many private domestic supply wells are screened in the Upper Aquifer of the Subbasin. Most municipal production wells and many larger irrigation production wells in the Northern and Central Delta-Mendota Regions are screened in the Lower Aquifer, below the Corcoran Clay.

5.2.9 Topography, Surface Water, Recharge, and Imported Supplies

This section describes the topography, surface water, soils, and groundwater recharge potential in the Delta-Mendota Subbasin.

5.2.9.1 Topography

As previously described, the Delta-Mendota Subbasin lies on the western side of the Central Valley and extends from the San Joaquin River on the east, along the axis of the Valley, to the Coast Range divide on the west side (LSCE, 2015). The Subbasin has ground surface elevations ranging from less than 100 feet above mean sea level (msl) along parts of the eastern edge to greater than 1,600 feet msl in the Coast Range mountains (Figure 5-58). Most of the lower elevation areas occur east of Interstate 5, in the eastern parts of the Delta-Mendota Subbasin; although some lower elevation areas also extend westward into the Coast Range, such as in Los Banos Creek Valley. Low elevation areas generally coincide with the extent of the Central Valley floor. Topography within the Delta-Mendota Subbasin consists largely of flat areas across the Central Valley floor, where slopes are generally less than 2 percent, with steepening slopes to the west. The topography outside of the Central Valley floor in the Coast Range mountains is characterized by steeper slopes, generally greater than 6 percent.

5.2.9.2 Surface Water Bodies

The San Joaquin River is the primary natural surface water feature within the Delta-Mendota Subbasin, flowing from south to north along the eastern edge of the Subbasin (LSCE, 2015). The Stanislaus, Tuolumne, Merced, and Chowchilla Rivers are tributaries to the San Joaquin River along the Subbasin boundary and generally flow east to west from the Sierra Nevada. During the 1960s, the San Joaquin River exhibited gaining flow conditions through much of the Subbasin (Hotchkiss and Balding, 1971). Numerous intermittent streams from the Coast Range enter the Delta-Mendota Subbasin from the west; however, none of these maintain perennial flow and only Orestimba Creek and Del Puerto Creek have channels that extend eastward to a junction with the San Joaquin River. Most of the flow in other notable west-side creeks, including Quinto Creek, San Luis Creek, Little Panoche Creek, and Los Banos Creek, is lost to infiltration (Hotchkiss and Balding, 1971). Flow from Los Banos and San Luis Creeks are impounded by dams on their respective systems. When flood releases are made from Los Banks Creek Reservoir, the vast majority of flows tend to be evacuated to the San Joaquin River as they tend to occur during times when demand isn't for beneficial use. The San Luis Reservoir on San Luis Creek, which is located along the western boundary of the Delta-Mendota Subbasin, is an artificial water storage facility for the Central Valley Project and California State Water Project and has no notable natural surface water inflows. Outflows from the reservoir go into the system of federal and state operated canals and aqueducts comprising the Central Valley and California State Water Projects. Surface water use within the Delta-Mendota Subbasin is derived largely from water deliveries provided by these projects, including from the California Aqueduct (sometimes referred to as San Luis Canal) and Delta-Mendota Canal, and also from the San Joaquin River (Figure 5-59).

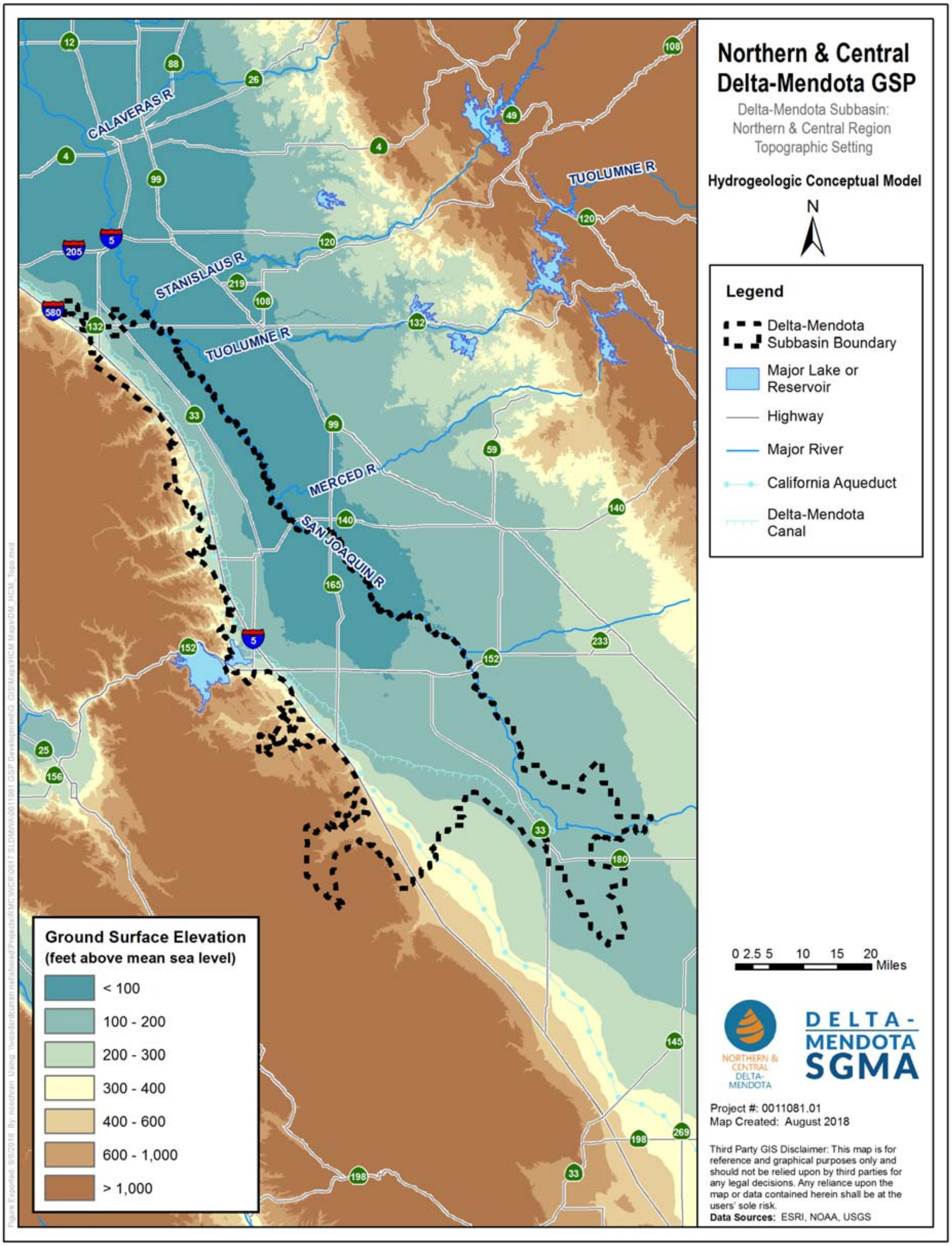


Figure 5-58. Ground Surface Elevation, Delta-Mendota Subbasin

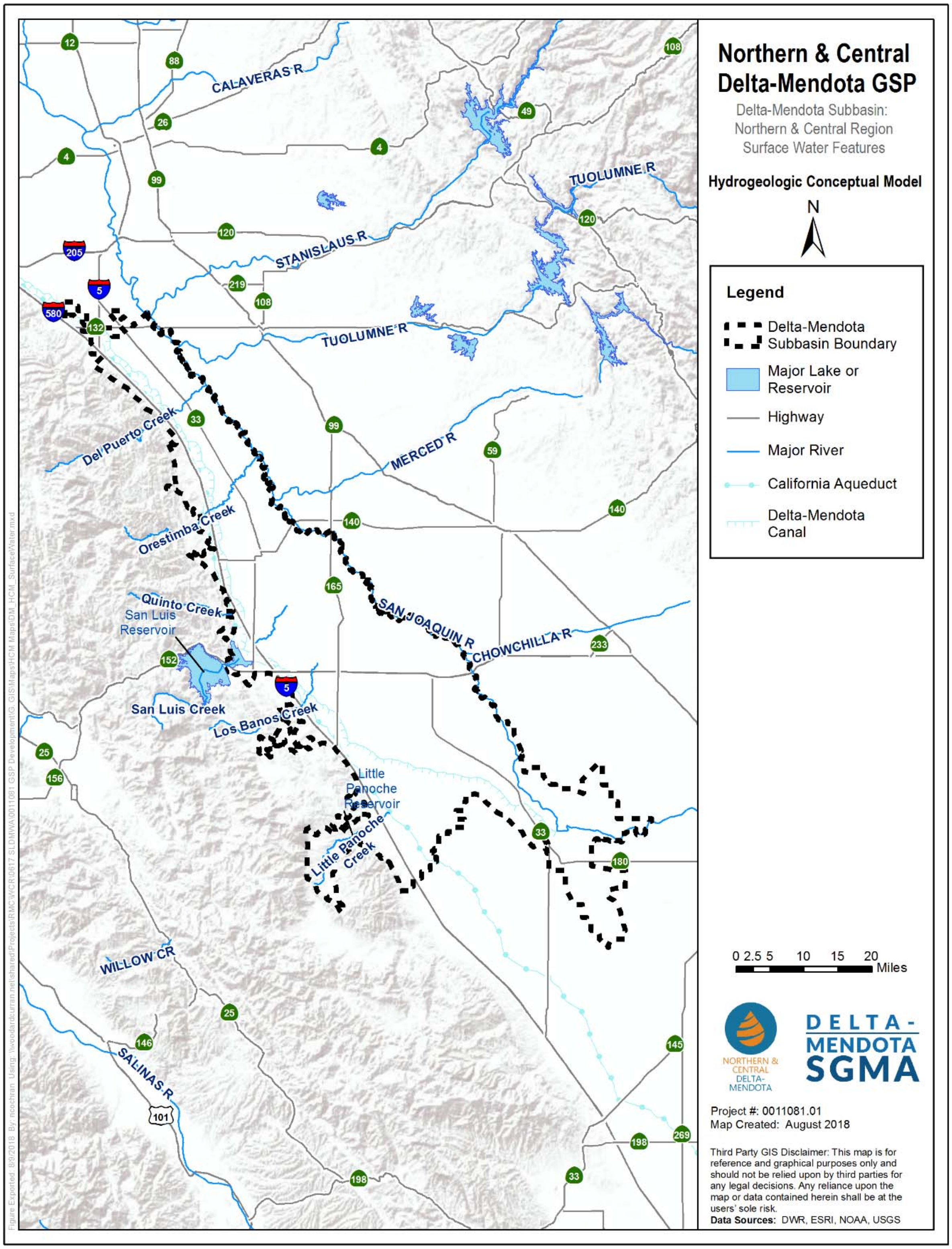


Figure 5-59. Surface Water Features, Delta-Mendota Subbasin

5.2.9.3 Soils

The predominant soil hydrologic groups within the Delta-Mendota Subbasin are soil types C and D (Figure 5-60). Group C soils have moderately high runoff potential when thoroughly wet (NRCS, 2009) with water transmission through the soil somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Group D soils have a high runoff potential when thoroughly wet and water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential.

Soil hydraulic conductivity groups are closely related to soil drainage characteristics and hydraulic conductivity. The fine-grained floodplain deposits present across much of the southeastern area of the Subbasin are evidenced as soils with lower hydraulic conductivity in Figure 5-20 and accordingly, these characteristics also make these areas poorly drained. Poorly draining soil conditions are extensive within the southern and eastern areas of the Subbasin extending from the vicinity of Tranquillity to near Gustine. As early as the 1950s, farmers in parts of the western San Joaquin Valley began implementing structural and land treatment approaches to manage areas with poorly drained soils and the associated shallow water table and build-up of soil salinity (Fio, 1994; Hotchkiss and Balding, 1971). Soils in the northern and western parts of the Delta-Mendota Subbasin exhibit better drainage characteristics, although areas of poorly drained soils are also present in the north and west in proximity to surface water courses, including most notably directly adjacent to the San Joaquin River and Los Banos Creek channels. Many of the upland soils, which are of generally coarser texture and located proximal to sediment sources derived from the Coast Range hill slopes, are characterized as moderately well drained.

Groundwater recharge potential on agricultural land based on the Soil Agricultural Groundwater Banking Index (SAGBI) is shown in Figure 5-62. The SAGBI is based on five major factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface conditions. The predominant recharge potential classification throughout the Delta-Mendota Subbasin ranges from Moderately Poor to Very Poor (571,572 acres out of 731,820 acres of agricultural and grazing land, or about 78%). Along the eastern portion of the Subbasin, the recharge potential is generally poorer than the western portion of the Subbasin, which contains soils with higher recharge potential (Excellent, Good, and Moderately Good).

In areas with low hydraulic conductivity, corresponding to areas without adequate natural drainage, tile drains are present to remove shallow groundwater from the rooting zone. Known tile drain locations are shown in Figure 5-61, which are primarily located along the eastern boundary of the Delta-Mendota Subbasin as well as the southern portion of the Subbasin in the Grassland Drainage Area. The Grassland Drainage Area contains a tile drainage system as part of the Grassland Bypass Project (also known as the San Joaquin River Improvement Project) to route drainage water through the Grassland Bypass Channel, which is then used for irrigated agriculture with a high salinity tolerance.

5.2.9.4 Areas of Recharge, Potential Recharge, and Groundwater Discharge Areas

The primary process for groundwater recharge within the Central Valley floor area is from percolation of applied irrigation water, although some groundwater subbasin recharge does occur in the Delta-Mendota Subbasin along the western boundary due to mountain front recharge. Within the Northern and Central Delta-Mendota Regions, SAGBI data categorizes 103,524 acres out of 288,785 acres (36%) of agricultural and grazing land within the regions as having Excellent, Good, or Moderately Good (Figure 5-62) recharge properties, and 185,261 acres out of 288,785 acres (or 64%) of agricultural and grazing land as having Moderately Poor, Poor, or Very Poor recharge properties. Of the 36% of land categorized as either having Excellent, Good, or Moderately Good recharge properties, the Northern and Central Delta-Mendota Regions contain the majority of the land in the Subbasin with the highest recharge potential, with 5,106 acres out of 7,916 total acres (64%) of land classified as having Excellent recharge properties. “Modified” SAGBI data shows higher potential for recharge than unmodified SAGBI data because the modified data assumes that soils have been or will be ripped to a depth of six feet, which can break up fine grained materials at the surface to improve percolation. The modified data set was determined to more accurately represent the Delta-Mendota Subbasin due to the heavy presence of agriculture. In almost all cases, recharge from applied water on irrigated lands recharges the Upper Aquifer of the Subbasin.

The Corcoran Clay is a known barrier restricting vertical flow between the Upper and Lower Aquifers (Figure 5-17 and Figure 5-18). Therefore, recharge of the Lower Aquifer is most likely restricted where the Corcoran Clay is present, including across most of the Central Valley floor. Primary recharge areas to the Lower Aquifer are most likely in western parts of the Central Valley floor, particularly in the vicinity and west of Los Banos, Orestimba, and Del Puerto Creeks, along the western margin of the Subbasin.

Groundwater discharge areas are identified as springs located within the Delta-Mendota Subbasin and the San Joaquin River. Figure 5-62 shows the location of historic springs identified by USGS. There are only six springs/seeps identified by USGS, which are located in the southwestern corner of the Subbasin. The springs shown represent a dataset collected by USGS and are not a comprehensive map of springs in the Subbasin.

5.2.9.5 Imported Supplies

Both the California Aqueduct and Delta-Mendota Canal run the length of the Delta-Mendota Subbasin, primarily following the Interstate 5 corridor (Figure 5-63). The following water purveyors in the Delta-Mendota Subbasin receive water from the Central Valley Project via the Delta-Mendota Canal: Central California Irrigation District, Columbia Canal Company, Del Puerto Water District, Eagle Field Water District, Firebaugh Canal Water District, Fresno Slough Water District, Grassland Water District, Laguna Water District, Mercy Springs Water District, Oro Loma Water District, Pacheco Water District, Panoche Water District, Patterson Irrigation District, San Luis Canal Company, San Luis Water District, Tranquillity Irrigation District, Turner Island Water District, West Stanislaus Irrigation District. Oak Flat Water District is the only recipient of State Water Project (SWP) water in the Delta-Mendota Subbasin. Oak Flat Water District initially bought into the SWP in 1968 and has a contracted Table A annual volume of 5,700 acre-feet (AF).

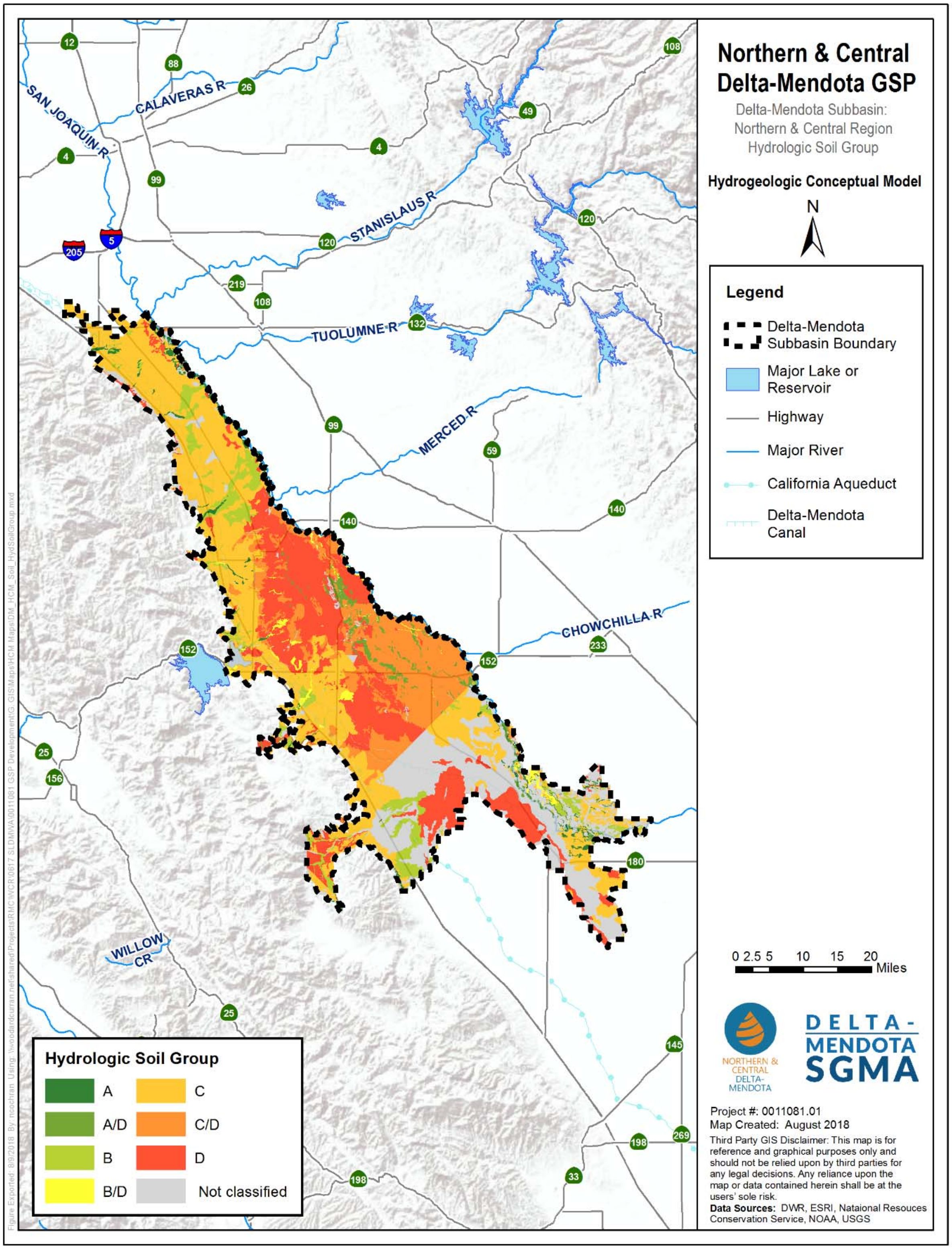


Figure 5-60. Hydrologic Soil Groups, Delta-Mendota Subbasin

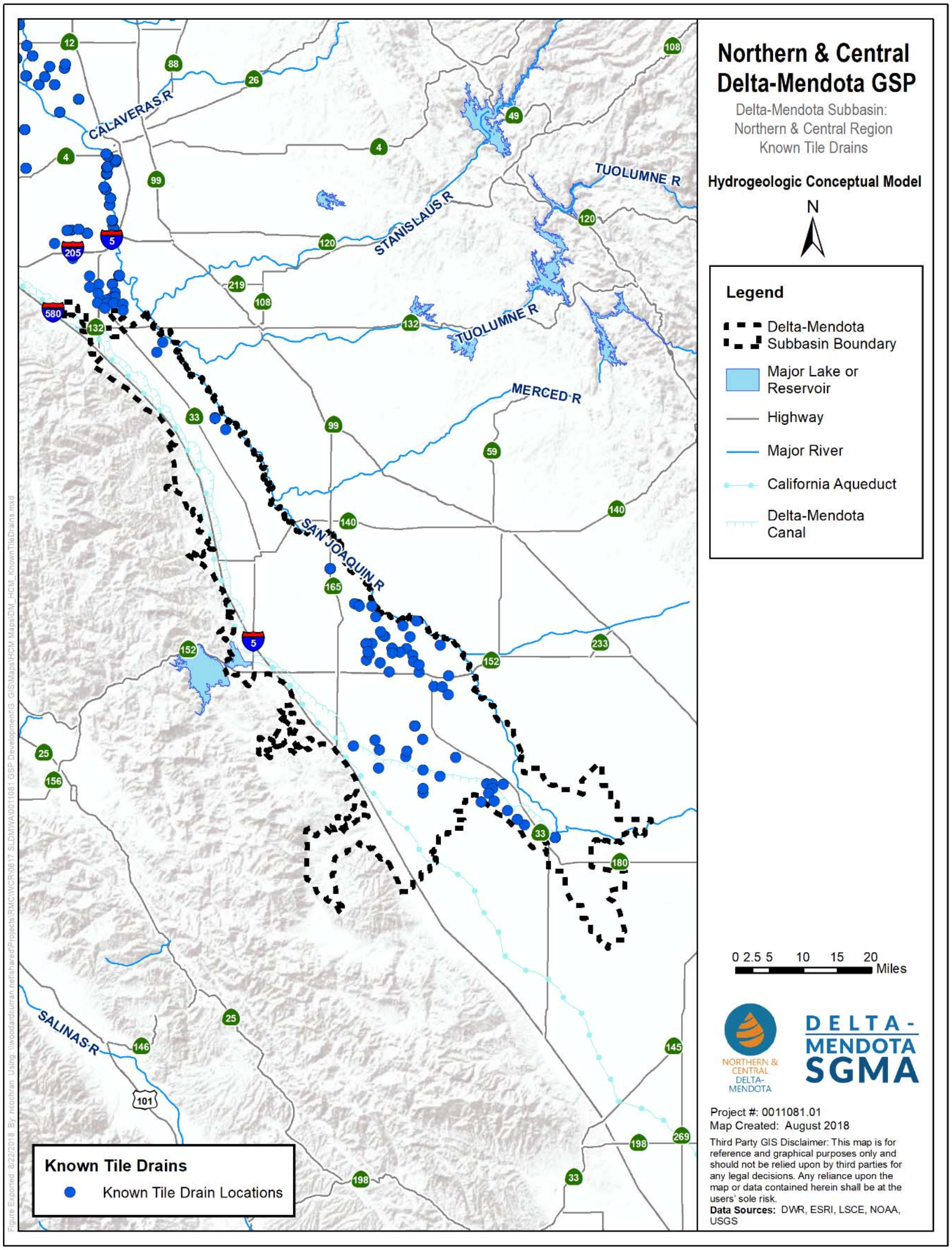


Figure 5-61. Tile Drains, Delta-Mendota Subbasin

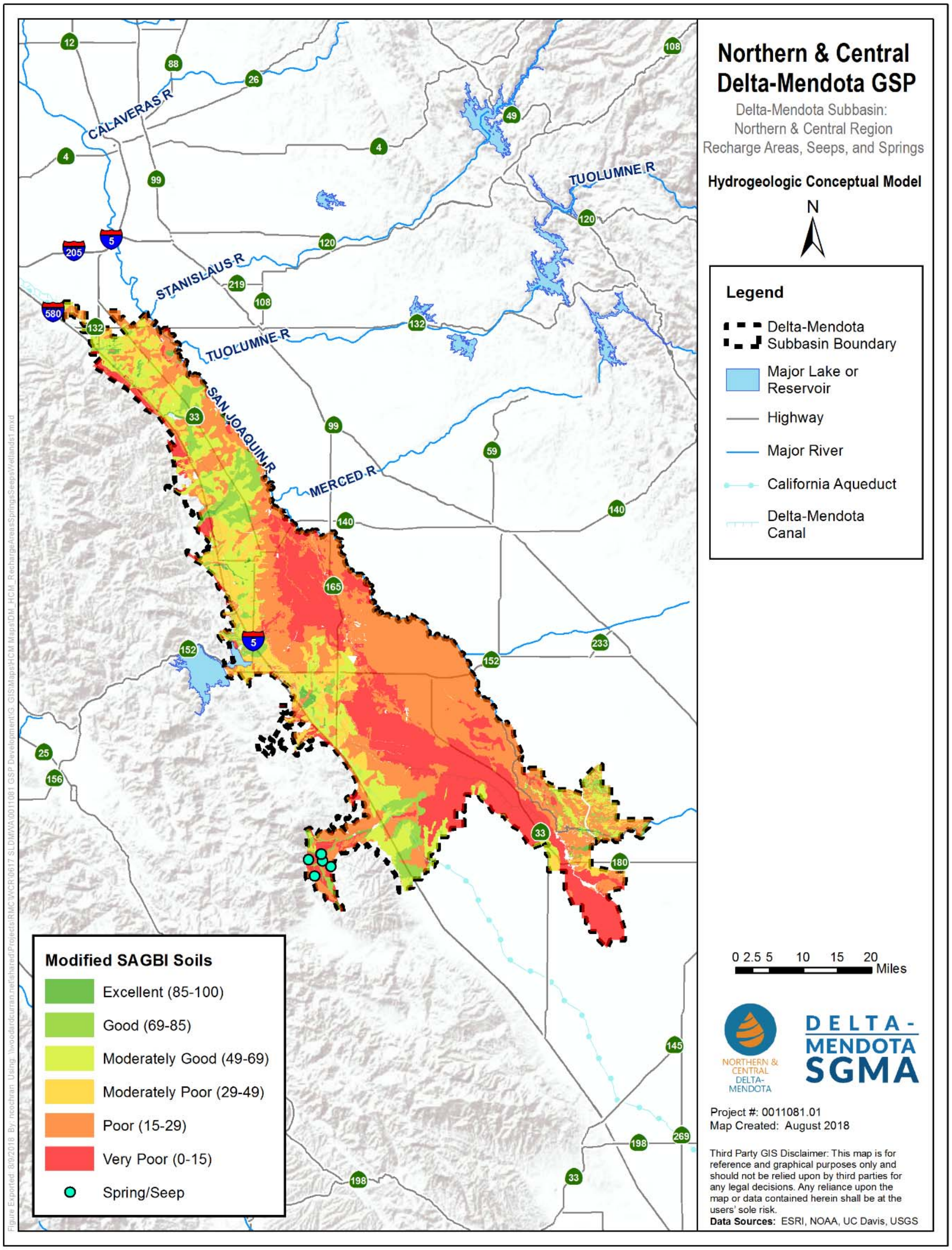


Figure 5-62. Recharge Areas, Seeps and Springs, Delta-Mendota Subbasin

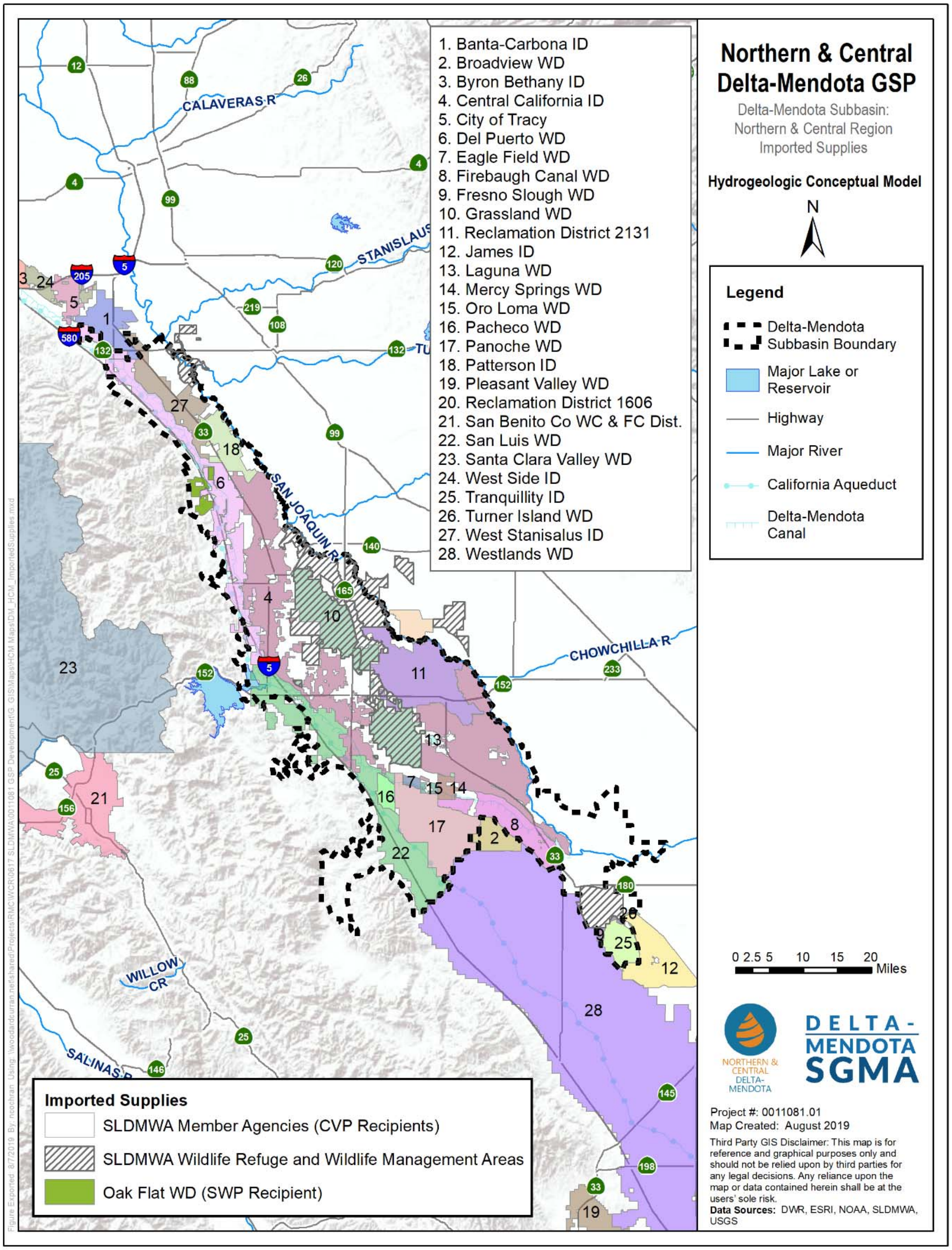


Figure 5-63. Imported Supplies, Delta-Mendota Subbasin

5.3 GROUNDWATER CONDITIONS

This section describes the current and historic groundwater conditions in the Northern and Central Regions of the Delta-Mendota Subbasin (Plan area of this Groundwater Sustainability Plan [GSP]), including data from January 1, 2015 to current conditions, for the following parameters: groundwater elevations, groundwater storage, groundwater quality, land subsidence, interconnected surface water systems, and groundwater dependent ecosystems (GDEs) (pursuant to Article 5 Plan Contents, Subarticle 2 Basin Setting, § 354.16 Groundwater Conditions of the GSP Emergency Regulations). Seawater intrusion is not discussed herein as the Delta-Mendota Subbasin is inland and is not impacted by seawater intrusion. For the purposes of this GSP, "current conditions" is represented by Water Year (WY) 2013 conditions, which is consistent with the year representing the Current Conditions Water Budget (see Section 5.4 for more information about Water Budgets). Data post-WY 2013 through present day are presented when available.

The purpose of describing groundwater conditions, as contained in this section, is to establish baseline conditions that will be used to monitor changes relative to measurable objectives and minimum thresholds. Therefore, these established baseline conditions will help support monitoring to demonstrate measurable efforts in achieving sustainability goals for the Northern and Central Regions as well as the whole Delta-Mendota Subbasin.

5.3.1 Useful Terminology

This groundwater conditions section includes descriptions of the amounts, quality, and movement of groundwater, among other related components. A list of technical terms and a description of the terms are listed below. The terms and their descriptions are identified here to guide readers through the section and are not a definitive definition of each term:

- Depth to Groundwater – The distance from the ground surface to first-detected non-perched groundwater, typically reported at a well.
- Upper Aquifer – The alluvial aquifer above the Corcoran Clay (or E-clay) layer.
- Lower Aquifer – The alluvial aquifer below the Corcoran Clay (or E-clay) layer.
- Horizontal gradient – The slope of the groundwater surface from one location to another when one location is higher or lower than the other. The gradient is shown on maps with an arrow showing the direction of groundwater flow in a horizontal direction.
- Vertical gradient – Describes the movement of groundwater perpendicular to the ground surface. Vertical gradient is measured by comparing the elevations of groundwater in wells that are of different depths. A downward gradient is one where groundwater is moving down into the ground towards deeper aquifers and an upward gradient is one where groundwater is upwelling towards the ground surface.
- Contour Map – A contour map shows changes in groundwater elevations by interpolating groundwater elevations between monitoring sites. The elevations are shown on the map with the use of a contour line, which represents groundwater being at the indicated elevation along the contour line. Contour maps can be presented in two ways:
    - Elevation of groundwater above mean sea level (msl), which can be used to identify the horizontal gradients of groundwater, and
    - Depth to water (i.e. the distance from the ground surface to groundwater), which can be used to identify areas of shallow or deep groundwater.
- Hydrograph – A graph that shows the changes in groundwater elevation or depth to groundwater over time at a specific location. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater is rising or descending over time.
- Maximum Contaminant Level (MCL) – MCLs are standards that are set by the State of California and the U.S. Environmental Protection Agency for drinking water quality. MCLs are legal threshold limits on the amount of an identified constituent that is allowed in public drinking water systems. At both the State and

Federal levels, there are Primary MCLs, set to be protective of human health, and Secondary MCLs for constituents that do not pose a human health hazard but do pose a nuisance through either smell, odor, taste, and/or color. The MCL is different for different constituents and have not been established for all constituents potentially found in groundwater.

- Assimilative Capacity – The difference between the ambient concentration of a water quality constituent of concern and the regulatory threshold.
- Elastic Land Subsidence – Reversible and temporary fluctuations in the elevation of the earth's surface in response to seasonal periods of groundwater extraction and recharge.
- Inelastic Land Subsidence – Irreversible and permanent decline in the elevation of the earth's surface resulting from the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system.
- Gaining Stream – A stream in which groundwater flows into a streambed and contributes to a net increase in surface water flows across an identified reach.
- Losing Stream – A stream in which surface water is lost through the streambed to the groundwater, resulting in a net decrease in surface water flows across an identified reach.
- Conjunctive Use – The combined use of surface water and groundwater supplies, typically with more surface water use in wet years and more groundwater use in dry years.

5.3.2 Groundwater Elevations

This section describes groundwater elevation data utilized and trends. Groundwater conditions vary widely across the Delta-Mendota Subbasin. Historic groundwater conditions through present day conditions, the role of imported surface water in the Subbasin, and how conjunctive use has impacted groundwater trends temporally and spatially are discussed. Groundwater elevation contour maps associated with current seasonal high and seasonal low for each principal aquifer, as well as hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients (both horizontal and vertical), are also described.

5.3.2.1 Available Data

Groundwater elevation data, and accompanying well construction information, within the Delta-Mendota Subbasin from the following sources and associated programs were utilized in this GSP:

- California Department of Water Resources (DWR)
  - California Statewide Groundwater Elevation Monitoring Program (CASGEM)
  - Water Data Library (WDL)
- Central Valley Regional Water Quality Control Board
  - Irrigated Lands Regulatory Program (ILRP)
    - Western San Joaquin Groundwater Quality Assessment Report (GAR)
    - Grassland Drainage Area GAR
- Local Agency Data

Data provided by these sources included well information such as location, well construction, owner, ground surface elevation and other related components, as well as groundwater elevation data (including information such as date measured, depth to water, groundwater surface elevation, questionable measurement code, and comments). At the time that this analysis was performed, groundwater elevation data were available for the time period from 1930 through 2018. There are many wells with monitoring data from some time in the past, but no recent data, while a small number of wells have monitoring data recorded for periods of greater than 50 years.

Not all groundwater elevation data received were used in preparing the groundwater elevation contour maps for both principal aquifers (defined in this GSP as the Upper and Lower Aquifers which are divided by the Corcoran Clay [E-clay] layer). Some groundwater elevation data were associated with wells with unknown screened depths and/or composite well screens constructed across the Corcoran Clay. Groundwater elevation data associated with wells with composite screens and/or unknown screened depths were removed from the data set, along with any data point that appears to be an outlier when compared with surrounding data from the same period. Duplicate well measurements were also removed prior to contouring and only one observation for a given well was used for the identified season, rather than averaging all measurements at a given well during the same season.

Figure 5-64 shows the locations of wells with known screened depths within the Delta-Mendota Subbasin as well as known spatial gaps where no well information is currently available. These wells include those monitored under CASGEM, the Delta-Mendota Canal Well Pump-in Program, and local owners or agencies. Monitoring data available for these wells varies by local owner and agency. Well locations were provided by local agencies to the best of their knowledge at the time of writing and may include wells that have been destroyed or are no longer in service.

5.3.2.2 Historic Conditions

Historic groundwater trends can generally be divided by the first deliveries of imported water deliveries to the Delta-Mendota Subbasin. Construction of the Delta-Mendota Canal (DMC) and the California Aqueduct herald the introduction of significant surface water supplies into the Subbasin and reduced dependence on groundwater as the primary water supply. These conveyance systems have resulted in significant increases in the conjunctive use of surface water and groundwater throughout the Subbasin. Various drought periods also punctuate critical understandings of groundwater use patterns throughout the Subbasin, as well as what is known regarding response and recovery of groundwater levels following notable droughts.

Prior to Imported Water Deliveries (1850-1950s)

Prior to 1850, the majority of agriculture and development in the San Joaquin Valley consisted of rain-fed grain and cattle production, with irrigated development beginning sporadically during this time via river and perennial stream diversions (SWRCB, 2011). Construction of the railroad through the San Joaquin Valley from 1869 through 1875 increased demand for more extensive agriculture, making markets in larger coastal cities more accessible to valley farmers. Significant irrigation sourced from surface water and resulting production began in the western side of the San Joaquin Valley in 1872 when the San Joaquin River was diverted through the Miller and Lux canal system west of Fresno (DWR, 1965). Within the Northern Delta-Mendota Region, diversions from the San Joaquin River by West Stanislaus Irrigation District, Patterson Irrigation District, El Solyo Water District, White Lake Mutual Water Company, and other private diverters began in the early 1900s and were the primary water supply for irrigation in this Region. By the 1890s and early 1900s, sizable areas of the San Joaquin Valley were being forced out of production by salt accumulation and shallow water tables. Much of this land lay idle until the 1920s when development of reliable electric pumps and the energy to power them accelerated the expansion of irrigated agriculture with the availability of vast groundwater resources. The resultant groundwater pumping lowered the water table in many areas (SWRCB, 1977 and Ogden, 1988) and allowed the leaching of salts, particularly near the valley trough and western side of the valley. Groundwater pumping for irrigation from around 1920 to 1950 drew the water table down as much as 200 feet in areas along the westside of the San Joaquin River (Belitz and Heimes, 1990). Declining water tables were causing higher pumping costs and land subsidence, and farmers were finding poorer quality water as water tables continued to decline. These issues created a desire for new surface water supplies, which would be fulfilled by the Central Valley Project.

Post-Imported Water Deliveries (1950s-2012)

Surface water deliveries from the Central Valley Project (CVP) via the Delta-Mendota Canal began in the early 1950s, and from the State Water Project (SWP) via the California Aqueduct in the early 1970s (Sneed et al., 2013). The CVP is the primary source of imported surface water in the Northern and Central Delta-Mendota Regions, where only Oak Flat Water District receives deliveries from the SWP. Introduction of imported water supplies to the Delta-Mendota Subbasin resulted in a decrease in groundwater pumping from some parts of the Subbasin and the greater Central Valley, which was accompanied by a steady recovery of water levels. During the droughts of 1976-1977 and 1987-1992, diminished deliveries of imported surface water prompted increased pumping of groundwater to meet irrigation demands, bringing water levels to near-historic lows. Following periods of drought, recovery of pre-drought water levels has been rapid, especially in the Upper Aquifer. This trend has been observed in historic hydrographs for wells across the Northern and Central Delta-Mendota Regions.

5.3.2.3 Current Conditions

Recent Drought (2012-2016)

During the most recent drought, from 2012 through 2016, similar groundwater trends were observed as during the 1976-1977 and 1987-1992 droughts. With diminished imported surface water deliveries, groundwater pumping increased throughout the Subbasin to meet irrigation needs. This resulted in historic or near-historic low groundwater levels during the height of the drought in 2014 and 2015, when CVP and SWP allocations were 0% and post-1914 surface water rights in the San Joaquin River watershed were curtailed. In June 2015, senior water rights holders with a priority date of 1903 or later in the San Joaquin and Sacramento watersheds and the Delta were ordered by the State Water Resources Control Board to curtail diversions (State of California, 2015). This marked the first time in recent history that pre-1914 water rights holders were curtailed.

Post-Drought (2016-present)

With wetter conditions following the 2012-2016 drought, groundwater levels began to recover and reach near historic highs by 2017, comparable to 2012 pre-drought levels (Figure 5-65 and Figure 5-66). This was largely a result of CVP allocations reaching 100% and full water rights supplies available from the San Joaquin River in 2017. Additionally, inelastic subsidence also drastically decreased in 2017 as imported water supplies were once again available, resulting in decreased groundwater pumping particularly from the Lower Aquifer. This pattern of increased drought-driven groundwater pumping, accompanied by declining groundwater elevations, followed by recovery is a predominant factor to be considered in the sustainable management of the Delta-Mendota Subbasin.

5.3.2.4 Groundwater Trends

Groundwater levels can fluctuate greatly throughout time due to various natural and anthropogenic factors, including long-term climatic conditions, adjacent well pumping, nearby surface water flows, and seasonal groundwater recharge or depletion (LSCE, 2015). As discussed in the Hydrogeologic Conceptual Model section of this GSP, the Delta-Mendota Subbasin is generally a two-aquifer system consisting of an Upper and Lower Aquifer that are subdivided by the Corcoran Clay layer, a regional aquitard. The Corcoran Clay layer, or E-Clay equivalent, restricts flow between the upper semi-confined aquifer and lower confined aquifer. The presence of a tile drain network along the Subbasin's eastern boundary, as well as the Grassland Drainage Area on the southern end of the Northern and Central Delta-Mendota Regions, affect the lateral and vertical water movement in the shallow groundwater zone (LSCE, 2016). The majority of production wells are perforated above the Corcoran Clay layer.

The Delta-Mendota Subbasin has a general flow direction to the east, where it loses groundwater to the adjoining San Joaquin River and its neighboring subbasins. Most recharge throughout the Subbasin is attributed to applied irrigation water, with other sources of recharge including local streams, canal seepage, and infiltration along the western margin of the Subbasin from the Coast Range.

Upper Aquifer

For very shallow groundwater (less than 50 feet depth to water), select hydrographs illustrating temporal groundwater level trends in very shallow wells across the Central Valley Floor area of the Subbasin are shown in Figure 5-67. Note, the hydrographs shown display different ranges of elevations on the vertical axes and all groundwater elevations are in relation to the North American Vertical Datum of 1988 (NAVD88). During the period from the 1970s through the early 2000s, wells in the western part of the Valley Floor tended to see an overall increase of around five feet in groundwater elevation during this time period, whereas in the eastern portion of the Subbasin, particularly nearer the San Joaquin River, hydrographs from very shallow wells indicate a decreased water table elevation over that same period of time.

For the Upper Aquifer, Figure 5-68 presents select hydrographs illustrating temporal groundwater level trends in the Upper Aquifer wells within the Subbasin. Hydrographs shown on Figure 5-68 are displayed with different ranges of elevation values on the vertical axes and all groundwater elevations are in relation to NAVD88. Wells in the Upper Aquifer exhibit decreasing trends to somewhat stable water levels until the mid-1980s, and increasing or stable water levels thereafter.

Figure 5-69 presents select hydrographs illustrating temporal groundwater level trends in the Grassland Drainage Area (including areas covered by the Central Delta-Mendota, Oro Loma Water District, and Widren Water District Groundwater Sustainability Agencies [GSAs]) at various depths. The three select hydrographs representing wells each show less than 10 years of available data, where all groundwater elevations are in relation to NAVD88. The two wells in the shallower portion of the Upper Aquifer show slight declines of about 10 feet or less from about 2003 through 2013. The one well in the deeper portion of the Upper Aquifer shows more drastic elevation changes, ranging from 100 ft msl to -20 ft msl over a 5-year period from 2010 to 2016.

Figure 5-70 through Figure 5-75 show contours of groundwater elevations (relative to NAVD88) in the shallower (upper 50 feet) portion of the Upper Aquifer and for wells screened in the deeper portions of the Upper Aquifer for recent spring and fall time periods in the Delta-Mendota Subbasin. Recent groundwater elevations include all available data from 2000 through 2016. Spring is defined as the months of January through April, and fall is defined as September through November. All available data for each season for each well were averaged to produce a single value of groundwater elevations for each season for that well in order to develop contour maps.

Both spring and fall maps indicate a prevailing southwest to northeast flow gradient above the Corcoran Clay (or E-Clay) layer. In general, little variation is apparent in groundwater elevations in spring (Figure 5-70, Figure 5-72, Figure 5-74, and Figure 5-75) relative to fall (Figure 5-71 and Figure 5-73). Spring piezometric heads were generally higher than those in the fall throughout most of the Subbasin. An area of lower groundwater elevation is observed in the vicinity of the San Joaquin River Improvement Project (SJRIP), potentially corresponding to areas of groundwater pumping (Figure 5-75). The effects of pumping and the resulting depression in groundwater elevations within the Upper Aquifer in the SJRIP vicinity may result in a more northernly gradient, instead of the natural northeastern flow direction (Figure 5-75).

Lower Aquifer

Figure 5-76 presents select hydrographs illustrating temporal groundwater level trends in Lower Aquifer wells, which are perforated below the Corcoran Clay layer within the Subbasin. Note, hydrographs shown on Figure 5-76 displayed different ranges of elevation on the vertical axes and all groundwater elevations are in relation to NAVD88. In the Lower Aquifer, piezometric head typically increased or remained relatively stable during the period from the 1980s through the early 2000s.

Figure 5-69 presents select hydrographs illustrating temporal groundwater level trends in the Grassland Drainage Area (including the Central Delta-Mendota, Oro Loma Water District, and Widren Water District GSAs) at various depths. The two select hydrographs representing wells in the Lower Aquifer each show similar elevation patterns post-2010 with a total elevation change of 50 ft msl or more (relative to NAVD88). USGS1000489 shows fairly stable and increasing groundwater elevation trends from the late 1950s through the mid-1980s with a data gap from the mid-1980s through 2010, where after 2010 groundwater levels have a steep decline through 2016.

Patterns in recent spring and fall groundwater elevations (relative to NAVD88) within the Lower Aquifer are illustrated in Figure 5-77 through Figure 5-79. Recent groundwater elevations include all available data from 2000 through

2016. Spring is defined as the months of January through April, and fall is defined as September through November. All available data for each season for each well were averaged to produce a single value of water level for each season for that well in order to develop contour maps.

The Lower Aquifer exhibits less seasonal difference in groundwater elevations than the Upper Aquifer. Throughout most of the Subbasin, the Lower Aquifer shows lower piezometric heads than the Upper Aquifer suggesting a downward vertical gradient where subsurface geologic conditions provide lesser hydraulic separation between these zones. Figure 5-79 shows a distinct trough-like depression in the Lower Aquifer's groundwater elevation indicative of groundwater pumping/depletion within the Central Delta-Mendota, Oro Loma Water District, and Widren Water District GSAs, which could induce deep southwestern direction groundwater flows from the valley axis toward these GSAs as indicated by the flow direction vectors. There are also deep northeast groundwater flows within the Lower Aquifer from the Coast Ranges toward the Central Delta-Mendota, Oro Loma Water District, and Widren Water District GSAs, which could result in deep, pumping-enhanced mixing of different quality groundwater within the Lower Aquifer groundwater trough.

Vertical Gradients

Throughout most of the Delta-Mendota Subbasin, the Corcoran Clay layer acts as a regional aquitard, limiting the vertical migration of groundwater. In areas outside the Corcoran Clay layer (along the western margin of the Subbasin), localized interfingered clays minimize the downward migration of groundwater; although in areas where the clay layers are not competent or non-existent, groundwater migrates from shallower to deeper groundwater zones. Similarly, in areas where the Corcoran Clay has been compromised by the construction of composite wells, groundwater generally flows from the Upper Aquifer to the Lower Aquifer, especially in areas where the Lower Aquifer is actively used as a water supply (lowering the potentiometric head in that zone).

Groundwater Contours

Figure 5-80 and Figure 5-81 depict groundwater surface elevation for the seasonal high (Spring 2013) and seasonal low (Fall 2013) for the Upper Aquifer relative to NAVD88. Spring is defined as groundwater surface elevation measurements from January 1 through April 8; where Fall is defined as groundwater surface elevation measurements from August 1 through October 31. For wells where multiple Spring 2013 or Fall 2013 measurements were available, the highest elevation for each season was used for contouring. In the Upper Aquifer, during Spring 2013, the general flow of groundwater in the Delta-Mendota Subbasin was from the Coastal Range along the western boundary of the Subbasin toward the San Joaquin River along the eastern boundary. In the southern-central portion of the Subbasin, groundwater flow was to the southwest toward Los Banos; while in the southern portion of the Subbasin, groundwater flow is to the southeast toward Aliso Water District and the Tranquillity area. Groundwater elevations tend to increase moving south throughout the Subbasin.

Spring groundwater elevations are the lowest within Stanislaus County, ranging between 40 and 80 feet above msl, and become increasingly higher in Merced and Fresno Counties, ranging between 80 and 140 feet above msl (Figure 5-80) with general Upper Aquifer groundwater flow directions to the east and north east. For Fall 2013, groundwater flows in a similar direction (west to east and northeast) with groundwater elevations in Stanislaus County still the lowest (ranging between 40 and 80 feet above msl). As with Spring 2013, groundwater elevations in Fall of 2013 (Figure 5-81) become increasingly higher in Merced County (ranging between 60 and 140 feet above msl) and Fresno County (ranging from 60 and 120 feet above msl).

Due to insufficient data, groundwater elevation contour maps for the Lower Aquifer for the seasonal high and low (Spring 2013 and Fall 2013, respectively) could not be accurately prepared. Figure 5-82 and Figure 5-83 show available groundwater elevation measurements for Spring 2013 and Fall 2013. Available Spring 2013 measurements range from -127 to 12 feet above msl in Stanislaus County, from -65 to 124 feet above msl in Merced County, and from -5 to 88 feet above msl in Fresno County (Figure 5-82). Available Fall 2013 measurements range from -138 to

156 feet above msl in Stanislaus County, from -94 to 19 feet above msl in Merced County, and from -72 to -4 feet above msl in Fresno County (Figure 5-83).

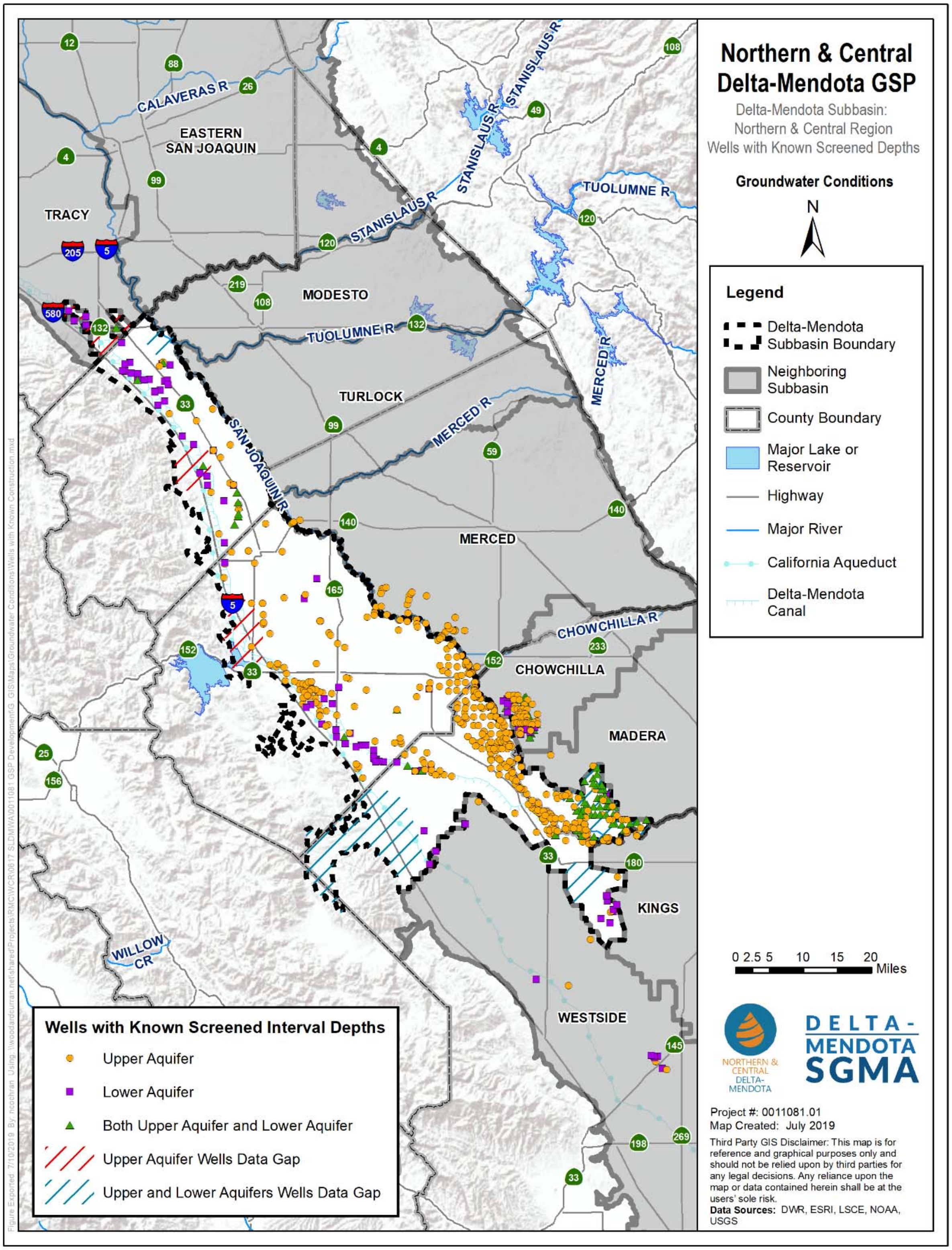


Figure 5-64. Wells with Known Screened Interval Depths, Delta-Mendota Subbasin

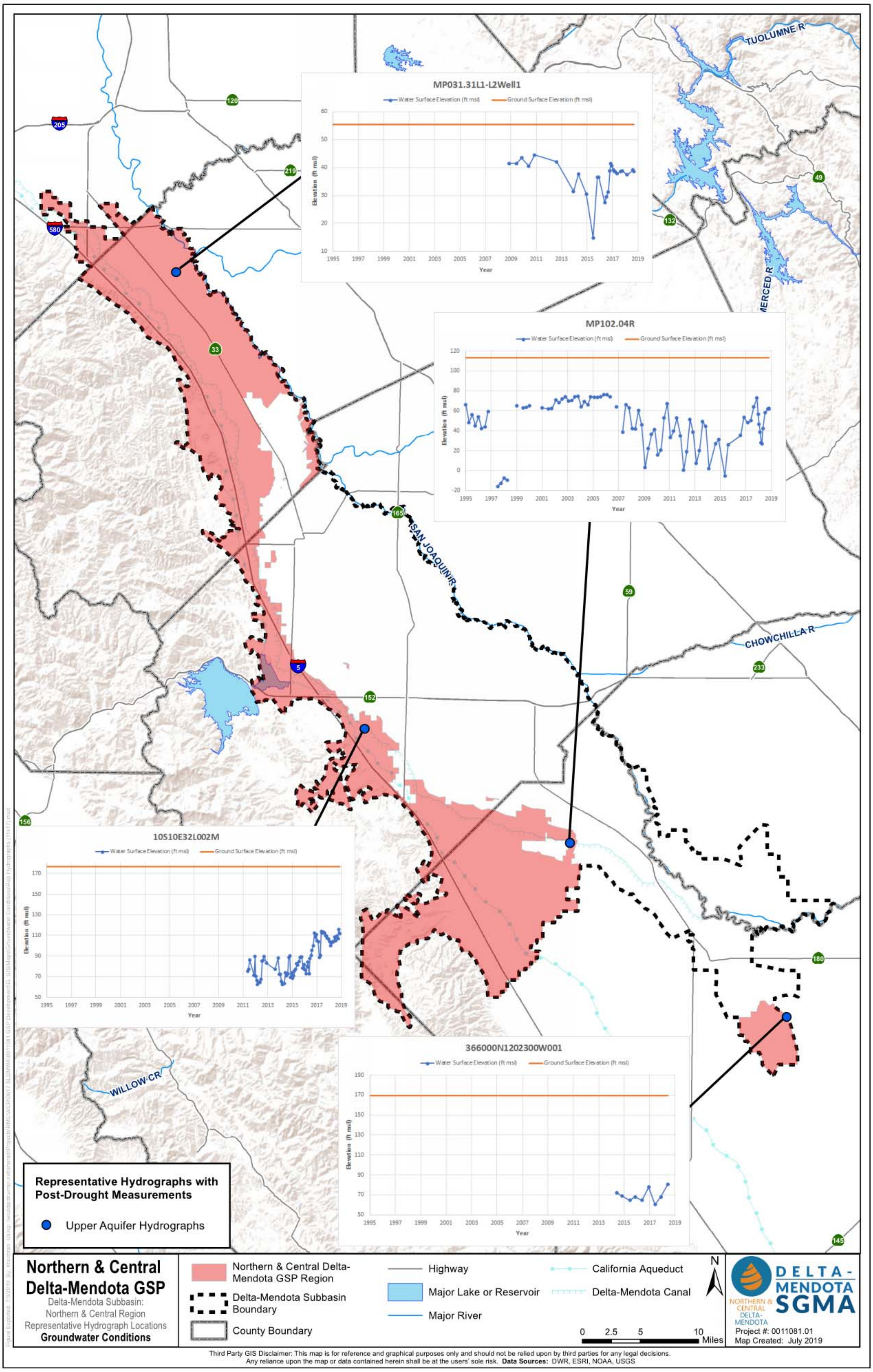


Figure 5-65. Representative Hydrographs with Post-Drought Measurements, Upper Aquifer

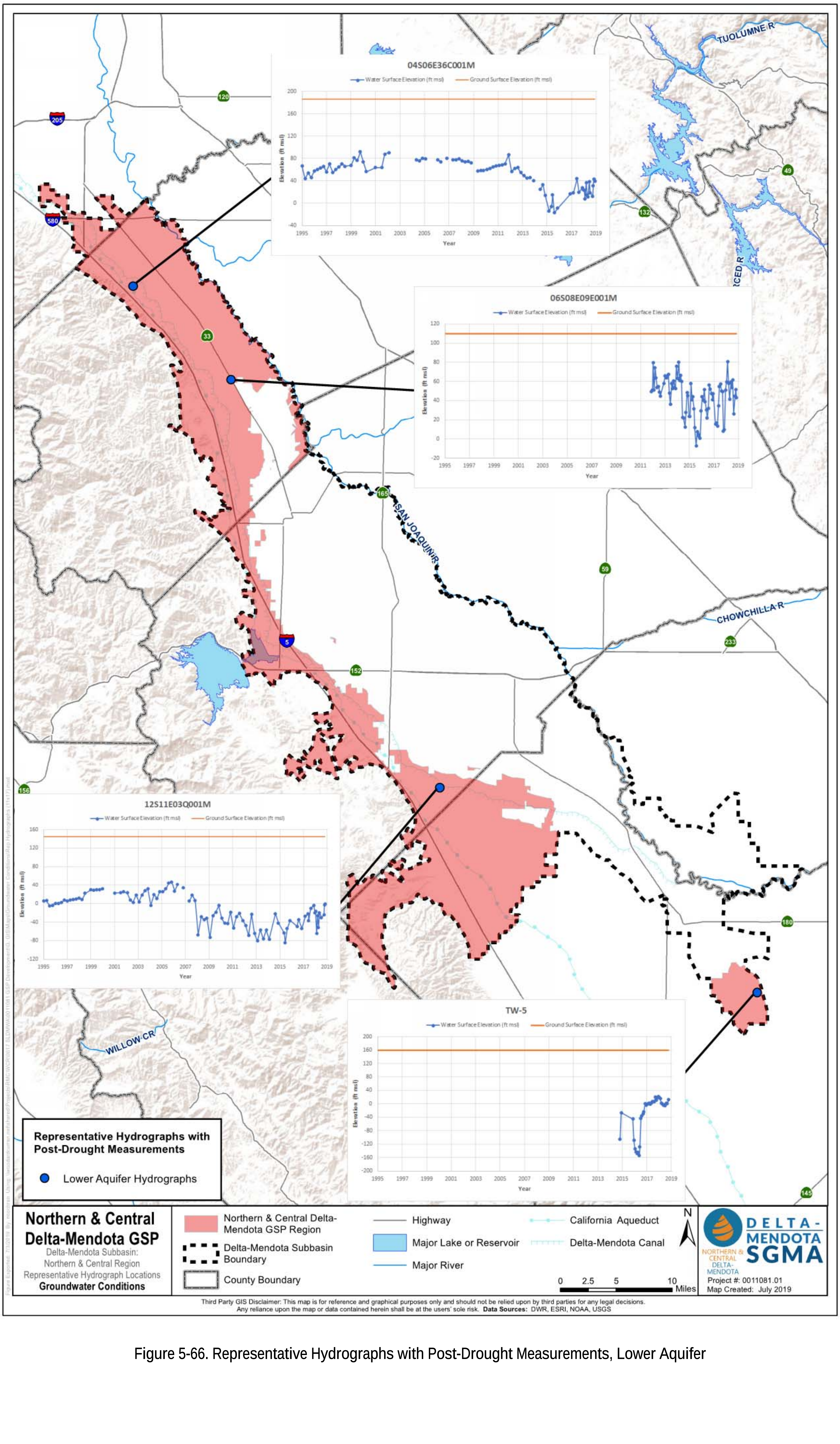
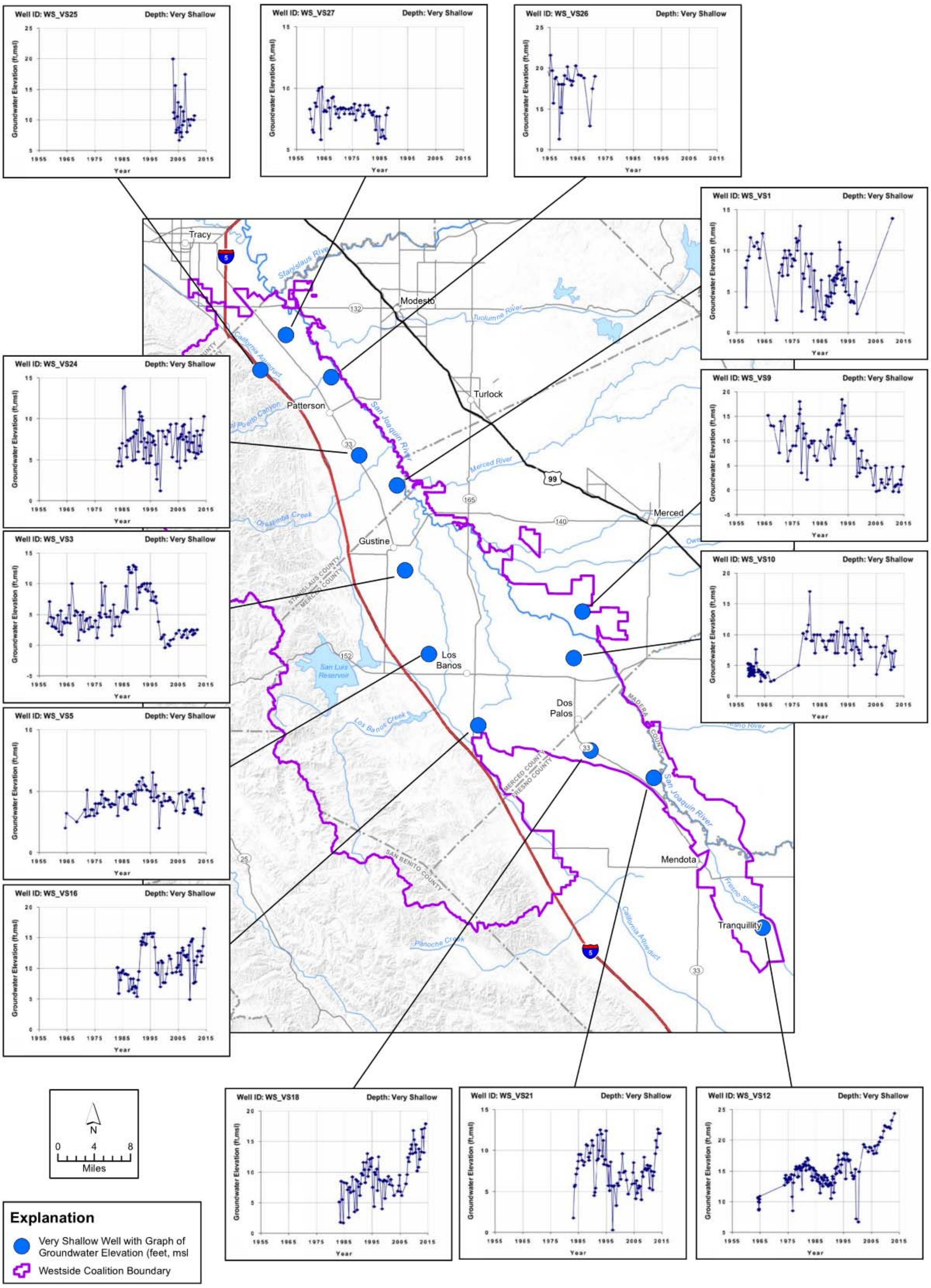


Figure 5-66. Representative Hydrographs with Post-Drought Measurements, Lower Aquifer

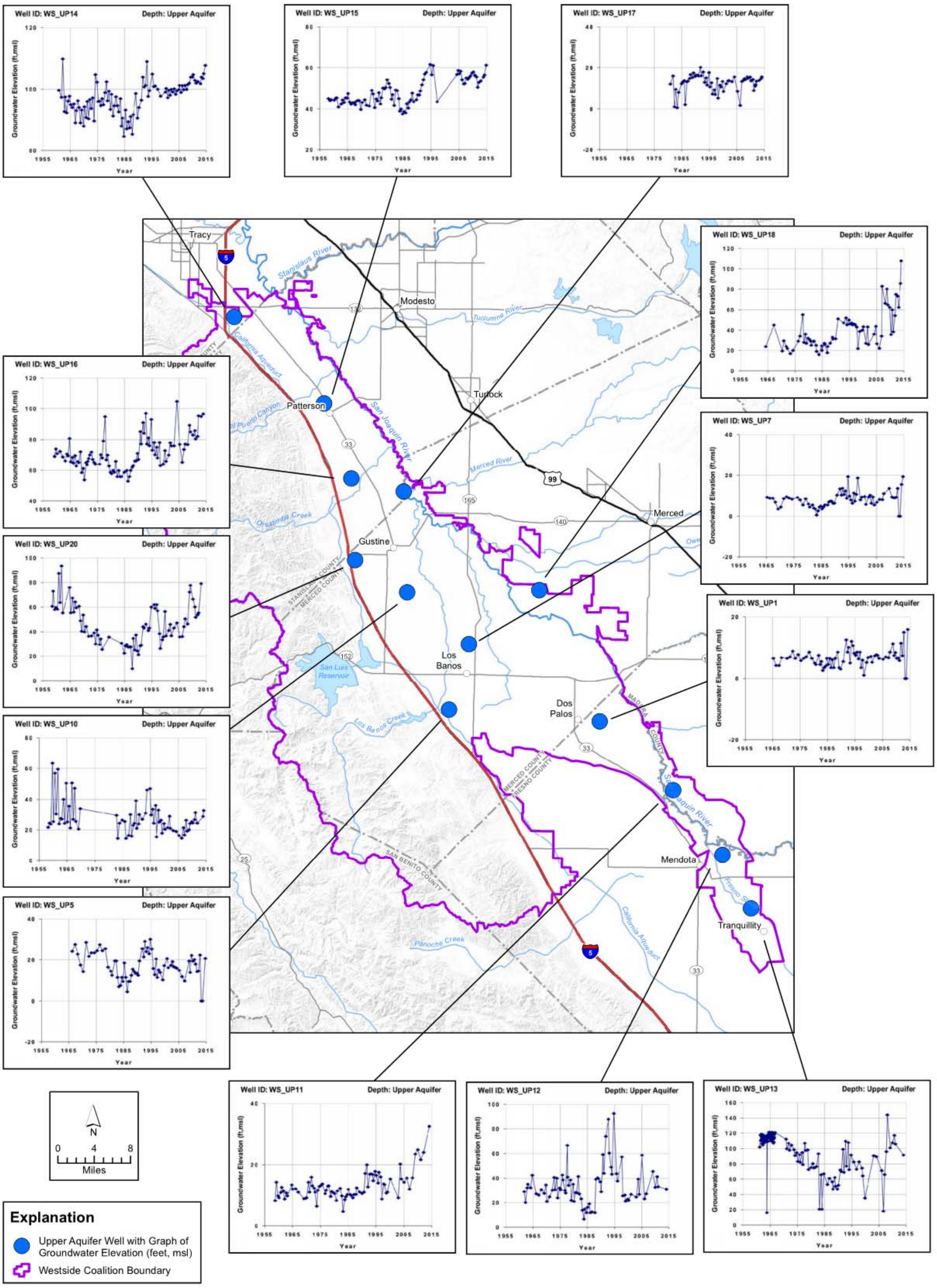


Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Notes:

1. Figure not to scale.
2. The intent of these hydrographs is to generally demonstrate groundwater trends across the Delta-Mendota Subbasin.

Figure 5-67. Select Graphs of Groundwater Elevations, Very Shallow Groundwater

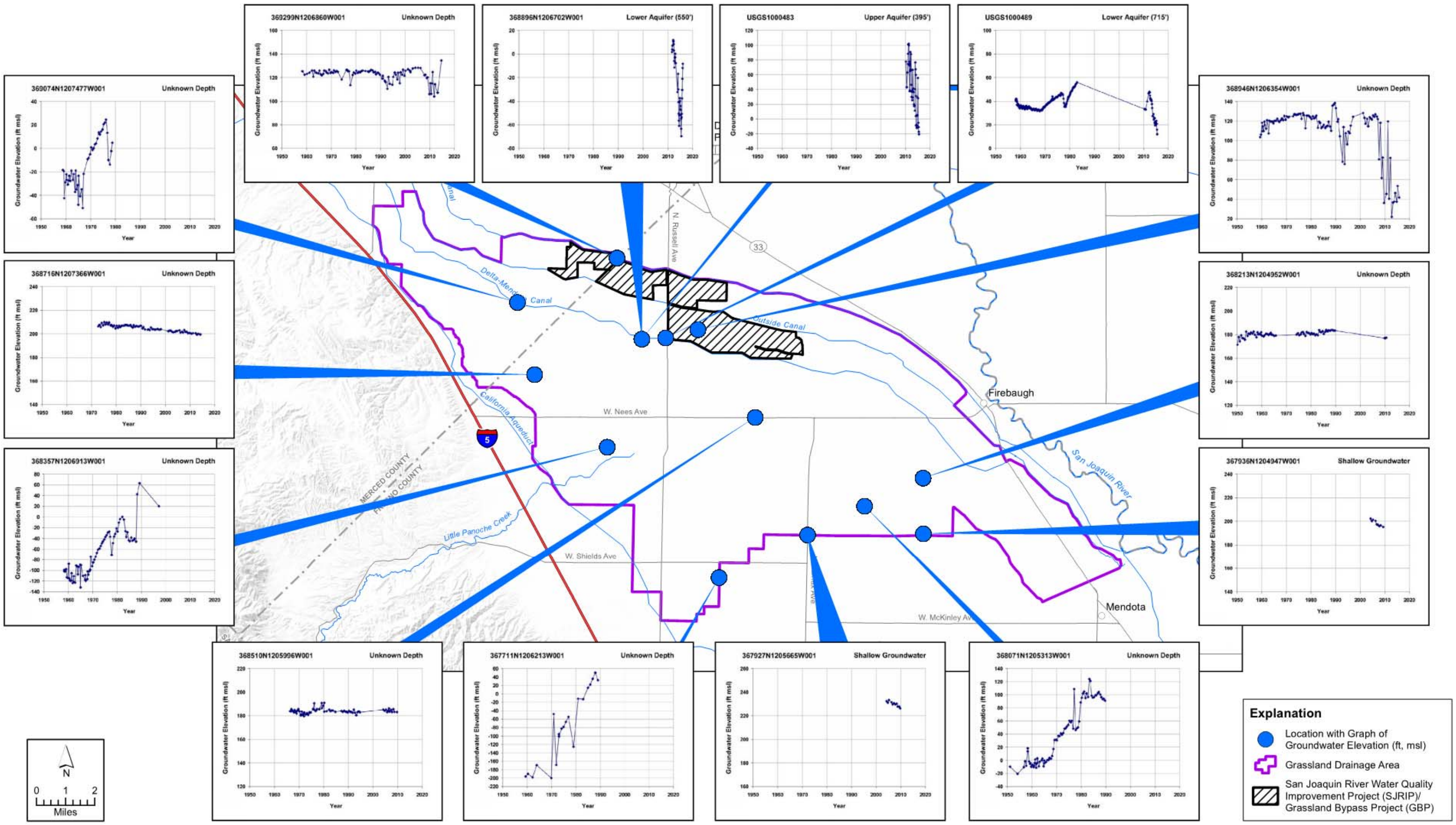


Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Notes:

1. Figure not to scale.
2. The intent of these hydrographs is to generally demonstrate groundwater trends across the Delta-Mendota Subbasin.

Figure 5-68. Select Graphs of Groundwater Elevations, Upper Aquifer



Source: *Grassland Drainage Area Groundwater Quality Assessment Report*, 2016

Notes:

1. Figure not to scale.
2. The intent of these hydrographs is to generally demonstrate groundwater trends across the Delta-Mendota Subbasin.

Figure 5-69. Select Graphs of Groundwater Elevations, Various Depths

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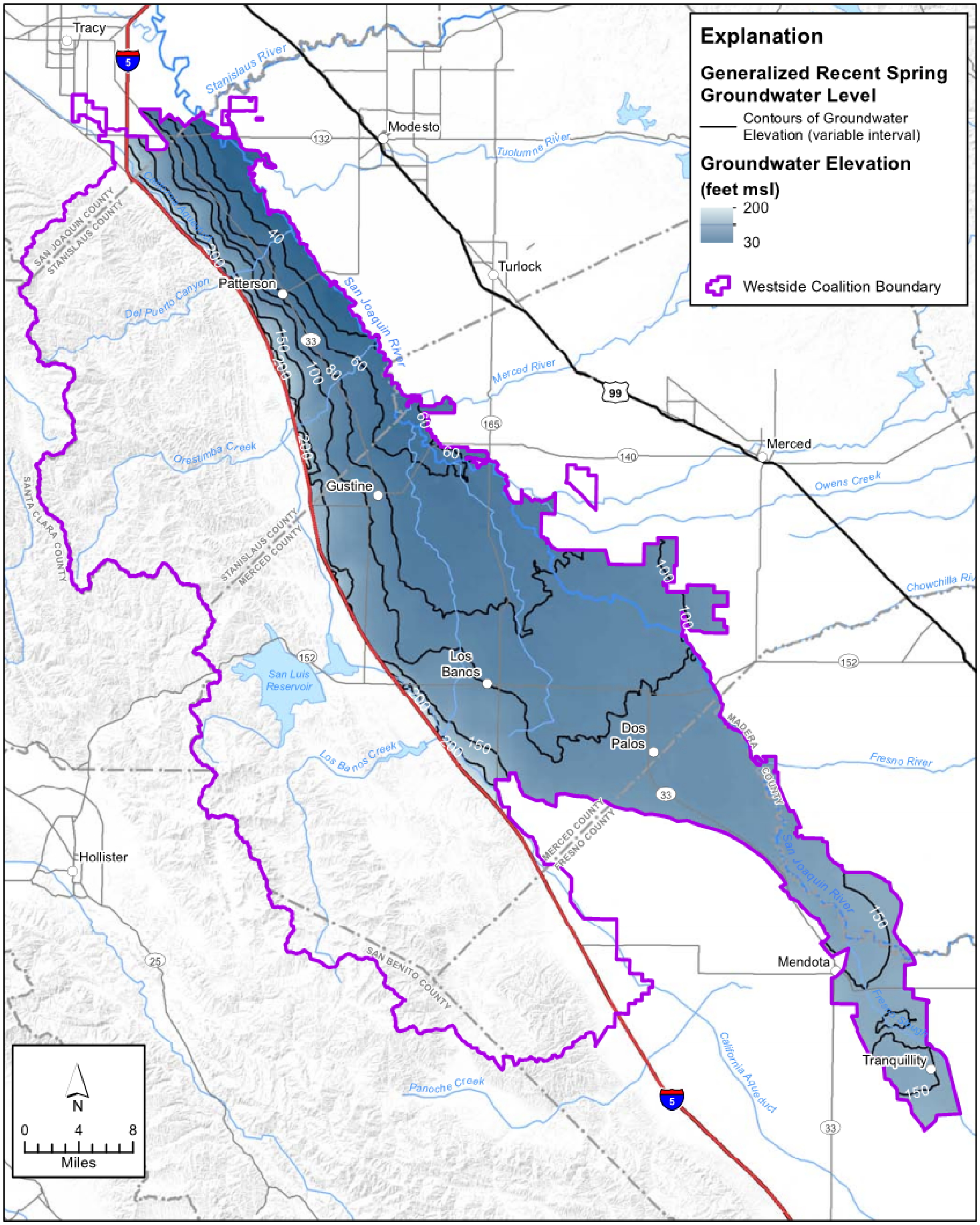
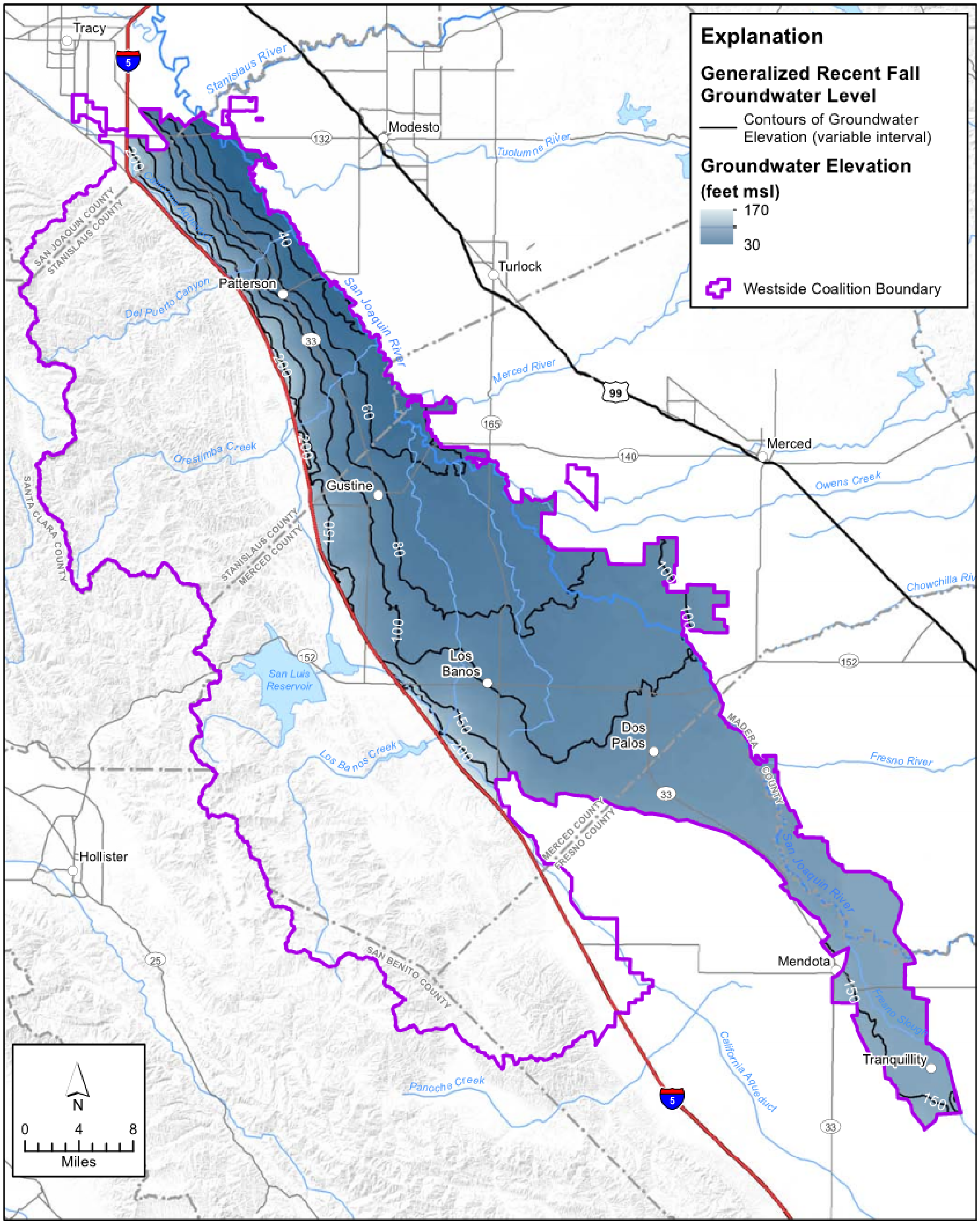


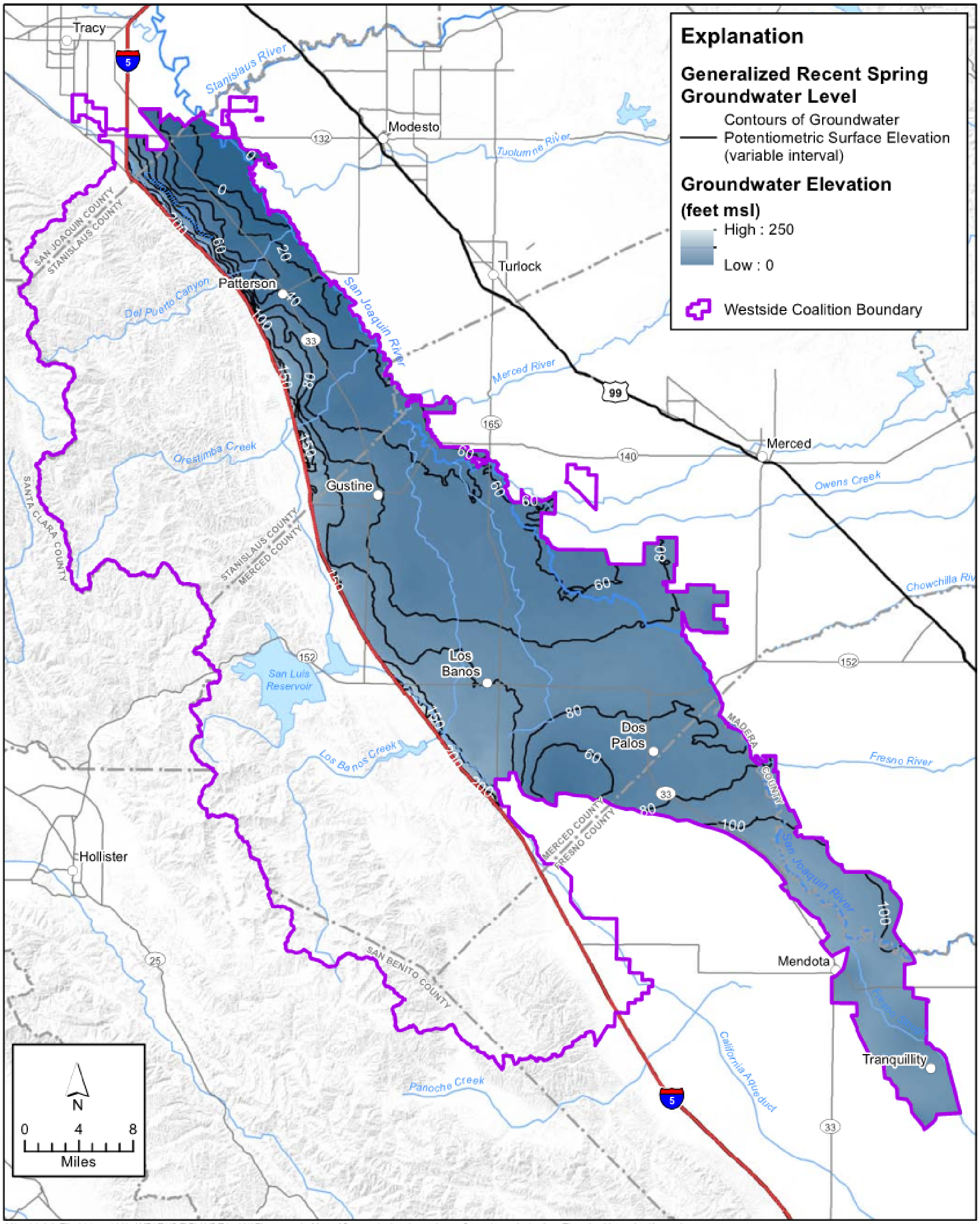
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-70. Map of Spring Groundwater Elevation (2000-2016 Average), Very Shallow Groundwater



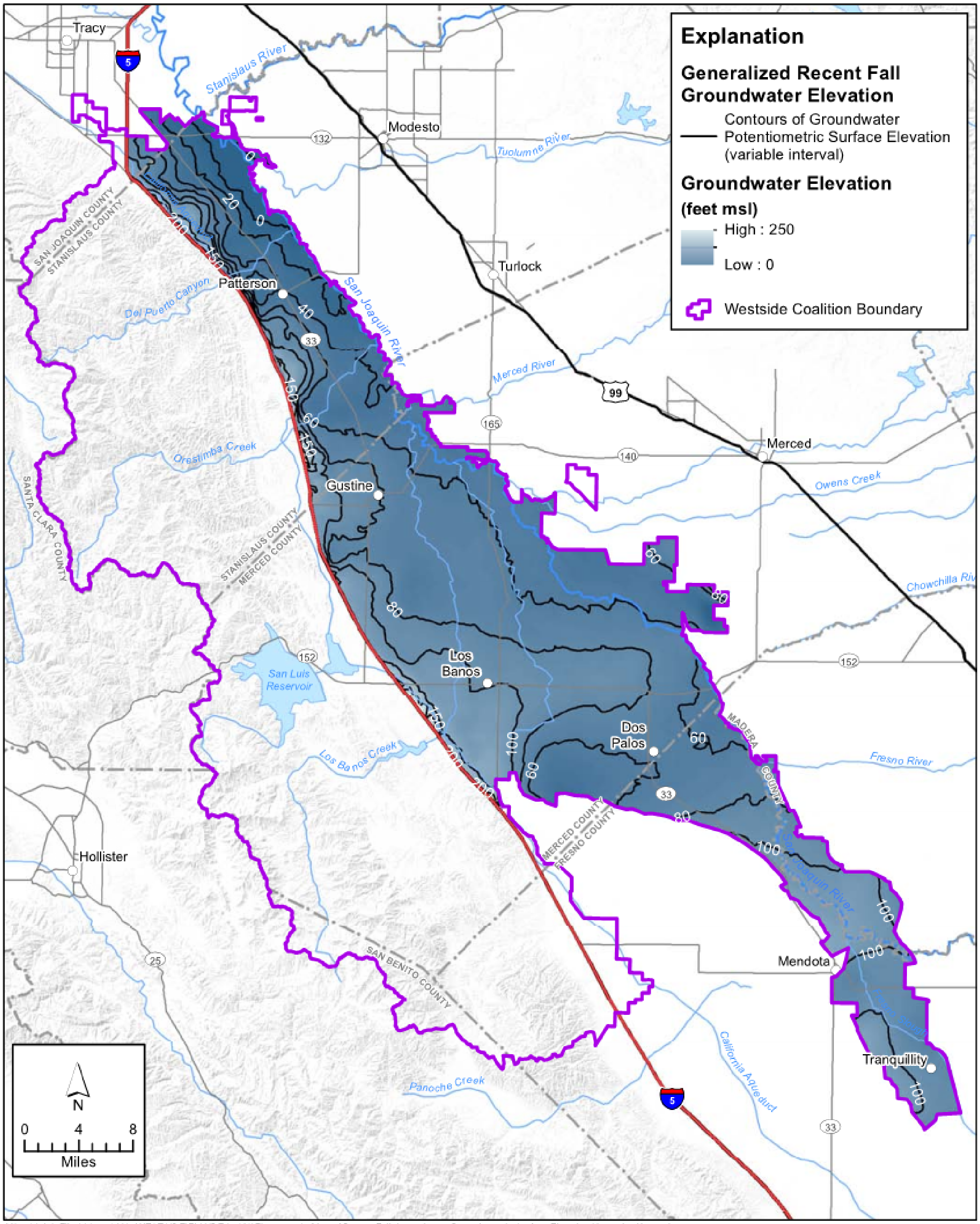
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-71. Map of Fall Groundwater Elevation (2000-2016 Average), Very Shallow Groundwater



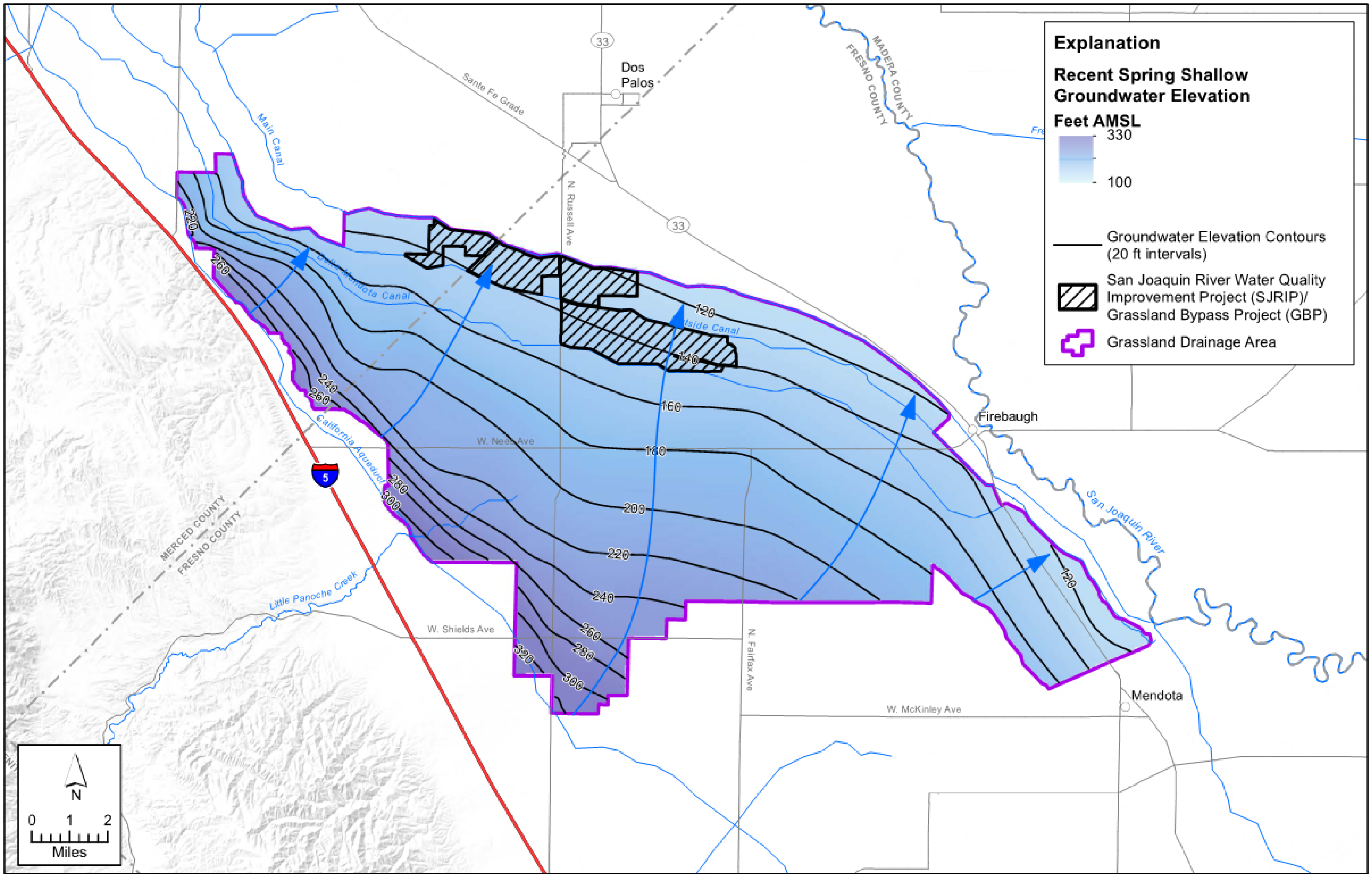
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-72. Map of Spring Groundwater Elevation (2000-2016 Average), Upper Aquifer



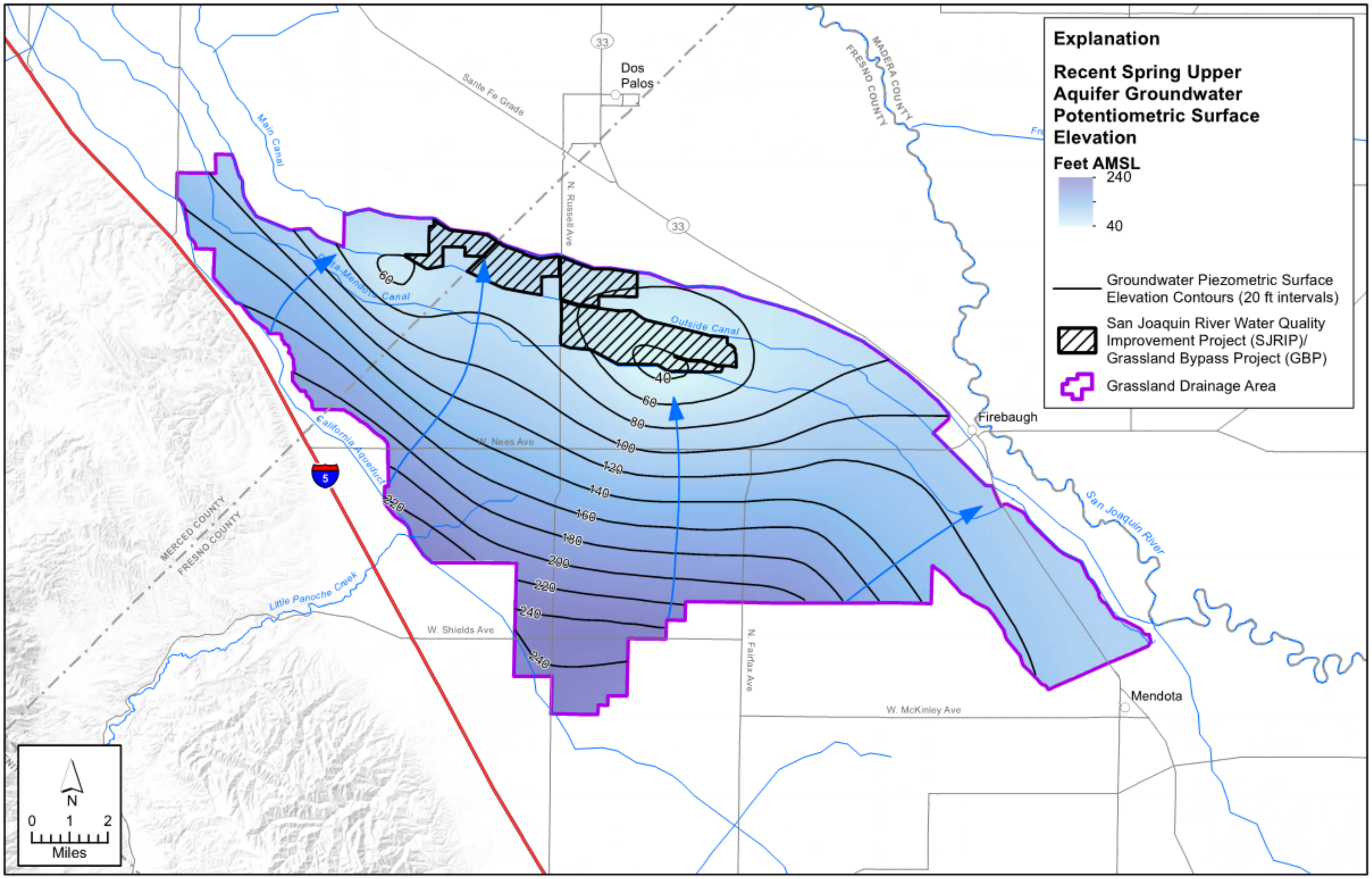
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-73. Map of Fall Groundwater Elevation (2000-2016 Average), Upper Aquifer



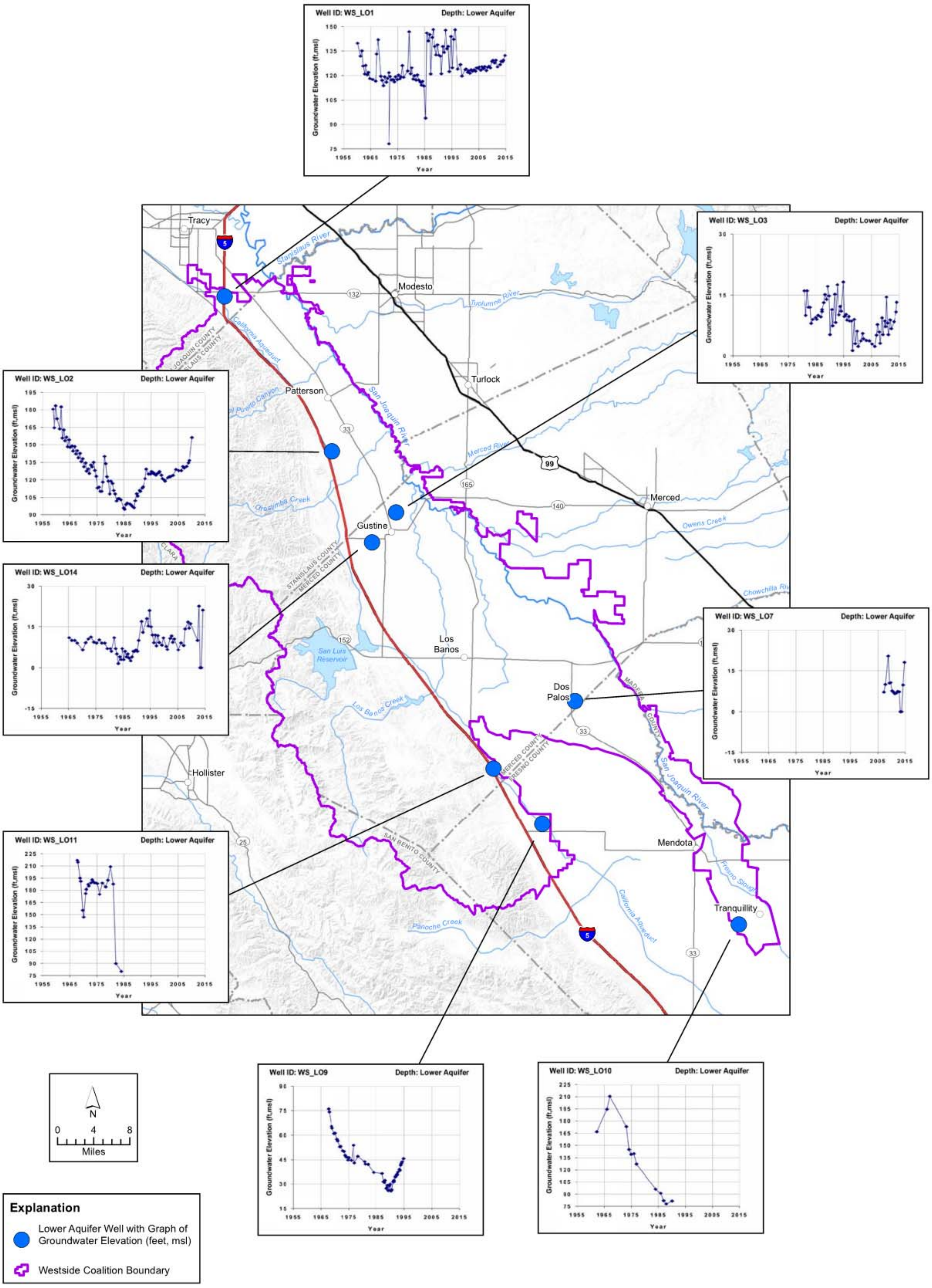
Source: *Grassland Drainage Area Groundwater Quality Assessment Report*, 2016

Figure 5-74. Map of Spring Groundwater Elevation (2000-2016 Average), Shallow Groundwater



Source: *Grassland Drainage Area Groundwater Quality Assessment Report*, 2016

Figure 5-75. Map of Spring Groundwater Elevation (2000-2016 Average), Upper Aquifer



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015
Note: The intent of these hydrographs is to generally demonstrate groundwater trends across the Delta-Mendota Subbasin.

Figure 5-76. Select Graphs of Groundwater Elevations, Lower Aquifer

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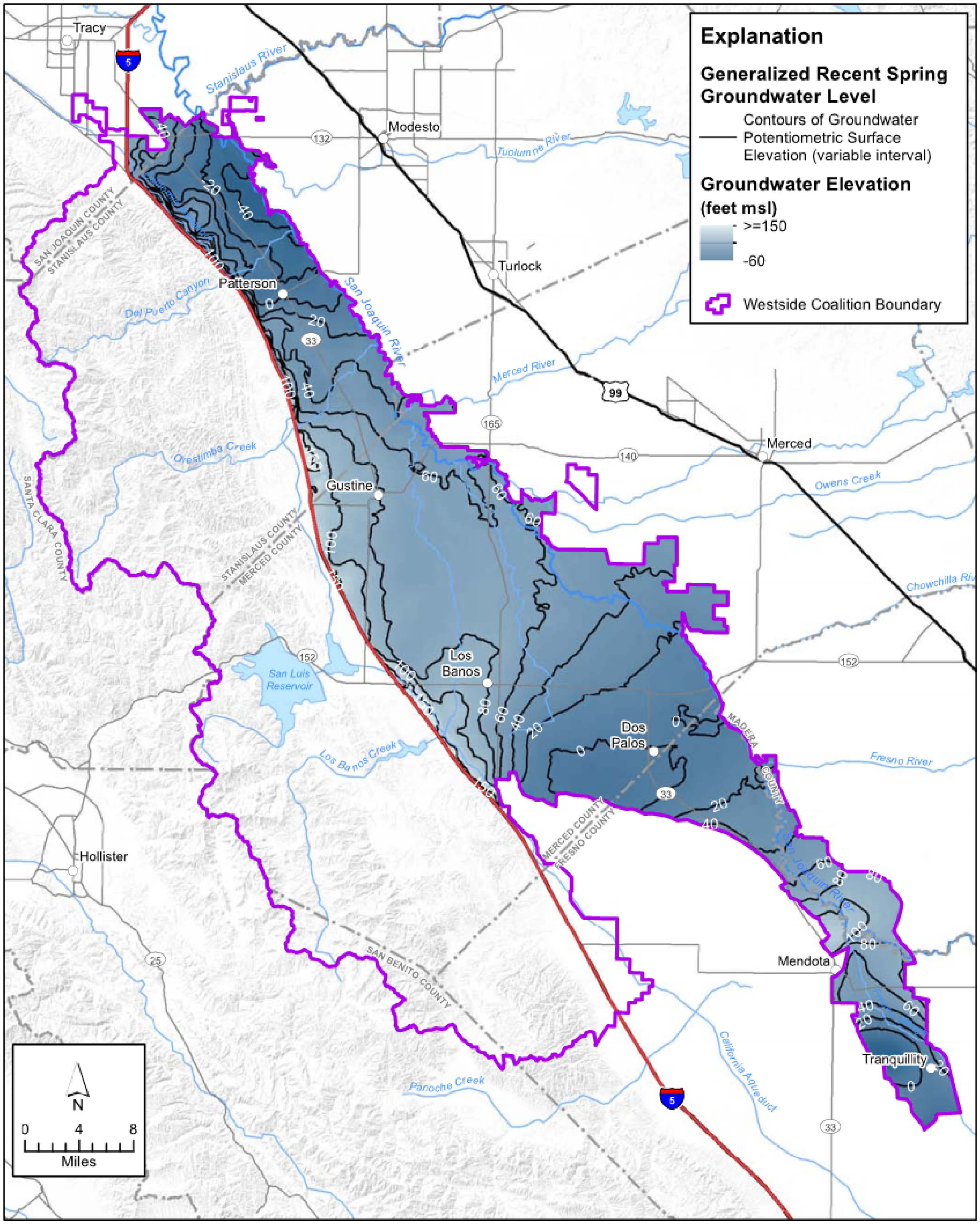
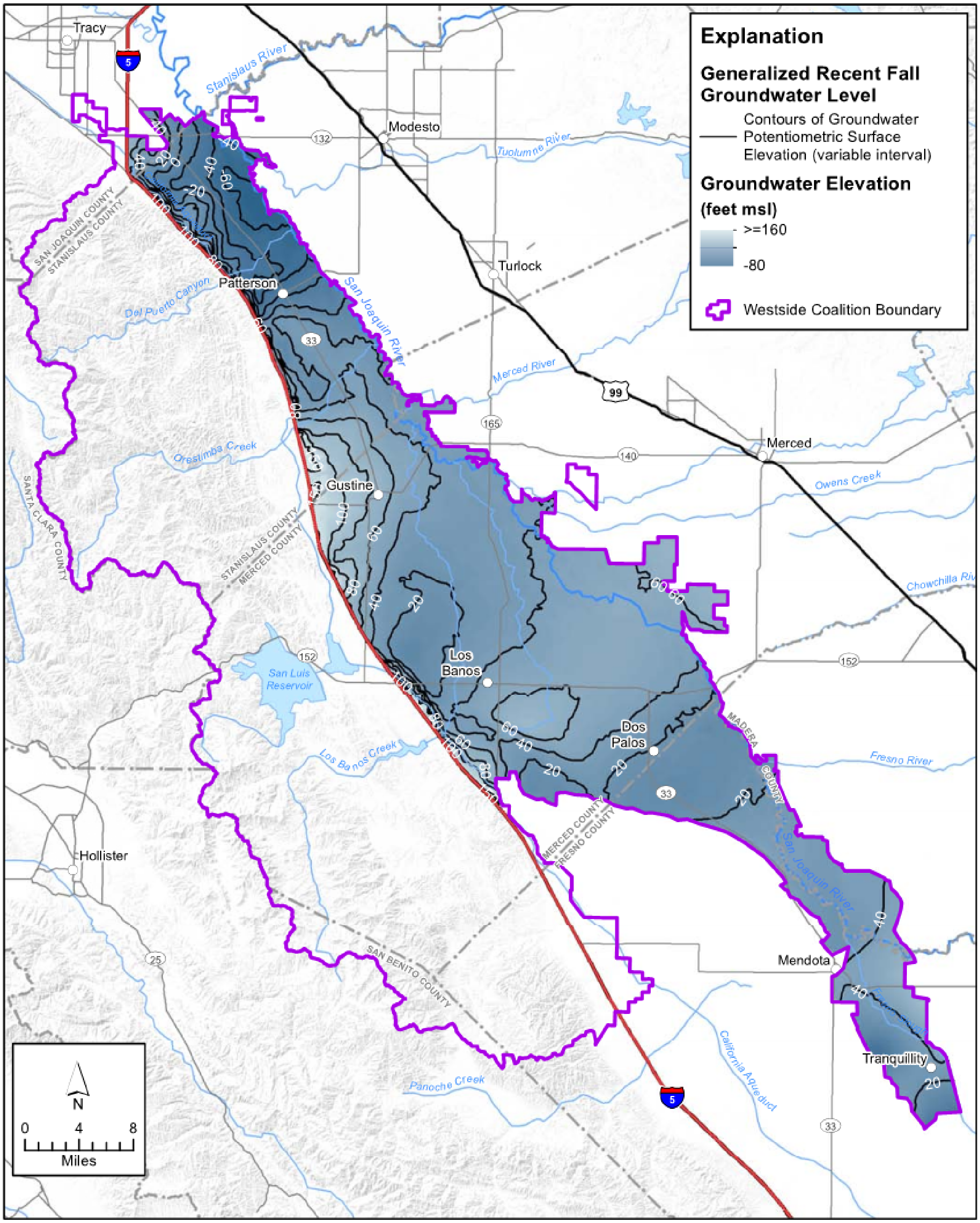


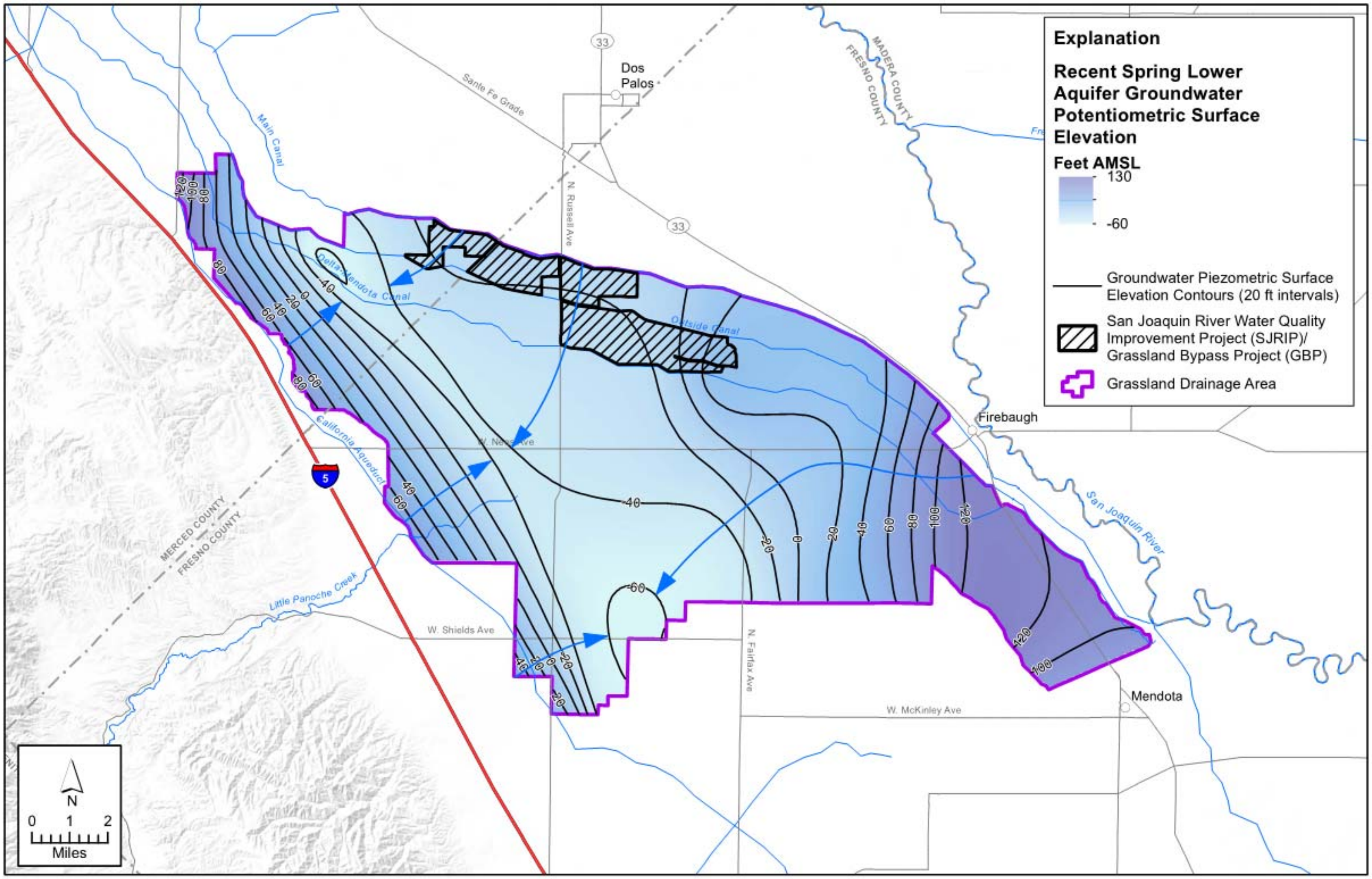
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-77. Map of Spring Groundwater Elevation (2000-2016 Average), Lower Aquifer



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-78. Map of Fall Groundwater Elevation (2000-2016 Average), Lower Aquifer



Source: *Grassland Drainage Area Groundwater Quality Assessment Report*, 2016

Figure 5-79. Map of Spring Groundwater Elevation (2000-2016 Average), Lower Aquifer

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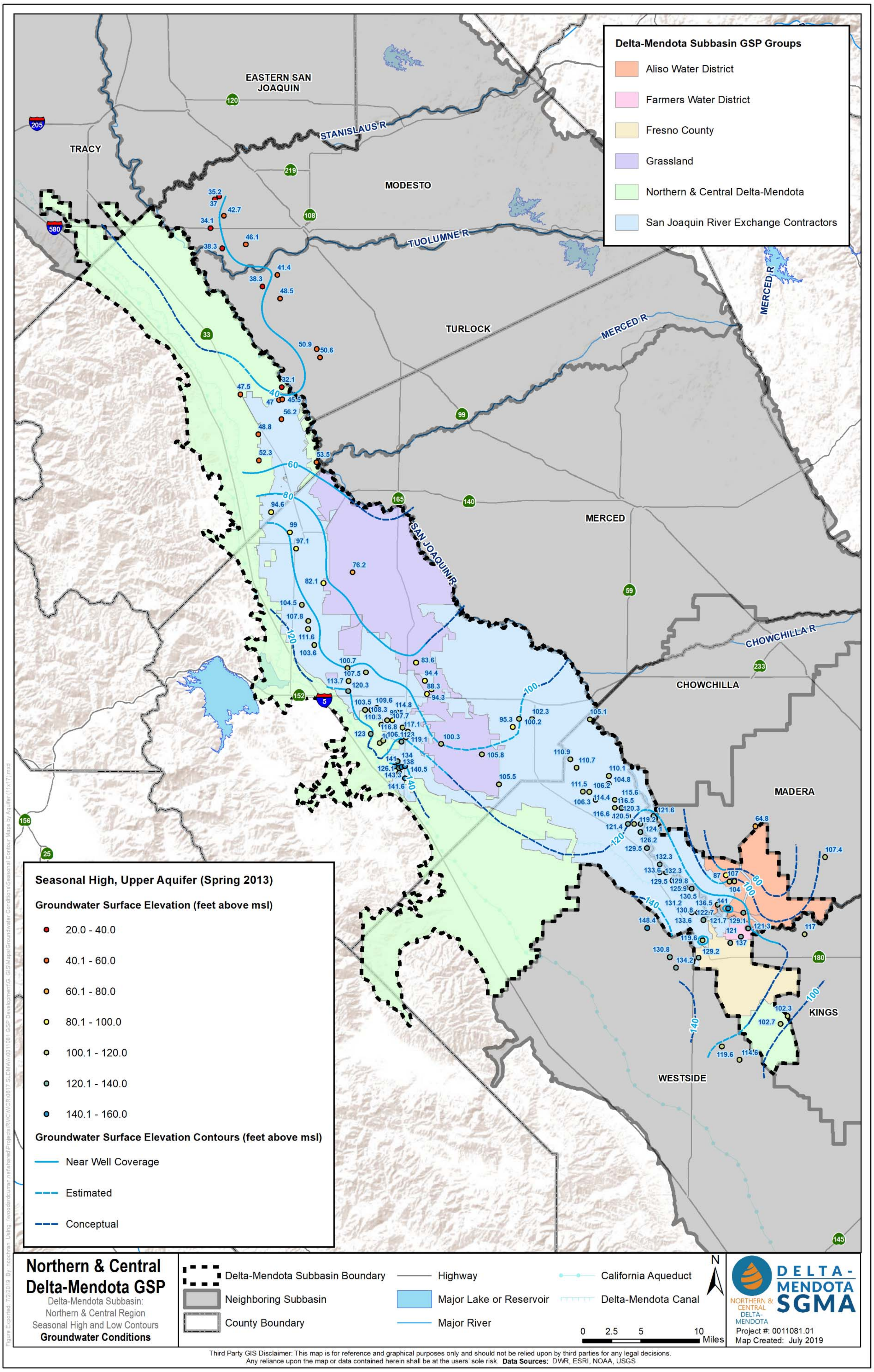

Figure 5-80. Spring 2013 Upper Aquifer Groundwater Contour Map, Delta-Mendota Subbasin

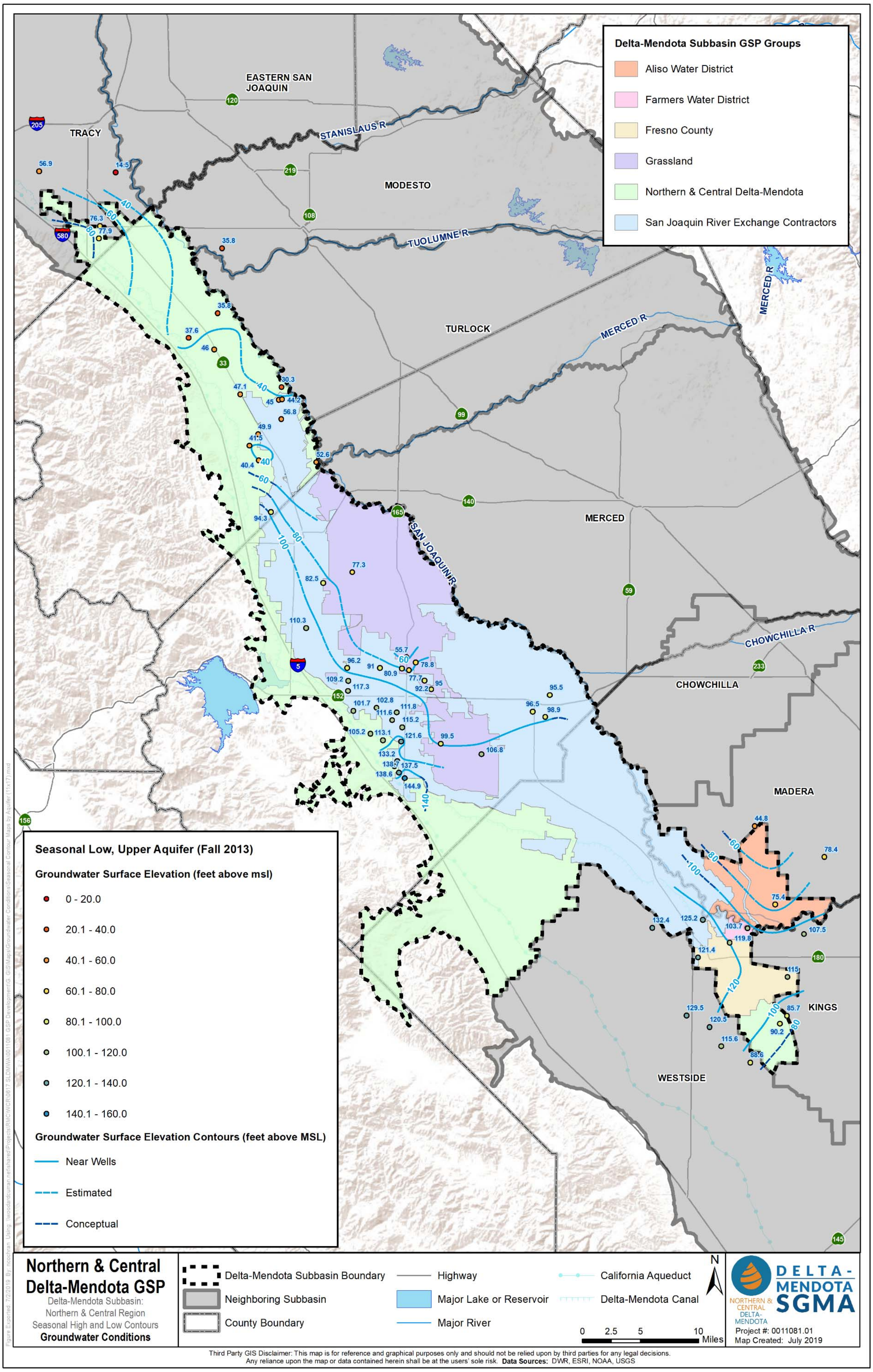

Figure 5-81. Fall 2013 Upper Aquifer Groundwater Contour Map, Delta-Mendota Subbasin

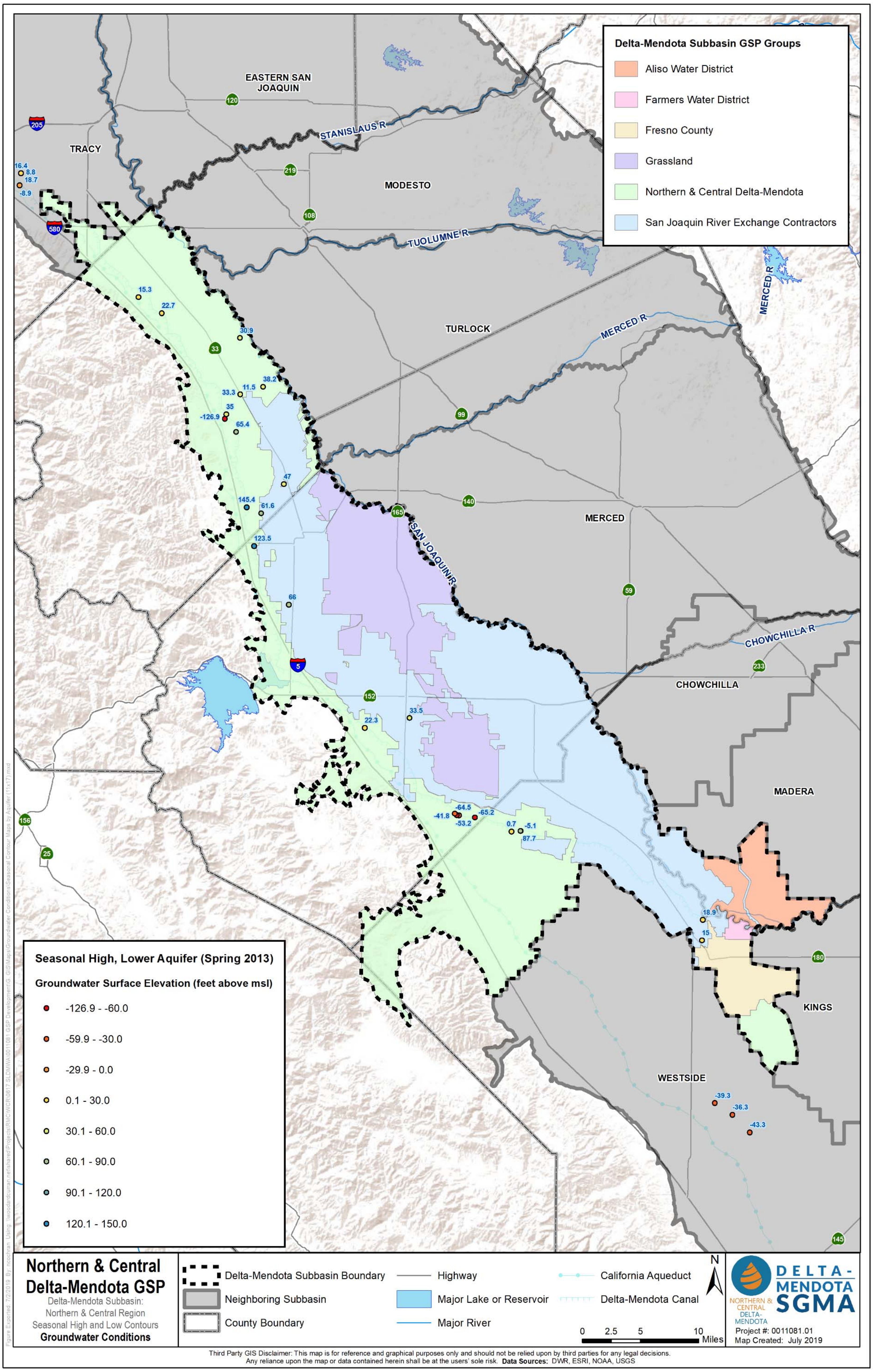

Figure 5-82. Spring 2013 Lower Aquifer Groundwater Elevation Measurements, Delta-Mendota Subbasin

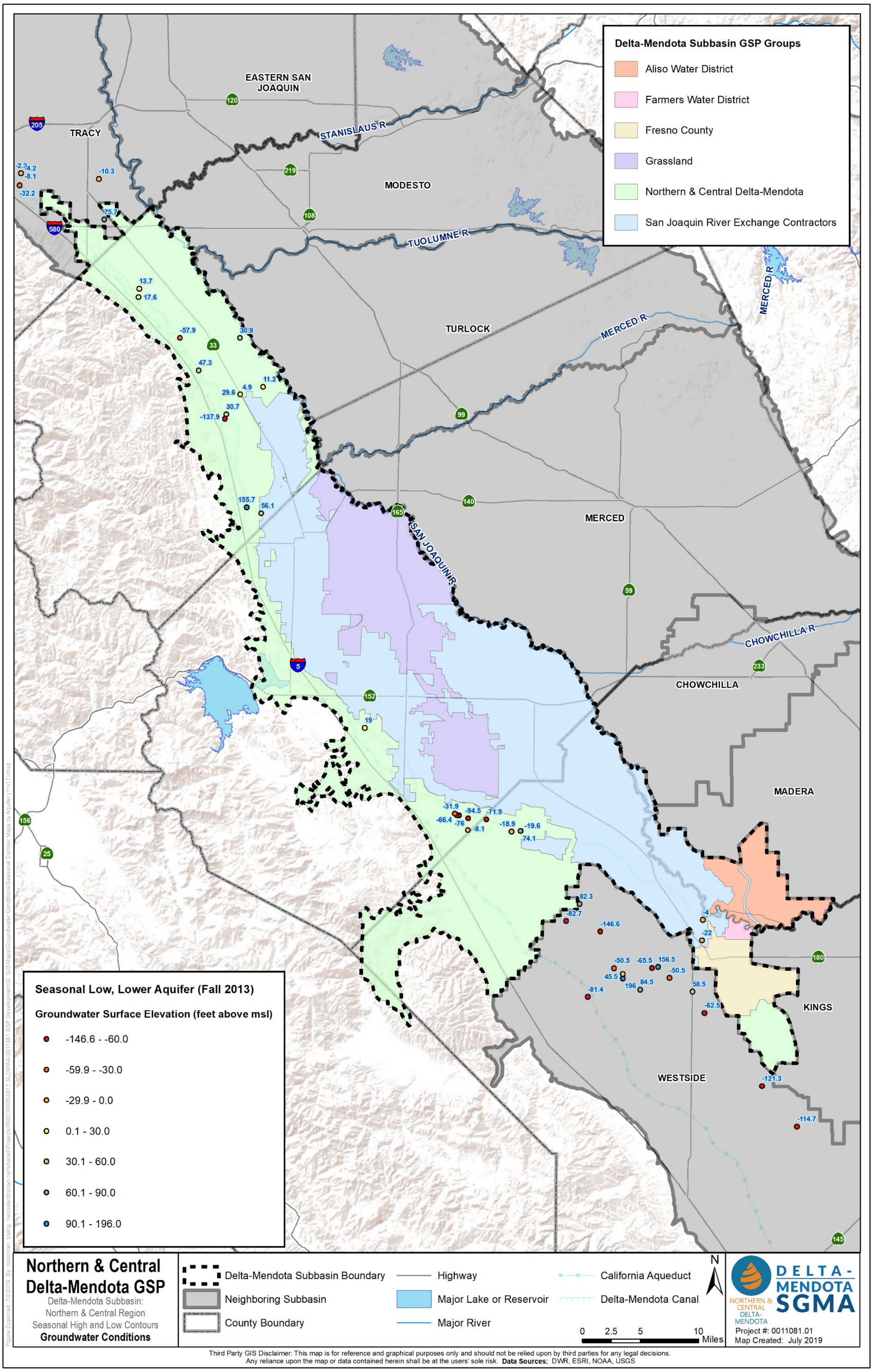

Figure 5-83. Fall 2013 Lower Aquifer Groundwater Elevation Measurements, Delta-Mendota Subbasin

5.3.3 Groundwater Storage

Annual change in groundwater storage for both the Upper and Lower Aquifers in the Northern and Central Delta-Mendota Regions was generated through the development of the historic and current water budgets (WY2003-2013). Aquifer-specific hydrographs available within the Northern and Central Delta-Mendota Regions were used to estimate annual and cumulative change in storage relative to the start of the historic water budget period in WY2003. Please refer to the Water Budget section (Section 5.4) and Water Budgets Model Development Technical Memorandum (Appendix D) for more detail regarding how change in storage was calculated.

Figure 5-84 and Figure 5-85 show annual change in storage, cumulative change in storage, and water year type for the Upper Aquifer and Lower Aquifer, respectively, from WY2003 through WY2018 for the Northern and Central Delta-Mendota Regions. Cumulative change in storage from WY2003 through WY2013 was derived from annual change in storage based on available hydrograph data (represented as a solid line in Figure 5-84 and Figure 5-85). Cumulative change in storage from WY2014 through WY2018 was estimated from annual change in storage based on the average change in storage by water year type from WY2003 to WY2013 (represented as a dashed line in Figure 5-84 and Figure 5-85). For the purposes of the water budget four water year types were utilized: wet, average (corresponding to above and below normal water years from the San Joaquin River Index), dry (corresponding to dry and critical water years from the San Joaquin River Index) and Shasta critical.

Change in storage is negative for 12 out of the 16 years and negative for 4 out of the 8 Wet and Average water year types in both the Upper Aquifer and Lower Aquifer. Despite periods of wet conditions with recharge outpacing extractions, an overall declining trend in groundwater storage can be observed in both the Upper and Lower Aquifers. Cumulative change in storage declined more rapidly in the Upper Aquifer compared to the Lower Aquifer, declining by about 830,000 acre-feet (AF) in the Upper Aquifer and 160,000 AF in the Lower Aquifer between WY2003 and WY2018.

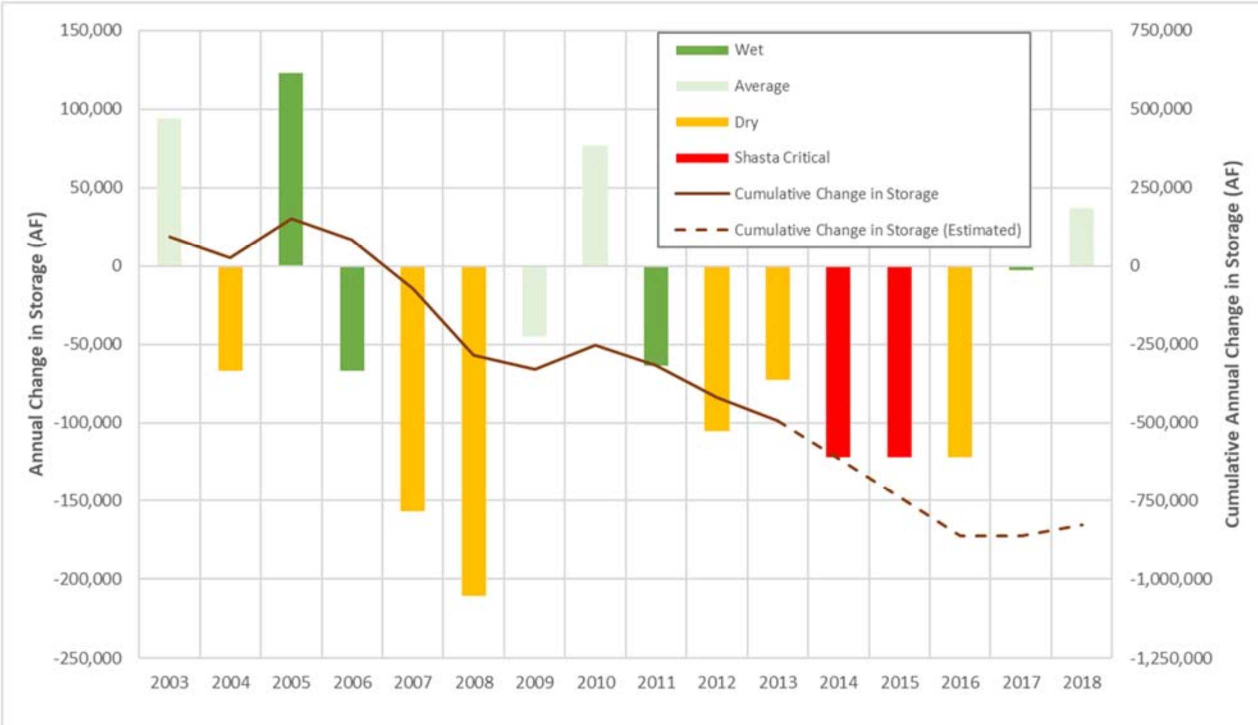

Figure 5-84. Calculated Upper Aquifer Change in Storage, Annual and Cumulative

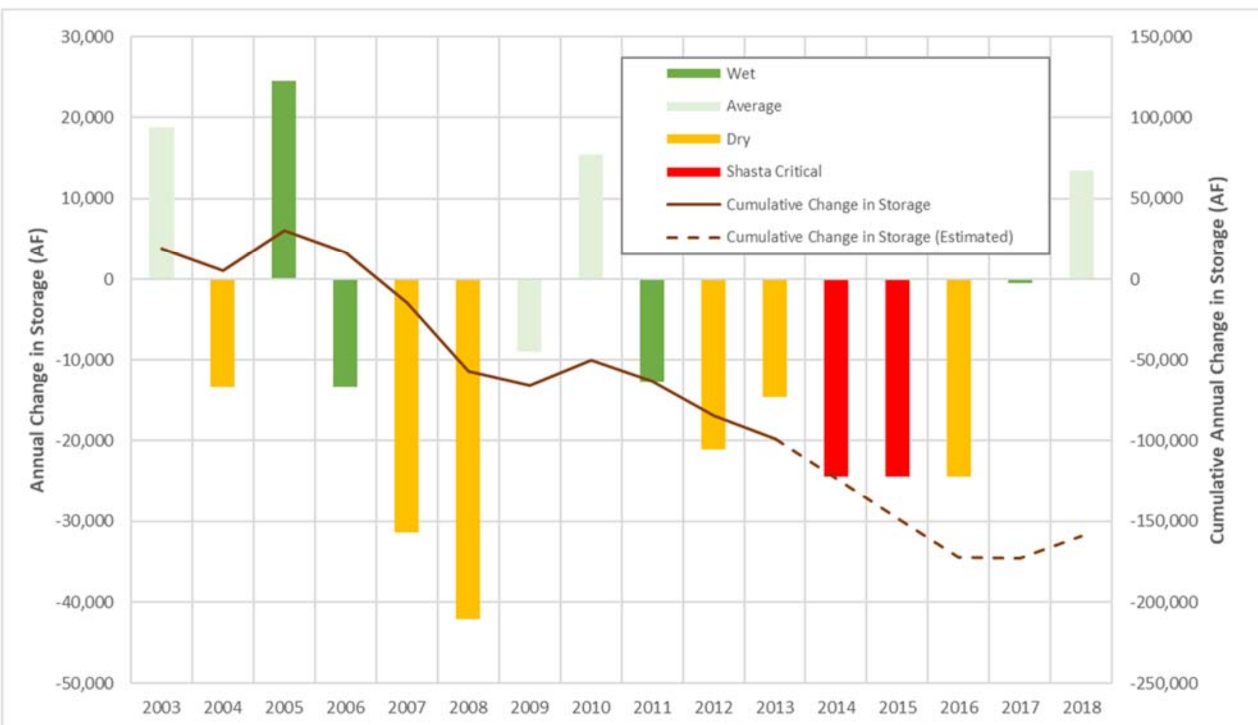

Figure 5-85. Calculated Lower Aquifer Change in Storage, Annual and Cumulative

5.3.4 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Delta-Mendota Subbasin as a whole. The Subbasin is located inland from the Pacific Ocean; thus, groundwater conditions related to seawater intrusion are not applicable to the Delta-Mendota Subbasin.

5.3.5 Groundwater Quality

Groundwater quality is a primary factor in groundwater supply reliability. There are no known groundwater contamination sites or plumes within the Northern and Central Delta-Mendota Regions. Groundwater quality concerns within the Northern and Central Delta-Mendota Regions are largely related to non-point sources and/or naturally-occurring constituents. Constituents of concern, both natural and anthropogenic, can impact human health and agricultural production. The following subsections attempt to identify and analyze available groundwater quality data and summarize groundwater quality conditions through a literature review and evaluation of existing publicly available data sets. It should be noted that constituents of concern discussed in this GSP are not exhaustive of all constituents of concern present in groundwater in the Delta-Mendota Subbasin. The presented constituents of concern were selected based on available data, the potential to impact existing or future groundwater use, the ability to address groundwater quality impacts through projects and/or management actions, and the source of the constituent.

Primary constituents of concern within the Northern and Central Delta-Mendota Regions are nitrate, total dissolved solids (TDS), and boron, which all have anthropogenic as well as natural sources. Table 5-2 includes the State and federal primary and secondary MCLs for drinking water in milligrams per liter (mg/L). These are also the Water Quality Objectives (WQOs) in the Central Valley Regional Water Quality Control Board's (CV-RWQCB) *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (or Basin Plan) (2009) for waters designated as having municipal (MUN) beneficial use. Table 5-3 includes WQOs for irrigated agriculture. Agricultural WQOs identified in Table 5-3 are derived from the *Delta-Mendota Canal Non-Project Water Pump-in Program Monitoring Plan* (2018).

While there are other constituents known to be found in localized areas throughout the Northern and Central Delta-Mendota Regions, these constituents generally characterize groundwater quality in the region of interest. It is important to note that the following discussion and analysis of ambient groundwater quality is not reflective of drinking water quality where treatment is applied to remove such constituents before public consumption.

Other known constituents of concern within the Delta-Mendota Subbasin include arsenic, selenium, and hexavalent chromium. These constituents are naturally occurring in the Delta-Mendota Subbasin and have been detected at concentrations above the WQOs at various locations throughout the Delta-Mendota Subbasin. Concentrations of these constituents do not appear to be linked to groundwater elevations, and as such, these constituents (and their associated concentrations) are considered to be existing conditions. There are no specific projects and/or management practices that can be implemented to mitigate for these constituents (other than groundwater treatment) that are not currently being implemented through other regulatory programs (such as the Irrigated Lands Regulatory Program). Therefore, these constituents are not considered manageable as part of this GSP other than through the coordination of GSP implementation with existing and anticipated future regulatory programs. Sustainability goals and indicators will therefore not be developed for these constituents. The water quality monitoring program will, however, continue to collect data relative to ongoing groundwater concentrations for these constituents for future assessment in coordination with other existing and anticipated future regulatory programs.

Table 5-2. State and Federal Primary and Secondary MCLs for Drinking Water, Constituents of Concern

Constituent	U.S. Environmental Protection Agency		State of California	
	Primary MCL (mg/L)	Secondary MCL (mg/L)	Primary MCL (mg/L)	Secondary MCL (mg/L)
Nitrate [1]	10 (as N)	-	45 (as NO_3)	-
TDS [2]	-	-	-	500 (Recommended) 1,000 (Upper) 1,500 (Short-term)
Boron [1]	N/A	N/A	N/A	N/A

[1] SWRCB, March 2018.
[2] State of California, 2006.

Table 5-3. Water Quality Objectives for Irrigation

Constituent	Water Quality Objective	Units
Nitrate (as Nitrogen) [1]	10	mg/L
TDS [2]	1,000	mg/L
Boron [3]	0.7	mg/L

[1] State of California (December 2017); Title 22. Table 64431-A Maximum Contaminant Levels, Inorganic Chemicals
[2] State of California (December 2017); Title 22. Table 64449-B Secondary Maximum Contaminant Levels "Consumer Acceptance Contaminant Level Ranges"
[3] Ayers and Westcot (1985), Table 21

5.3.5.1 Available Data

Groundwater quality data within the Delta-Mendota Subbasin are available from the following sources and associated programs:

- Central Valley Regional Water Quality Control Board
  - ILRP
    - Western San Joaquin GAR
    - Grassland Drainage Area GAR
- State Water Resources Control Board (SWRCB)
  - Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)
  - Geotracker Groundwater Ambient Monitoring and Assessment Program (GAMA)
- United States Bureau of Reclamation
  - Delta-Mendota Canal Warren Act Pump-in Program
- Local Agency Data

Data provided by these sources include information such as parameter sampled, sample location, sample date, sampling method, concentration, and other related information, such as questionable measurement code, well construction information, and well type. These data were synthesized to support the following discussions of constituents of concern. Data were obtained predominantly from the data sets identified above to characterize groundwater quality from 2000 to 2018. Figure 5-86 through Figure 5-87 show the locations of wells with available water quality monitoring data and known aquifer designation. Groundwater quality varies based on location and depth by constituent. The following discusses the primary water quality data and analyses recently completed for the Delta-Mendota Subbasin and utilized herein.

Central Valley Salt and Nutrient Management Plan (SNMP). The Central Valley SNMP, prepared under the CV-SALTs program administered under the CV-RWQCB, contains an analysis of nitrate and TDS concentrations for the entire Central Valley. For the purposes of this GSP, data from the SNMP are summarized for the Delta-Mendota Subbasin.

The SNMP examined ambient conditions and Assimilative Capacity for both TDS and nitrate using data ranging from pre-1960 through 2012. Assimilative Capacity was computed by taking the difference between the ambient concentration and the regulatory threshold (or WQO). For the purposes of this GSP, discussion focuses on data analyzed for the Upper Zone (defined generally in the SNMP as the vadose zone generally where domestic wells are perforated) and the production zone (defined generally in the SNMP as a combination of the Upper Zone and Lower Zone, which extends to the top of the Corcoran Clay where present, correlating to the Upper Aquifer defined in this GSP, as discussed in the Hydrogeologic Conceptual Model [HCM] [see Section 5.2]).

Western San Joaquin River Watershed Groundwater Quality Assessment Report. The Western San Joaquin River Watershed Coalition ("Coalition") published a GAR in March 2015 (LSCE, 2015). The GAR covers the Coalition region, which encompasses the Delta-Mendota and Merced Subbasins, as well as the Los Banos Creek Valley Groundwater Basin located in the Coast Range mountains. The intent of the GAR is to characterize groundwater quality conditions within the area. Data on nitrate, salinity (TDS and specific conductance or electrical conductivity [EC]), and pesticides were gathered from Coalition members, as well as from the California Department of Public Health's (CDPH's) Water Quality Analysis Data Files, DWR's Water Data Library, United States Geological Survey's (USGS) National Water Information System, SWRCB Geotracker GAMA, and the California Department of Pesticide Regulation (DPR) pesticide sampling database. Sampling dates for nitrate range from 1944 to 2014, while sampling dates for TDS range from 1930 to 2014. Although some data extends past 2012 (the end of the "historic" period for GSP purposes), information from the GAR is still considered to fall under historic conditions given the overall data range. Pesticide data for the GAR were limited to data obtained from the DPR. DPR well locations were not provided with pesticide data; they were associated with a Public Land Survey System (PLSS) section (one square mile) for analysis.

Grasslands Drainage Area Groundwater Quality Assessment Report. The Grassland Drainage Area published a GAR in July 2016 (LSCE, 2016). The Grassland Drainage Area GAR covers a portion of the Delta-Mendota Subbasin generally south of Dos Palos, east of Firebaugh, and north of the boundary with the Westside Subbasin (which encompasses portions of the Central Delta-Mendota, Oro Loma Water District, and Widren Water District GSAs). The GAR contains information on nitrate, salinity (TDS and EC), selenium, boron, and pesticides. Data was gathered from Coalition members, as well as CDPH's Water Quality Analysis Data Files, DWR's Water Data Library, USGS's National Water Information System, SWRCB Geotracker GAMA, and the DPR pesticide sampling database. Sampling dates for nitrate, TDS, and boron range from the 1940s through 2010s. Sampling dates for selenium range from the 1980s through 2010s. Pesticide data for the GAR were limited to data obtained from the DPR. DPR well locations were not provided with pesticide data; they were associated with a PLSS section (one square mile) for analysis.

Groundwater Quality in the Western San Joaquin Valley Study Unit, 2010: California GAMA Priority Basin Project. Water quality in groundwater resources used for public drinking-water supply in the Western San Joaquin Valley (WSJV) was investigated by the USGS in cooperation with the California SWRCB as part of its GAMA

Program Priority Basin Project (SWRCB, July 2018). The WSJV includes two study areas: the Delta–Mendota and Westside Subbasins of the San Joaquin Valley Groundwater Basin. As documented in the published study entitled *Groundwater Quality in the Western San Joaquin Valley Study Unit, 2010: California GAMA Priority Basin Project* (Scientific Investigations Report 2017-5032 by Miranda Fram), the study objectives included two assessment types: (1) a status assessment yielding quantitative estimates of the current (2010) status of groundwater quality in the groundwater resources used for public drinking water, and (2) an evaluation of natural and anthropogenic factors that could be affecting the groundwater quality. The assessments characterized the quality of untreated groundwater based on data collected from 43 wells sampled by the USGS for the GAMA Priority Basin Project (USGS-GAMA) in 2010 and data compiled in the SWRCB Division of Drinking Water (DDW) database for 74 additional public-supply wells sampled for regulatory compliance purposes between 2007 and 2010. To provide context, concentrations of constituents measured in groundwater were compared to U.S. Environmental Protection Agency (EPA) and DDW regulatory and non-regulatory benchmarks for drinking-water quality.

In general, the study found that groundwater resources used for public drinking water in the WSJV study unit are among the most saline and most affected by high concentrations of inorganic constituents of all groundwater resources used for public drinking water that have been assessed by the GAMA Priority Basin Project statewide. Among the 82 GAMA Priority Basin Project study areas statewide, the Delta–Mendota Subbasin ranked above the 90th percentile for aquifer-scale proportions of groundwater resources having concentrations of TDS, sulfate, chloride, manganese, boron, hexavalent chromium, selenium, and strontium above benchmarks. The study also found that recharge of water used for irrigation has direct and indirect effects on groundwater quality. Elevated nitrate concentrations and detections of herbicides and fumigants in the Delta-Mendota Subbasin generally were associated with greater agricultural land use near wells and with water recharged during the last 60 years.

5.3.5.2 Historic and Current Conditions and Trends

As previously noted, arsenic, hexavalent chromium, and selenium are naturally-occurring constituents in the Delta-Mendota Subbasin whose ambient concentrations sometimes exceed the WQO from the Basin Plan. However, these constituents are ubiquitous, and concentrations cannot be directly correlated to groundwater elevations or other groundwater management practices. As such, these constituents are considered to be 'unmanageable' by the GSAs and therefore sustainability indicators have not been developed. Constituents for which sustainability indicators have been developed include nitrate, TDS, and boron.

<u>Nitrate</u>

Using data from the Central Valley SNMP for the period ranging from 2000 through 2016, concentrations of nitrate (as N) in excess of 10 mg/L were found to exist north of Patterson, south of Dos Palos, and southwest of Patterson extending southwest past Los Banos. The ambient concentrations of nitrate in the upper zone are elevated north of Patterson, on the western side of the Subbasin (roughly from Patterson to Los Banos), and south of Dos Palos, with similar patterns seen in the production zone (Figure 5-88). Figure 5-89 displays nitrate (as N) concentration in the production zone for the entire Delta-Mendota Subbasin. Lower nitrate (as N) concentrations (<2.5 mg/L) were found to exist in the areas east of Los Banos and south of Firebaugh.

Throughout the Delta-Mendota Subbasin, nitrate concentrations were below 5 mg/L (nitrate as N) in the majority of wells, as described in the Western San Joaquin GAR (LSCE, 2015). However, there are several areas where higher concentrations occur, including locations where the MCL of 10 mg/L is exceeded. In the Upper Aquifer, notable areas of elevated nitrate concentrations occur immediately south of Los Banos and northwest, along Highway 33, toward Patterson. Geologic formations with naturally-occurring elevated levels of nitrate have been identified in Origalita Creek alluvium in the southern portion of the Subbasin. In the Lower Aquifer, fewer data are available, but most wells have a maximum nitrate concentration above 5 mg/L. In the most recent available data, some Lower Aquifer wells have concentrations greater than 10 mg/L. In general, higher nitrate concentrations in the Lower Aquifer occur in areas where the Corcoran Clay is thin or non-existent (particularly to the west and northwest of Gustine) (LSCE, 2015). In the Grassland Drainage Area, only six wells in the Upper Aquifer had nitrate data available. Of these, only one had a nitrate concentration above 10 mg/L; other wells were below 2.5 mg/L. Data for the Lower Aquifer were also limited, including only 14 wells. The majority of observed nitrate concentrations were below 2.5 mg/L, with none exceeding 10 mg/L (LSCE, 2016).

Nitrate (as N) concentrations in the Upper Aquifer (above the Corcoran Clay) have been mostly low and stable over time since 1985 (Figure 5-90 and Figure 5-91). Overall, in the northern portion of the Subbasin, nitrate (as N) concentrations in the Upper Aquifer were generally below the MCL of 10 mg/L, with concentrations generally increasing further south in the Subbasin and reaching and stabilizing at a maximum of 15 mg/L south of Dos Palos since 2007. Similar to the Upper Aquifer, nitrate concentrations in the Lower Aquifer (below the Corcoran Clay) have been low and stable since 1985 with no recorded exceedances above the MCL (Figure 5-92). Generally, timeseries data for nitrate concentrations south of Dos Palos within Fresno County was largely unavailable with sufficient temporal range to warrant evaluation and presentation through timeseries graphs, with most data only available for a short timeframe from the late 1980s to the early 1990s.

The Western San Joaquin and Grassland Drainage Area GARs also assessed the present temporal trends in nitrate for all available historical data through 2016 (wells with a minimum of three sampling events) using a linear regression trend analysis with a p-value of 0.05 and 0.1 indicating significance, respectively from each GAR. Table 5-4 indicates the degree of trends for nitrate as presented in the GARs. Figure 5-93 illustrates statistically-significant temporal trends in nitrate concentration in the Upper Aquifer. Significant trends in the increasing and decreasing directions are observed in the Upper Aquifer. Wells near Patterson, Gustine, and Los Banos largely show Mildly Increasing trends with a cluster of wells near the San Joaquin River in central Merced County, and two wells south of Dos Palos showing Mildly Decreasing and Decreasing trends. Wells with very small changes in nitrate concentration are scattered throughout the Subbasin.

Figure 5-94 illustrates statistically significant temporal trends in nitrate concentration in the Lower Aquifer. Wells with sufficient data to demonstrate a statistically significant trend are limited to the Stanislaus County portion of the Delta-Mendota Subbasin and south of Dos Palos. Trends show largely Mildly Increasing and Increasing nitrate concentrations with a few wells showing Mildly Decreasing and Decreasing trends northwest of Gustine. South of Dos Palos, one well shows a very small change in nitrate concentration and another shows a Mildly Increasing trend. Figure 5-95 illustrates statistically significant temporal trends in nitrate concentration in composite wells screened in both the Upper Aquifer and Lower Aquifer. Only two composite wells with statistically significant trends in nitrate concentration are present in the Delta-Mendota Subbasin. One well located near Dos Palos has a Mildly Increasing trend, with the other well located south of Gustine has a Mildly Decreasing trend.

Table 5-4. Nitrate (as N) Trend Significance

from Western San Joaquin and Grassland GARs

Trend	Nitrate (mg/L/year)
Increasing	> 1.0
Mildly Increasing	0.1 - 1.0
Very Small Change	-0.1 - 0.1
Mildly Decreasing	-1.0 - -0.1
Decreasing	< -1.0

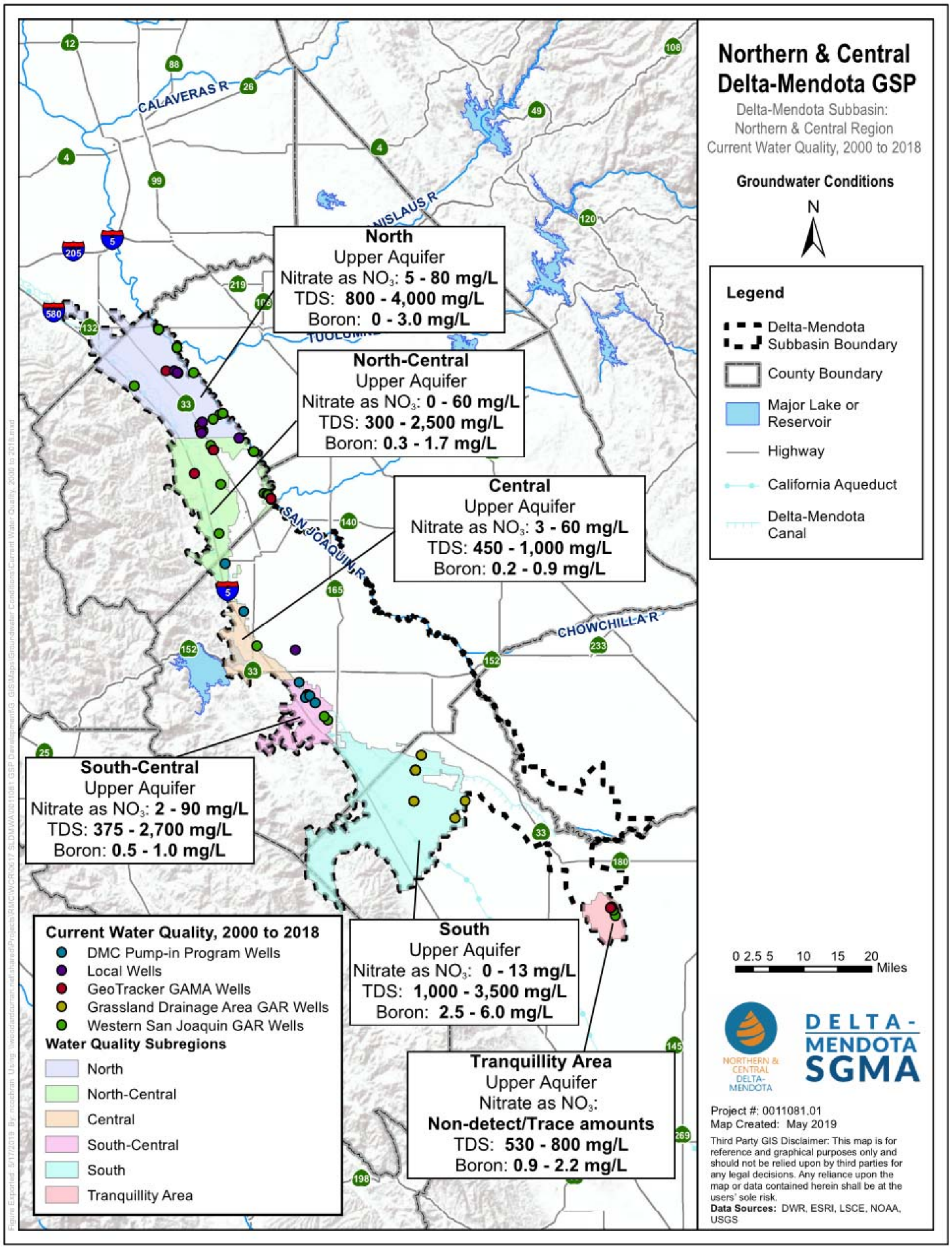

Figure 5-86. Upper Aquifer, Current Groundwater Quality (2000-2018)

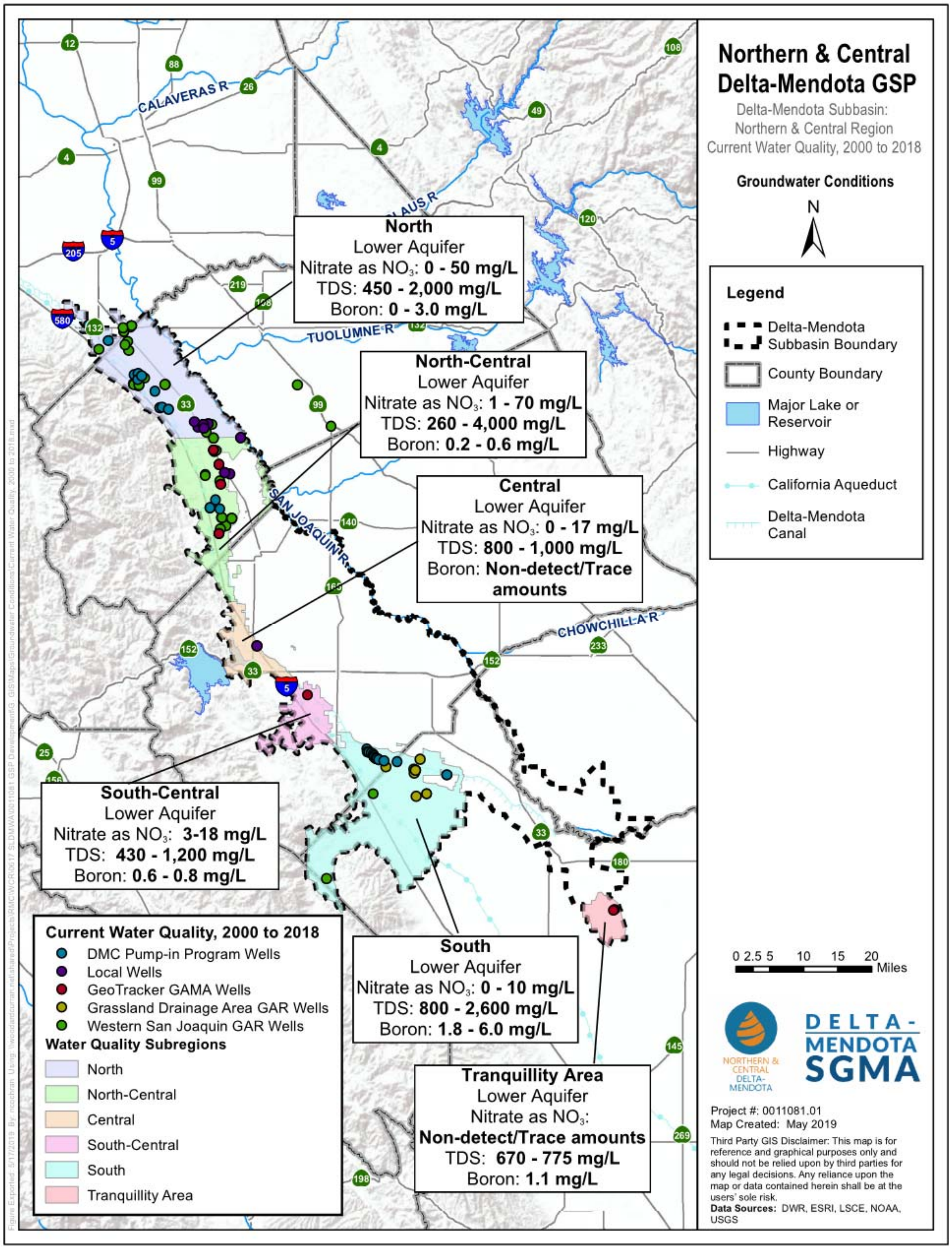

Figure 5-87. Lower Aquifer, Current Groundwater Quality (2000-2018)

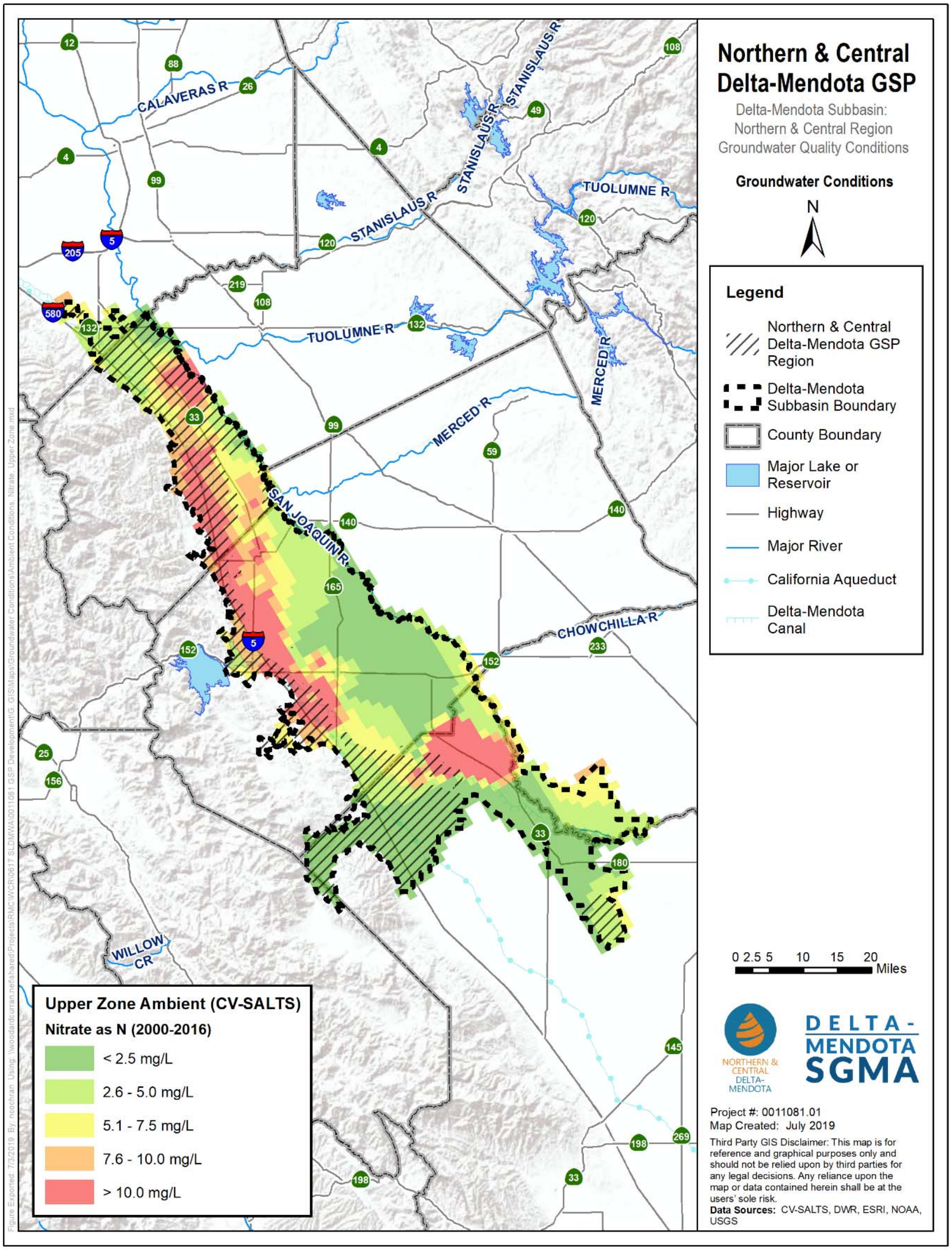

Figure 5-88. Upper Zone Ambient Nitrate as N, Delta-Mendota Subbasin

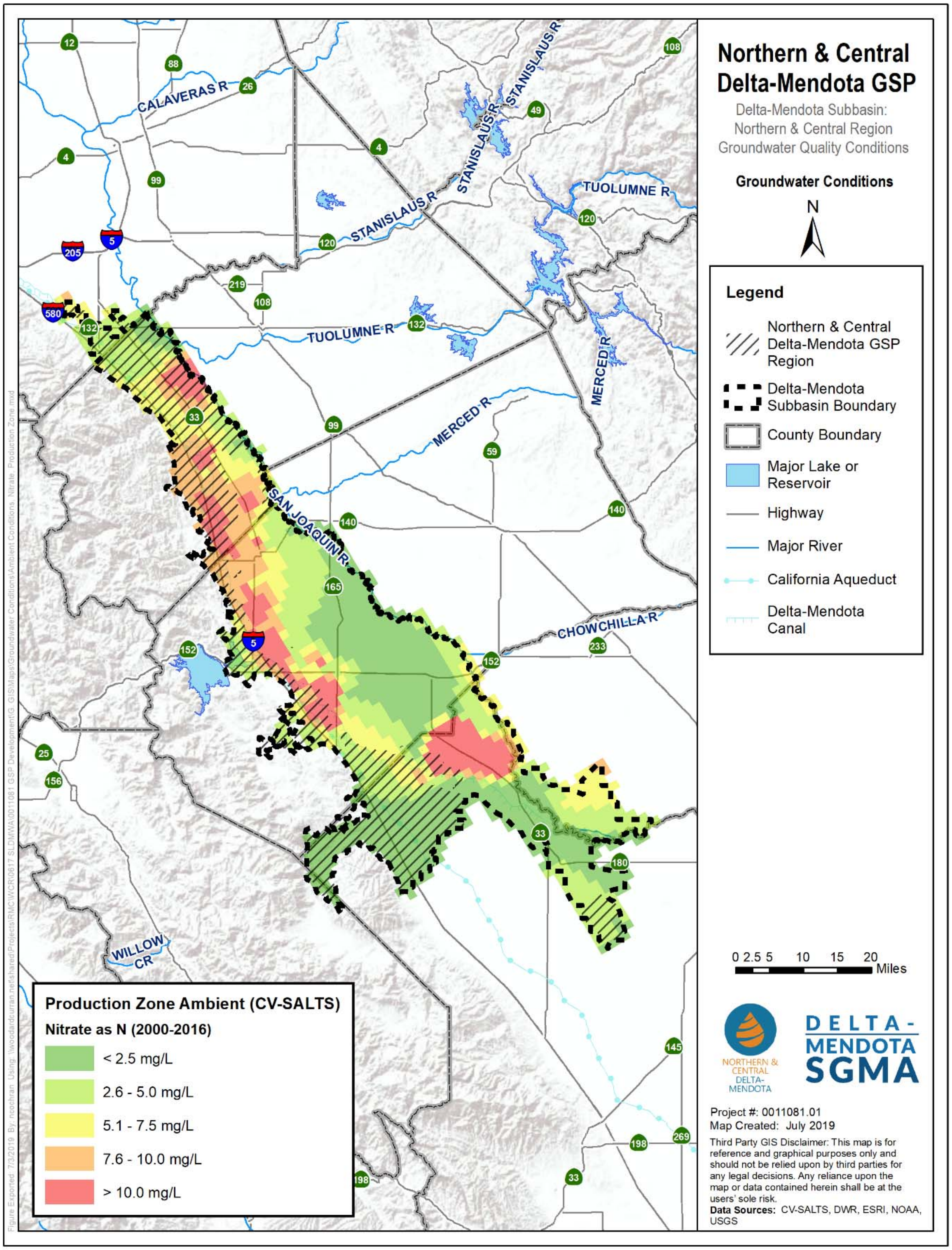

Figure 5-89. Production Zone Ambient Nitrate as N, Delta-Mendota Subbasin

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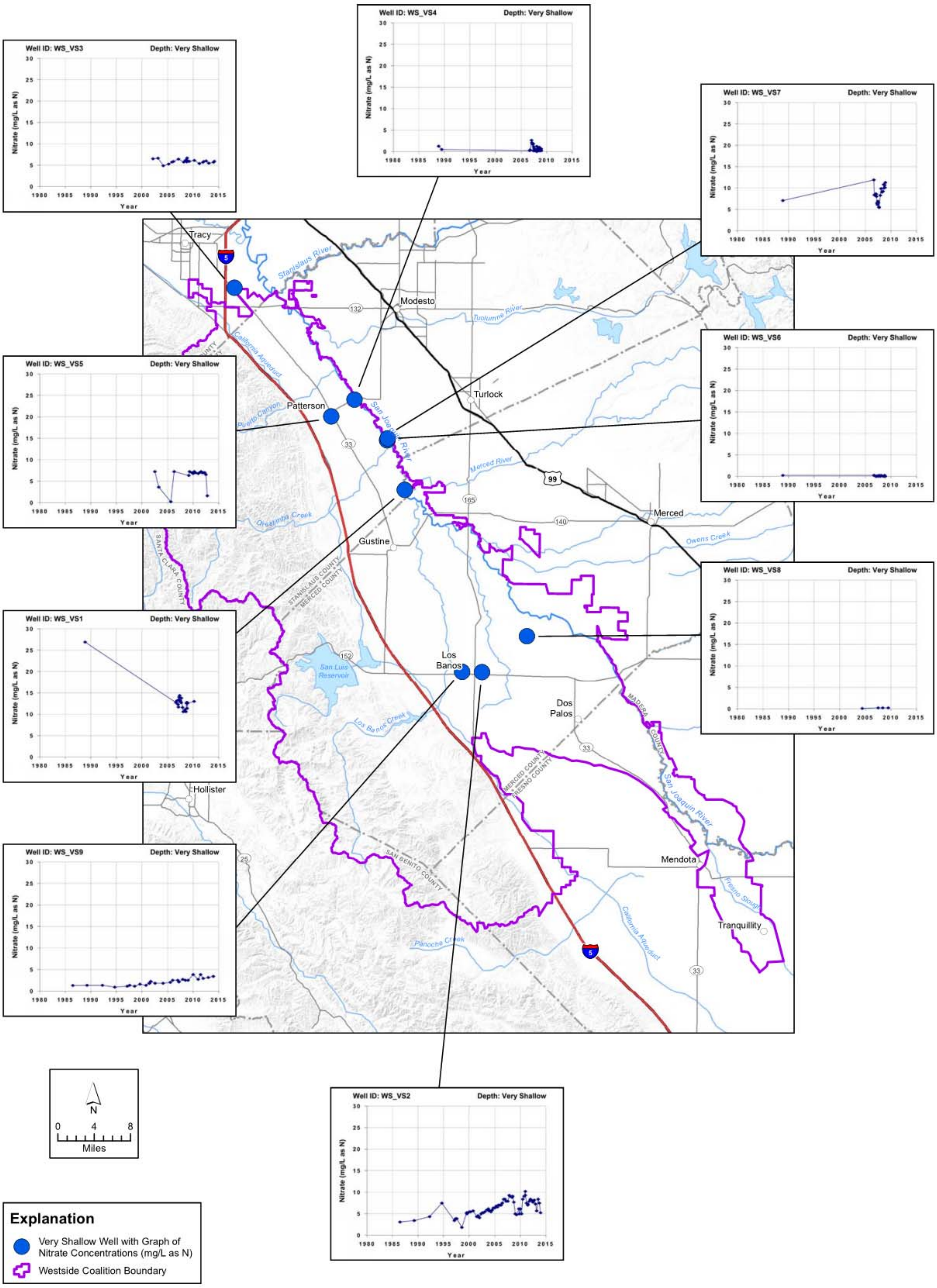
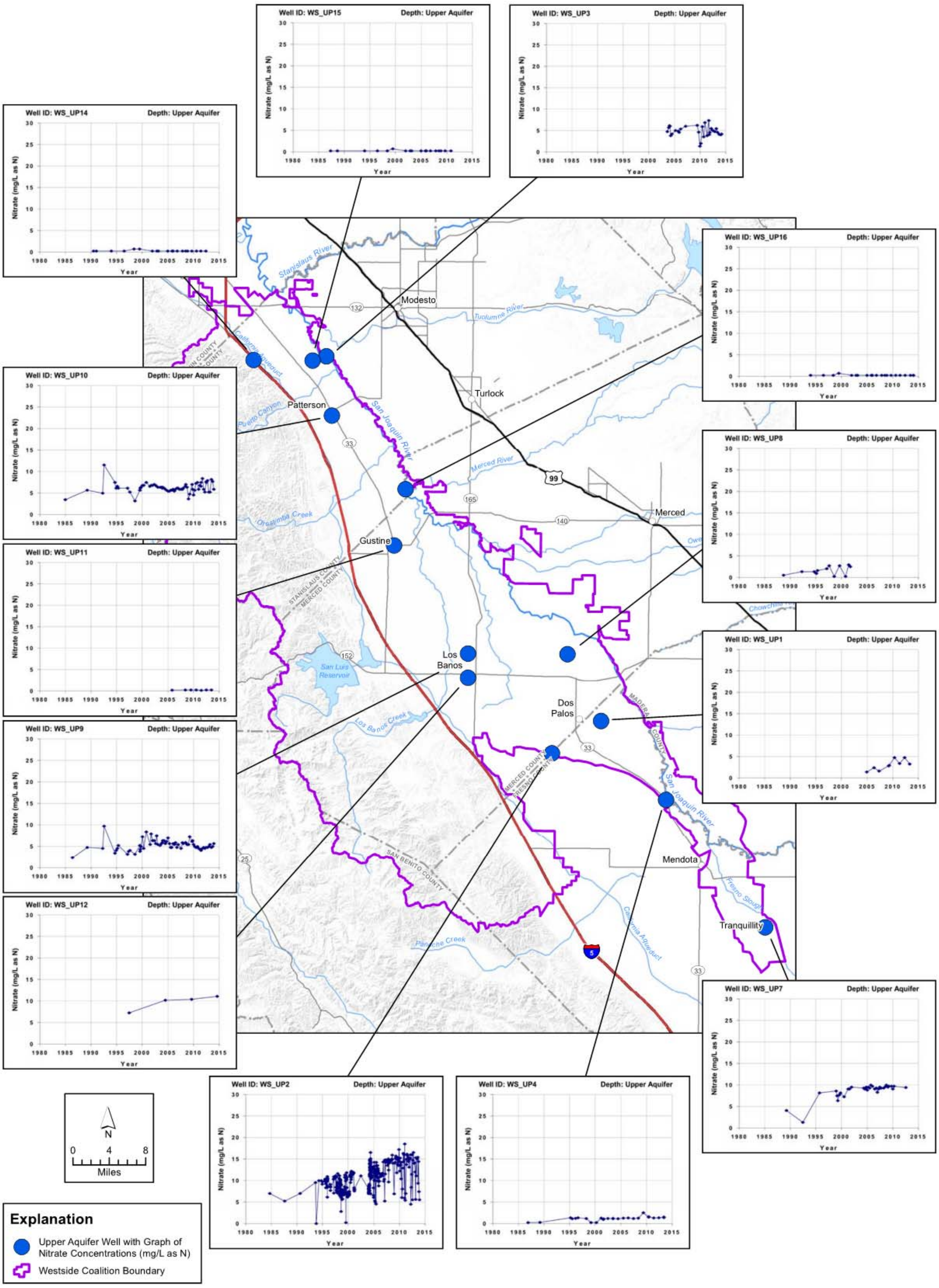


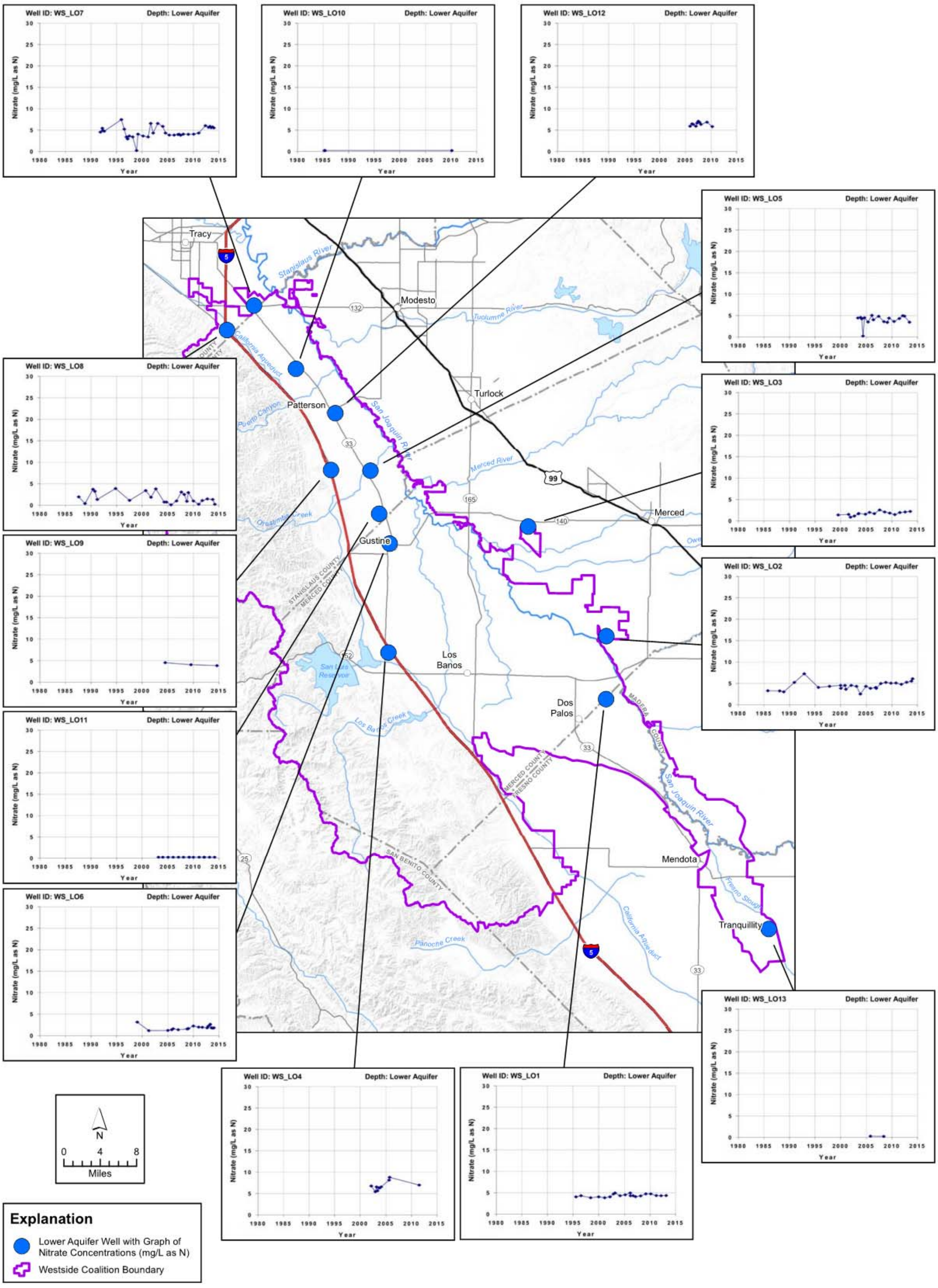
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-90. Select Graphs of Nitrate Concentrations, Shallow Groundwater



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-91. Select Graphs of Nitrate Concentrations, Upper Aquifer



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-92. Select Graphs of Nitrate Concentrations, Lower Aquifer

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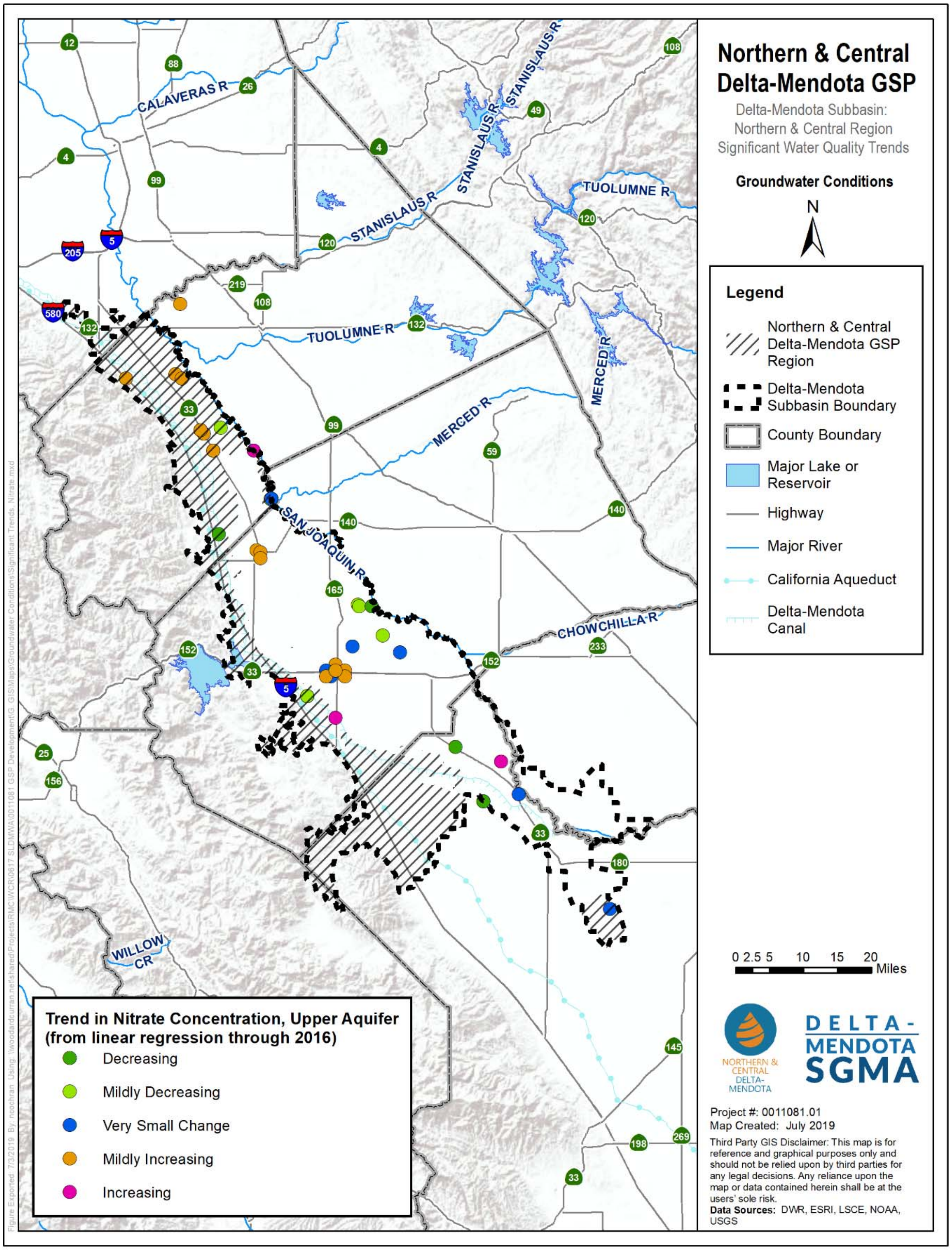

Figure 5-93. Significant Temporal Trends in Nitrate Concentrations, Upper Aquifer

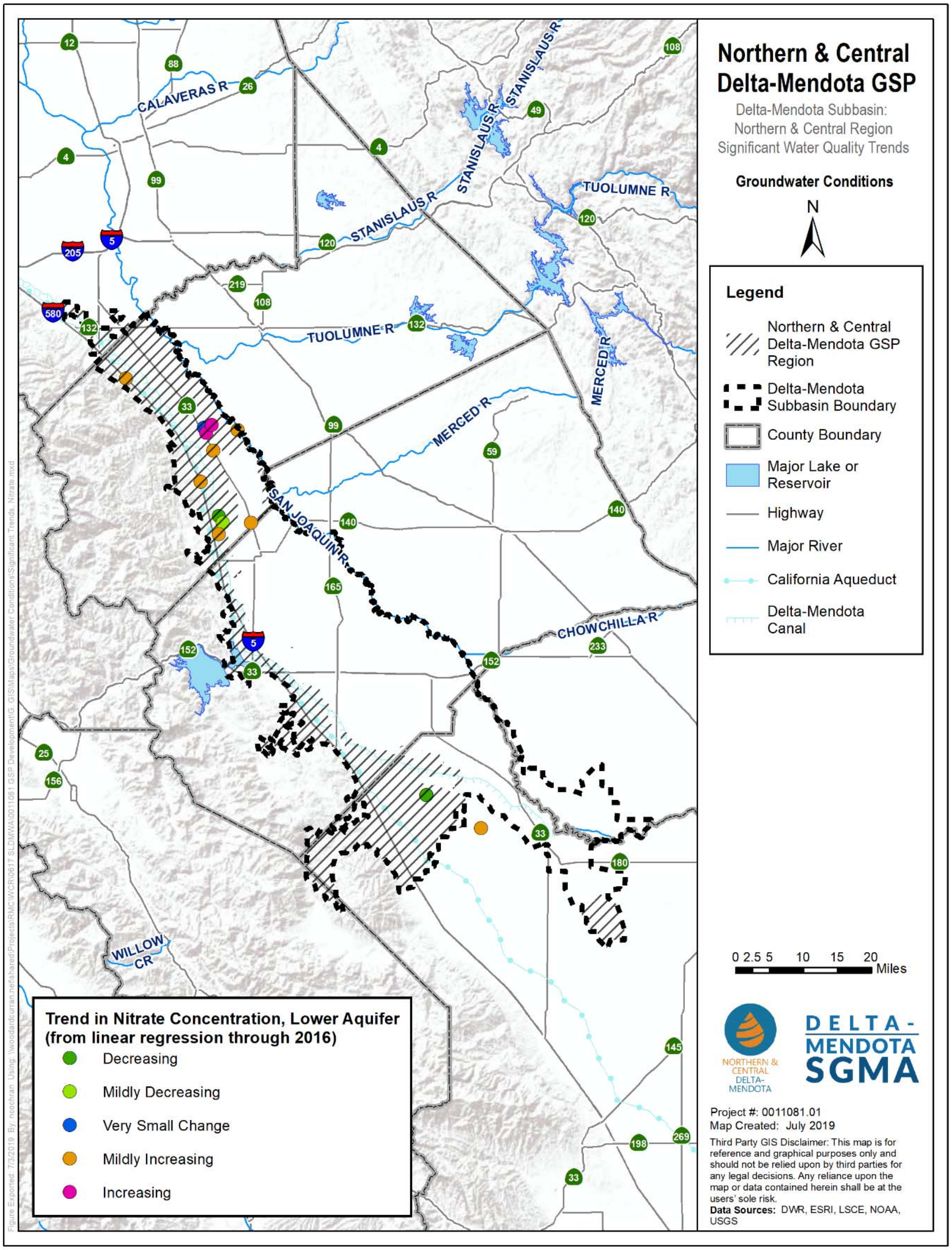

Figure 5-94. Significant Temporal Trends in Nitrate Concentrations, Lower Aquifer

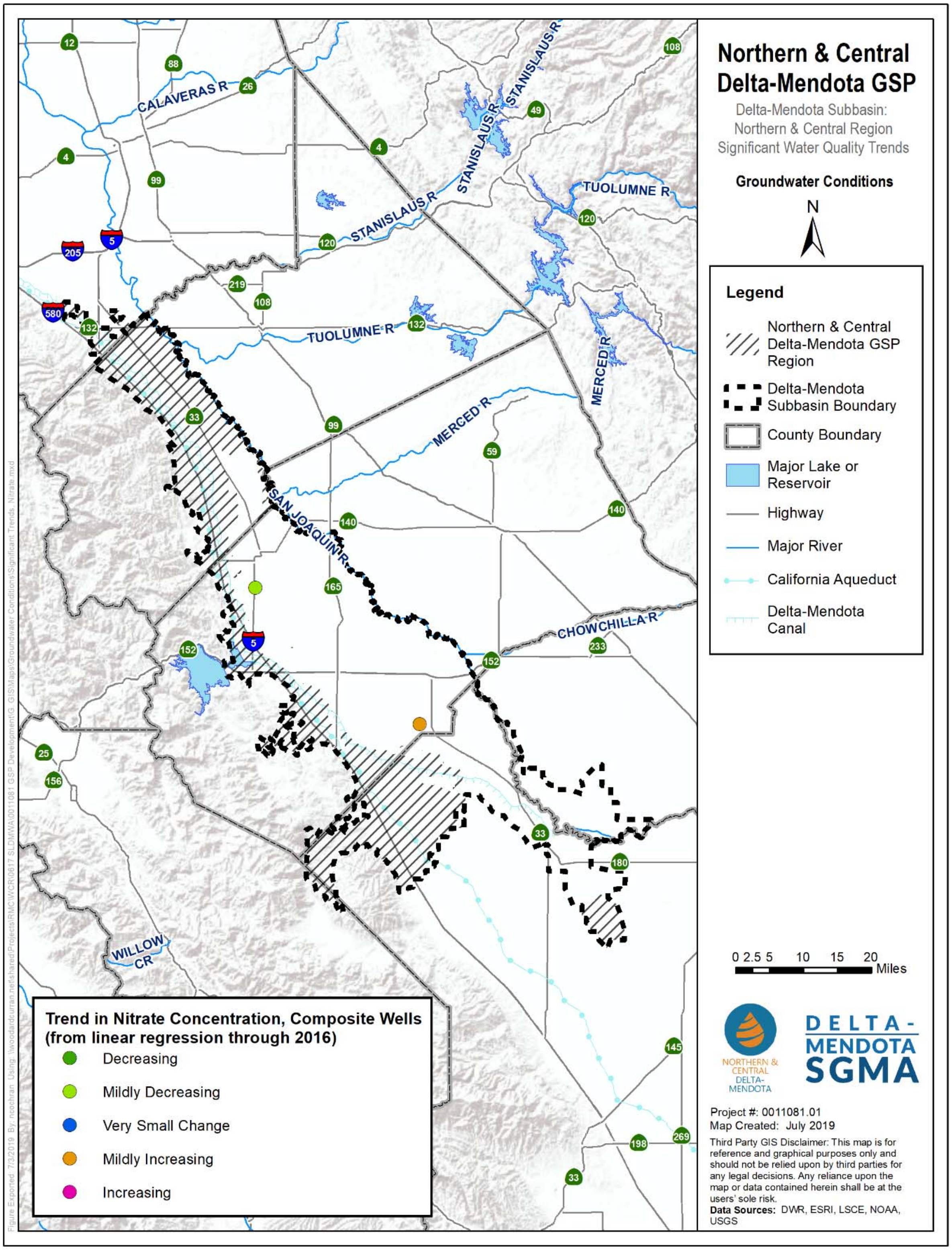

Figure 5-95. Significant Temporal Trends in Nitrate Concentrations, Composite Wells

Total Dissolved Solids

The Central Valley SNMP's analysis of TDS showed elevated concentrations throughout much of the Delta-Mendota Subbasin. Ambient TDS conditions follow similar patterns in the upper zone as in the production zone (Figure 5-96 and Figure 5-97). Ambient TDS concentrations exceed 1,000 mg/L in areas to the south and west of Dos Palos, extending to the western and southern borders of the Subbasin, and to the north and southeast of Patterson. The areas of lowest TDS concentration (<250 mg/L) exist on the western border of the Subbasin, west of Newman and Gustine, and just west of Los Banos.

The Western San Joaquin GAR's analysis of TDS data found similar spatial patterns as with nitrate. The majority of wells in the Coalition region have maximum TDS concentrations below 1,000 mg/L. In the Upper Aquifer, higher TDS concentrations (>1,500 mg/L) exist south of Los Banos and to the north along the San Joaquin River (an area with poor drainage). In the Lower Aquifer, data were limited, but most wells had maximum TDS concentrations below 1,500 mg/L. Along the northwestern edge of the Coalition region, TDS concentrations were mostly below 1,000 mg/L (LSCE, 2015). The Grassland GAR's analysis of TDS showed that most TDS concentrations in both the Upper and Lower Aquifers exceeded 1,000 mg/L, although as with nitrate, data were limited (LSCE, 2016).

TDS concentrations in the Upper Aquifer show a combination of stable trends near or below the TDS Secondary MCL of 1,000 mg/L and increasing TDS concentrations exceeding 1,500 mg/L, with data available back to the 1980s (Figure 5-98 and Figure 5-99). In the portion of the Subbasin south of Dos Palos, TDS concentrations are generally higher than the rest of the Subbasin with concentrations considerably higher than 1,500 mg/L; though, noticeable decreases are observed from the 1990s through the early 2000s and since 2010. In the Lower Aquifer, TDS concentrations since the 1990s appear to be largely stable, with exceedances above 1,000 mg/L observed (Figure 5-100). Wells south of Dos Palos in the Lower Aquifer have limited data available, but generally concentrations range from 1,000 to 2,000 mg/L. In general, increasing TDS trends in the Upper Aquifer stem from a myriad of causes, including increased salinity concentrations from the leaching of salts from naturally-occurring high salinity formations and land-applied soil amendments, an increasing salinity front from the San Joaquin River and adjacent tile drains, and localized causes such as seepages on Little Panoche Creek, downstream of Little Panoche Creek Reservoir, potentially the result of the concentration of salts in the impoundment through evaporation.

Both the Western San Joaquin (LSCE, 2015) and Grassland Drainage Area (LSCE, 2016) GARs assessed temporal trends of TDS concentrations for all available historical data through 2016 (wells with a minimum of three sampling events) using linear regression trend analysis, with a p-value of 0.05 and 0.1 indicating significance, respectively from each GAR.

Table 5-5 indicates the degree of trends TDS as presented in the GARs. Figure 5-101 illustrates statistically significant temporal trends in TDS concentration in the Upper Aquifer. There is no discernable spatial pattern in trend direction throughout much of the northern portion of the Delta-Mendota Subbasin except near Los Banos where TDS is Mildly Increasing and Increasing. Southwest of Dos Palos along the Delta-Mendota Canal, there is a cluster of wells with an Increasing trend in TDS concentration, whereas moving downstream along the canal, there are more wells with a Decreasing trend in TDS concentration. Figure 5-102 illustrates statistically significant temporal trends in TDS concentration in the Lower Aquifer. While sufficient data available for trend analysis are unavailable for the Lower Aquifer, there are several wells near and north of Gustine and near the San Luis Reservoir showing Mildly Increasing trends in TDS concentration. South of Dos Palos, there are two wells showing Decreasing trends and one well showing an Increasing trend in TDS concentration. Figure 5-103 illustrates statistically significant temporal trends in TDS concentration in composite wells. Only one composite well exhibited statistically significant TDS trends and is located near Patterson showing a very small change.

Table 5-5. TDS Trend Significance

from Western San Joaquin and Grassland GARs

Trend	TDS (mg/L/year)
Increasing	> 50
Mildly Increasing	10 - 50
Very Small Change	-10 - 10
Mildly Decreasing	-50 - -10
Decreasing	< -50

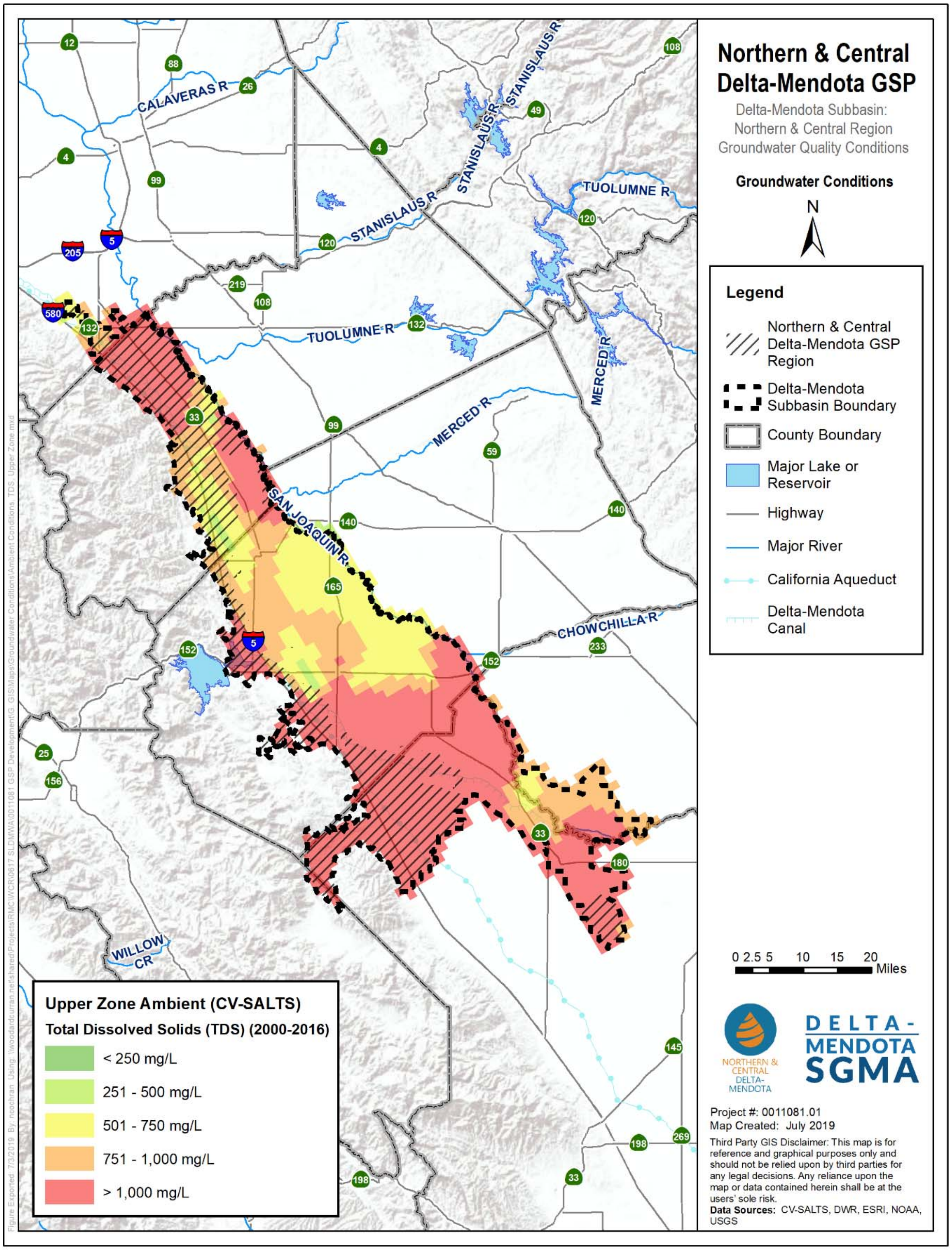

Figure 5-96. Upper Zone Ambient TDS, Delta-Mendota Subbasin

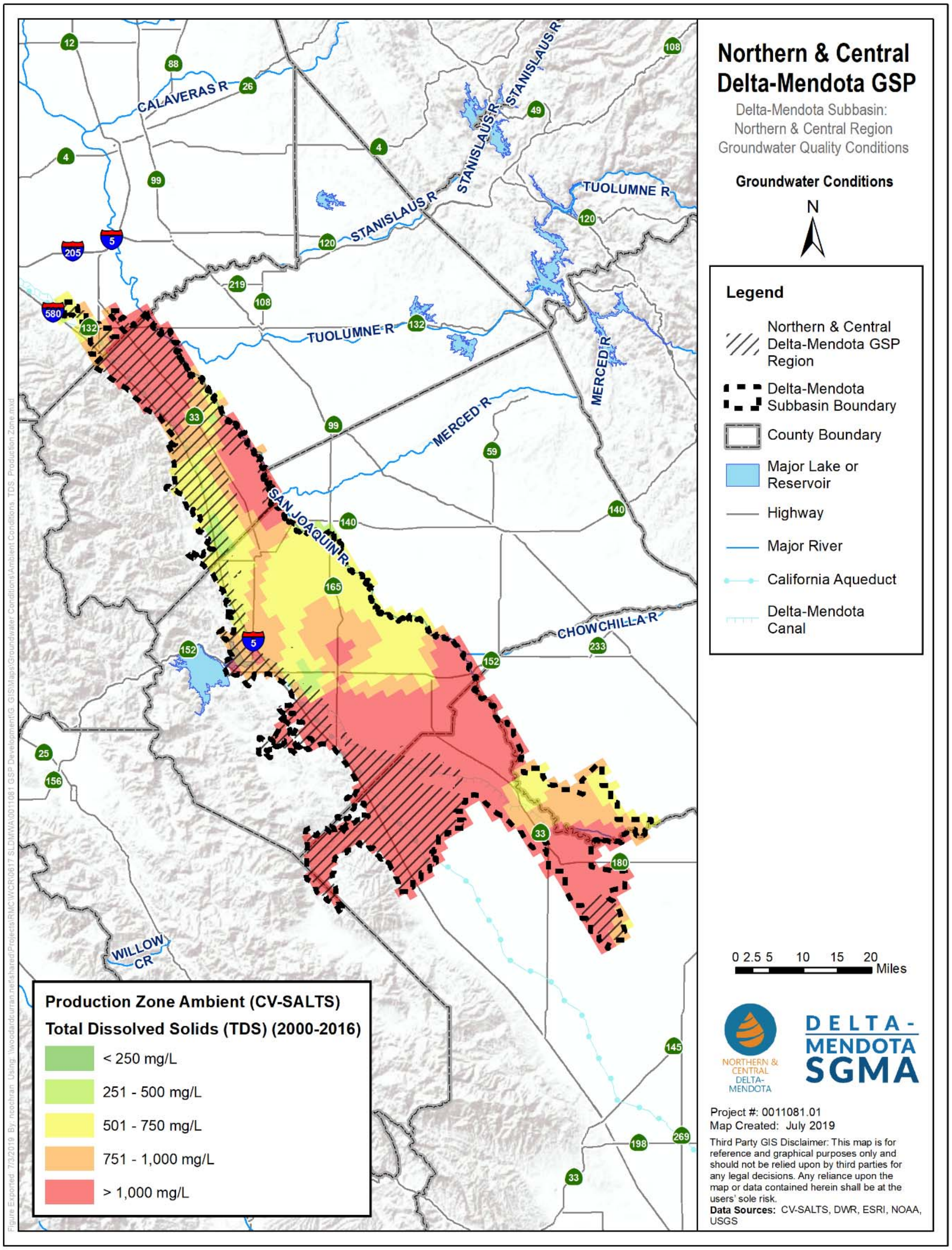

Figure 5-97. Production Zone Ambient TDS, Delta-Mendota Subbasin

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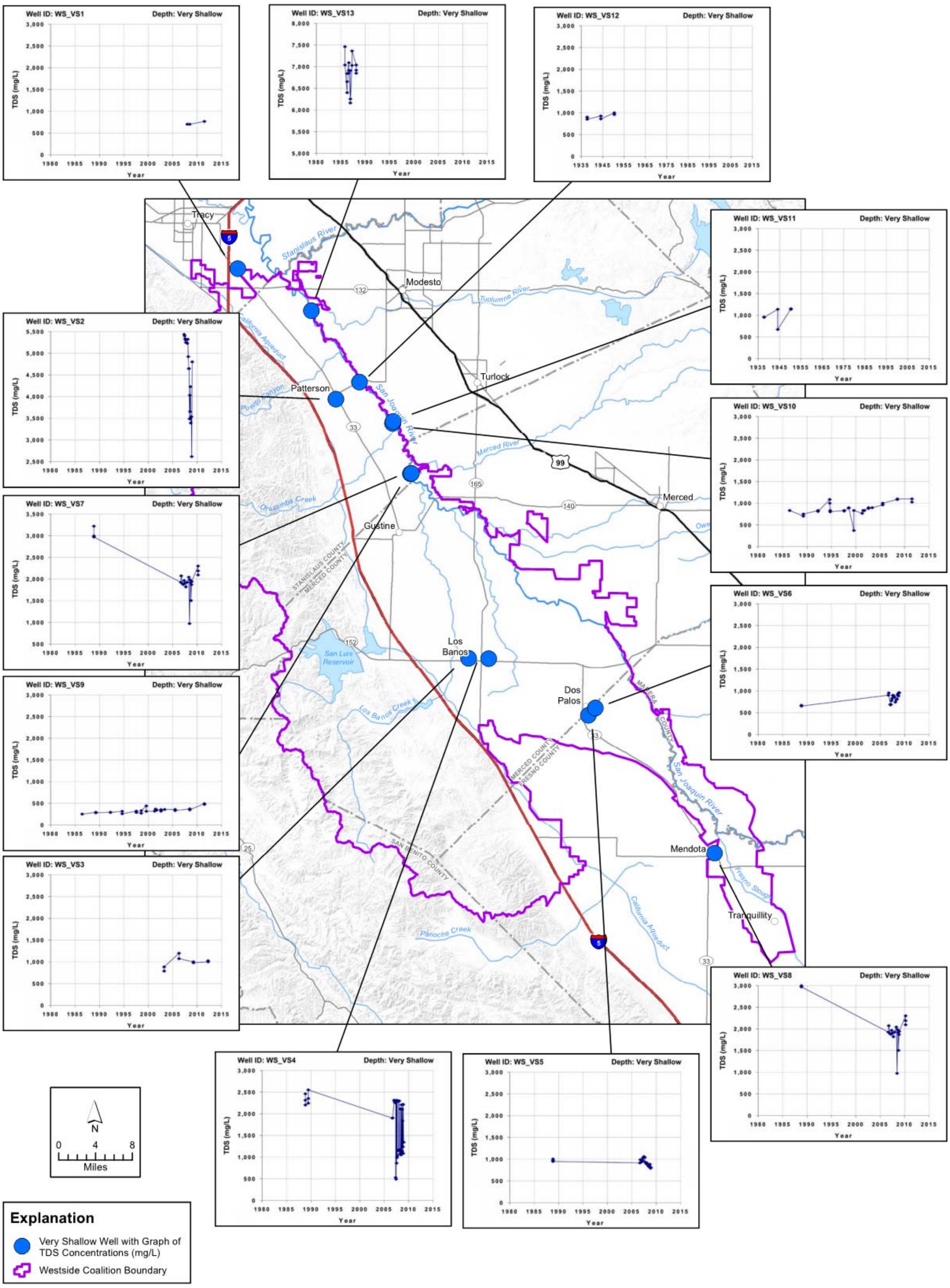
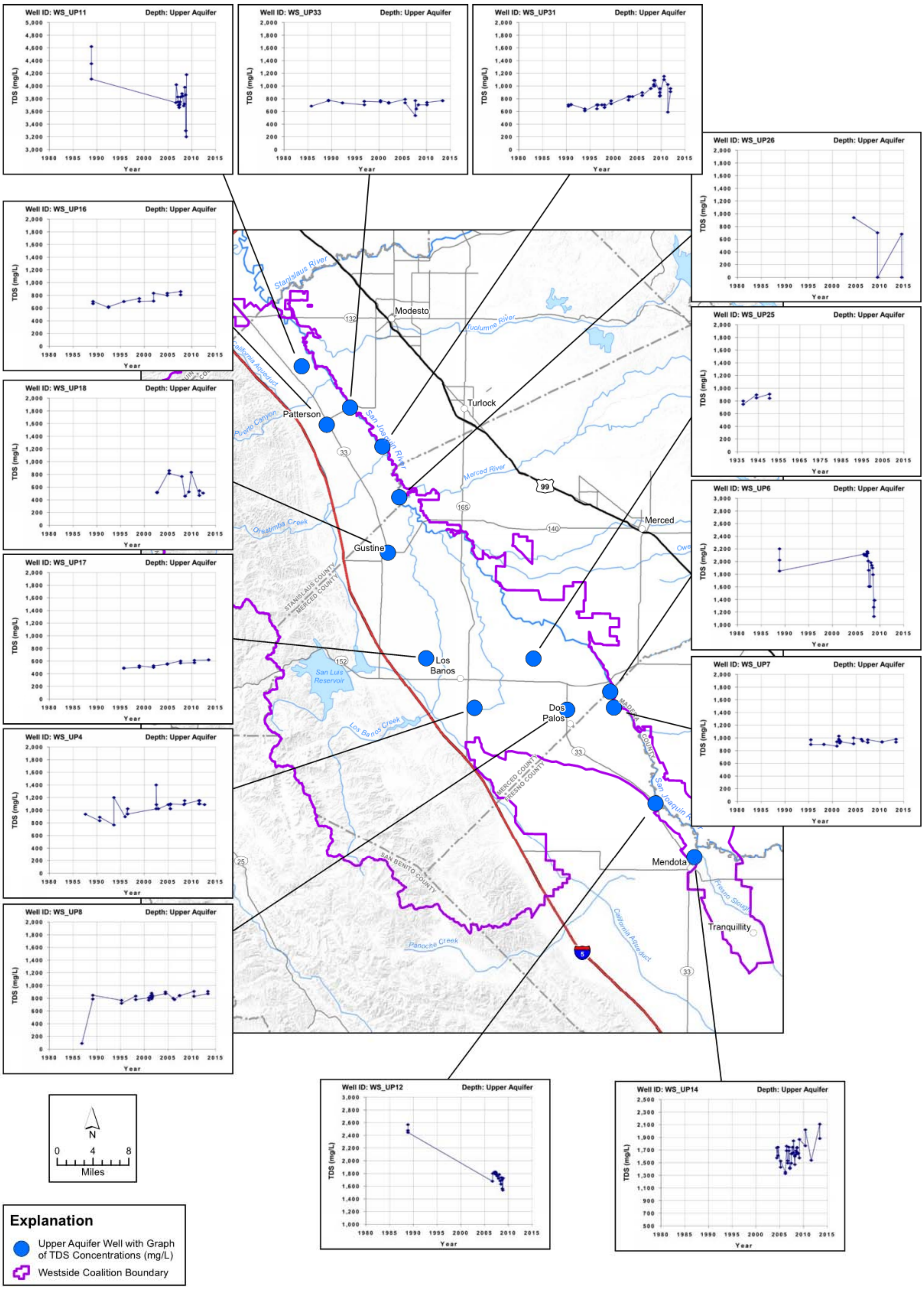


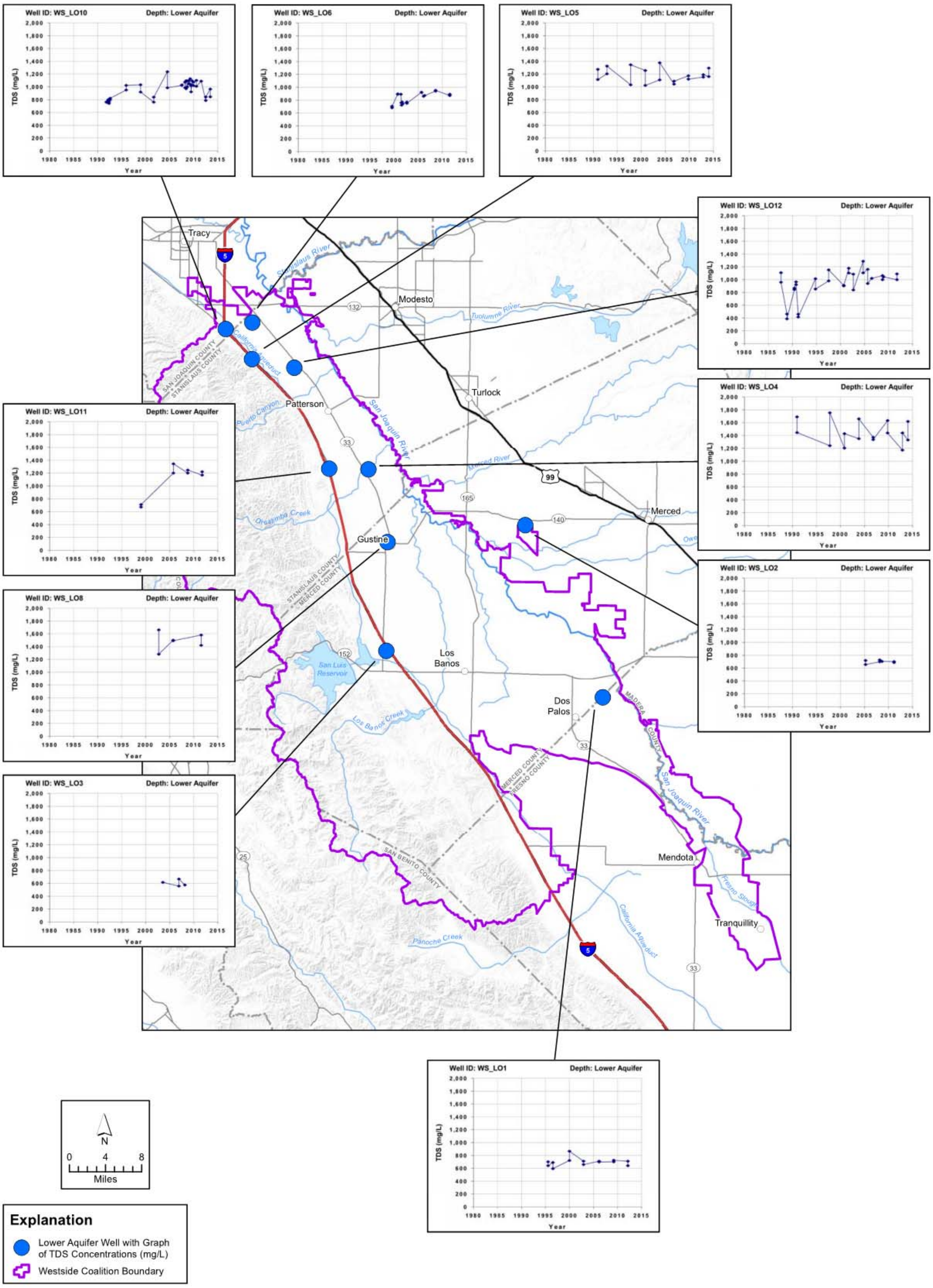
Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-98. Select Graphs of TDS Concentrations, Shallow Groundwater



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-99. Select Graphs of TDS Concentrations, Upper Aquifer



Source: *Western San Joaquin River Watershed Groundwater Quality Assessment Report*, 2015

Figure 5-100. Select Graphs of TDS Concentrations, Lower Aquifer

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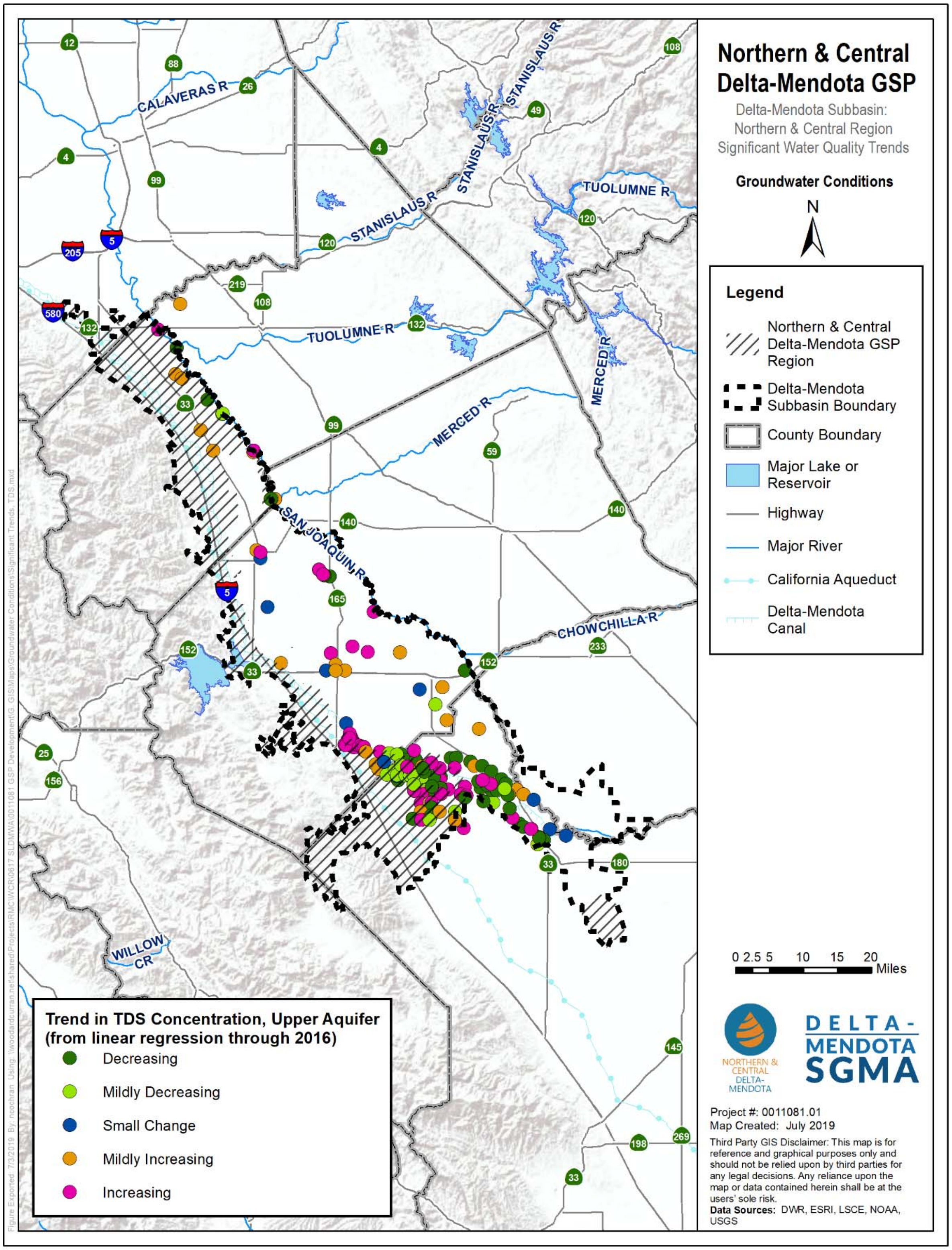


Figure 5-101. Significant Temporal Trends in TDS Concentrations, Upper Aquifer

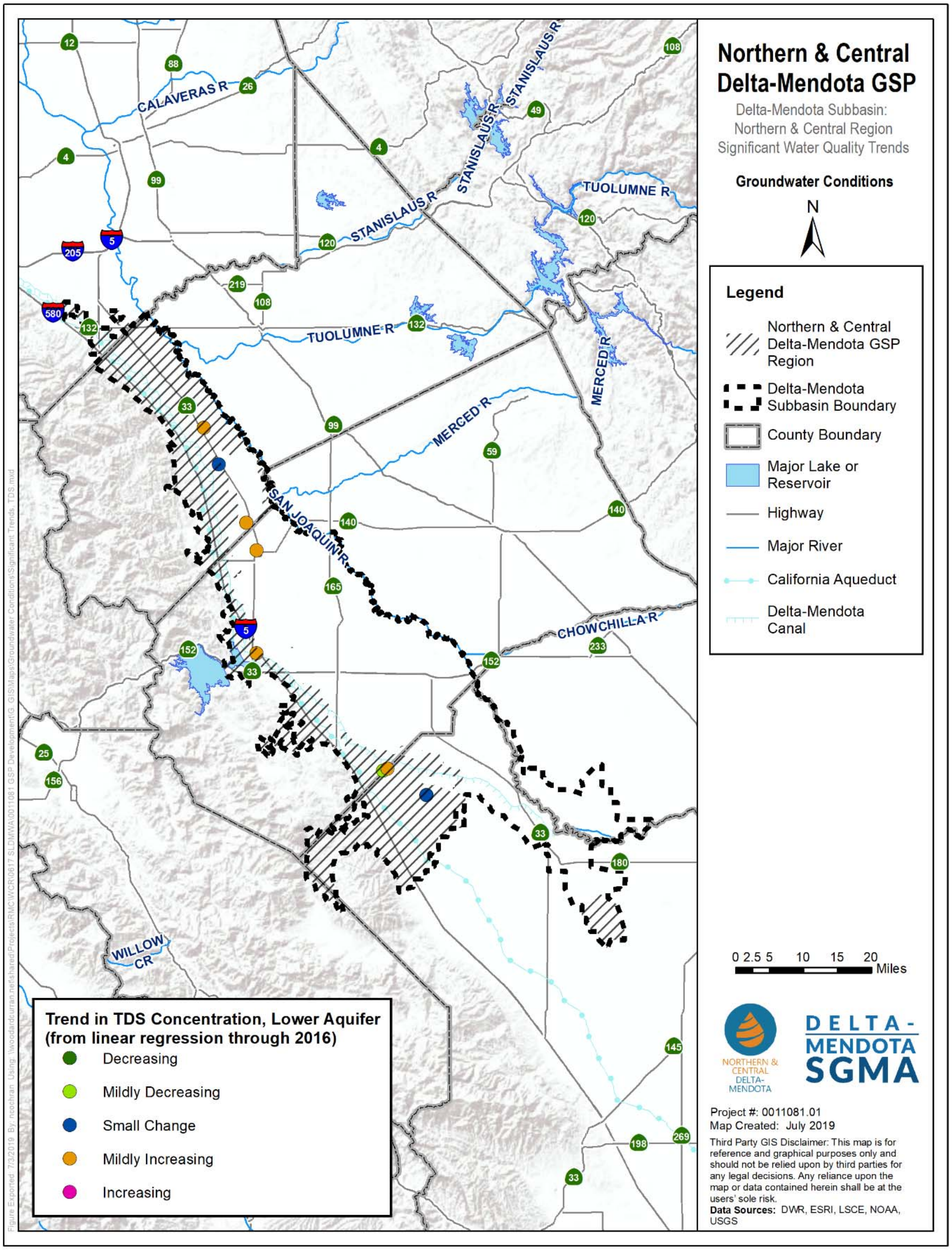


Figure 5-102. Significant Temporal Trends in TDS Concentrations, Lower Aquifer

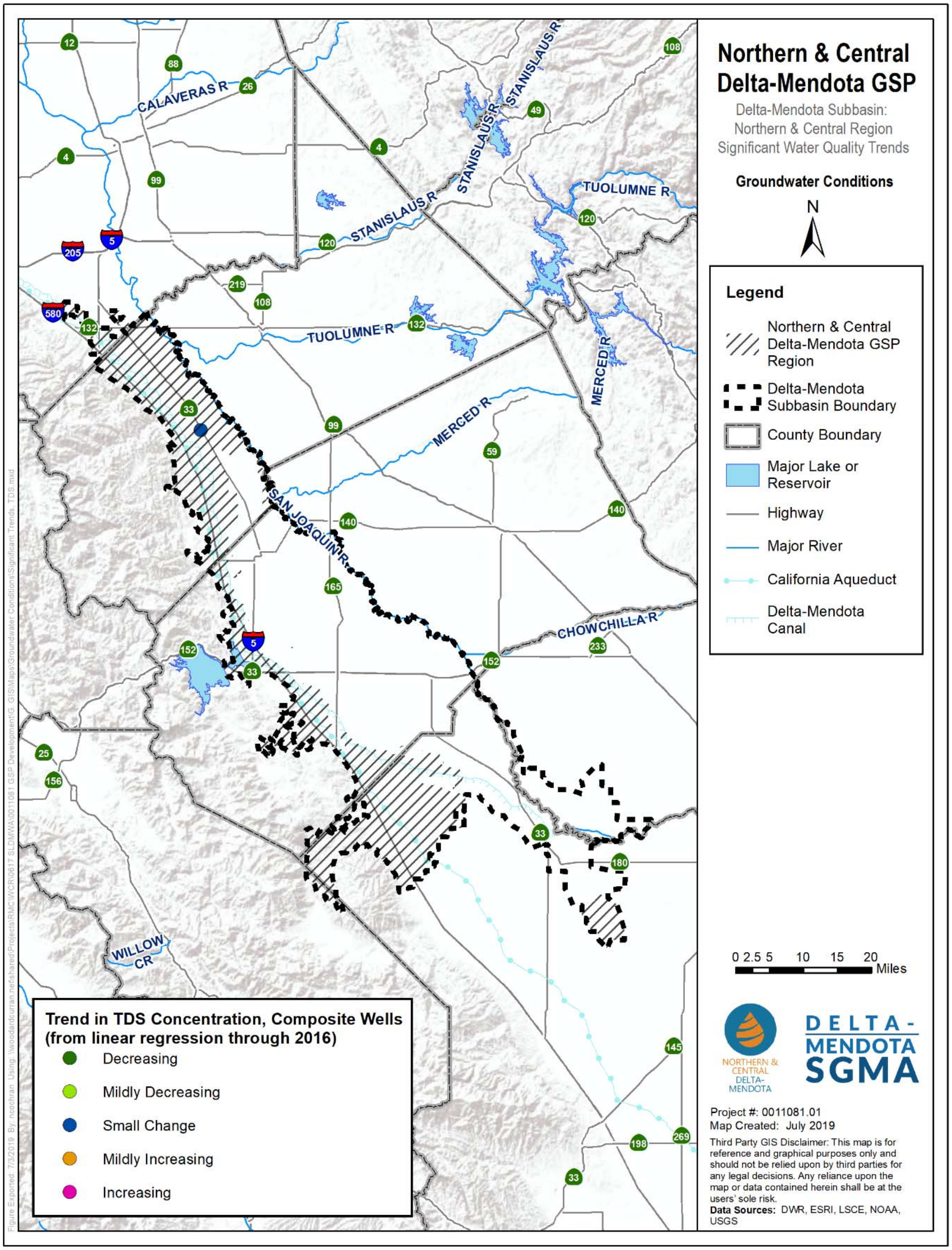


Figure 5-103. Significant Temporal Trends in TDS Concentrations, Composite Wells

Boron

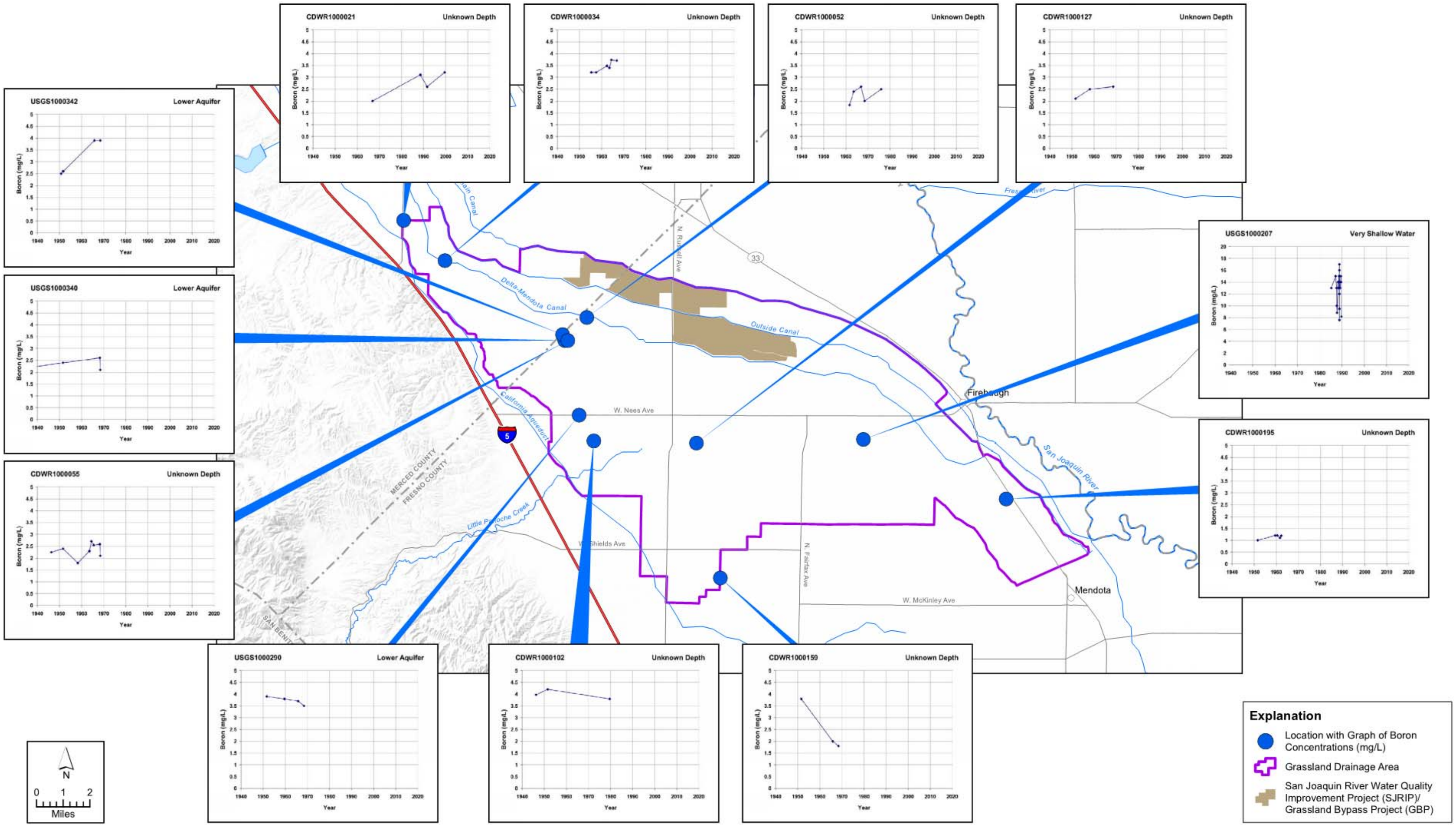
Although boron has no MCL, it has an agricultural goal of 0.7 mg/L as many crops are sensitive to high boron concentrations. Historical data from within the Grassland Drainage Area shows boron concentrations of greater than 2 mg/L, well above the agricultural goal (LSCE, 2016). The City of Patterson Consumer Confidence Reports from 2011 to 2013 show boron levels consistently near 0.4 mg/L. Boron trends were also analyzed within the Grassland Drainage Area (which encompasses portions of the Central Delta-Mendota, Oro Loma Water District, and Widren Water District GSAs). Time series charts of boron concentrations in the Upper Aquifer and Lower Aquifer are presented together in Figure 5-104 due to a limited number of sites with sufficient data to warrant graphing. Boron trends are generally stable but relatively high, with some seasonal fluctuations likely resulting from irrigation influences.

Table 5-6 indicates the degree of trends for boron as presented in the GAR for all available historical data through 2016 (wells with a minimum of three sampling events). No statistically-significant temporal trends in boron concentrations were observed in the Upper Aquifer for boron. Two wells in the Lower Aquifer have significant trends in boron concentration, one with an Increasing trend and the other with a Mildly Decreasing trend (Figure 5-105).

Table 5-6. Boron Trend Significance

from Grassland GAR

Trend	Boron (mg/L/year)
Increasing	> 0.05
Mildly Increasing	0.01 - 0.05
Very Small Change	-0.01 - 0.01
Mildly Decreasing	-0.05 - -0.01
Decreasing	< -0.05



Source: *Grassland Drainage Area Groundwater Quality Assessment Report*, 2016

Figure 5-104. Select Graphs of Boron Concentrations, Various Depths

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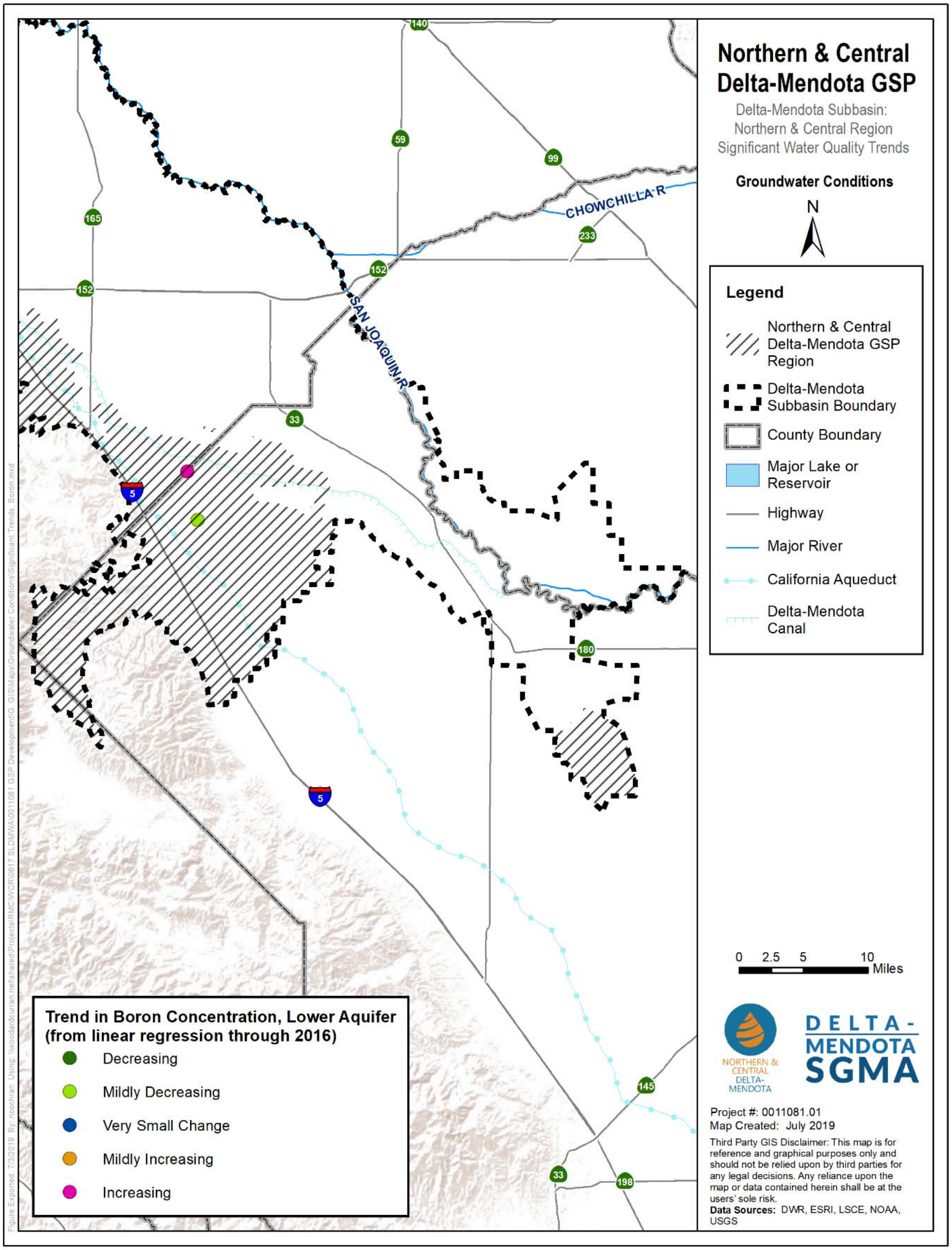

Figure 5-105. Significant Temporal Trends in Boron Concentrations, Lower Aquifer

5.3.6 Land Subsidence

Long-term groundwater level declines can result in a one-time release of "water of compaction" from compacting silt and clay layers (aquitards) resulting in inelastic land subsidence (Galloway et al., 1999). There are several other types of subsidence in the San Joaquin Valley, including subsidence related to hydrocompaction of moisture-deficient deposits above the water table, subsidence related to fluid withdrawal from oil and gas fields, subsidence caused by deep-seated tectonic movements, and subsidence caused by oxidation of peat soils that is a major factor in the Sacramento-San Joaquin Delta (Sneed et al., 2013). However, aquifer-system compaction caused by groundwater pumping causes the largest magnitude and areal extent of land subsidence in the San Joaquin Valley (Poland et al., 1975; Ireland et al., 1984; Farrar and Bertoldi, 1988; Bertoldi et al., 1991; Galloway and Riley, 1999).

Land subsidence is a prevalent issue in the Delta-Mendota Subbasin as it has impacted prominent infrastructure of statewide importance, namely the DMC and the California Aqueduct, as well as local canals, causing serious operational, maintenance, and construction-design issues (Sneed et al., 2013). Reduced freeboard and flow capacity for the DMC and California Aqueduct have rippling effects on imported water availability throughout the State. Even small amounts of subsidence in critical locations, especially where canal gradients are small, can impact canal operations (Sneed and Brandt, 2015). Differential land subsidence can also result in piping ruptures, resulting in the loss of water or other substances. While some subsidence is reversable (referred to as elastic subsidence), inelastic or irreversible subsidence is caused mainly by pumping groundwater from below the Corcoran Clay, thus causing compaction and reducing storage in the lower confined aquifer as well as damaging well infrastructure. As a result, important and extensive damages and repairs have resulted in the loss of conveyance capacity in canals that deliver water or remove floodwaters, the realignment of canals as their constant gradient becomes variable, the raising of infrastructure such as canal check stations, and the releveling of furrowed fields.

5.3.6.1 Available Data

There are six University NAVSTAR Consortium (UNAVCO) Continuous Global Positioning System (CGPS) locations that monitor subsidence within the Delta-Mendota Subbasin, five of which are within the Northern and Central Delta-Mendota Regions (Figure 5-106). Changes in land surface elevation have also been measured at DMC Check Structures (Figure 5-106). Figure 5-107 through Figure 5-112 show the vertical change in land surface elevation from a given time point (specified on charts) for the UNAVCO CGPS stations within the Delta-Mendota Subbasin, along with annual CVP allocations. Table 5-7 summarizes the greatest land subsidence rate and corresponding year(s) of that change at each UNAVCO CGPS station. Overall, the greatest monthly subsidence rates occurring after January 1, 2015 occurred during the Spring of 2016 to the Spring of 2017.

Land subsidence was measured by United States Bureau of Reclamation (USBR) showing annual subsidence rates from December 2011 to December 2014 (Figure 5-113). Based on these data, within the majority of the Northern and Central Delta-Mendota Regions, annual subsidence rates were between -0.15 and 0 feet/year during this period (or between -0.45 and 0 feet of total subsidence over this 3-year period). A small portion within the southwestern horn of the Delta-Mendota Subbasin saw an uplifting of land surface between 0.15 and 0.3 feet/year during this period (0.45 and 0.9 feet total subsidence during this period). From July 2012 to December 2016, during the most recent drought period, subsidence rates increased (Figure 5-114). Throughout the majority of the Northern and Central Delta-Mendota Region, subsidence was less than 0.5 feet/year (or less than 2.25 feet total over this 4.5-year period). In the Tranquillity Irrigation District (TRID) area, subsidence rates were higher, around 1 to 1.5 foot/year or more, during the drought years.

Table 5-7. Subsidence Monitoring Trends, UNAVCO CGPS Stations

Station ID	Greatest Monthly Land Subsidence Rate as of January 1, 2015 (feet)	Year(s) of Greatest Monthly Land Subsidence Rate
P255	-0.0292	Spring 2016 to 2017
P259	-0.0183	Spring 2016 to 2017
P252	-0.033	Spring 2016 to 2017
P303	-0.2190	Spring 2016 to 2017
P301	-0.0029	Spring 2016 to 2017
P304	-0.0003	Spring 2013 to 2017

5.3.6.2 Historic Conditions

Along the DMC in the northern portion of the San Joaquin Valley, extensive withdrawal of groundwater from unconsolidated deposits caused subsidence exceeding 8.5 meters (or about 28 feet) between 1926 and 1970 (Poland et al., 1975), reaching 9 meters (or about 30 feet) in 1980 (Ireland, 1986). Land subsidence from groundwater pumping began in the San Joaquin Valley in the mid-1920s (Poland et al., 1975; Bertoldi et al., 1991; Galloway and Riley, 1999) and by 1970, about half of the San Joaquin Valley had land subsidence of more than 0.3 meters (or about 1 foot) (Poland et al., 1975). While groundwater pumping decreased in the Delta-Mendota Subbasin following imported water deliveries from the CVP via the DMC in the early 1950s, compaction rates were reduced in certain areas and water levels recovered. Notable droughts of 1976-1977 and 1987-1992 saw renewed compaction during these periods, with increased groundwater pumping as imported supplies were reduced or unavailable. However, following these droughts, compaction virtually ceased, and groundwater levels rose to near pre-drought levels quite rapidly (Swanson, 1998; Galloway et al., 1999). Similarly, during the 2007-2009 and 2012-2015 droughts, groundwater levels declined during these periods in response to increased pumping, approaching or surpassing historical low levels, which reinstated compaction (Sneed and Brandt, 2015).

Subsidence contours for 1926-1970 (Poland et al., 1975) show the area of maximum active subsidence was southwest of the community of Mendota. Historical subsidence rates in the Mendota area exceeded 500 millimeters/year (or about 20 inches/year) during the mid-1950s and early 1960s (Ireland et al., 1984). The area southwest of Mendota has experienced some of the highest levels of subsidence in California, where from 1925 to 1977, this area sustained over 29 feet of subsidence (USGS, 2017). Historical subsidence rates along Highway 152 calculated from leveling-survey data from 1972, 1988, and 2004 show that for the two 16-year periods (1972-1988 and 1988-2004), maximum subsidence rates of about 50 millimeters/year (or about 2 inches/year) were found just south of El Nido (Sneed et al., 2013). Geodetic surveys completed along the DMC in 1935, 1953, 1957, 1984, and annually from 1996-2001 indicated that subsidence rates were greatest between 1953 and 1957 surveys, and that the maximum subsidence along the DMC (about 3 meters, or about 10 feet) was just east of DMC Check Structure Number 18.

Subsidence related to the California Aqueduct, which runs parallel and in close proximity to the Delta-Mendota Canal across the Subbasin, is of statewide importance. During the construction of the California Aqueduct, it was thought that subsidence within the San Joaquin Valley would cease with the delivery of water from the State Water Project, though additional freeboard to attempt to mitigate future subsidence was incorporated into the design and construction of the Aqueduct (DWR, June 2017). After water deliveries from the Aqueduct began, subsidence rates decreased to an average of less than 0.1 inches/year during normal to wet hydrologic years. During dry to critical hydrologic years, subsidence increased to an average of 1.1 inches per year. The 2012-2015 drought produced subsidence similar to those seen before the Aqueduct began delivering water, with some areas experiencing nearly 1.25 inches of sinking per month (based on NASA Uninhabited Aerial Vehicle Synthetic Aperture Radar [UAVSAR] flight measurements). Dry and critically dry water years since Aqueduct deliveries began have resulted in extensive groundwater withdrawals, causing some areas near the Aqueduct to subside nearly 6 feet.

After 1974, land subsidence was demonstrated to have slowed or largely stopped (DWR, June 2017); however, land subsidence remained poised to resume under certain conditions. Such an example includes the severe droughts that occurred between 1976 and 1977 and between 1987 and 1991. Those droughts lead to diminished deliveries of imported water, which prompted some water agencies and farmers (especially in the western Valley) to refurbish old pumps, drill new water wells, and begin pumping groundwater to make up for cutbacks in the imported water supply. The decisions to renew groundwater pumping were encouraged by the fact that groundwater levels had recovered to near-predevelopment levels. During the most recent drought of 2012-2015, subsidence rates were greatest between March 2015 and August 2015 with as much as nearly 9 inches of subsidence in 6 months along the Aqueduct. With water levels near or below historical lows were observed during the most recent drought, it indicates that preconsolidation stress was likely exceeded, meaning the resulting subsidence is likely mostly permanent (Sneed and Brandt, 2015).

5.3.6.3 Current Conditions

Based on subsidence rates observed over the last decade, it is anticipated that subsidence will continue to impact operations of the DMC and California Aqueduct without mitigation. For example, recently, Reach 4A of the San Joaquin River near Dos Palos (at the lower end of the Northern and Central Delta-Mendota Regions, where most land subsidence has historically occurred) experienced between 0.38 and 0.42 feet/year in subsidence between 2008 and 2016. As a result of subsidence, freeboard in Reach 4A is projected to be reduced by 0.5 foot by 2026 as compared to 2016, resulting in a 50 percent reduction in designed flow capacity (DWR, May 2018). Reduced flow capacities in the California Aqueduct will impact deliveries and transfers throughout the State and result in the need to pump more groundwater, thus contributing to further subsidence.

More recent subsidence measurements indicate subsidence hot spots within and adjacent to the Subbasin, including the area east of Los Banos and the TRID area. The USGS began periodic measurements of the land surface in parts of the San Joaquin Valley over the last decade. Between December 2011 and December 2014, total subsidence in the area east of Los Banos, within the Merced Subbasin (also referred to as the El Nido-Red Top area, ranged from 0.15 to 0.75 feet, or 1.8 to 9 inches respectively (Schmidt, 2015). The National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA JPL) at the California Institute of Technology has also been monitoring subsidence in California using interferometric synthetic aperture radar (or InSAR), and a recent progress report documenting data for the period from May of 2015 to September of 2016 indicates that the two previously-identified primary subsidence areas near the community of Corcoran (and centered on El Nido) was joined by a third area of significant subsidence near TRID. For the study period (as shown in Figure 5-115), maximum total subsidence of 22 inches was measured near Corcoran, while the El Nido area subsided 16 inches and the TRID area subsided around 20 inches. Analyses at two particular stations near El Nido show interesting trends. At Station P303, between 2007 and 2014, 50 mm of subsidence occurred at this location (or nearly 2 inches). Vertical displacement at P303 showed subsidence at fairly consistent rates during and between drought periods (Figure 5-116), indicating that these areas continued to pump groundwater despite climatic variations (possibly due to a lack of surface water availability). Residual compaction may also be a factor. Vertical displacement at Station P304 indicated that most subsidence occurred during drought periods and very little subsidence occurring between drought periods (Figure 5-116). This suggests that this area received other sources of water, most likely surface water, between drought periods, and also that residual compaction did not significantly occur in this area. These two areas demonstrate a close link between the availability of surface water, groundwater pumping, and inelastic land subsidence. Total land subsidence in the San Joaquin Valley from May 7, 2015 to September 10, 2016 is shown in Figure 5-116.

As managers of the DMC, the San Luis & Delta-Mendota Water Authority (SLDMWA) has been making periodic subsidence surveys along the DMC to identify key areas of active land subsidence and to estimate subsidence rates. Table 5-8 summarizes the average yearly elevation change along the DMC between 2014, 2016 and 2018. Figure 5-117 shows the change in land surface elevation between the 2014 and 2016 and the 2014 and 2018 subsidence surveys performed by SLDMWA at each milepost along the DMC.

Lower Aquifer groundwater extractions has been identified as one of the key causes of inelastic land subsidence in the Delta-Mendota Subbasin. The City of Patterson, which is the only major municipality within the Plan area, relies solely on groundwater from the Lower Aquifer for potable supply. The City of Patterson is located directly east of the DMC within Pool 7, where subsidence occurred at a rate of 0.22 feet/year during the most recent drought (2014-2016) and decreased to 0.06 feet/year immediately following the drought (2016-2018) (Table 5-8); thus reinforcing the connection between Lower Aquifer groundwater pumping and inelastic subsidence.

Table 5-8. Subsidence Rates Along the Delta-Mendota Canal
in the Northern and Central Delta-Mendota Regions
Elevation Differences between 2014, 2016, and 2018 Subsidence Surveys

Pool	Milepost Range	Checkpoints	Average Yearly Elevation Change (ft/yr)		
			2014-2016	2016-2018	2014-2018
3	16.20-20.63	2 – 3	-0.08	-0.12	-0.1
4	20.64 - 24.43	3 – 4	-0.11	-0.14	-0.13
5	24.44 - 29.82	4 – 5	-0.15	-0.11	-0.13
6	29.83 - 34.42	5 – 6	-0.19	-0.11	-0.15
7	34.43 - 38.68	6 – 7	-0.22	-0.06	-0.14
8	38.69 - 44.26	7 – 8	-0.27	-0.01	-0.14
9	44.27 - 48.62	8 – 9	-0.26	0.02	-0.12
10	48.63 - 54.41	9 – 10	-0.26	0.02	-0.12
11	54.42 - 58.28	10 – 11	-0.24	0.01	-0.12
12	58.29 - 63.98	11 – 12	-0.21	-0.03	-0.12
13	63.99 - 70.01	12 – 13	-0.17	-0.04	-0.1
14	70.02 - 74.40	13 – 14	-0.14	-0.01	-0.07
15	74.41 - 79.64	14 – 15	-0.14	0.02	-0.07
16	79.65 - 85.09	15 – 16	-0.15	0.01	-0.08
17	85.10 - 90.54	16 – 17	-0.17	-0.05	-0.11
18	90.55 - 96.81	17 – 18	-0.23	-0.09	-0.16

For the TRID area at the southern end of the Northern & Central Delta-Mendota Region GSP Plan area, regular surveys of wellhead elevations between 2014 and 2018 have provided insight into subsidence rates in this area. Per these data, TRID has experienced over two feet of subsidence between 2014 and 2018, with an average subsidence rate of 0.53 feet/year for that period.

5.3.6.4 Groundwater Trends

The rapid decline of groundwater levels in the San Joaquin Valley during post-1975 droughts in response to relatively small volumes of pumping (compared to those of the 1960s) results from a loss of storage space in the aquifer system — mostly from inelastic compaction of aquitards during the 1950s and 1960s — and from reduced hydraulic conductivity (permeability) of those compacted aquitards that restrict drainage of water to permeable parts of the aquifer system (Borchers and Carpenter, 2014). Observations showed that Lower Aquifer water levels were considerably higher than during the 1960s, yet there was renewed land subsidence during droughts. Since 1962, groundwater storage in the Central Valley aquifer system has been depleted at an average rate of 1.85 km^3/year (or about 1.5 million AF/year) and at more than twice this rate during the most recent drought of 2012-2015 (Faunt et al., 2015). This illustrates the complex effects of unequal distribution of preconsolidation stress within the aquitards and between the aquitards and more permeable units of the aquifer system.

Subsidence monitoring in the Delta-Mendota Subbasin, and in the San Joaquin Valley as a whole, demonstrated significant inelastic land subsidence as a result of the last drought, with effects continuing to the present time (as evidenced by continued subsidence between 2016 and 2018 through the SLDMWA surveys). While the impacts appeared to have slowed, the temporal and spatial impacts of continued subsidence have not yet been evaluated.

Land use changes in some parts of the San Joaquin Valley are likely to impact future subsidence. Trends toward the planting of permanent crops since 2000, such as vineyards and orchards, and away from non-permanent land uses like rangeland and row crops can result in “demand hardening,” which requires stable water supplies to irrigate crops that cannot be fallowed (Sneed et al., 2013 and Faunt et al., 2015). As land use and surface water availability continue to vary in the San Joaquin Valley, additional water level declines and associated subsidence are likely to occur. Increased monitoring of groundwater levels and land subsidence will be essential to better understand the connection between land use, groundwater levels, and subsidence and enable management strategies to mitigate subsidence hazards and impacts while optimizing water supplies.

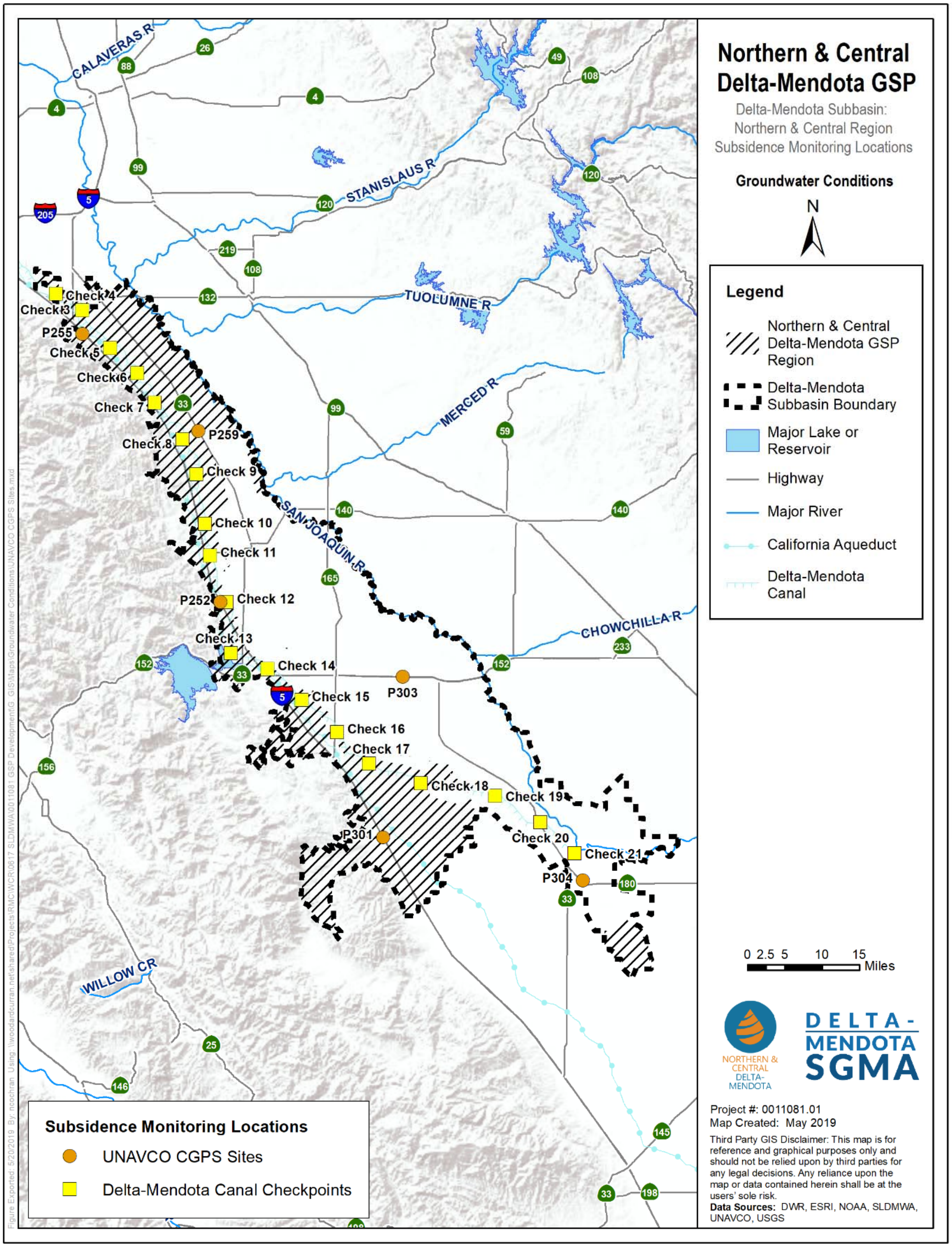

Figure 5-106. Subsidence Monitoring Locations, Delta-Mendota Subbasin

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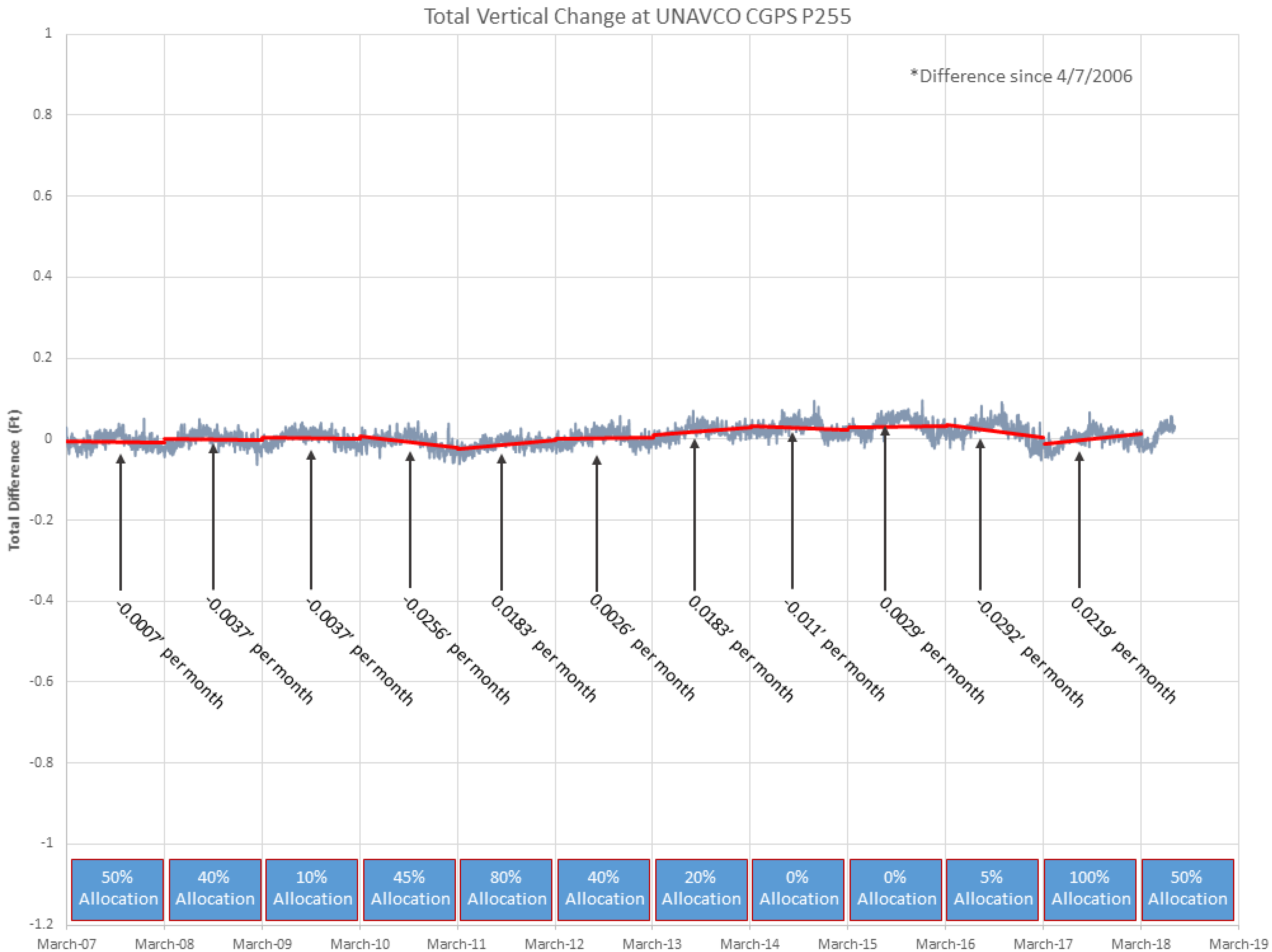

Figure 5-107. Vertical Elevation Change at UNAVCO CGPS P255, Spring 2007 to 2018

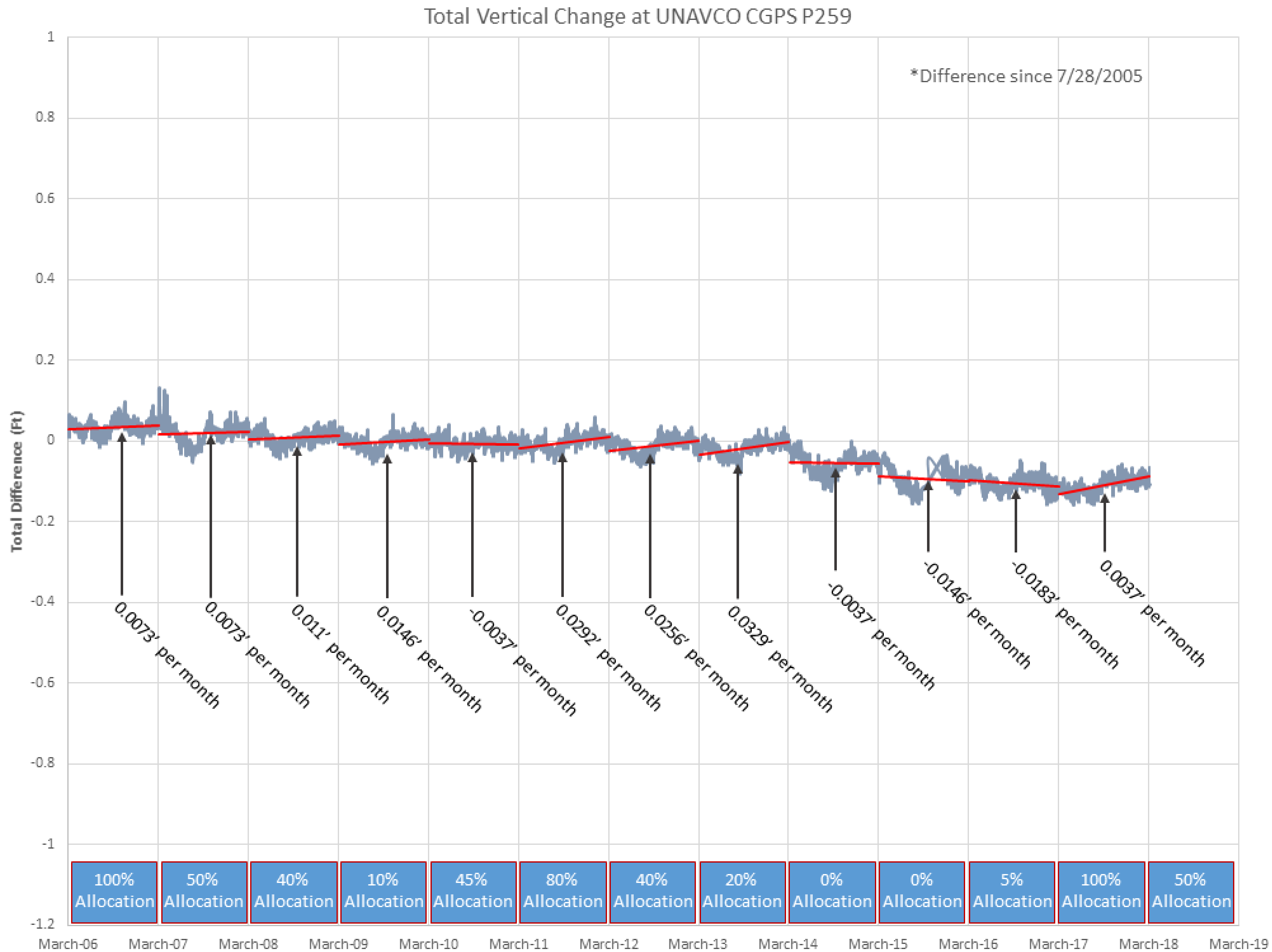

Figure 5-108. Vertical Elevation Change at UNAVCO CGPS P259, Spring 2006 to 2018

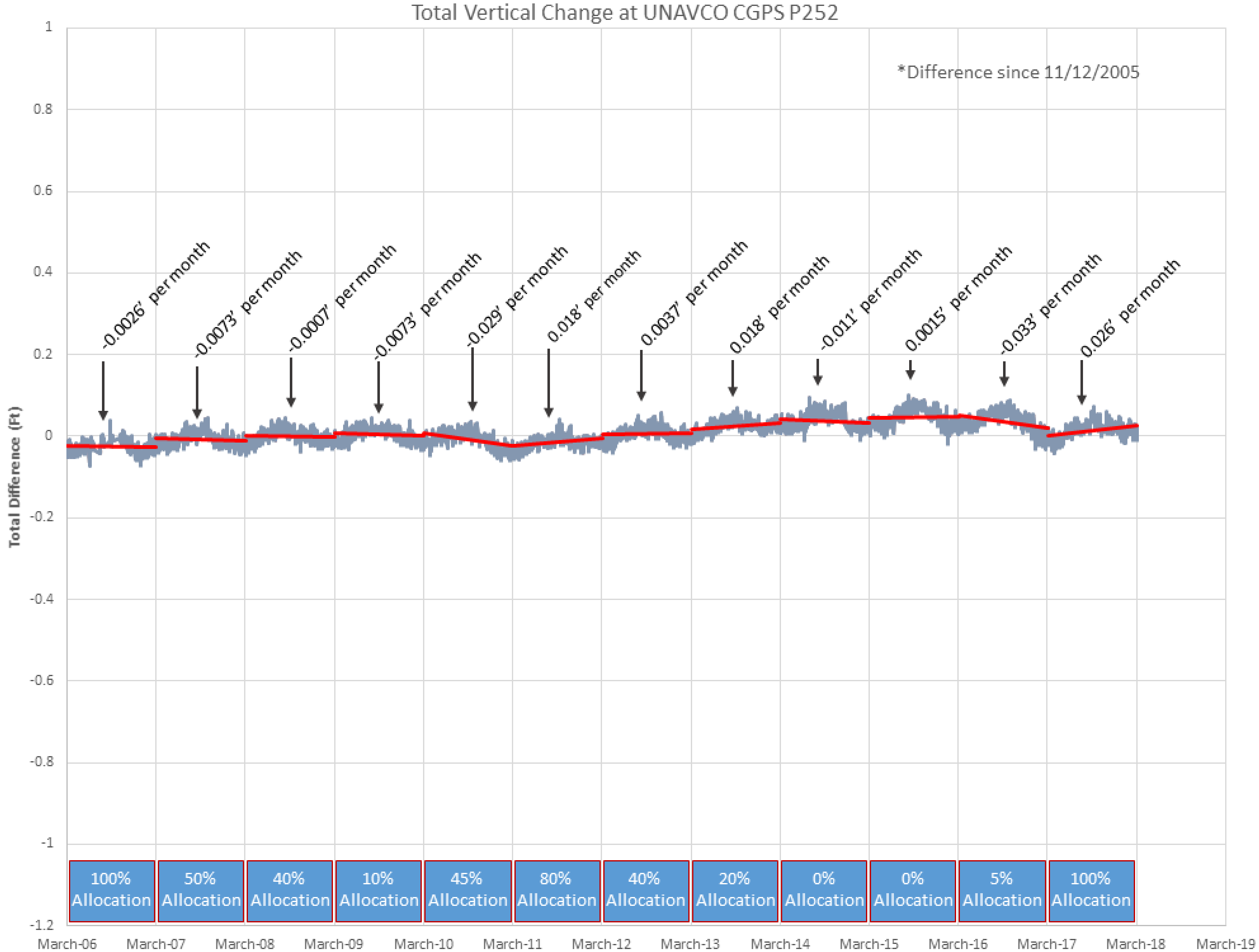

Figure 5-109. Vertical Elevation Change at UNAVCO CGPS P252, Spring 2006 to 2018

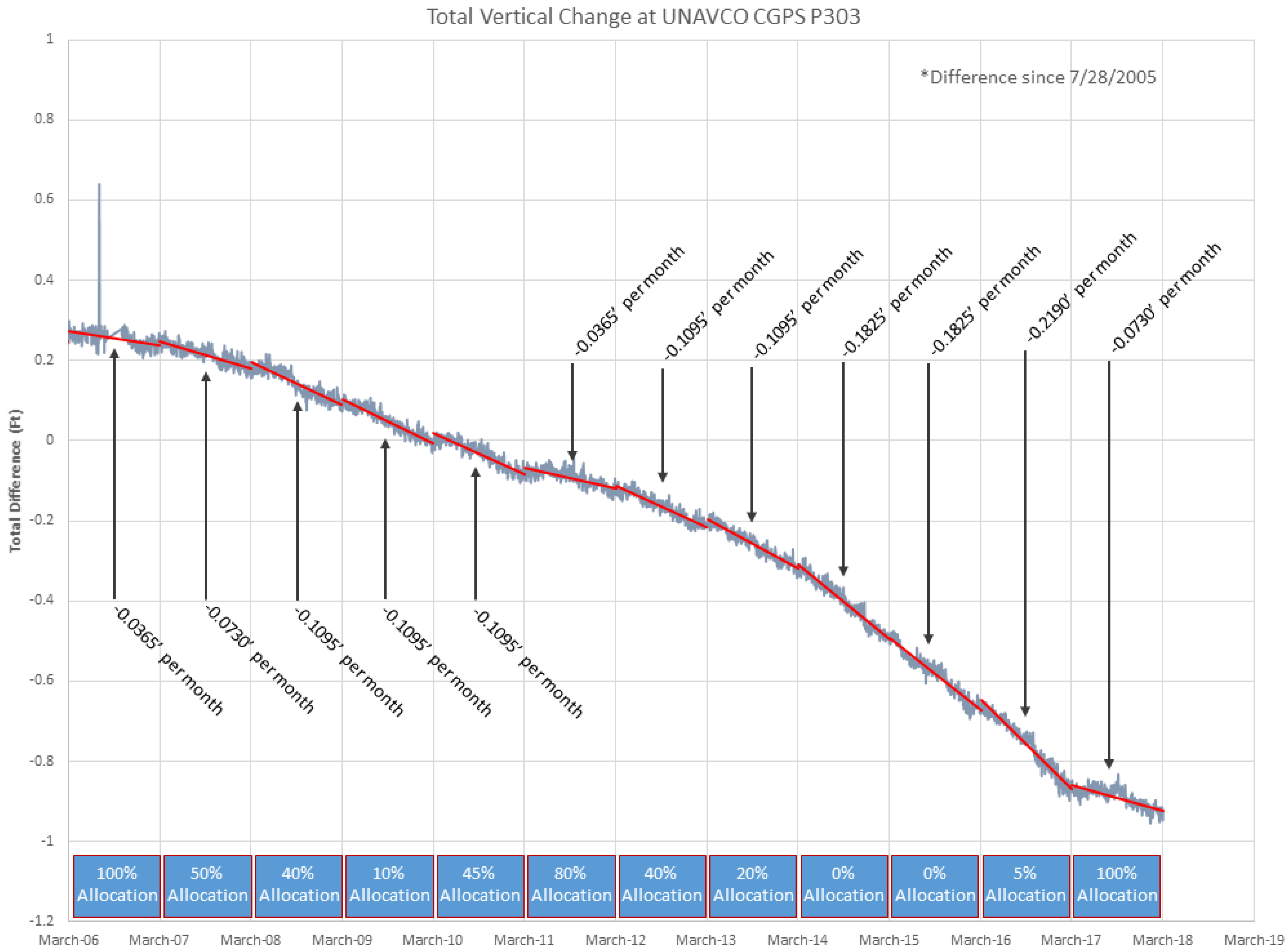

Figure 5-110. Vertical Elevation Change at UNAVCO CGPS P303, Spring 2006 to 2018

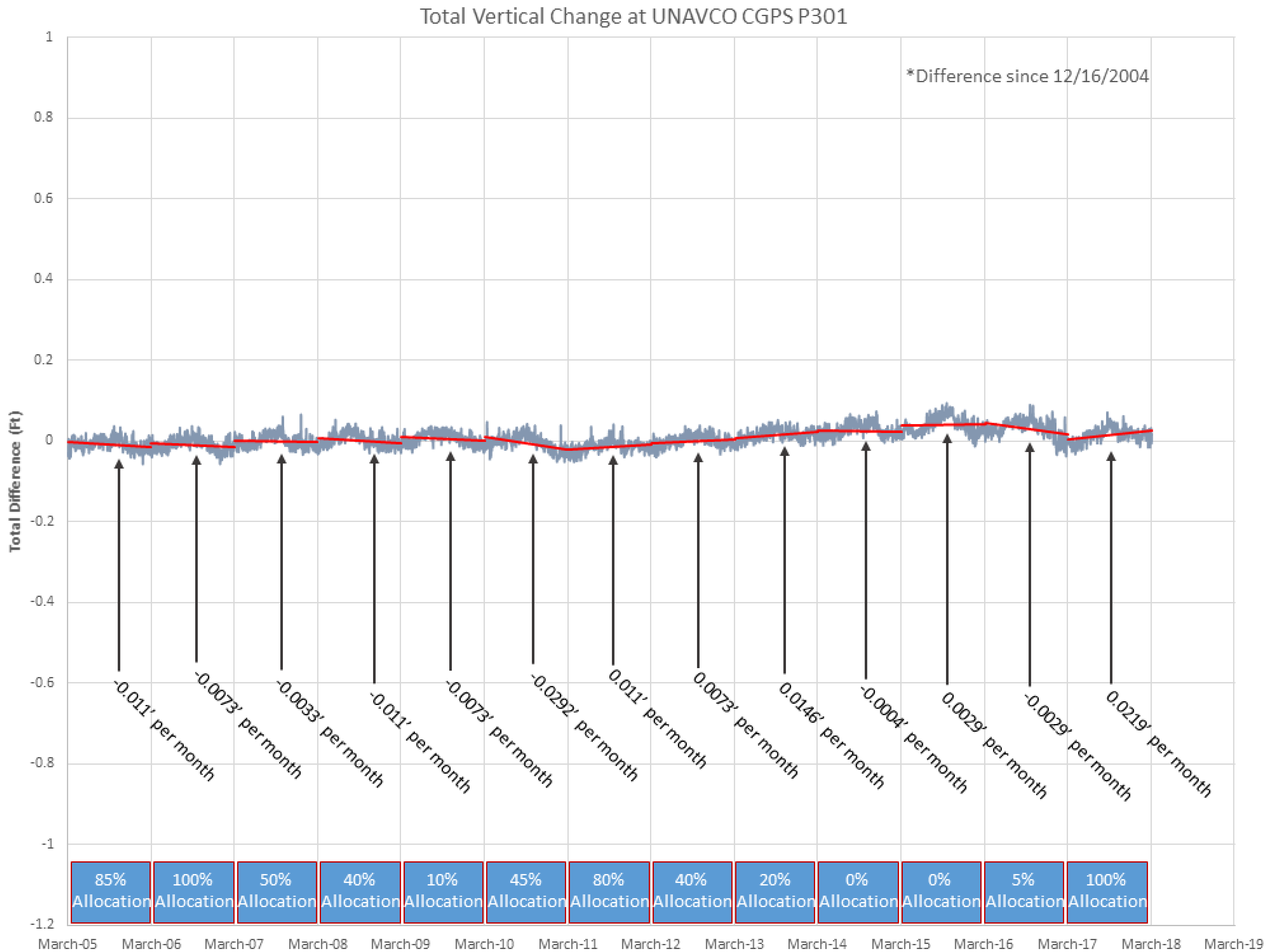

Figure 5-111. Vertical Elevation Change at UNAVCO CGPS P301, Spring 2005 to 2018

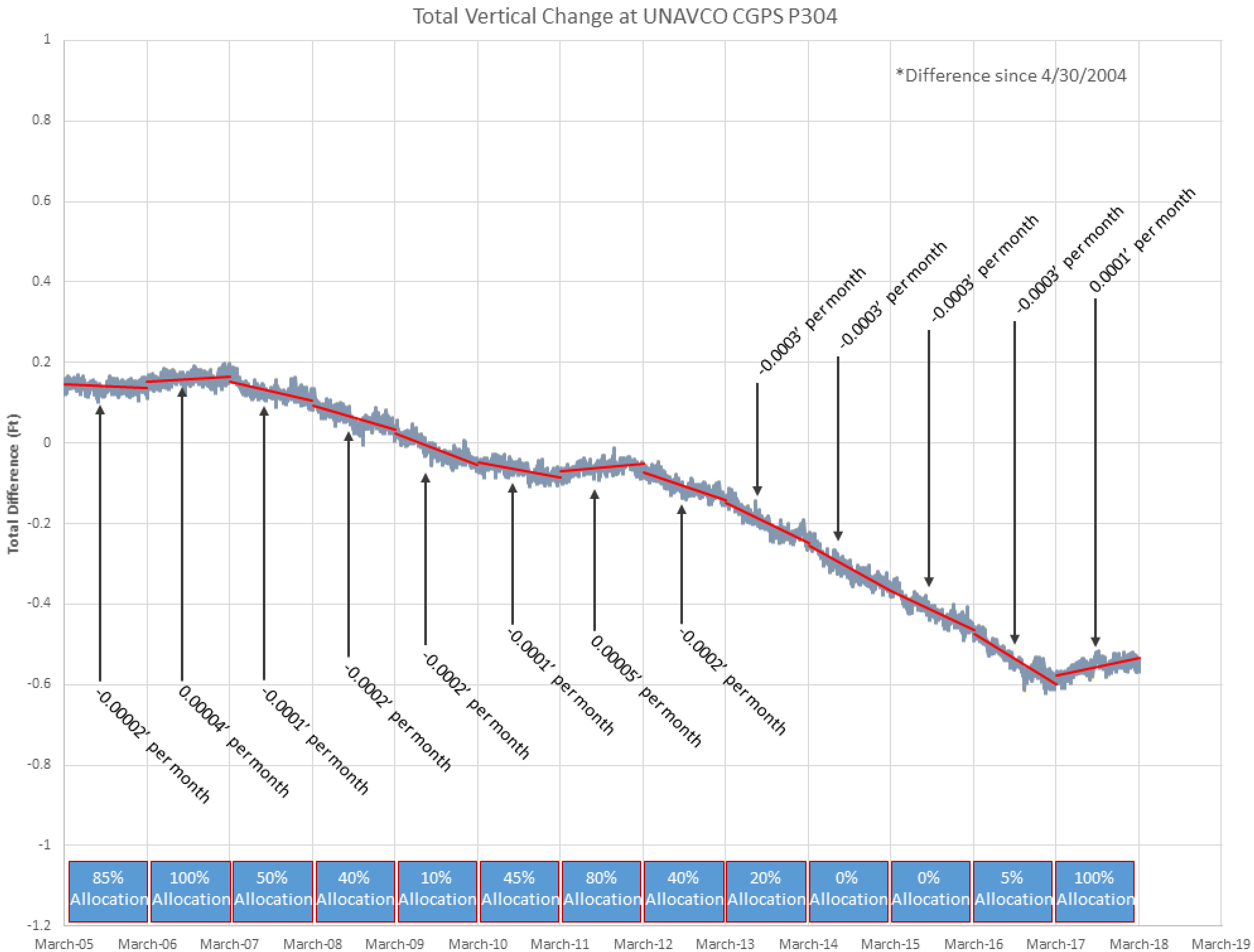

Figure 5-112. Vertical Elevation Change at UNAVCO CGPS P304, Spring 2005 to 2018

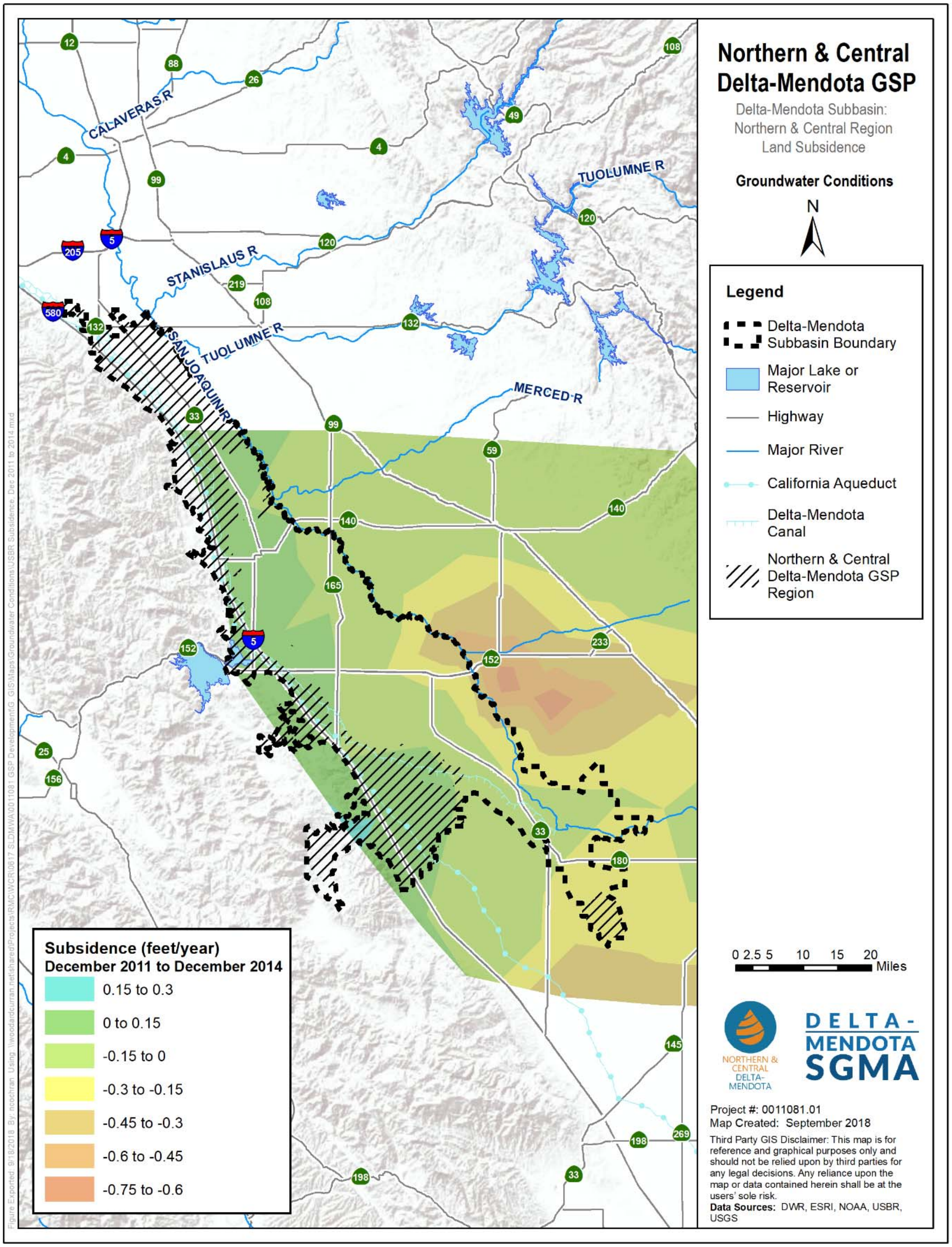

Figure 5-113. Land Subsidence, December 2011 to December 2014

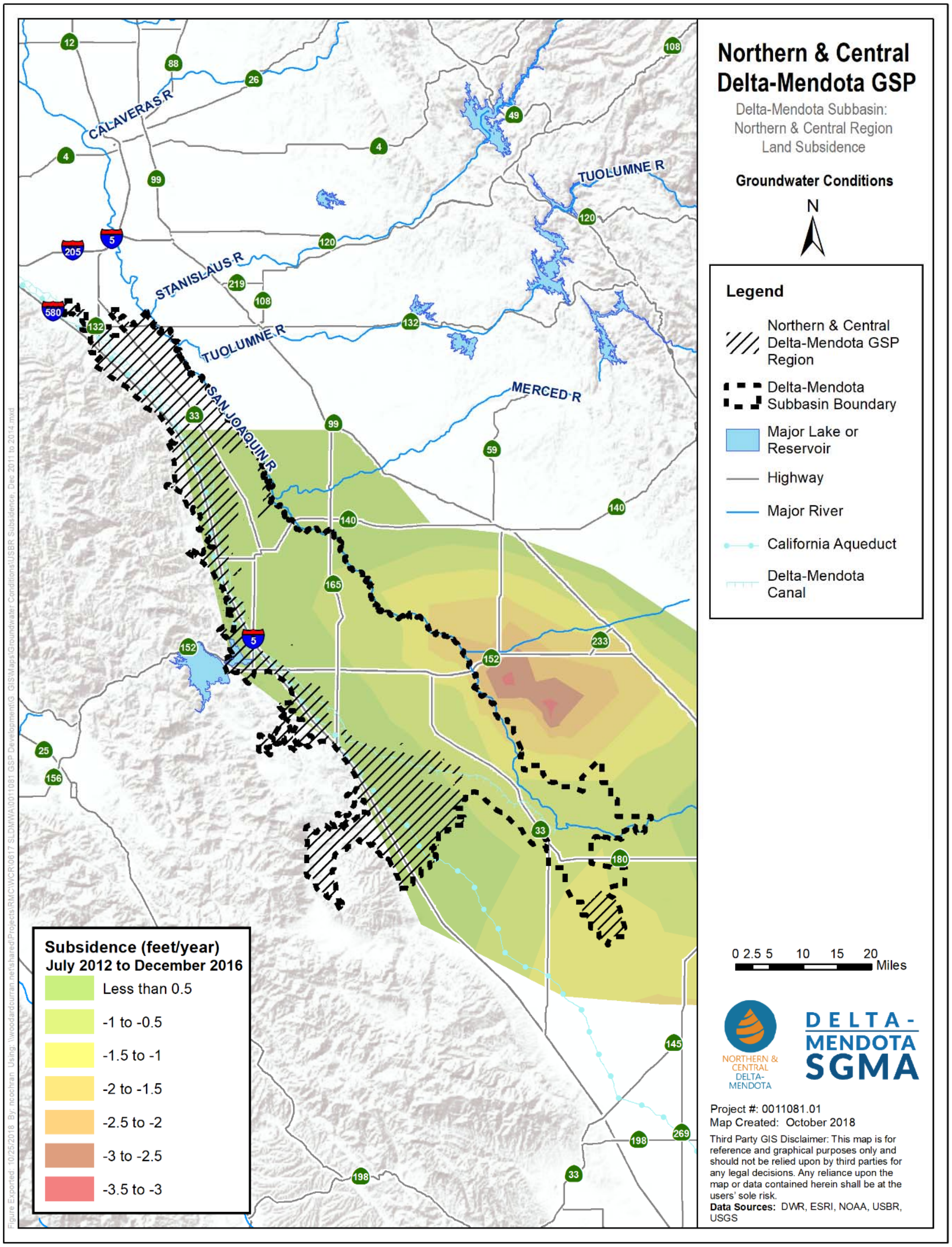

Figure 5-114. Land Subsidence, July 2012 to December 2016

Figure 5-115. Recent Land Subsidence at Key San Joaquin Valley Locations (Source: *Progress Report: Subsidence in California, March 2015 – September 2016*, Farr et. al. JPL, 2017)

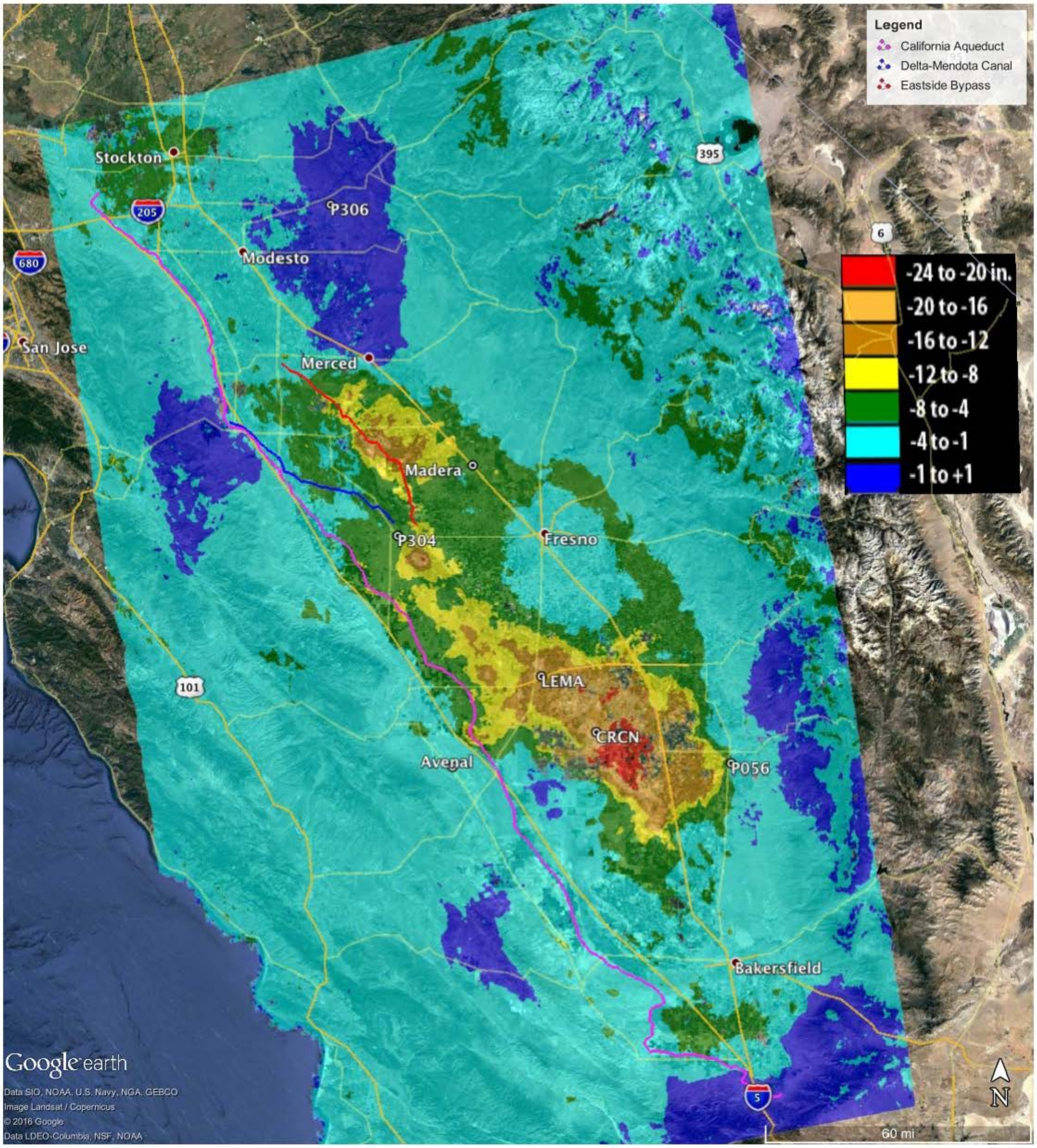

Figure 5-116. Total Land Subsidence in San Joaquin Valley from May 7, 2015 – September 10, 2016 as measured by ESA's Sentinel-1A and processed by JPL (Source: *Progress Report: Subsidence in California, March 2015 – September 2016*, Farr et. al. JPL, 2017

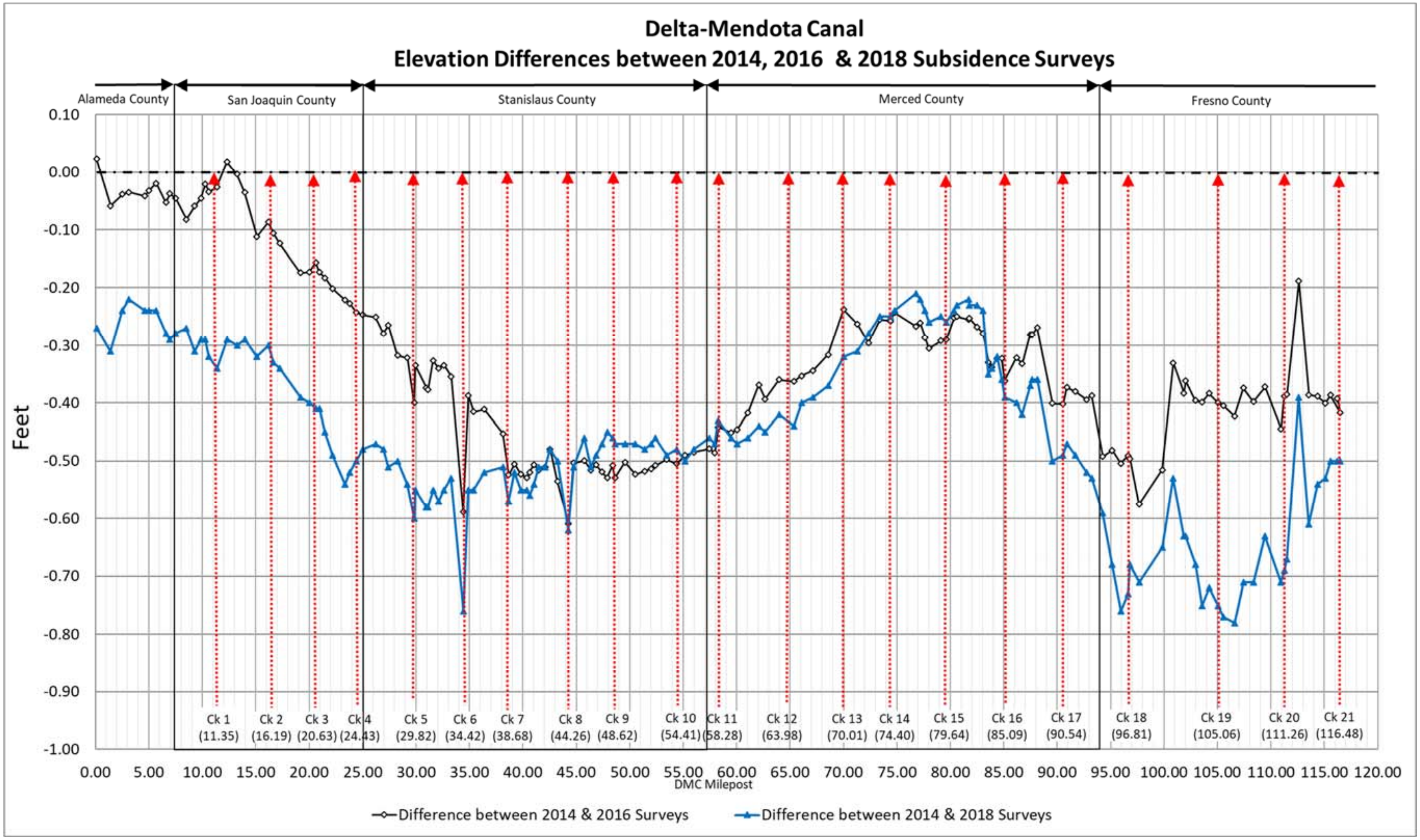

Figure 5-117. Elevation Change along the Delta-Mendota Canal, 2014 through 2018

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5.3.7 Interconnected Surface Water Systems

Understanding the location, timing and magnitude of groundwater pumping impacts on interconnected surface water systems is important for the proper management of groundwater resources in order to minimize impacts on interconnected surface waters and the biological communities and permitted surface water diverters that rely on those resources. Historically, throughout the San Joaquin Valley, many interconnected stream reaches have transitioned from net-gaining to net-losing streams (TNC, 2014). Gaining streams occur when streamflows increase as a result of groundwater contribution, and losing streams occur when streamflows decrease due to infiltration into the surrounding groundwater basin through the bed of the stream (McBain & Trush, Inc., 2002). Lowered groundwater levels have the ability to result in stream depletion similar in amount to the consumptive use of applied water, with the nature, rate, and location of increased pumping being a function of distance to the river, as well as depth, timing, and rate of groundwater pumping; however, it is important to recognize that groundwater pumping adjacent to an interconnected surface water body may be one of many causes of loss of surface water flows.

5.3.7.1 Available Data

Two communities in the Northern and Central Delta-Mendota Regions are most vulnerable to impacts from the loss of interconnected surface water as a result of the lowering of groundwater elevations: San Joaquin River surface water diverters and GDEs. These communities represent the primary users of interconnected surface water and groundwater. Permitted San Joaquin River diverters at the northern end of the Delta-Mendota Subbasin include West Stanislaus Irrigation District (post-1914 appropriative rights holder) and Patterson Irrigation District (which holds a pre-1914 water right), in addition to smaller agencies and private diverters. Similarly, GDEs in the Northern and Central Delta-Mendota Regions are found adjacent to the San Joaquin River, predominantly at the San Joaquin National Wildlife Refuge, which provides important habitat to birds and wildlife. Streams stemming from the west side of the Delta-Mendota Subbasin are ephemeral in nature, and only two of these creeks reach the San Joaquin River (Del Puerto Creek and Orestimba Creek). These creeks lose their flows to the underlying vadose zone (net-losing streams) and therefore do not represent areas of potential GDEs.

Groundwater dependent ecosystems are defined under Article 2 Definitions, § 351 Definitions of the GSP Emergency Regulations as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.” The Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (2018a) provided by DWR in conjunction with The Nature Conservancy (TNC) was initially used to identify GDEs within the Delta-Mendota Subbasin, following the associated guidance document provided by TNC (Rohde et al., 2018). Local verification efforts were conducted in the Delta-Mendota Subbasin by different GSA representatives to ground-truth GDEs based on local knowledge. Specifically, areas where natural communities have been urbanized or otherwise modified were eliminated from the data set use to identify GDEs.

5.3.7.2 Identification of Interconnected Surface Water Systems

The San Joaquin River is the primary surface water body interconnected with Delta-Mendota Subbasin groundwater. Within the Northern and Central Delta-Mendota Regions, four reaches of the San Joaquin River have been identified as gaining streams with their associated California Data Exchange Center (CDEC) stream gauges: Newman (NEW) to Crows Landing (SCL), Crows Landing to Patterson (SJP), Patterson to Maze Road Bridge (MRB), and Maze Road Bridge to Vernalis (VNS). These reaches of the San Joaquin River were identified as gaining from a compendium of sources including a 2014 analysis of diversion water demand for diverters of the San Joaquin River between Hills Ferry Bridge and Mossdale Bridge (Provost & Pritchard, June 2014) as well as the following:

- Babbit, C., D.M. Dooley, M. Hall, R.M. Moss, D.L. Orth, and G.W. Sawyers. July 2018. *Groundwater Pumping Allocations under California’s Sustainable Groundwater Management Act: Considerations for Groundwater Sustainability Agencies*.

https://www.edf.org/sites/default/files/documents/edf_california_sgma_allocations.pdf. Accessed on November 13, 2018.

- Cantor, A., D. Owen, T. Harter, N.G. Nylen, and M. Kiparsky. March 2018. *Navigating Groundwater-Surface Water Interactions under the Sustainable Groundwater Management Act*. Center for Law, Energy & the Environment, UC Berkeley School of Law, Berkeley, CA. 50 pp. https://doi.org/10.15779/J23P87. Accessed on August 7, 2018.
- Hall, M., C. Babbitt, A.M. Saracino, and S.A. Leake. 2018. *Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act*. https://www.edf.org/sites/default/files/documents/edf_california_sgma_surface_water.pdf. Accessed on November 13, 2018.
- McBain & Trush, Inc. 2002. *San Joaquin River Restoration Study Background Report*, prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council. https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/mcbainandtrush_2002.pdf. Accessed on October 1, 2018.
- San Joaquin River Restoration Program. April 2011. *DRAFT Program Environmental Impact Statement/Report, Chapter 12.0 Hydrology – Groundwater*. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=7557. Accessed on August 29, 2018.
- San Joaquin River Restoration Program. August 2013. *Flow Loss Analysis (DRAFT)*. http://www.restoresjr.net/?wpfb_dl=686. Accessed on August 28, 2018.
- San Luis & Delta-Mendota Water Authority. March 22, 2011. *Guidelines for Use of the San Luis Drain during Flood Conditions*. Received via personal communication via Andrew Garcia on October 2, 2018.
- The Nature Conservancy. 2014. Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management. https://www.scienceforconservation.org/assets/downloads/GroundwaterStreamInteraction_2016.pdf. Accessed on August 29, 2018.
- The Nature Conservancy. January 2018. *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans*. https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf. Accessed on February 1, 2018.
- United States Bureau of Reclamation. April 2005. *CALSIM II San Joaquin River Model (DRAFT)*. http://www.calwater.ca.gov/science/pdf/calsim/CALSIMSJR_DRAFT_072205_1-50.pdf and http://www.calwater.ca.gov/science/pdf/calsim/CALSIMSJR_DRAFT_072205_51-100.pdf. Accessed on December 28, 2018.

5.3.7.3 Historic Conditions

The San Joaquin River and its tributaries drain approximately 13,500 mi^2 (measured at the USGS gaging station at Vernalis) along the western flank of the Sierra Nevada and eastern flank of the Coast Range, and flows northward into the Sacramento-San Joaquin Delta where it is joined by the Calaveras and Mokelumne Rivers before combining with the Sacramento River. Typical of Mediterranean climate catchments, river flows vary widely seasonally and from year to year. Three major tributaries join the San Joaquin from the east: the Merced, Tuolumne, and Stanislaus Rivers. Smaller tributaries include the Fresno River, Chowchilla River, Bear Creek, and Fresno Slough (from the Kings River). Precipitation is predominantly snow above about 5,500 to 6,000 feet in the Sierra Nevada, with rain in the middle and lower elevations of the Sierra foothills and in the Coast Range. As a result, the natural hydrology historically reflected a mixed runoff regime dominated by winter-spring rainfall runoff and spring-summer snowmelt runoff. Most flow is derived from snowmelt from the Sierra Nevada, with relatively little runoff contributed from the western side of the drainage basin in the rain shadow of the Coast Range. The unimpaired average annual water yield (WY 1906-2002) of the San Joaquin River, as measured immediately above Millerton Reservoir, is 1,801,000 AF (USBR, 2002); the post-Friant Dam average annual water yield (WY 1950-2000) to the lower San Joaquin River is 695,500 AF (USGS, 2000). As average precipitation decreases from north to south, the San Joaquin River basin (including the Stanislaus, Tuolumne, and Merced Rivers) contributes about 22% of the total runoff to the Delta (DWR, 1998).

5.3.7.4 Current Conditions

Historically, most of the San Joaquin River, which forms the great majority of the Delta-Mendota Subbasin's eastern border, was a gaining reach. Snowmelt runoff during the spring and early summer resulted in these conditions through a good portion of the year. However, significant decreases in groundwater elevations due to pumping, storage, and upstream diversions on the river have reversed this condition so most reaches are now losing reaches. Some localized gaining reaches still remain on the lower river, such as between the Stanislaus and Merced Rivers, corresponding to the reaches of the San Joaquin River boarding the Northern and Central Delta-Mendota Regions.

5.3.7.5 Estimates of Timing and Quantity of Gains/Depletions

Using available data, the quantity of gains and/or depletions from the groundwater at each reach of the San Joaquin River identified along the Northern and Central Delta-Mendota Regions was estimated. Table 5-9 summarizes these estimates. Estimates of the timing of gains and/or depletions were unavailable in related literature, and insufficient data were available to estimate the timing of losses and gains in the Northern and Central Delta-Mendota Regions. Such information will be gathered through future monitoring efforts related to this GSP.

Table 5-9. Estimated Quantity of Gains/Depletions for Interconnected Stream Reaches, Northern and Central Delta-Mendota Regions

Reach	Quantified Gain (cubic feet per second [cfs])	Reach Length (mile [mi])
Newman to Crows Landing [1]	50	11
Crows Landing to Patterson [1]	-50 to 200	10
Patterson to Maze Road Bridge [2]	190	30.8
Maze Road Bridge to Vernalis [2]		

[1] Provost & Pritchard, 2014

[2] Cooley, 2001

5.3.7.6 Groundwater Dependent Ecosystems

A GDE is defined under the GSP Emergency Regulations as referring "to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (§351(m)). Under §354.16(g) of the GSP Emergency Regulations, each Plan is required to identify GDEs within the subbasin utilizing data provided by the Department of Water Resources, or the best available information. The following section describes the process for verifying GDEs within the Delta-Mendota Subbasin and the location of verified and potential GDEs.

The NCCAG dataset (2018a) provided by DWR was used in conjunction with information provided by TNC to identify GDEs within the Delta-Mendota Subbasin. To further screen available information regarding GDEs, the following standards were set for identifying GDEs in the Northern and Central Delta-Mendota Regions: (1) areas with depths to groundwater levels greater than 30 feet were eliminated unless the vegetation identified in those areas were consistent with species with deep root systems (e.g. live oaks); (2) seasonally-managed areas and wetlands were eliminated due to their dependence on applied surface water; and (3) a 100-foot buffer was applied around the San Joaquin River within the Northern Delta-Mendota Region to include all communities in the NCCAG dataset as potential GDEs, except where professional judgement and local knowledge determined GDEs were not present. The selected 100-foot buffer corresponds with Caltrans standards under the Coastal Act that requires a 100-foot setback around wetland resources for their protection during project construction. To determine where groundwater is typically deeper than 30 feet below the ground surface, Spring 2015 depth to water contour mapping was used as a basis for establishing a connection between shallow groundwater and potential GDEs. The ESRI World Imagery layer (2017) was also used by local GSA representatives for ground-truthing and identifying potential mapping errors.

Based on the screening process described above, GDE polygons determined not to be GDEs were removed from the mapping. There were no GDE communities added to the mapping for the Northern and Central Delta-Mendota Regions. Figure 5-118 and Figure 5-119 summarize the results of the GDE analysis for the Subbasin, where red polygon indicates the Northern and Central Delta-Mendota Regions. Results are compiled into two habitat classes: wetlands (Figure 5-118) and vegetation (Figure 5-119). Wetland features are commonly associated with surface expression of groundwater under natural, unmodified conditions. Vegetation feature types are commonly associated with the sub-surface presence of groundwater (phreatophytes – deep rooted plants). Out of a total of 13,253 acres identified in the NCCAG dataset within the Northern and Central Delta-Mendota Regions, 11,711 acres were retained as Possible GDEs. Confirmed GDEs have been grouped into larger polygons based on proximity and aquifer connection.

In general, identified Possible GDEs are located along the San Joaquin River corridor. Possible GDEs in the Northern and Central Delta-Mendota Regions are located primarily in the northern portion of the Plan area, within about two miles from the San Joaquin River. Possible GDEs have also been identified along streams originating from the Coast Range; however, these areas are topographically disconnected from the Subbasin's principal aquifers and are located in areas of *de minimus* or zero groundwater use and are therefore are unmanageable through the Sustainable Groundwater Management Act (SGMA). Table 5-10 includes all freshwater species within the Northern and Central Delta-Mendota Regions, as identified by TNC (2018). These species (listed in Table 5-10) have either been observed or have the potential to exist within the Northern and Central Delta-Mendota Regions. Future efforts in GDE mapping prior to the 2025 5-Year GSP Update will further refine GDE locations within the Plan area.

As a result of the identification of Possible GDEs for the purpose of this GSP under SGMA, no land use protections for GDEs are conveyed unless the law otherwise requires. Management and protection of GDEs may require more focus on land use or irrigation activities more so than groundwater management. This rigorous analysis to identify potential GDEs was developed to focus groundwater management activities on the most appropriate areas.

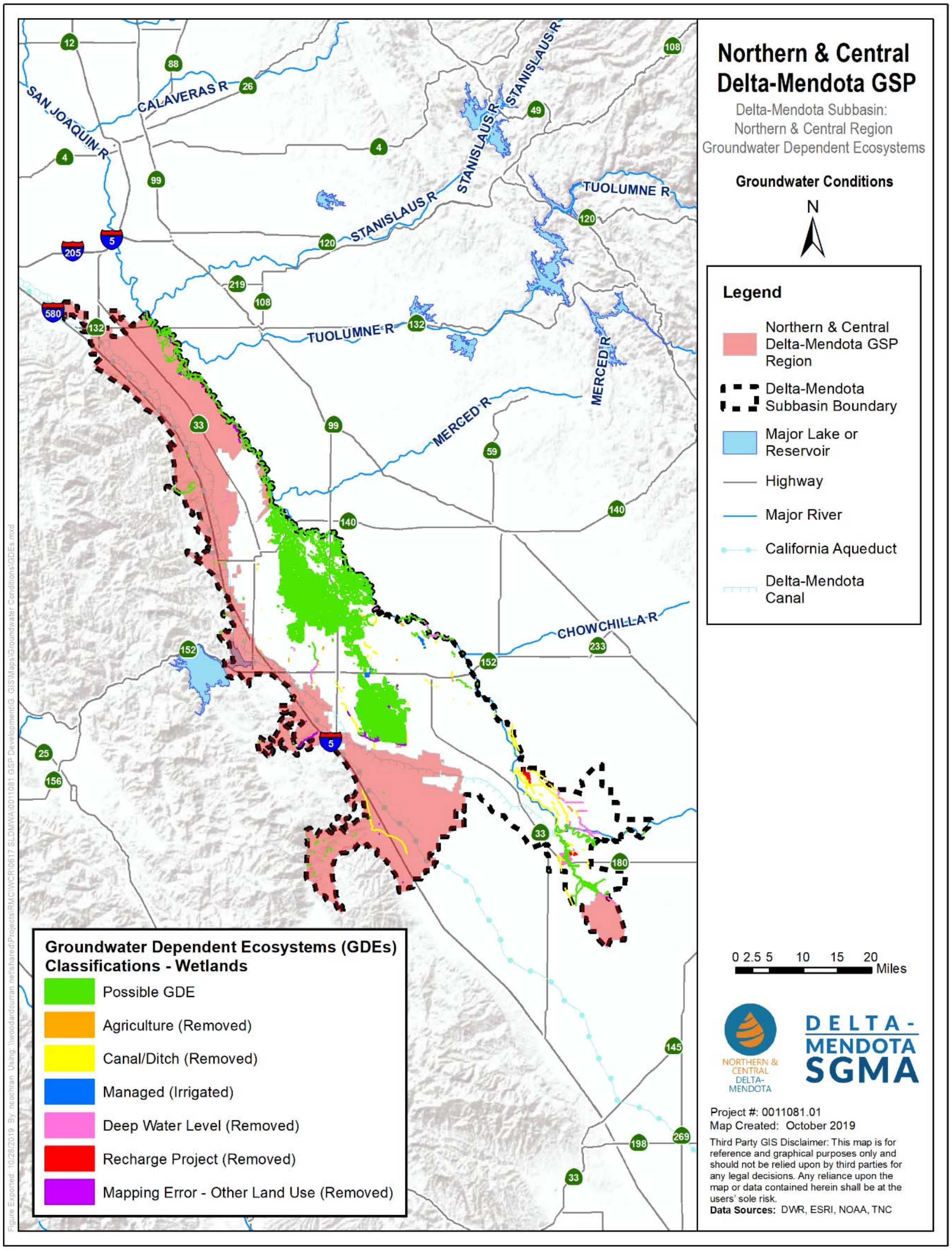

Figure 5-118. Groundwater Dependent Ecosystems in the Delta-Mendota Subbasin, Wetlands

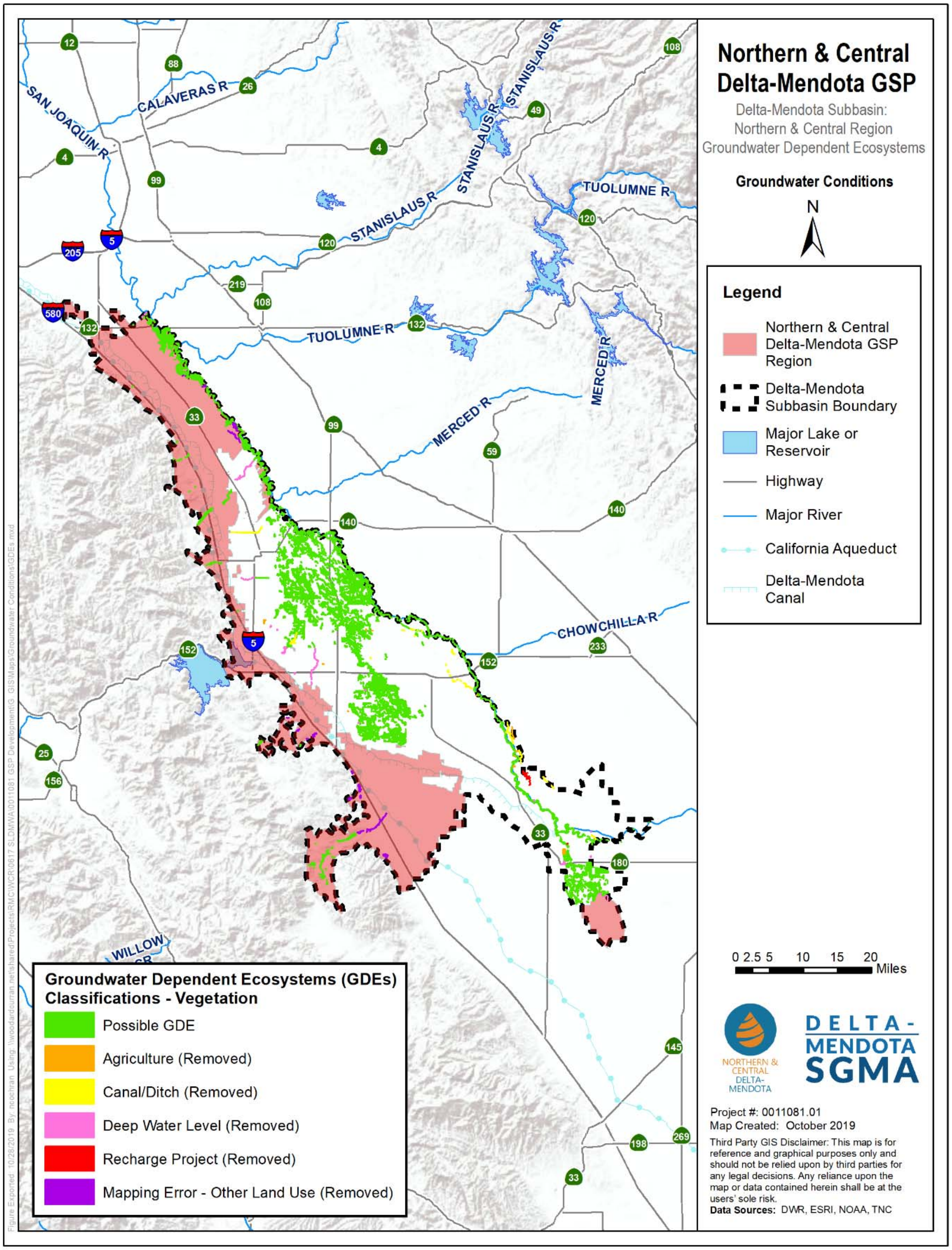

Figure 5-119. Groundwater Dependent Ecosystems in the Delta-Mendota Subbasin, Vegetation

Table 5-10. List of Potential Freshwater Species, Northern and Central Delta-Mendota Regions

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Actitis macularius	Spotted Sandpiper	Birds		
Aechmophorus clarkii	Clark's Grebe	Birds		
Aechmophorus occidentalis	Western Grebe	Birds		
Agelaius tricolor	Tricolored Blackbird	Birds	Bird of Conservation Concern	Special Concern
Aix sponsa	Wood Duck	Birds		
Anas acuta	Northern Pintail	Birds		
Anas americana	American Wigeon	Birds		
Anas clypeata	Northern Shoveler	Birds		
Anas crecca	Green-winged Teal	Birds		
Anas cyanoptera	Cinnamon Teal	Birds		
Anas discors	Blue-winged Teal	Birds		
Anas platyrhynchos	Mallard	Birds		
Anas strepera	Gadwall	Birds		
Anser albifrons	Greater White-fronted Goose	Birds		
Ardea alba	Great Egret	Birds		
Ardea herodias	Great Blue Heron	Birds		
Aythya affinis	Lesser Scaup	Birds		
Aythya americana	Redhead	Birds		Special Concern
Aythya collaris	Ring-necked Duck	Birds		
Aythya marila	Greater Scaup	Birds		
Aythya valisineria	Canvasback	Birds		Special
Botaurus lentiginosus	American Bittern	Birds		
Bucephala albeola	Bufflehead	Birds		
Bucephala clangula	Common Goldeneye	Birds		
Butorides virescens	Green Heron	Birds		
Calidris alpina	Dunlin	Birds		
Calidris mauri		Birds		
Calidris minutilla	Least Sandpiper	Birds		
Chen caerulescens	Snow Goose	Birds		
Chen rossii	Ross's Goose	Birds		
Chlidonias niger	Black Tern	Birds		Special Concern
Chroicocephalus philadelphia	Bonaparte's Gull	Birds		

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Cistothorus palustris	Marsh Wren	Birds		
Cygnus columbianus	Tundra Swan	Birds		
Cypseloides niger	Black Swift	Birds	Bird of Conservation Concern	Special Concern
Egretta thula	Snowy Egret	Birds		
Empidonax traillii	Willow Flycatcher	Birds	Bird of Conservation Concern	Endangered
Fulica americana	American Coot	Birds		
Gallinago delicata	Wilson's Snipe	Birds		
Gallinula chloropus		Birds		
Geothlypis trichas		Birds		
Grus canadensis	Sandhill Crane	Birds		
Haliaeetus leucocephalus	Bald Eagle	Birds	Bird of Conservation Concern	Endangered
Himantopus mexicanus	Black-necked Stilt	Birds		
Icteria virens	Yellow-breasted Chat	Birds		Special Concern
Limnodromus scolopaceus	Long-billed Dowitcher	Birds		
Lophodytes cucullatus	Hooded Merganser	Birds		
Megaceryle alcyon	Belted Kingfisher	Birds		
Mergus merganser	Common Merganser	Birds		
Mergus serrator	Red-breasted Merganser	Birds		
Numenius americanus	Long-billed Curlew	Birds		
Numenius phaeopus	Whimbrel	Birds		
Nycticorax	Black-crowned Night-Heron	Birds		
Oxyura jamaicensis	Ruddy Duck	Birds		
Pandion haliaetus		Birds		Watch list
Pelecanus erythrorhynchos	American White Pelican	Birds		Special Concern
Phalacrocorax auritus	Double-crested Cormorant	Birds		
Phalaropus tricolor	Wilson's Phalarope	Birds		
Plegadis chihi	White-faced Ibis	Birds		Watch list
Pluvialis squatarola	Black-bellied Plover	Birds		
Podiceps nigricollis	Eared Grebe	Birds		
Podilymbus podiceps	Pied-billed Grebe	Birds		
Porzana carolina	Sora	Birds		
Rallus limicola	Virginia Rail	Birds		
Recurvirostra americana	American Avocet	Birds		
Riparia	Bank Swallow	Birds		Threatened

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Setophaga petechia	Yellow Warbler	Birds		
Tachycineta bicolor	Tree Swallow	Birds		
Tringa melanoleuca	Greater Yellowlegs	Birds		
Tringa semipalmata	Willet	Birds		
Vireo bellii		Birds		
Vireo bellii pusillus		Birds	Endangered	Endangered
Xanthocephalus		Birds		Special Concern
Branchinecta lynchi	Vernal Pool Fairy Shrimp	Crustaceans	Threatened	Special
Lepidurus packardi	Vernal Pool Tadpole Shrimp	Crustaceans	Endangered	Special
Oncorhynchus mykiss - CV		Fishes	Threatened	Special
Oncorhynchus mykiss irideus		Fishes		
Pogonichthys macrolepidotus		Fishes		Special Concern
Actinemys marmorata	Western Pond Turtle	Herps		Special Concern
Ambystoma californiense	California Tiger Salamander	Herps	Threatened	Threatened
Anaxyrus boreas	Boreal Toad	Herps		
Pseudacris regilla	Northern Pacific Chorus Frog	Herps		
Rana boylii	Foothill Yellow-legged Frog	Herps	Under Review in the Candidate or Petition Process	Special Concern
Rana draytonii	California Red-legged Frog	Herps	Threatened	Special Concern
Spea hammondii	Western Spadefoot	Herps	Under Review in the Candidate or Petition Process	Special Concern
Thamnophis atratus		Herps		
Thamnophis elegans		Herps		
Thamnophis gigas	Giant Gartersnake	Herps	Threatened	Threatened
Thamnophis sirtalis	Common Gartersnake	Herps		
Capnia hitchcocki		Insects & other inverts		
Mesocapnia bulbosa		Insects & other inverts		
Paraleptophlebia associata		Insects & other inverts		
Castor canadensis	American Beaver	Mammals		
Lontra canadensis		Mammals		
Neovison vison	American Mink	Mammals		
Ondatra zibethicus	Common Muskrat	Mammals		
Anodonta californiensis	California Floater	Mollusks		Special
Margaritifera falcata	Western Pearlshell	Mollusks		Special
Pyrgulopsis diablensis		Mollusks		Special
Arundo donax		Plants		

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
Baccharis salicina		Plants		
Cotula coronopifolia		Plants		
Eryngium castrense		Plants		
Eryngium spinosepalum		Plants		Special
Eryngium vaseyi vallicola		Plants		
Eryngium vaseyi		Plants		
Hydrocotyle verticillata		Plants		
Juncus xiphioides		Plants		
Ludwigia peploides		Plants		
Persicaria lapathifolia		Plants		
Persicaria maculosa		Plants		
Phacelia distans		Plants		
Pilularia americana		Plants		
Plantago elongata		Plants		
Potamogeton foliosus		Plants		
Puccinellia simplex	Little Alkali Grass	Plants		
Salix gooddingii		Plants		
Schoenoplectus acutus occidentalis		Plants		
Schoenoplectus americanus		Plants		
Typha domingensis		Plants		

5.3.8 Data Gaps

The Delta-Mendota Subbasin is an extensive subbasin covering a large area extending along the northwestern end of the San Joaquin Valley. While there is a significant amount of data available regarding various groundwater-related aspects of the Subbasin, much is still not known in multiple locations around the Northern and Central Delta-Mendota Regions. To this end, the following data gaps have been identified and will be addressed as part of the interim period between adoption of this GSP and its first 5-year update.

- Information regarding subsidence varies in extent around the region. While there is a large amount of land elevation survey data available in association with the DMC and other regional infrastructure, other areas in the Northern and Central Delta-Mendota Regions require additional data collection to both further establish and monitor future land subsidence rates.

- Only three shallow groundwater wells exist proximate to the San Joaquin River within the Northern and Central Delta-Mendota Regions, the primary interconnected surface water body in the Delta-Mendota Subbasin. Additional nested or clustered monitoring wells are required adjacent to the river to evaluate horizontal and vertical groundwater gradients, and in connection with river stage monitoring, an assessment of the interconnection between the San Joaquin River and the Delta-Mendota Subbasin.

- There are a large number of wells in the Northern and Central Delta-Mendota Regions where no construction information available. Video surveys and other surveys should be conducted to (1) identify where the wells are screened, and (2) determine if the well(s) are appropriate as additions to the Regions' groundwater monitoring programs.

- Mapping of GDEs in the Northern and Central Delta-Mendota Regions, as contained in this GSP, is an initial assessment of their location. This mapping needs to be refined using most recent groundwater elevation/depth to water contour mapping.

- Monitoring networks contained in this GSP are preliminary and were formulated based on existing well information. As additional wells are installed in the Subbasin and additional well construction information is obtained for existing wells, these networks will need to be refined to improve on the spatial (areal and vertical) distribution of monitoring points and the data collected for evaluation of conditions of the groundwater basin.

- In developing the water budgets contained herein, it was discovered that several of the California Irrigation Management Information System (CIMIS) stations available for use have questionable data. Additional CIMIS and/or other weather stations need to be established around the Subbasin, both to provide good quality data and to further refine the spatial variability of precipitation and evapotranspiration (ET) around the Subbasin.

- The sustainable yield estimates contained in this GSP for both the Upper and Lower Aquifers were developed using limited data. As additional data are collected over the first five years, improved sustainable yield estimates and estimates of water in storage in both principle aquifers should be prepared utilizing the new data.

- An updated DMC Conveyance Capacity Analysis should be conducted to provide data for refining the sustainability indicators for subsidence in the Northern and Central Delta-Mendota Regions.

5.4 WATER BUDGETS

This section describes the historic, current, and projected water budgets developed for the Northern and Central Delta-Mendota Regions as required by §354.18 of the Groundwater Sustainability Plan (GSP) Emergency Regulations. These water budgets provide an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the Northern and Central Regions of the Delta-Mendota Subbasin under the respective conditions, and the change in volume of water stored. Specifically, the water budgets quantify the following:

- Total surface water entering and leaving the Plan area by water source type
- Inflow to the groundwater system by water source type
- Outflows from the groundwater system by water use sector
- The change in the annual volume of groundwater in storage between seasonal high conditions
- If overdraft conditions occur, a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions
- The water year type associated with the annual supply, demand, and change in groundwater stored
- An estimate of sustainable yield for the Delta-Mendota Subbasin

5.4.1 Useful Terms

A list and description of technical terms used throughout this section to discuss water budgets are included below. The terms and their descriptions are identified here to guide readers through this section and are not a definitive definition of each term.

- Land Surface System - The collective term for the land surface area above an aquifer and the interacting flows and into and out of that control volume.
- Groundwater System - The collective term for the groundwater aquifer and the interacting flows into and out of the groundwater aquifer(s).
- Water Budget - An accounting of water flows into and out of a defined area, which are tabulated as total volumes transmitted over a given time period.
- Land Surface Budget - An accounting of water flows into and out of the land surface above an aquifer within a defined area. Inflows and outflows include flow between adjacent land surface areas, the atmosphere, and the groundwater aquifer below.
- Groundwater Budget - An accounting of water flows into and out of the groundwater aquifer(s) within a defined area. Inflows and outflows include flow between adjacent aquifer areas and the above land surface.
- Balance Error - The difference between actual inflow and outflow equals actual change in storage (Inflow – Outflow – Change in Storage = 0). The difference between estimated inflow and estimated outflow does not equal estimated change in storage, where this difference is the balance error (Estimated Inflow – Estimated Outflow – Estimated Change in Storage = Balance Error).
- Applied Water - The collective name for water applied to the land surface, excluding precipitation.

- ET$_0$ - Crop Evapotranspiration (Crop-ET$_0$) is a value used for calculating reference and crop evapotranspiration from meteorological data and crop coefficients.
- Water Losses - The collective name for water leaving the land surface.
- Water Year - The annual period beginning October 1st of a specific year and ending September 30th of the subsequent year.
- Historic Water Budget - Water budget tabulating the flows into and out of the Northern & Central Delta-Mendota Region GSP Plan area during Water Years (WYs) 2003 through 2012, which is an accounting of annual observed flows and calculated flows.
- Current Water Budget - Water budget tabulating the flows into and out of the Northern & Central Delta-Mendota Region GSP Plan area during WY2013. This is an accounting of observed flows and calculated flows for the 'current year.'
- Baseline Projected Water Budget - Water budget tabulating predicted flows into and out of the Northern & Central Delta-Mendota Region GSP Plan area during WYs 2014 through 2070. This is an accounting of annual predicted flows based on the existing climate scenario, without the influence of additional projects or management actions for the purposes of the Sustainable Groundwater Management Act (SGMA) and for establishing changes in the system as a result of projected future land use and water use patterns.
- Projected Water Budget with Climate Change (CC) - Water budget tabulating predicted flows into and out of the Northern & Central Delta-Mendota Region GSP Plan area during the WYs 2014 through 2070 with the California Department of Water Resources' (DWR's) climate change factors (CCFs) applied to Subbasin hydrology. This is an accounting of annual predicted flows based on the climate change scenario, without the influence of additional projects or management actions for the purposes of SGMA and evaluating the impacts of CCF application to the water budget.
- Projected Water Budget with Climate Change and Projects & Management Actions - Water budget tabulating predicted flows into and out of the Northern & Central Delta-Mendota Region GSP Plan area during WYs 2014 through 2070. This is an accounting of annual predicted flows based on the climate change scenario with the additional influence of additional projects and management actions for the purposes of SGMA and evaluating the impacts of future projected conditions on the GSP region.

5.4.2 Water Budget Purpose and Information

Historic, current and projected water budgets were developed to provide a quantitative accounting of water entering and leaving the Northern and Central Delta-Mendota Regions over a specified period of time. Water entering the Plan area includes water entering at the surface and through the subsurface. Similarly, water leaving the Plan area leaves at the surface and through the subsurface. Water enters and leaves naturally, such as through precipitation and streamflow, and through human activities, such as pumping and recharge from irrigation. Figure 5-120 presents a simplified vertical slice through the land surface and underlying aquifers of the Delta-Mendota Subbasin to summarize the water balance components used in the following analysis.

The values presented in the water budgets provide information about historic, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate change, groundwater and surface water interaction, and subsurface groundwater flow. This information can assist in managing groundwater in the Plan area by identifying the scale of different uses, highlighting potential risks, and identifying potential opportunities to improve water supply conditions.

Water budgets can be developed on different spatial scales. For agricultural purposes, water budgets may be limited to the root zone in soil, improving irrigation techniques by estimating the inflows and outflows of water from the upper portion of the soil accessible to plants through their roots. In a strictly groundwater study, water budgets may be limited to water flow in the subsurface, helping analysts understand how water flows beneath the surface. In this section, consistent with the SGMA regulations, water budgets investigate the combined land surface and groundwater system in the Northern and Central Delta-Mendota Regions. The combined water budgets for the entire Delta-Mendota Subbasin are presented in the Delta-Mendota Subbasin Common Chapter.

Water budgets can be developed at various temporal scales. Daily water budgets may be used to demonstrate how evaporation and transpiration increase during the day and decrease at night. Monthly water budgets may be used to demonstrate how groundwater pumping increases in the dry, hot summer months and decreases in the cool, wet winter months. In this section, and consistent with SGMA regulations, the water budgets contained herein are annual, representing a full water year (i.e., the 12 months spanning from October of the previous year to September of the current year).

The SGMA regulations require that annual water budgets are based on three different periods: a ten-year historic period, the 'current' year, and a 50-year (minimum) projected period. The historic water budget is intended to evaluate availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. The current water budget is intended to evaluate the effects of current land and water use on groundwater conditions, and to accurately estimate current inflows and outflows. The projected water budgets are used to estimate future conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components.

Water budgets are developed to capture typical conditions during an identified time period. Typical conditions are developed by averaging over hydrologic conditions that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions in the water budgets, an analysis of the water system under certain hydrologic conditions, such as drought, can be performed along with and compared to an analysis of long-term average conditions.

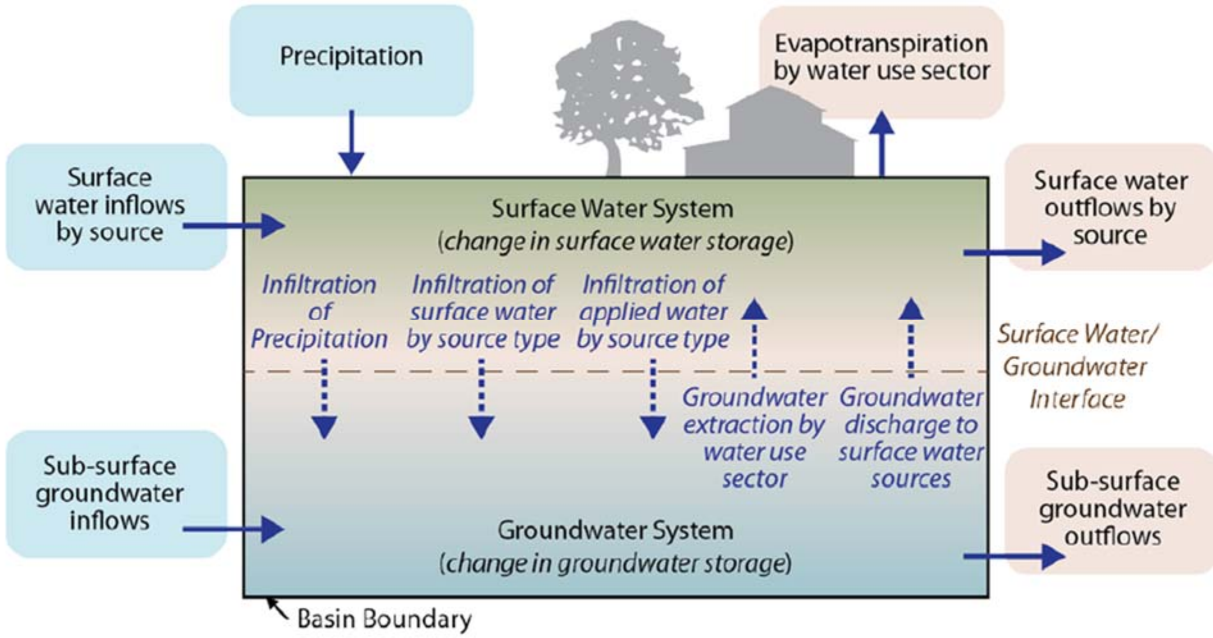

Figure 5-120. Generalized Water Budget Diagram

5.4.3 Key Coordinated Water Budget Decisions

The hydrologic time periods for the historic, current, and projected water budgets of the Delta-Mendota Subbasin were the recommendation of the Delta-Mendota Subbasin Technical Working Group (Technical Working Group), approved by the Delta-Mendota Subbasin Coordination Committee (Coordination Committee), and implemented by the Northern and Central Delta-Mendota Regions in their GSP-specific water budgets. This section documents those decisions, along with other key coordinated decisions agreed upon by all GSPs developed within the Delta-Mendota Subbasin, such as hydrologic period selection and application of climate change factors. A list of all common assumptions and decisions reached by the Delta-Mendota Subbasin GSP Groups may be found as an attachment to the Subbasin Coordination Agreement (Appendix A).

Historic Water Budget

The historic water budget period is defined as WY2003 through WY2012. The Coordination Committee determined that the WY2003-2012 timeframe captured a balance of wet and dry conditions largely prior to the most recent drought (Figure 5-121). The selected time period is also consistent with GSP Emergency Regulations §354.18(c)(2)(C), which requires "a quantitative assessment of the historic water budget, starting with the most recently available information and extending back a minimum of 10 years…," where WY2013 is defined as the year with the most recently available information.

Current Water Budget

The current water budget year is defined as WY2013. While "current water budget conditions" are defined in the GSP Emergency Regulations §354.18(c)(1) as the year with "the most recent population, land use, and hydrologic conditions," WY2015, WY2016 and WY2017 were not thought to be representative of the Delta-Mendota Subbasin under "normal" or "average" conditions. Response to the most recent drought began in WY2014 with some initial fallowing of lands. By WY2015 and WY2016, which are both classified as dry years, more lands were fallowed throughout the Subbasin in response to multiple dry year conditions. Agricultural production was higher in WY2017, compared to WY2015 and WY2016, but the delivery allocations from the Central Valley Project (CVP) came late in the season, so a considerable amount of land was still fallowed. By WY2018, agricultural land production increased and was similar to conditions in WY2013, however complete datasets were not yet available for use in the water budgets. Therefore, the Coordination Committee agreed that WY2013 represents the most recent water year with a complete data set representing typical demands and supplies.

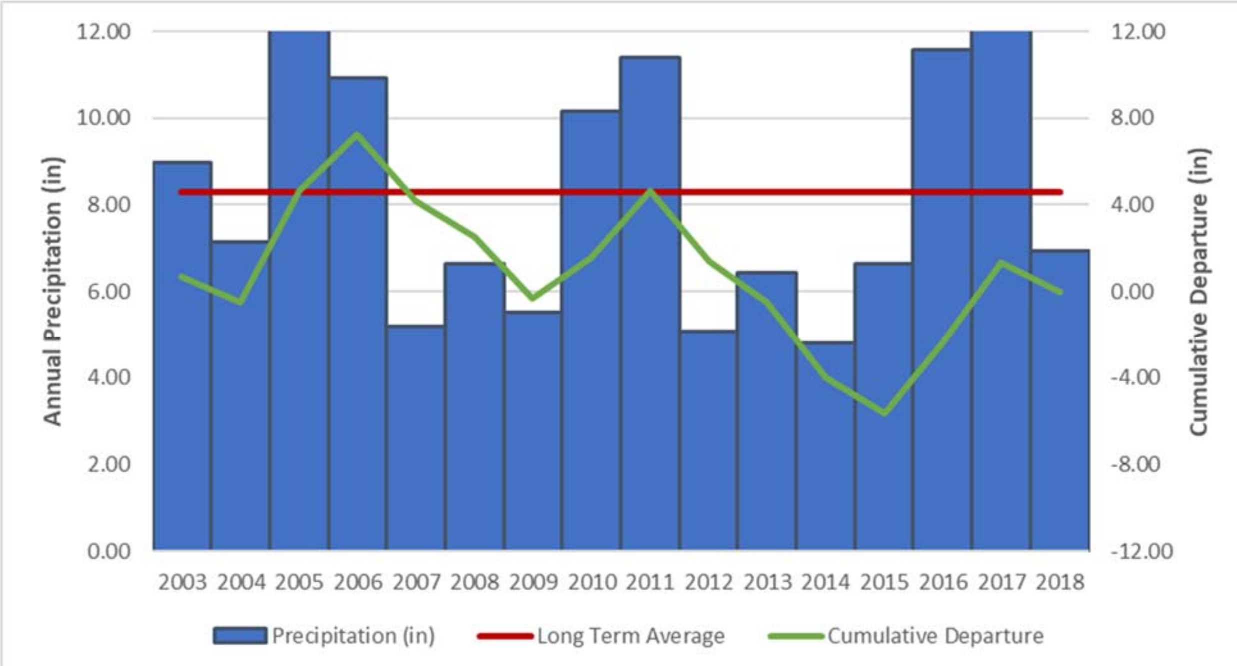

Figure 5-121. Precipitation and Cumulative Departure from Mean, WY2003-2018

Projected Water Budgets

The projected water budget period is defined as WY2014 through WY2070. According to the GSP Emergency Regulations §354.18(c)(3)(A), "projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology." The selected period for the projected water budgets meets this requirement by establishing a 50-year period, where the timeframe is continuous between the historic, current, and projected water budgets. Where available, actual data was incorporated for WY2014 through WY2018.

Based on discussion among the Technical Working Group members, the hydrologic period for simulating the projected water budget hydrologic schema was chosen as WY1979-2017, then wrapping around to include WY1965-1978 hydrology to fill the projected water budget period. Actual data and hydrology were used for WY2014 through WY2017, with the representative water years simulating WY2018 and beyond (e.g. WY2018 is represented by the hydrology from WY1979; WY2019 is represented by the hydrology from WY1980; and so forth).

Climate change data under 2030 and 2070 conditions was provided by DWR for use in development of the projected water budgets with climate change conditions (DWR, 2018b). These data, however, did not span the full projection period, with a gap in CCFs provided for WY2051 through WY2056. Per communications with DWR and in coordination with the Technical Working Group and Coordination Committee, hydrologic water years from the DWR dataset were selected for these years in order to identify the appropriate CCF. The methodology for applying DWR-provided climate change factors was agreed upon by the Technical Working Group. Climate change factors under 2030 conditions were applied to WY2018 through WY2045 and climate change factors under 2070 conditions were applied to WY2046 through WY2070. The precipitation and evapotranspiration datasets provided by DWR include monthly climate change factors from Calendar Year 1915 through 2011. The hydrologic years chosen to fill gaps in the CCF dataset for the precipitation and evapotranspiration climate change factors for representative WY2012 through WY2017 are shown in Table 5-11. These hydrologic years were selected to best approximate the water conditions of the representative water year.

Streamflow climate change factors from DWR were not applied within the Northern and Central Delta-Mendota Regions' projected water budgets as they were based on out-of-date modeling and, when applied, resulted in skewed results for future surface water deliveries that were not deemed to be reasonable. Agencies within the Northern and Central Delta-Mendota Regions instead provided projections by water year type for future surface water deliveries.

Table 5-11. Representative Water Years for Climate Change Factors, Precipitation, and Evapotranspiration

Simulated Projected Water Budget Year	Hydrologic Year	Proxy Water Year for Climate Change Factors
2051	2012	2001
2052	2013	1992
2053	2014	1976
2054	2015	1977
2055	2016	2002
2056	2017	2011

Other Common Decisions

The following water year type designations were agreed upon by all GSP Groups: Wet, Average, Dry, and Shasta Critical (Table 5-12). Wet and Dry water year designations are consistent with the San Joaquin River Index and "Average" combines the Above Normal and Below Normal designations from the San Joaquin River Index. Shasta Critical years are also designated upon the request of the San Joaquin River Exchange Contractors (SJREC), as it impacts surface water deliveries to exchange contracts through the CVP. Shasta Critical designations are dependent on the volume of storage in Shasta Reservoir and U.S. Bureau of Reclamation's operating rules for CVP deliveries.

Since there are no known barriers restricting horizontal gradients between GSP Groups, boundary flows to and from portions of the Delta-Mendota Subbasin adjacent to the Northern and Central Delta-Mendota Regions were coordinated with the GSP Groups preparing those water budgets and compared for consistency prior to the adoption of the historic and current water budgets. Representatives from the Northern and Central Delta-Mendota Regions met with the SJREC and Fresno County GSP Groups to compare boundary flow conditions.

Table 5-12. Modeled Water Year by Water Year Type

Modeled Year	Hydrologic Year	San Joaquin River Index Water Year Type	Delta-Mendota Subbasin Water Year Type	Modeled Year	Hydrologic Year	San Joaquin River Index Water Year Type	Delta-Mendota Subbasin Water Year Type
2003	2003	Below Normal	Average	2037	1998	Wet	Wet
2004	2004	Dry	Dry	2038	1999	Above Normal	Average
2005	2005	Wet	Wet	2039	2000	Above Normal	Average
2006	2006	Wet	Wet	2040	2001	Dry	Dry
2007	2007	Critical	Dry	2041	2002	Dry	Dry
2008	2008	Critical	Dry	2042	2003	Below Normal	Average
2009	2009	Below Normal	Average	2043	2004	Dry	Dry
2010	2010	Above Normal	Average	2044	2005	Wet	Wet
2011	2011	Wet	Wet	2045	2006	Wet	Wet
2012	2012	Dry	Dry	2046	2007	Critical	Dry
2013	2013	Critical	Dry	2047	2008	Critical	Dry
2014	2014	Critical	Shasta Critical	2048	2009	Below Normal	Average
2015	2015	Critical	Shasta Critical	2049	2010	Above Normal	Average
2016	2016	Dry	Dry	2050	2011	Wet	Wet
2017	2017	Wet	Wet	2051	2012	Dry	Dry
2018	1979	Above Normal	Average	2052	2013	Critical	Dry
2019	1980	Wet	Wet	2053	2014	Critical	Shasta Critical
2020	1981	Dry	Dry	2054	2015	Critical	Shasta Critical
2021	1982	Wet	Wet	2055	2016	Dry	Dry
2022	1983	Wet	Wet	2056	2017	Wet	Wet
2023	1984	Above Normal	Average	2057	1965	Wet	Wet
2024	1985	Dry	Dry	2058	1966	Below Normal	Average
2025	1986	Wet	Wet	2059	1967	Wet	Wet
2026	1987	Critical	Dry	2060	1968	Dry	Dry
2027	1988	Critical	Dry	2061	1969	Wet	Wet
2028	1989	Critical	Dry	2062	1970	Above Normal	Average
2029	1990	Critical	Dry	2063	1971	Below Normal	Average
2030	1991	Critical	Shasta Critical	2064	1972	Dry	Dry
2031	1992	Critical	Shasta Critical	2065	1973	Above Normal	Average
2032	1993	Wet	Wet	2066	1974	Wet	Wet
2033	1994	Critical	Dry	2067	1975	Wet	Wet
2034	1995	Wet	Wet	2068	1976	Critical	Dry
2035	1996	Wet	Wet	2069	1977	Critical	Dry
2036	1997	Wet	Wet	2070	1978	Wet	Wet

5.4.4 Methodology Selected and Spreadsheet Model Development

Groundwater Sustainability Agencies (GSAs) in the Northern and Central Delta-Mendota Regions initially planned to use the Central Valley Hydrologic Model 2 (CVHM2) to develop water budgets for their GSP regions. In recent years, local agencies within the Delta-Mendota Subbasin invested in a cooperative agreement with the U.S. Geological Survey (USGS) to refine CVHM2 and increase the amount of local data from the Subbasin incorporated in the model update. Funding and data were provided to USGS from local agencies for this effort. As of July 2019, CVHM2 remains under development by the USGS and therefore not available for use in developing the required water budgets.

A beta version of CVHM2 was released in April 2018 for use by the Northern and Central Delta-Mendota Regions, with a subsequent updated version provided in July 2018. An evaluation of the calibration status of the July 2018 version determined that this version of CVHM2 was not adequately calibrated to the Plan area and therefore would not produce reasonable and usable water budgets. Additional groundwater pumping, surface water delivery, and canal seepage data from local entities were provided to the USGS for further local calibration in July and August 2018. However, as previously noted, as of July 2019, USGS is still in the process of further calibrating CVHM2 within the Plan area. Due to differences in USGS's timeline for the release of CVHM2 and the timeline for this GSP, an alternative approach was selected for developing the required water budgets.

The selected alternative approach for water budget development for the Northern and Central Delta-Mendota Regions is a hybrid approach that combines the use of local data and CVHM2 parameters with standard numerical calculations derived from peer-reviewed literature or professional judgment. All water budgets presented herein are based primarily on local land use, water supply, and groundwater elevation data received from agencies as well as data from publicly available sources. Where local data are unavailable, data from CVHM2 is used. Groundwater gradient, underflow, and change in storage calculations are derived from available hydrograph data for the historic and current water budget time periods. Inputs related to approved projects and management actions were derived from other planning documents, such as Integrated Regional Water Management Plans, or from local agencies. For more detail regarding the spreadsheet model developed for the Northern and Central Delta-Mendota Regions, refer to Appendix D *Water Budgets Model Development Technical Memorandum*.

The spreadsheet model for the Northern and Central Delta-Mendota Regions was used to develop five water budget scenarios:

- Historic water budget represents land surface system and groundwater system conditions from WY2003 through WY2012.
- Current water budget represents land surface system and groundwater system conditions during WY2013.
- Projected Baseline water budget represents the simulated future condition of the land surface system and groundwater system from WY2014 through WY2070 under historic hydrologic conditions and water use patterns within the Plan area.
- Projected water budget with Climate Change (CC) represents the simulated future condition of the land surface system and groundwater system from WY2014 through WY2070 relative to the projected baseline water budget with the addition of the application of DWR's climate change factors.
- Projected water budget with Climate Change (CC) and Projects & Management Actions (P&MAs) represents simulated future condition of the land surface system and groundwater system from WY2014 through WY2070 relative to the projected baseline water budget with the addition of DWR's climate change factors as well as projects and management actions to achieve groundwater sustainability within the Plan area by 2040, as required by SGMA.

5.4.5 Water Budget Definitions and Assumptions

The spreadsheet model simulates the major hydrologic processes that affect the flow of surface water and groundwater within the Northern and Central Delta-Mendota Regions. The primary components of the land surface budget and groundwater budget are presented in Table 5-13 and Table 5-14, respectively.

Table 5-13. Land Surface Budget Category Definitions

Water Budget Flow Category	Definition
Inflow	*Includes volumes that are applied to the land surface within the defined budget area.*
Precipitation	Total atmospheric precipitation that occurs onto the defined budget area.
Pumping	Total volume of water applied to the defined budget area from production wells within the defined budget area.
Tile Drainage	Total volume of water applied to the defined budget area from tile drains within the defined budget area.
Surface Water Deliveries	Total volume of water delivered to the defined budget area from diversions off the San Joaquin River, Delta-Mendota Canal, California Aqueduct, and other local surface water sources.
Outflow	*Includes volumes that flow out of the land surface within the defined budget area. This includes flows to the aquifer and to other land surface budget areas.*
Deep Percolation	Total volume of water that seeps past the root zone and into the groundwater aquifer. This includes applied water seepage, as well as stream seepage (from the San Joaquin River, Delta-Mendota Canal, and California Aqueduct) and delivery losses.
Runoff	Total volume of water that leaves the defined budget area through surface runoff. This does not include river flows but is a portion of applied water and precipitation.
Evapotranspiration	Total volume of water that returns to the atmosphere through either evaporation or through transpiration.

Note: Surface water flows are not directly tabulated in the water budgets, but river seepage is accounted for in the Deep Percolation category. This limitation is discussed in Appendix D *Water Budgets Model Development Technical Memorandum*.

Table 5-14. Groundwater Budget Category Definitions

Water Budget Flow Category	Definition
Inflow	*Includes volumes that flow into the groundwater aquifer within the defined budget area. This includes volumes coming from the surface water budget and from adjacent budget areas.*
Deep Percolation	Total volume of water that seeps past the root zone and into the groundwater aquifer. This includes applied water seepage, as well as stream seepage (from the San Joaquin River, Delta-Mendota Canal, and California Aqueduct) and delivery losses.
Upper Aquifer Underflows	Groundwater inflows into the defined budget area in the Upper Aquifer from adjacent water budgets.
Lower Aquifer Underflows	Groundwater inflows into the defined budget area in the Lower Aquifer from adjacent water budgets.
Outflow	*Includes volumes that flow out of the groundwater aquifer within the defined budget area. This includes volumes pumped to the surface and flows to adjacent budget areas.*
Pumping	Total volume of water extracted from the defined budget area from production wells within the defined budget area.
Tile Drainage	Total volume of water removed from the defined budget area from tile drains within the defined budget area.
Upper Aquifer Underflows	Groundwater flows out of the defined budget area in the Upper Aquifer into adjacent water budgets.
Lower Aquifer Underflows	Groundwater flows out of the defined budget area in the Lower Aquifer into adjacent water budgets.
Change in Storage	*Includes volumetric differences of storage in the aquifer as compared to the previous water year. In an ideal case, volumes should sum to be equal to inflows minus outflows.*
Upper Aquifer Change in Storage	Change in storage in the Upper Aquifer compared to prior the water year. This is not a total storage amount.
Lower Aquifer Change in Storage	Change in storage in the Lower Aquifer compared to prior the water year. This is not a total storage amount.

Note: Surface water flows are not directly tabulated in the budgets, but river seepage is accounted for in the Deep Percolation category. This limitation is discussed in Appendix D *Water Budgets Model Development Technical Memorandum*.

Historic and Current Water Budget Assumptions

The historic and current water budgets are presented side-by-side and operate under the same assumptions and with the same data sources. Assumptions and sources for each of the budget flow categories are listed in Table 5-15 and Table 5-16.

Table 5-15. Historic and Current Land Surface Budget Assumptions

Water Budget Flow Category	Data Source	Data Assumptions
Precipitation	Various CIMIS stations	CIMIS data was applied across the Plan area so that the nearest or most representative station's data were applied to each GSA member agency. The monthly precipitation data were then used to calculate yearly precipitation volumes.
Pumping	GSA member agencies historic agricultural pumping, and urban pumping historic data	Agricultural pumping was combined with urban pumping volumes.
Tile Drainage	GSA member agencies tile drainage historic data	All reported tile drainage was reapplied and treated as another applied water source.
Surface Water Deliveries	GSA member agencies surface water delivery and diversion historic data	All reported surface water delivery data counted as a source for applied water. The differences between diversions and deliveries (where available) were used to quality check calculated Deep Percolation rates.
Deep Percolation	Calculated from other applied water volumes	CVHM2 trends were aggregated and trends in applied water and precipitation proportions becoming deep percolation were used for the Historic & Current Period. Since Deep Percolation in CVHM2 accounts for Delta-Mendota Canal, California Aqueduct, and San Joaquin River seepage, these rates implicitly account for stream seepage volumes.
Runoff	Calculated from other applied water volumes	CVHM2 trends were aggregated based on Water Year Types during the Historic & Current period. Trends in applied water and precipitation proportions becoming runoff were used.
Evapotranspiration	Various CIMIS Stations ET_0 data, Cal Poly ITRC Crop Coefficient data, GSA member agencies historic land use data	CIMIS data was applied across the Plan area so that the nearest or most representative station's data were applied to each GSA member agency. The monthly ET_0 data were then used with observed seasonal land use trends, and crop coefficients (for each crop type from the Cal Poly Crop Coefficients) to calculate evapotranspiration volumes.

Table 5-16. Historic and Current Groundwater Budget Assumptions

Water Budget Flow Category	Data Source	Data Assumptions
Deep Percolation	See Table 5-15	See Table 5-15
Upper Aquifer Underflows	GSA member agencies observation well data, CASGEM observation well data, Westside Subbasin's Groundwater Model results, SJREC transmissivity data	Hydrographs were created and considered with transmissivity data to calculate intra-subbasin underflows. The Westside Subbasin's Groundwater Model results were used on the southern Subbasin boundary with the Westside Subbasin to determine underflows. Hydrographs were also developed to evaluate underflows to Tracy, Modesto, Turlock, and Kings Subbasins.
Lower Aquifer Underflows	Calculated from Upper Aquifer Underflows	Lower Aquifer Underflows were assumed to be a portion of Upper Aquifer Underflows. The proportion utilized was the same as the proportion of pumping volumes from the Upper Aquifer versus the Lower Aquifer.
Pumping	See Table 5-15	See Table 5-15
Upper Aquifer Change in Storage	GSA member agencies observation well data, CASGEM observation well data, CVHM2 storativity data	Hydrographs were grouped spatially into designated zones in the Plan area for the calculation of change in storage on a sub-regional basis. Change in water surface elevations between water years were determined for each sub-regional zone. These data and local storativity values were combined to determine the change in storage for each sub-regional zone for each water year.
Lower Aquifer Change in Storage	Calculated from Upper Aquifer Change in Storage	Lower Aquifer Change in Storage was assumed to be a portion of Upper Aquifer Change in Storage. The proportion was based on professional judgment and local knowledge.

Projected Water Budget Data Sources

The results of the three projected water budgets are presented separately, but they operate under the same assumptions and with the same data sources. Assumptions and sources for the flow categories in the baseline projected water budget are listed in Table 5-17 and Table 5-18. Differences in assumptions and sources between the three projected budgets are described in Table 5-19. To estimate future flows, historic data were applied according to the representative years selected for the projected budget timeline. Those years are specified in Table 5-11, and the assignment of the representative water years is discussed in Section 5.4.3.

Table 5-17. Projected Land Surface Budget Assumptions

Water Budget Flow Category	Data Source	Data Assumptions
Precipitation	Various CIMIS stations	CIMIS data were applied across the Plan area so that the nearest or most representative station's data were applied to each GSA area. The monthly precipitation data were then used to calculate yearly precipitation volumes.
Pumping	Calculated	For irrigated lands, precipitation and surface water (where available) were assumed to be used to meet crop demands with groundwater used to meet any remaining crop demand. Pumping was therefore calculated to meet the remaining agricultural demand after applied water, precipitation, and water losses were accounted for. Additional runoff and deep percolation were then accounted for after groundwater was 'applied'. Agricultural demands were calculated seasonally, by crop type, and by GSA member agencies operational patterns.
Tile Drainage	GSA member agencies tile drainage historic data	All reported tile drainage was assumed to be reapplied as irrigation and therefore was treated as another applied water source.
Surface Water Deliveries	GSA member agencies surface water delivery and diversion historic data	All reported surface water delivery data counted as a source for applied water. The differences between diversions and deliveries (where available) were used to quality check calculated deep percolation rates.
Deep Percolation	Calculated from other applied water volumes	CVHM2 trends were aggregated and trends in applied water and precipitation proportions becoming deep percolation were used for the Historic & Current Period and aggregated into trends by Water Year Type. Since Deep Percolation in CVHM2 accounts for Delta-Mendota Canal, California Aqueduct, and San Joaquin River seepage, these rates implicitly account for stream seepage volumes.
Runoff	Calculated from other applied water volumes	CVHM2 trends were aggregated and trends in applied water and precipitation proportions becoming runoff were used for the Historic & Current Period and aggregated by Water Year Type.
Evapotranspiration	Various CIMIS Stations ET_0 data, Cal Poly Crop Coefficient data, GSA member agencies historic land use data	CIMIS data were applied across the Plan area so that the nearest or most representative station's data were applied to each GSA area. The monthly ET_0 data were then used with observed seasonal land use trends and crop coefficients (for each crop type from the Cal Poly Crop Coefficients[1]) to calculate Evapotranspiration volumes.

[1] Cal Poly ITRC Crop Coefficient data for Zone 14, aggregated by irrigation type, water year type, and crop type.

Table 5-18. Projected Groundwater Budget Assumptions

Water Budget Flow Category	Data Sources	Data Assumptions
Deep Percolation	See Table 5-17	See Table 5-17
Upper Aquifer Underflows	See Table 5-16	Underflows were averaged from the historic period according to water year type and by principal aquifer. Underflows were adjusted in the two projected water budgets with CCF and P&MAs budgets to reflect changes in interactions with the land surface.
Lower Aquifer Underflows	See Table 5-16	
Pumping	See Table 5-17	See Table 5-17
Upper Aquifer Change in Storage	GSA member agencies observation well data, CASGEM observation well data, CVHM2 storativity data	Hydrographs were grouped spatially into sub-regional zones in the Plan area. Change in water surface elevations between water years were determined for each sub-regional zone. These data and local storativity data were combined to determine the change in storage for each sub-regional zone for each water year in the projected period. These changes were averaged by water year type and used for each projected year.
Lower Aquifer Change in Storage	Calculated from Upper Aquifer Change in Storage	Lower Aquifer Change in Storage was assumed to be a portion of Upper Aquifer Change in Storage. The proportion was based on professional judgment and local knowledge.

Table 5-19. Differences in Sources and Assumptions Between Projected Water Budgets

Water Budget Flow Category	Changes Made between the Baseline Projected Budget and Budget with CC	Changes Made between Budget with CC and the P&MAs Budget
Precipitation	Precipitation rates were adjusted according to multipliers from the VIC hydrological gridded data set.[1] Precipitation was scaled according to the spatial overlap of the gridded data set and the Plan area.	No additional changes were made.
Pumping	Additional estimated pumping volume is due to the changes in Precipitation and Evapotranspiration.	The decreased estimated pumping volume in the P&MAs budget is due to the effects of Projects & Management Actions on increased Surface Water Deliveries.
Tile Drainage	No changes were made.	No changes were made.
Surface Water Deliveries	No changes were made.[2]	Additional volume of surface water deliveries in the P&MAs budget is due to the effects of Projects & Management Actions. (which are anticipated to increase surface water deliveries to the GSP area)
Deep Percolation	Additional volume of deep percolation estimated is due to the changes in Precipitation and Evapotranspiration.	Additional volume of deep percolation in the P&MAs budget is due to the effects of anticipated increases in applied surface water resulting from the Projects & Management Actions
Runoff	Additional volume of runoff is due to the changes in Precipitation and Evapotranspiration.	Additional volume of percolation in the P&MAs budget is due to the effects of anticipated increases in applied surface water resulting from the Projects & Management Actions.
Evapotranspiration	ET_0 rates were adjusted according to multipliers from the VIC hydrological gridded data set.[1] ET_0 was scaled according to the spatial overlap of the VIC hydrological gridded data set* and the GSP Area.	No additional changes were made.
Upper Aquifer Underflows	No changes were made.[2]	No changes were made.
Lower Aquifer Underflows	No changes were made. [2]	No changes were made.
Upper Aquifer Change in Storage	Additional Pumping volumes were split between the Upper and Lower Aquifer Change in Storage volumes. Additional Deep Percolation volumes were applied to the Upper Aquifer Change in Storage volume.	Reduced Pumping volumes were split between the Upper and Lower Aquifer Change in Storage volumes. Additional Deep Percolation volumes were applied to the Upper Aquifer Change in Storage volume.
Lower Aquifer Change in Storage	Additional Pumping volumes were split between the Upper and Lower Aquifer Change in Storage volumes.	Reduced pumping volumes were split between the Upper and Lower Aquifer Change in Storage volumes. Reductions that were due to projects and management actions specifically targeted at Lower Aquifer Pumping rates were not split between the Aquifers but were attributed entirely to the Lower Aquifer Change in Storage volume.

[1] Gridded Statewide Precipitation and Evapotranspiration (ET) Change Factors were developed for the Water Storage Investment Program (WSIP), using the Variable Infiltration Capacity (VIC) Macroscale Hydrology Model. (CA DWR 2018).
[2] Projected surface water deliveries were based on volumes provided by the GSAs Member Agencies. These volumes represent their anticipated future supplies. Climate change factors provided by DWR were not applied to Historic and Current surface water deliveries as they are based on an outdated model. These climate change factors, when applied, result in projected future surface water deliveries that do not represent anticipated future conditions.

5.4.6 Water Budget Estimates

Flow category definitions, data sources, and their assumptions are described in Section 5.4.5. The annual estimates for the historic, current, and projected water budgets are detailed in the following tables in acre-feet per year (AFY):

- Historic Water Budget
    - Land Surface Budget (Table 5-20)
    - Groundwater Budget (Table 5-21)
    - Change in Storage (Table 5-22)
- Current Water Budget
    - Land Surface Budget (Table 5-23)
    - Groundwater Budget (Table 5-24)
    - Change in Storage (Table 5-25)
- Baseline Projected Water Budget
    - Land Surface Budget (Table 5-26)
    - Groundwater Budget (Table 5-27)
    - Change in Storage (Table 5-28)
- Projected Water Budget with Climate Change
    - Land Surface Budget (Table 5-29)
    - Groundwater Budget (Table 5-30)
    - Change in Storage (Table 5-31)
- Projected Water Budget with Climate Change and Projects & Management Actions
    - Land Surface Budget (Table 5-32)
    - Groundwater Budget (Table 5-33)
    - Change in Storage (Table 5-34)

Table 5-20. Land Surface Budget, Historic Water Budget (AFY)

Land Surface Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2003	Average	78,000	365,000	4,000	0	3,000	92,000	30	200,000	742,000	63,000	66,000	606,000	736,000
2004	Dry	85,000	359,000	5,000	0	3,000	86,000	30	174,000	711,000	52,000	57,000	580,000	688,000
2005	Wet	79,000	347,000	4,000	0	4,000	102,000	30	312,000	848,000	62,000	75,000	662,000	799,000
2006	Wet	66,000	353,000	4,000	0	4,000	99,000	30	248,000	774,000	60,000	65,000	663,000	788,000
2007	Dry	93,000	344,000	4,000	0	4,000	97,000	30	114,000	656,000	33,000	47,000	560,000	639,000
2008	Dry	97,000	269,000	2,000	0	4,000	140,000	30	142,000	654,000	56,000	47,000	598,000	700,000
2009	Average	109,000	234,000	2,000	0	4,000	128,000	30	125,000	602,000	28,000	42,000	647,000	717,000
2010	Average	105,000	271,000	3,000	0	4,000	112,000	30	227,000	721,000	49,000	60,000	590,000	699,000
2011	Wet	104,000	356,000	3,000	0	4,000	76,000	30	258,000	802,000	60,000	68,000	682,000	811,000
2012	Dry	124,000	316,000	3,000	0	4,000	106,000	30	112,000	665,000	28,000	47,000	559,000	634,000
Historic Average		94,000	322,000	3,000	0	4,000	104,000	30	191,000	718,000	49,000	58,000	615,000	722,000

[1] Runoff includes return flows to all surface water sources leaving the Plan area. Return flows were not separated due to model limitations.

Table 5-21. Groundwater Budget, Historic Water Budget (AFY)

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2003	Average	66,000	50,000	27,000	143,000	95,000	30	60,000	32,000	186,000
2004	Dry	57,000	56,000	29,000	142,000	89,000	30	65,000	34,000	188,000
2005	Wet	75,000	73,000	39,000	187,000	105,000	30	54,000	29,000	188,000
2006	Wet	65,000	61,000	32,000	158,000	103,000	30	54,000	29,000	186,000
2007	Dry	47,000	35,000	18,000	100,000	101,000	30	67,000	36,000	204,000
2008	Dry	47,000	40,000	21,000	108,000	144,000	30	76,000	40,000	259,000
2009	Average	42,000	36,000	19,000	98,000	132,000	30	67,000	35,000	234,000
2010	Average	60,000	56,000	30,000	146,000	115,000	30	60,000	32,000	207,000
2011	Wet	68,000	63,000	33,000	164,000	80,000	30	61,000	32,000	173,000
2012	Dry	47,000	38,000	20,000	105,000	110,000	30	66,000	35,000	212,000
Historic Average		58,000	51,000	27,000	136,000	108,000	30	63,000	33,000	204,000

Table 5-22. Change in Storage, Historic Water Budget (AFY)

Change in Storage				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2003	Average	94,000	19,000	113,000
2004	Dry	(67,000)	(13,000)	(80,000)
2005	Wet	123,000	25,000	147,000
2006	Wet	(67,000)	(13,000)	(80,000)
2007	Dry	(157,000)	(31,000)	(188,000)
2008	Dry	(211,000)	(42,000)	(253,000)
2009	Average	(45,000)	(9,000)	(54,000)
2010	Average	77,000	15,000	92,000
2011	Wet	(64,000)	(13,000)	(76,000)
2012	Dry	(105,000)	(21,000)	(126,000)
Historic Average		(42,000)	(8,000)	(50,000)

Table 5-23. Land Surface Budget, Current Water Budget (AFY)

Land Surface Budget															
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows				
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2013	Dry	127,000	283,000	3,000	0	4,000	119,000	30	149,000	685,000	51,000	50,000	568,000	669,000

[1] Runoff includes return flows to all surface water sources leaving the Plan area. Return flows were not separated due to model limitations.

Table 5-24. Groundwater Budget, Current Water Budget (AFY)

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2013	Dry	50,000	42,000	22,000	114,000	124,000	0	52,000	27,000	203,000

Table 5-25. Change in Storage, Current Water Budget (AFY)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2013	Dry	(73,000)	(15,000)	(88,000)

Table 5-26. Land Surface Budget, Baseline Projected Water Budget (AFY)

Land Surface Budget														
		Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping								
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural	Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	197,000	8,000	127,000	671,000	47,000	61,000	578,000	686,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	198,000	8,000	134,000	615,000	38,000	48,000	542,000	628,000
2016	Dry	80,000	231,000	3,000	0	4,000	136,000	11,000	260,000	724,000	55,000	87,000	572,000	714,000
2017	Wet	74,000	303,000	3,000	0	4,000	123,000	12,000	264,000	784,000	65,000	90,000	648,000	803,000
2018	Average	60,000	320,000	2,000	0	4,000	121,000	10,000	196,000	713,000	51,000	74,000	585,000	710,000
2019	Wet	118,000	332,000	4,000	0	4,000	85,000	12,000	342,000	897,000	76,000	107,000	683,000	867,000
2020	Dry	141,000	272,000	3,000	0	5,000	115,000	11,000	211,000	757,000	50,000	67,000	584,000	700,000
2021	Wet	118,000	332,000	4,000	0	4,000	86,000	12,000	342,000	898,000	76,000	107,000	683,000	867,000
2022	Wet	118,000	332,000	4,000	0	5,000	79,000	12,000	410,000	960,000	81,000	114,000	697,000	893,000
2023	Average	126,000	310,000	3,000	0	5,000	109,000	10,000	327,000	891,000	66,000	93,000	617,000	776,000
2024	Dry	141,000	272,000	3,000	0	5,000	110,000	11,000	320,000	863,000	65,000	89,000	594,000	748,000
2025	Wet	118,000	332,000	4,000	0	5,000	80,000	12,000	461,000	1,012,000	87,000	120,000	695,000	902,000
2026	Dry	141,000	272,000	3,000	0	6,000	111,000	11,000	304,000	848,000	62,000	86,000	593,000	741,000
2027	Dry	141,000	272,000	3,000	0	6,000	110,000	11,000	336,000	879,000	67,000	92,000	585,000	744,000
2028	Dry	141,000	272,000	3,000	0	6,000	112,000	11,000	277,000	823,000	58,000	77,000	601,000	735,000
2029	Dry	141,000	272,000	3,000	0	6,000	115,000	11,000	217,000	764,000	49,000	64,000	575,000	689,000
2030	Shasta Critical	122,000	244,000	2,000	0	6,000	186,000	8,000	155,000	722,000	47,000	59,000	585,000	691,000
2031	Shasta Critical	122,000	244,000	2,000	0	6,000	186,000	8,000	165,000	732,000	48,000	63,000	582,000	694,000
2032	Wet	118,000	332,000	4,000	0	6,000	97,000	12,000	334,000	903,000	76,000	106,000	699,000	881,000
2033	Dry	141,000	272,000	3,000	0	6,000	116,000	11,000	189,000	739,000	48,000	63,000	564,000	676,000
2034	Wet	118,000	332,000	4,000	0	6,000	80,000	12,000	341,000	893,000	76,000	107,000	659,000	842,000
2035	Wet	118,000	332,000	4,000	0	6,000	91,000	12,000	332,000	894,000	74,000	101,000	695,000	870,000
2036	Wet	118,000	332,000	4,000	0	6,000	140,000	12,000	289,000	900,000	72,000	98,000	719,000	889,000
2037	Wet	118,000	332,000	4,000	0	6,000	83,000	12,000	393,000	948,000	85,000	127,000	653,000	866,000
2038	Average	126,000	310,000	3,000	0	6,000	152,000	10,000	196,000	805,000	59,000	84,000	593,000	735,000
2039	Average	126,000	310,000	3,000	0	6,000	167,000	10,000	177,000	800,000	55,000	72,000	615,000	742,000
2040	Dry	141,000	272,000	3,000	0	6,000	141,000	11,000	199,000	773,000	54,000	77,000	573,000	704,000
2041	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	152,000	739,000	48,000	62,000	571,000	682,000
2042	Average	126,000	310,000	3,000	0	6,000	153,000	10,000	200,000	809,000	58,000	81,000	606,000	746,000
2043	Dry	141,000	272,000	3,000	0	7,000	151,000	11,000	174,000	759,000	53,000	73,000	580,000	706,000
2044	Wet	118,000	332,000	4,000	0	6,000	110,000	12,000	312,000	894,000	75,000	105,000	662,000	842,000
2045	Wet	118,000	332,000	4,000	0	7,000	121,000	12,000	248,000	841,000	68,000	89,000	663,000	820,000

Land Surface Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2046	Dry	141,000	272,000	3,000	0	7,000	156,000	11,000	114,000	704,000	44,000	52,000	560,000	656,000
2047	Dry	141,000	272,000	3,000	0	7,000	170,000	11,000	142,000	746,000	47,000	57,000	598,000	702,000
2048	Average	126,000	310,000	3,000	0	6,000	209,000	10,000	125,000	790,000	53,000	63,000	647,000	762,000
2049	Average	126,000	310,000	3,000	0	6,000	130,000	10,000	227,000	814,000	60,000	90,000	590,000	740,000
2050	Wet	118,000	332,000	4,000	0	7,000	124,000	12,000	258,000	854,000	66,000	84,000	682,000	832,000
2051	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	112,000	699,000	44,000	52,000	559,000	654,000
2052	Dry	141,000	272,000	3,000	0	7,000	143,000	11,000	149,000	726,000	47,000	57,000	568,000	672,000
2053	Shasta Critical	122,000	244,000	2,000	0	7,000	220,000	8,000	128,000	729,000	49,000	62,000	601,000	711,000
2054	Shasta Critical	122,000	244,000	2,000	0	7,000	216,000	8,000	138,000	735,000	40,000	48,000	562,000	650,000
2055	Dry	141,000	272,000	3,000	0	7,000	152,000	11,000	262,000	848,000	56,000	87,000	587,000	730,000
2056	Wet	118,000	332,000	4,000	0	7,000	156,000	12,000	275,000	903,000	68,000	91,000	696,000	855,000
2057	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2058	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2059	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2060	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2061	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2062	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2063	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2064	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2065	Average	126,000	310,000	3,000	0	6,000	147,000	10,000	199,000	803,000	57,000	78,000	607,000	741,000
2066	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2067	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
2068	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2069	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	211,000	770,000	50,000	67,000	584,000	701,000
2070	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	342,000	911,000	77,000	107,000	683,000	868,000
Projected Average		124,000	295,000	3,000	0	6,000	132,000	11,000	246,000	817,000	61,000	83,000	620,000	764,000

[1] Runoff includes return flows to all surface water sources leaving the Plan area. Return flows were not separated due to model limitations.

Table 5-27. Groundwater Budget, Baseline Projected Water Budget (AFY)

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2014	Shasta Critical	61,000	45,000	24,000	*131,000*	201,000	8,000	65,000	34,000	*308,000*
2015	Shasta Critical	48,000	45,000	24,000	*117,000*	203,000	8,000	65,000	34,000	*310,000*
2016	Dry	87,000	45,000	24,000	*157,000*	140,000	11,000	65,000	34,000	*251,000*
2017	Wet	90,000	73,000	38,000	*201,000*	127,000	12,000	56,000	30,000	*226,000*
2018	Average	74,000	51,000	27,000	*153,000*	125,000	10,000	62,000	33,000	*230,000*
2019	Wet	107,000	73,000	38,000	*219,000*	89,000	12,000	56,000	30,000	*188,000*
2020	Dry	67,000	45,000	24,000	*136,000*	119,000	11,000	65,000	34,000	*230,000*
2021	Wet	107,000	73,000	38,000	*219,000*	90,000	12,000	56,000	30,000	*189,000*
2022	Wet	114,000	73,000	38,000	*226,000*	84,000	12,000	56,000	30,000	*182,000*
2023	Average	93,000	51,000	27,000	*172,000*	114,000	10,000	62,000	33,000	*219,000*
2024	Dry	89,000	45,000	24,000	*158,000*	115,000	11,000	65,000	34,000	*226,000*
2025	Wet	120,000	73,000	38,000	*232,000*	85,000	12,000	56,000	30,000	*184,000*
2026	Dry	86,000	45,000	24,000	*155,000*	116,000	11,000	65,000	34,000	*227,000*
2027	Dry	92,000	45,000	24,000	*161,000*	116,000	11,000	65,000	34,000	*227,000*
2028	Dry	77,000	45,000	24,000	*146,000*	118,000	11,000	65,000	34,000	*229,000*
2029	Dry	64,000	45,000	24,000	*134,000*	121,000	11,000	65,000	34,000	*231,000*
2030	Shasta Critical	59,000	45,000	24,000	*128,000*	192,000	8,000	65,000	34,000	*299,000*
2031	Shasta Critical	63,000	45,000	24,000	*133,000*	192,000	8,000	65,000	34,000	*299,000*
2032	Wet	106,000	73,000	38,000	*218,000*	103,000	12,000	56,000	30,000	*202,000*
2033	Dry	63,000	45,000	24,000	*133,000*	122,000	11,000	65,000	34,000	*233,000*
2034	Wet	107,000	73,000	38,000	*219,000*	86,000	12,000	56,000	30,000	*185,000*
2035	Wet	101,000	73,000	38,000	*213,000*	97,000	12,000	56,000	30,000	*196,000*
2036	Wet	98,000	73,000	38,000	*209,000*	146,000	12,000	56,000	30,000	*244,000*
2037	Wet	127,000	73,000	38,000	*239,000*	89,000	12,000	56,000	30,000	*188,000*
2038	Average	84,000	51,000	27,000	*162,000*	158,000	10,000	62,000	33,000	*263,000*
2039	Average	72,000	51,000	27,000	*151,000*	173,000	10,000	62,000	33,000	*279,000*
2040	Dry	77,000	45,000	24,000	*146,000*	147,000	11,000	65,000	34,000	*258,000*
2041	Dry	62,000	45,000	24,000	*132,000*	159,000	11,000	65,000	34,000	*270,000*
2042	Average	81,000	51,000	27,000	*160,000*	159,000	10,000	62,000	33,000	*264,000*
2043	Dry	73,000	45,000	24,000	*143,000*	158,000	11,000	65,000	34,000	*269,000*
2044	Wet	105,000	73,000	38,000	*217,000*	116,000	12,000	56,000	30,000	*215,000*
2045	Wet	89,000	73,000	38,000	*201,000*	127,000	12,000	56,000	30,000	*226,000*
2046	Dry	52,000	45,000	24,000	*122,000*	163,000	11,000	65,000	34,000	*274,000*

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2047	Dry	57,000	45,000	24,000	*127,000*	177,000	11,000	65,000	34,000	*288,000*
2048	Average	63,000	51,000	27,000	*142,000*	215,000	10,000	62,000	33,000	*321,000*
2049	Average	90,000	51,000	27,000	*169,000*	137,000	10,000	62,000	33,000	*242,000*
2050	Wet	84,000	73,000	38,000	*195,000*	130,000	12,000	56,000	30,000	*229,000*
2051	Dry	52,000	45,000	24,000	*121,000*	160,000	11,000	65,000	34,000	*271,000*
2052	Dry	57,000	45,000	24,000	*127,000*	150,000	11,000	65,000	34,000	*260,000*
2053	Shasta Critical	62,000	45,000	24,000	*131,000*	227,000	8,000	65,000	34,000	*334,000*
2054	Shasta Critical	48,000	45,000	24,000	*117,000*	223,000	8,000	65,000	34,000	*330,000*
2055	Dry	87,000	45,000	24,000	*156,000*	159,000	11,000	65,000	34,000	*270,000*
2056	Wet	91,000	73,000	38,000	*203,000*	162,000	12,000	56,000	30,000	*261,000*
2057	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
2058	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*
2059	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
2060	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*
2061	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
2062	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*
2063	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*
2064	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*
2065	Average	78,000	51,000	27,000	*156,000*	154,000	10,000	62,000	33,000	*259,000*
2066	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
2067	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
2068	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*
2069	Dry	67,000	45,000	24,000	*136,000*	132,000	11,000	65,000	34,000	*243,000*
2070	Wet	107,000	73,000	38,000	*219,000*	103,000	12,000	56,000	30,000	*202,000*
Projected Average		83,000	56,000	30,000	169,000	138,000	11,000	62,000	32,000	243,000

Table 5-28. Change in Storage, Baseline Projected Water Budget (AFY)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	(128,000)	(28,000)	(156,000)
2015	Shasta Critical	(127,000)	(27,000)	(154,000)
2016	Dry	(102,000)	(14,000)	(115,000)
2017	Wet	(12,000)	(5,000)	(17,000)
2018	Average	41,000	8,000	48,000
2019	Wet	4,000	3,000	7,000
2020	Dry	(111,000)	(19,000)	(130,000)
2021	Wet	4,000	3,000	7,000
2022	Wet	18,000	10,000	28,000
2023	Average	67,000	22,000	88,000
2024	Dry	(89,000)	(7,000)	(97,000)
2025	Wet	28,000	15,000	43,000
2026	Dry	(93,000)	(9,000)	(102,000)
2027	Dry	(86,000)	(6,000)	(92,000)
2028	Dry	(98,000)	(12,000)	(110,000)
2029	Dry	(110,000)	(18,000)	(128,000)
2030	Shasta Critical	(123,000)	(25,000)	(147,000)
2031	Shasta Critical	(121,000)	(24,000)	(144,000)
2032	Wet	2,000	2,000	4,000
2033	Dry	(116,000)	(21,000)	(137,000)
2034	Wet	4,000	3,000	6,000
2035	Wet	2,000	2,000	4,000
2036	Wet	(7,000)	(3,000)	(9,000)
2037	Wet	14,000	8,000	22,000
2038	Average	41,000	8,000	48,000
2039	Average	37,000	6,000	43,000
2040	Dry	(114,000)	(20,000)	(134,000)
2041	Dry	(123,000)	(25,000)	(148,000)
2042	Average	41,000	8,000	50,000
2043	Dry	(119,000)	(23,000)	(141,000)
2044	Wet	(2,000)	0	(2,000)
2045	Wet	(15,000)	(7,000)	(22,000)
2046	Dry	(131,000)	(29,000)	(160,000)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2047	Dry	(125,000)	(26,000)	(151,000)
2048	Average	26,000	0	27,000
2049	Average	47,000	11,000	58,000
2050	Wet	(13,000)	(6,000)	(19,000)
2051	Dry	(131,000)	(29,000)	(160,000)
2052	Dry	(124,000)	(25,000)	(149,000)
2053	Shasta Critical	(128,000)	(27,000)	(155,000)
2054	Shasta Critical	(126,000)	(26,000)	(152,000)
2055	Dry	(101,000)	(13,000)	(114,000)
2056	Wet	(9,000)	(4,000)	(14,000)
2057	Wet	4,000	3,000	7,000
2058	Average	41,000	8,000	49,000
2059	Wet	4,000	3,000	7,000
2060	Dry	(111,000)	(19,000)	(130,000)
2061	Wet	4,000	3,000	7,000
2062	Average	41,000	8,000	49,000
2063	Average	41,000	8,000	49,000
2064	Dry	(111,000)	(19,000)	(130,000)
2065	Average	41,000	8,000	49,000
2066	Wet	4,000	3,000	7,000
2067	Wet	4,000	3,000	7,000
2068	Dry	(111,000)	(19,000)	(130,000)
2069	Dry	(111,000)	(19,000)	(130,000)
2070	Wet	4,000	3,000	7,000
Projected Average		(43,000)	(7,000)	(50,000)

Table 5-29. Land Surface Budget, Projected Water Budget with Climate Change (AFY)

Land Surface Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	208,000	8,000	131,000	686,000	48,000	63,000	598,000	709,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	196,000	8,000	141,000	620,000	39,000	49,000	543,000	631,000
2016	Dry	80,000	231,000	3,000	0	4,000	130,000	11,000	280,000	738,000	57,000	93,000	574,000	724,000
2017	Wet	74,000	303,000	3,000	0	4,000	125,000	12,000	259,000	781,000	64,000	88,000	649,000	801,000
2018	Average	60,000	320,000	2,000	0	4,000	120,000	10,000	200,000	717,000	52,000	75,000	586,000	712,000
2019	Wet	118,000	332,000	4,000	0	4,000	84,000	12,000	347,000	900,000	76,000	109,000	684,000	869,000
2020	Dry	141,000	272,000	3,000	0	5,000	117,000	11,000	200,000	749,000	48,000	64,000	583,000	695,000
2021	Wet	118,000	332,000	4,000	0	4,000	83,000	12,000	351,000	904,000	76,000	109,000	685,000	870,000
2022	Wet	118,000	332,000	4,000	0	5,000	77,000	12,000	437,000	984,000	84,000	118,000	701,000	902,000
2023	Average	126,000	310,000	3,000	0	5,000	106,000	10,000	342,000	903,000	67,000	97,000	618,000	783,000
2024	Dry	141,000	272,000	3,000	0	5,000	109,000	11,000	325,000	866,000	65,000	89,000	596,000	750,000
2025	Wet	118,000	332,000	4,000	0	5,000	79,000	12,000	460,000	1,010,000	86,000	119,000	696,000	901,000
2026	Dry	141,000	272,000	3,000	0	6,000	108,000	11,000	315,000	856,000	63,000	88,000	595,000	746,000
2027	Dry	141,000	272,000	3,000	0	6,000	108,000	11,000	343,000	884,000	68,000	94,000	587,000	748,000
2028	Dry	141,000	272,000	3,000	0	6,000	110,000	11,000	296,000	839,000	60,000	80,000	604,000	744,000
2029	Dry	141,000	272,000	3,000	0	6,000	113,000	11,000	223,000	768,000	49,000	65,000	577,000	691,000
2030	Shasta Critical	122,000	244,000	2,000	0	6,000	185,000	8,000	156,000	722,000	46,000	59,000	586,000	691,000
2031	Shasta Critical	122,000	244,000	2,000	0	6,000	184,000	8,000	173,000	738,000	49,000	65,000	584,000	697,000
2032	Wet	118,000	332,000	4,000	0	6,000	93,000	12,000	347,000	911,000	77,000	109,000	699,000	885,000
2033	Dry	141,000	272,000	3,000	0	6,000	115,000	11,000	196,000	743,000	49,000	64,000	565,000	679,000
2034	Wet	118,000	332,000	4,000	0	6,000	79,000	12,000	345,000	895,000	76,000	108,000	660,000	843,000
2035	Wet	118,000	332,000	4,000	0	6,000	88,000	12,000	342,000	901,000	75,000	104,000	695,000	874,000
2036	Wet	118,000	332,000	4,000	0	6,000	128,000	12,000	337,000	936,000	78,000	110,000	719,000	908,000
2037	Wet	118,000	332,000	4,000	0	6,000	87,000	12,000	382,000	940,000	83,000	124,000	654,000	861,000
2038	Average	126,000	310,000	3,000	0	6,000	152,000	10,000	199,000	806,000	59,000	84,000	593,000	736,000
2039	Average	126,000	310,000	3,000	0	6,000	169,000	10,000	171,000	796,000	54,000	71,000	615,000	740,000
2040	Dry	141,000	272,000	3,000	0	6,000	139,000	11,000	204,000	777,000	54,000	77,000	574,000	706,000
2041	Dry	141,000	272,000	3,000	0	7,000	151,000	11,000	158,000	743,000	49,000	63,000	573,000	685,000
2042	Average	126,000	310,000	3,000	0	6,000	150,000	10,000	207,000	813,000	58,000	82,000	608,000	748,000
2043	Dry	141,000	272,000	3,000	0	7,000	146,000	11,000	197,000	777,000	55,000	80,000	582,000	717,000
2044	Wet	118,000	332,000	4,000	0	6,000	107,000	12,000	320,000	900,000	76,000	106,000	663,000	846,000
2045	Wet	118,000	332,000	4,000	0	7,000	123,000	12,000	241,000	836,000	67,000	86,000	665,000	817,000

Land Surface Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [1]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2046	Dry	141,000	272,000	3,000	0	7,000	157,000	11,000	112,000	703,000	44,000	51,000	560,000	655,000
2047	Dry	141,000	272,000	3,000	0	7,000	167,000	11,000	158,000	759,000	48,000	60,000	601,000	709,000
2048	Average	126,000	310,000	3,000	0	6,000	210,000	10,000	119,000	786,000	52,000	61,000	648,000	760,000
2049	Average	126,000	310,000	3,000	0	6,000	127,000	10,000	238,000	821,000	61,000	92,000	591,000	744,000
2050	Wet	118,000	332,000	4,000	0	7,000	123,000	12,000	259,000	854,000	65,000	82,000	685,000	832,000
2051	Dry	141,000	272,000	3,000	0	7,000	153,000	11,000	112,000	699,000	44,000	51,000	560,000	655,000
2052	Dry	141,000	272,000	3,000	0	7,000	142,000	11,000	149,000	726,000	45,000	55,000	570,000	671,000
2053	Shasta Critical	122,000	244,000	2,000	0	7,000	222,000	8,000	121,000	725,000	48,000	59,000	600,000	707,000
2054	Shasta Critical	122,000	244,000	2,000	0	7,000	216,000	8,000	138,000	735,000	40,000	47,000	563,000	650,000
2055	Dry	141,000	272,000	3,000	0	7,000	155,000	11,000	252,000	841,000	54,000	82,000	590,000	725,000
2056	Wet	118,000	332,000	4,000	0	7,000	154,000	12,000	279,000	905,000	67,000	90,000	699,000	856,000
2057	Wet	118,000	332,000	4,000	0	7,000	97,000	12,000	339,000	909,000	75,000	104,000	687,000	866,000
2058	Average	126,000	310,000	3,000	0	6,000	149,000	10,000	193,000	798,000	55,000	74,000	609,000	738,000
2059	Wet	118,000	332,000	4,000	0	7,000	96,000	12,000	345,000	913,000	77,000	107,000	685,000	869,000
2060	Dry	141,000	272,000	3,000	0	7,000	130,000	11,000	198,000	762,000	49,000	63,000	584,000	695,000
2061	Wet	118,000	332,000	4,000	0	7,000	95,000	12,000	347,000	913,000	76,000	106,000	688,000	869,000
2062	Average	126,000	310,000	3,000	0	6,000	150,000	10,000	192,000	798,000	55,000	75,000	609,000	739,000
2063	Average	126,000	310,000	3,000	0	6,000	148,000	10,000	197,000	801,000	56,000	76,000	609,000	740,000
2064	Dry	141,000	272,000	3,000	0	7,000	127,000	11,000	211,000	772,000	50,000	65,000	585,000	700,000
2065	Average	126,000	310,000	3,000	0	6,000	145,000	10,000	206,000	808,000	57,000	78,000	609,000	744,000
2066	Wet	118,000	332,000	4,000	0	7,000	97,000	12,000	340,000	909,000	75,000	105,000	687,000	867,000
2067	Wet	118,000	332,000	4,000	0	7,000	94,000	12,000	349,000	915,000	76,000	107,000	687,000	871,000
2068	Dry	141,000	272,000	3,000	0	7,000	126,000	11,000	205,000	765,000	49,000	63,000	586,000	698,000
2069	Dry	141,000	272,000	3,000	0	7,000	125,000	11,000	210,000	770,000	50,000	65,000	586,000	700,000
2070	Wet	118,000	332,000	4,000	0	7,000	95,000	12,000	344,000	911,000	76,000	106,000	687,000	868,000
Projected Average		124,000	295,000	3,000	0	6,000	131,000	11,000	250,000	820,000	60,000	83,000	622,000	765,000

[1] Runoff includes return flows to all surface water sources leaving the Plan area. Return flows were not separated due to model limitations.

Table 5-30. Groundwater Surface Budget, Projected Water Budget with Climate Change (AFY)

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2014	Shasta Critical	63,000	45,000	24,000	132,000	*212,000*	*8,000*	*65,000*	*34,000*	319,000
2015	Shasta Critical	49,000	45,000	24,000	118,000	*200,000*	*8,000*	*65,000*	*34,000*	308,000
2016	Dry	93,000	45,000	24,000	162,000	*134,000*	*11,000*	*65,000*	*34,000*	244,000
2017	Wet	88,000	73,000	38,000	199,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000
2018	Average	75,000	51,000	27,000	154,000	*124,000*	*10,000*	*62,000*	*33,000*	229,000
2019	Wet	109,000	73,000	38,000	220,000	*88,000*	*12,000*	*56,000*	*30,000*	186,000
2020	Dry	64,000	45,000	24,000	133,000	*122,000*	*11,000*	*65,000*	*34,000*	232,000
2021	Wet	109,000	73,000	38,000	221,000	*87,000*	*12,000*	*56,000*	*30,000*	186,000
2022	Wet	118,000	73,000	38,000	229,000	*82,000*	*12,000*	*56,000*	*30,000*	180,000
2023	Average	97,000	51,000	27,000	176,000	*111,000*	*10,000*	*62,000*	*33,000*	216,000
2024	Dry	89,000	45,000	24,000	159,000	*115,000*	*11,000*	*65,000*	*34,000*	225,000
2025	Wet	119,000	73,000	38,000	231,000	*84,000*	*12,000*	*56,000*	*30,000*	183,000
2026	Dry	88,000	45,000	24,000	157,000	*113,000*	*11,000*	*65,000*	*34,000*	224,000
2027	Dry	94,000	45,000	24,000	163,000	*114,000*	*11,000*	*65,000*	*34,000*	225,000
2028	Dry	80,000	45,000	24,000	149,000	*116,000*	*11,000*	*65,000*	*34,000*	227,000
2029	Dry	65,000	45,000	24,000	135,000	*118,000*	*11,000*	*65,000*	*34,000*	229,000
2030	Shasta Critical	59,000	45,000	24,000	128,000	*191,000*	*8,000*	*65,000*	*34,000*	298,000
2031	Shasta Critical	65,000	45,000	24,000	134,000	*190,000*	*8,000*	*65,000*	*34,000*	297,000
2032	Wet	109,000	73,000	38,000	221,000	*98,000*	*12,000*	*56,000*	*30,000*	197,000
2033	Dry	64,000	45,000	24,000	134,000	*121,000*	*11,000*	*65,000*	*34,000*	231,000
2034	Wet	108,000	73,000	38,000	219,000	*84,000*	*12,000*	*56,000*	*30,000*	183,000
2035	Wet	104,000	73,000	38,000	216,000	*93,000*	*12,000*	*56,000*	*30,000*	192,000
2036	Wet	110,000	73,000	38,000	222,000	*134,000*	*12,000*	*56,000*	*30,000*	232,000
2037	Wet	124,000	73,000	38,000	235,000	*92,000*	*12,000*	*56,000*	*30,000*	191,000
2038	Average	84,000	51,000	27,000	163,000	*158,000*	*10,000*	*62,000*	*33,000*	263,000
2039	Average	71,000	51,000	27,000	149,000	*175,000*	*10,000*	*62,000*	*33,000*	281,000
2040	Dry	77,000	45,000	24,000	147,000	*146,000*	*11,000*	*65,000*	*34,000*	256,000
2041	Dry	63,000	45,000	24,000	133,000	*158,000*	*11,000*	*65,000*	*34,000*	269,000
2042	Average	82,000	51,000	27,000	161,000	*156,000*	*10,000*	*62,000*	*33,000*	262,000
2043	Dry	80,000	45,000	24,000	149,000	*153,000*	*11,000*	*65,000*	*34,000*	263,000
2044	Wet	106,000	73,000	38,000	218,000	*114,000*	*12,000*	*56,000*	*30,000*	213,000
2045	Wet	86,000	73,000	38,000	197,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000
2046	Dry	51,000	45,000	24,000	120,000	*164,000*	*11,000*	*65,000*	*34,000*	274,000

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2047	Dry	60,000	45,000	24,000	129,000	*174,000*	*11,000*	*65,000*	*34,000*	284,000
2048	Average	61,000	51,000	27,000	140,000	*217,000*	*10,000*	*62,000*	*33,000*	322,000
2049	Average	92,000	51,000	27,000	171,000	*133,000*	*10,000*	*62,000*	*33,000*	238,000
2050	Wet	82,000	73,000	38,000	194,000	*129,000*	*12,000*	*56,000*	*30,000*	228,000
2051	Dry	51,000	45,000	24,000	120,000	*160,000*	*11,000*	*65,000*	*34,000*	270,000
2052	Dry	55,000	45,000	24,000	125,000	*149,000*	*11,000*	*65,000*	*34,000*	260,000
2053	Shasta Critical	59,000	45,000	24,000	129,000	*229,000*	*8,000*	*65,000*	*34,000*	336,000
2054	Shasta Critical	47,000	45,000	24,000	117,000	*223,000*	*8,000*	*65,000*	*34,000*	330,000
2055	Dry	82,000	45,000	24,000	151,000	*161,000*	*11,000*	*65,000*	*34,000*	272,000
2056	Wet	90,000	73,000	38,000	201,000	*160,000*	*12,000*	*56,000*	*30,000*	259,000
2057	Wet	104,000	73,000	38,000	216,000	*104,000*	*12,000*	*56,000*	*30,000*	202,000
2058	Average	74,000	51,000	27,000	153,000	*156,000*	*10,000*	*62,000*	*33,000*	261,000
2059	Wet	107,000	73,000	38,000	219,000	*102,000*	*12,000*	*56,000*	*30,000*	201,000
2060	Dry	63,000	45,000	24,000	132,000	*137,000*	*11,000*	*65,000*	*34,000*	247,000
2061	Wet	106,000	73,000	38,000	217,000	*101,000*	*12,000*	*56,000*	*30,000*	200,000
2062	Average	75,000	51,000	27,000	153,000	*156,000*	*10,000*	*62,000*	*33,000*	261,000
2063	Average	76,000	51,000	27,000	154,000	*154,000*	*10,000*	*62,000*	*33,000*	260,000
2064	Dry	65,000	45,000	24,000	135,000	*134,000*	*11,000*	*65,000*	*34,000*	244,000
2065	Average	78,000	51,000	27,000	157,000	*152,000*	*10,000*	*62,000*	*33,000*	257,000
2066	Wet	105,000	73,000	38,000	216,000	*104,000*	*12,000*	*56,000*	*30,000*	202,000
2067	Wet	107,000	73,000	38,000	218,000	*101,000*	*12,000*	*56,000*	*30,000*	199,000
2068	Dry	63,000	45,000	24,000	132,000	*133,000*	*11,000*	*65,000*	*34,000*	244,000
2069	Dry	65,000	45,000	24,000	135,000	*132,000*	*11,000*	*65,000*	*34,000*	243,000
2070	Wet	106,000	73,000	38,000	217,000	*102,000*	*12,000*	*56,000*	*30,000*	201,000
Projected Average		83,000	56,000	30,000	169,000	137,000	11,000	62,000	32,000	242,000

Table 5-31. Change in Storage, Projected Water Budget with Climate Change (AFY)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	(135,000)	(29,000)	(164,000)
2015	Shasta Critical	(123,000)	(26,000)	(148,000)
2016	Dry	(87,000)	(10,000)	(97,000)
2017	Wet	(17,000)	(6,000)	(23,000)
2018	Average	43,000	8,000	52,000
2019	Wet	7,000	4,000	11,000
2020	Dry	(119,000)	(20,000)	(139,000)
2021	Wet	10,000	4,000	14,000
2022	Wet	28,000	13,000	41,000
2023	Average	76,000	24,000	100,000
2024	Dry	(88,000)	(7,000)	(94,000)
2025	Wet	28,000	15,000	43,000
2026	Dry	(86,000)	(7,000)	(93,000)
2027	Dry	(81,000)	(4,000)	(85,000)
2028	Dry	(90,000)	(9,000)	(99,000)
2029	Dry	(106,000)	(17,000)	(123,000)
2030	Shasta Critical	(121,000)	(24,000)	(146,000)
2031	Shasta Critical	(115,000)	(22,000)	(138,000)
2032	Wet	12,000	4,000	16,000
2033	Dry	(112,000)	(20,000)	(132,000)
2034	Wet	6,000	3,000	10,000
2035	Wet	10,000	4,000	13,000
2036	Wet	26,000	4,000	30,000
2037	Wet	5,000	7,000	12,000
2038	Average	42,000	8,000	50,000
2039	Average	33,000	5,000	37,000
2040	Dry	(111,000)	(19,000)	(130,000)
2041	Dry	(120,000)	(24,000)	(144,000)
2042	Average	46,000	9,000	55,000
2043	Dry	(103,000)	(19,000)	(122,000)
2044	Wet	3,000	1,000	4,000
2045	Wet	(22,000)	(8,000)	(30,000)
2046	Dry	(133,000)	(29,000)	(162,000)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2047	Dry	(116,000)	(24,000)	(140,000)
2048	Average	22,000	(1,000)	21,000
2049	Average	54,000	13,000	67,000
2050	Wet	(13,000)	(6,000)	(19,000)
2051	Dry	(132,000)	(29,000)	(161,000)
2052	Dry	(125,000)	(25,000)	(150,000)
2053	Shasta Critical	(133,000)	(28,000)	(162,000)
2054	Shasta Critical	(126,000)	(26,000)	(153,000)
2055	Dry	(110,000)	(15,000)	(125,000)
2056	Wet	(8,000)	(3,000)	(12,000)
2057	Wet	0	2,000	2,000
2058	Average	35,000	7,000	42,000
2059	Wet	5,000	3,000	9,000
2060	Dry	(122,000)	(21,000)	(142,000)
2061	Wet	5,000	4,000	8,000
2062	Average	35,000	7,000	42,000
2063	Average	38,000	8,000	46,000
2064	Dry	(114,000)	(19,000)	(133,000)
2065	Average	45,000	9,000	54,000
2066	Wet	0	3,000	3,000
2067	Wet	7,000	4,000	11,000
2068	Dry	(117,000)	(19,000)	(137,000)
2069	Dry	(113,000)	(19,000)	(132,000)
2070	Wet	3,000	3,000	7,000
Projected Average		(42,000)	(6,000)	(48,000)

Table 5-32. Land Surface Budget, Projected Water Budget with Climate Change and Projects & Management Actions (AFY)

Land Surface Budget															
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows				
		Surface Water Deliveries [1]				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [2]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2014	Shasta Critical	105,000	229,000	2,000	0	4,000	208,000	8,000	131,000	686,000	48,000	63,000	598,000	709,000
2015	Shasta Critical	60,000	210,000	1,000	0	4,000	196,000	8,000	141,000	620,000	39,000	49,000	543,000	631,000
2016	Dry	80,000	231,000	3,000	0	4,000	130,000	11,000	280,000	738,000	57,000	93,000	574,000	724,000
2017	Wet	74,000	303,000	3,000	0	4,000	125,000	12,000	259,000	781,000	64,000	88,000	649,000	801,000
2018	Average	60,000	320,000	2,000	0	4,000	114,000	10,000	200,000	710,000	51,000	75,000	586,000	712,000
2019	Wet	118,000	332,000	4,000	2,000	4,000	76,000	12,000	347,000	895,000	76,000	108,000	684,000	868,000
2020	Dry	141,000	272,000	3,000	9,000	5,000	111,000	11,000	200,000	752,000	48,000	67,000	583,000	698,000
2021	Wet	118,000	332,000	4,000	7,000	4,000	76,000	12,000	351,000	904,000	76,000	119,000	685,000	881,000
2022	Wet	118,000	332,000	4,000	7,000	5,000	70,000	12,000	437,000	984,000	83,000	128,000	701,000	912,000
2023	Average	126,000	310,000	3,000	6,000	5,000	98,000	10,000	342,000	901,000	67,000	100,000	618,000	785,000
2024	Dry	141,000	272,000	3,000	6,000	5,000	106,000	11,000	325,000	869,000	65,000	92,000	596,000	753,000
2025	Wet	118,000	332,000	4,000	7,000	5,000	72,000	12,000	460,000	1,010,000	86,000	130,000	696,000	912,000
2026	Dry	141,000	272,000	3,000	52,000	6,000	64,000	11,000	315,000	864,000	63,000	94,000	595,000	753,000
2027	Dry	141,000	272,000	3,000	49,000	6,000	67,000	11,000	343,000	893,000	68,000	103,000	587,000	758,000
2028	Dry	141,000	272,000	3,000	50,000	6,000	69,000	11,000	296,000	847,000	60,000	89,000	604,000	753,000
2029	Dry	141,000	272,000	3,000	55,000	6,000	66,000	11,000	223,000	778,000	50,000	75,000	577,000	701,000
2030	Shasta Critical	122,000	244,000	2,000	49,000	6,000	138,000	8,000	156,000	725,000	46,000	68,000	586,000	700,000
2031	Shasta Critical	122,000	244,000	2,000	51,000	6,000	136,000	8,000	173,000	741,000	49,000	74,000	584,000	706,000
2032	Wet	118,000	332,000	4,000	46,000	6,000	62,000	12,000	347,000	925,000	78,000	131,000	699,000	909,000
2033	Dry	141,000	272,000	3,000	60,000	6,000	68,000	11,000	196,000	757,000	50,000	75,000	565,000	690,000
2034	Wet	118,000	332,000	4,000	47,000	6,000	49,000	12,000	345,000	913,000	77,000	130,000	660,000	867,000
2035	Wet	118,000	332,000	4,000	48,000	6,000	55,000	12,000	342,000	917,000	76,000	126,000	695,000	898,000
2036	Wet	118,000	332,000	4,000	50,000	6,000	97,000	12,000	337,000	955,000	79,000	133,000	719,000	931,000
2037	Wet	118,000	332,000	4,000	49,000	6,000	58,000	12,000	382,000	961,000	85,000	146,000	654,000	885,000
2038	Average	126,000	310,000	3,000	53,000	6,000	105,000	10,000	199,000	812,000	59,000	99,000	593,000	751,000
2039	Average	126,000	310,000	3,000	52,000	6,000	123,000	10,000	171,000	801,000	54,000	86,000	615,000	756,000
2040	Dry	141,000	272,000	3,000	66,000	6,000	94,000	11,000	204,000	797,000	55,000	88,000	574,000	717,000
2041	Dry	141,000	272,000	3,000	62,000	7,000	99,000	11,000	158,000	753,000	49,000	73,000	573,000	695,000
2042	Average	126,000	310,000	3,000	51,000	6,000	104,000	10,000	207,000	819,000	59,000	97,000	608,000	763,000
2043	Dry	141,000	272,000	3,000	68,000	7,000	98,000	11,000	197,000	797,000	57,000	90,000	582,000	729,000
2044	Wet	118,000	332,000	4,000	53,000	6,000	70,000	12,000	320,000	916,000	77,000	129,000	663,000	870,000
2045	Wet	118,000	332,000	4,000	53,000	7,000	78,000	12,000	241,000	844,000	67,000	108,000	665,000	840,000

Land Surface Budget														
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows									Outflows			
		Surface Water Deliveries [1]				Groundwater Pumping		Tile Drainage	Precipitation	Total Inflows	Runoff [2]	Deep Percolation	Evapotranspiration	Total Outflows
		San Joaquin River	Central Valley Project	State Water Project	Local Supplies	Municipal & Industrial	Agricultural							
2046	Dry	141,000	272,000	3,000	68,000	7,000	100,000	11,000	112,000	714,000	44,000	61,000	560,000	666,000
2047	Dry	141,000	272,000	3,000	64,000	7,000	111,000	11,000	158,000	768,000	48,000	70,000	601,000	719,000
2048	Average	126,000	310,000	3,000	49,000	6,000	161,000	10,000	119,000	786,000	52,000	75,000	648,000	775,000
2049	Average	126,000	310,000	3,000	62,000	6,000	98,000	10,000	238,000	854,000	63,000	108,000	591,000	762,000
2050	Wet	118,000	332,000	4,000	54,000	7,000	83,000	12,000	259,000	869,000	66,000	105,000	685,000	856,000
2051	Dry	141,000	272,000	3,000	69,000	7,000	102,000	11,000	112,000	718,000	45,000	61,000	560,000	666,000
2052	Dry	141,000	272,000	3,000	67,000	7,000	97,000	11,000	149,000	747,000	47,000	66,000	570,000	682,000
2053	Shasta Critical	122,000	244,000	2,000	47,000	7,000	178,000	8,000	121,000	728,000	48,000	68,000	600,000	716,000
2054	Shasta Critical	122,000	244,000	2,000	34,000	7,000	187,000	8,000	138,000	740,000	40,000	55,000	563,000	658,000
2055	Dry	141,000	272,000	3,000	49,000	7,000	115,000	11,000	252,000	851,000	54,000	91,000	590,000	735,000
2056	Wet	118,000	332,000	4,000	46,000	7,000	109,000	12,000	279,000	906,000	67,000	112,000	699,000	878,000
2057	Wet	118,000	332,000	4,000	55,000	7,000	63,000	12,000	339,000	930,000	77,000	127,000	687,000	891,000
2058	Average	126,000	310,000	3,000	54,000	6,000	100,000	10,000	193,000	803,000	55,000	90,000	609,000	754,000
2059	Wet	118,000	332,000	4,000	55,000	7,000	62,000	12,000	345,000	935,000	78,000	130,000	685,000	893,000
2060	Dry	141,000	272,000	3,000	69,000	7,000	78,000	11,000	198,000	779,000	50,000	73,000	584,000	706,000
2061	Wet	118,000	332,000	4,000	55,000	7,000	61,000	12,000	347,000	936,000	77,000	128,000	688,000	894,000
2062	Average	126,000	310,000	3,000	58,000	6,000	100,000	10,000	192,000	806,000	56,000	90,000	609,000	755,000
2063	Average	126,000	310,000	3,000	54,000	6,000	99,000	10,000	197,000	806,000	56,000	91,000	609,000	756,000
2064	Dry	141,000	272,000	3,000	70,000	7,000	77,000	11,000	211,000	792,000	51,000	76,000	585,000	712,000
2065	Average	126,000	310,000	3,000	58,000	6,000	98,000	10,000	206,000	818,000	57,000	94,000	609,000	760,000
2066	Wet	118,000	332,000	4,000	55,000	7,000	63,000	12,000	340,000	931,000	77,000	127,000	687,000	891,000
2067	Wet	118,000	332,000	4,000	55,000	7,000	61,000	12,000	349,000	938,000	78,000	130,000	687,000	895,000
2068	Dry	141,000	272,000	3,000	69,000	7,000	75,000	11,000	205,000	782,000	50,000	73,000	586,000	709,000
2069	Dry	141,000	272,000	3,000	66,000	7,000	75,000	11,000	210,000	785,000	50,000	75,000	586,000	712,000
2070	Wet	118,000	332,000	4,000	55,000	7,000	62,000	12,000	344,000	933,000	77,000	128,000	687,000	892,000
Projected Average		124,000	295,000	3,000	45,000	6,000	96,000	11,000	250,000	830,000	61,000	95,000	622,000	778,000

[1] Projects & Management Actions aim to increase the amount of Surface Water transfers between GSA Member Agencies by approximately 45,000 AFY. The source of these Surface Water volumes is yet to be determined. The total volume of these transfers will not exceed the cumulative volumes remaining after demands are met within each GSA Member Agency. For a more detailed explanation of these Projects & Management Actions, see Section 7.1 of the *Sustainability Implementation* chapter.

[2] Runoff includes return flows to all surface water sources leaving the Plan area. Return flows were not separated due to model limitations.

Table 5-33. Groundwater Budget, Projected Water Budget with Climate Change and Projects & Management Actions (AFY)

Groundwater Budget											
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows					
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2014	Shasta Critical	63,000	45,000	24,000	132,000	212,000	8,000	65,000	34,000	319,000
2015	Shasta Critical	49,000	45,000	24,000	118,000	200,000	8,000	65,000	34,000	308,000
2016	Dry	93,000	45,000	24,000	162,000	134,000	11,000	65,000	34,000	244,000
2017	Wet	88,000	73,000	38,000	199,000	129,000	12,000	56,000	30,000	228,000
2018	Average	75,000	51,000	27,000	153,000	118,000	10,000	62,000	33,000	223,000
2019	Wet	108,000	73,000	38,000	220,000	81,000	12,000	56,000	30,000	179,000
2020	Dry	67,000	45,000	24,000	136,000	115,000	11,000	65,000	34,000	226,000
2021	Wet	119,000	73,000	38,000	231,000	80,000	12,000	56,000	30,000	179,000
2022	Wet	128,000	73,000	38,000	239,000	75,000	12,000	56,000	30,000	173,000
2023	Average	100,000	51,000	27,000	179,000	103,000	10,000	62,000	33,000	208,000
2024	Dry	92,000	45,000	24,000	161,000	111,000	11,000	65,000	34,000	222,000
2025	Wet	130,000	73,000	38,000	241,000	78,000	12,000	56,000	30,000	176,000
2026	Dry	94,000	45,000	24,000	164,000	70,000	11,000	65,000	34,000	180,000
2027	Dry	103,000	45,000	24,000	172,000	73,000	11,000	65,000	34,000	183,000
2028	Dry	89,000	45,000	24,000	158,000	74,000	11,000	65,000	34,000	185,000
2029	Dry	75,000	45,000	24,000	144,000	72,000	11,000	65,000	34,000	183,000
2030	Shasta Critical	68,000	45,000	24,000	137,000	144,000	8,000	65,000	34,000	251,000
2031	Shasta Critical	74,000	45,000	24,000	143,000	142,000	8,000	65,000	34,000	249,000
2032	Wet	131,000	73,000	38,000	243,000	67,000	12,000	56,000	30,000	166,000
2033	Dry	75,000	45,000	24,000	144,000	74,000	11,000	65,000	34,000	185,000
2034	Wet	130,000	73,000	38,000	242,000	55,000	12,000	56,000	30,000	153,000
2035	Wet	126,000	73,000	38,000	238,000	61,000	12,000	56,000	30,000	160,000
2036	Wet	133,000	73,000	38,000	244,000	102,000	12,000	56,000	30,000	201,000
2037	Wet	146,000	73,000	38,000	258,000	64,000	12,000	56,000	30,000	163,000
2038	Average	99,000	51,000	27,000	178,000	111,000	10,000	62,000	33,000	216,000
2039	Average	86,000	51,000	27,000	164,000	129,000	10,000	62,000	33,000	234,000
2040	Dry	88,000	45,000	24,000	157,000	100,000	11,000	65,000	34,000	211,000
2041	Dry	73,000	45,000	24,000	143,000	106,000	11,000	65,000	34,000	216,000
2042	Average	97,000	51,000	27,000	176,000	110,000	10,000	62,000	33,000	216,000
2043	Dry	90,000	45,000	24,000	160,000	104,000	11,000	65,000	34,000	215,000
2044	Wet	129,000	73,000	38,000	241,000	77,000	12,000	56,000	30,000	176,000
2045	Wet	108,000	73,000	38,000	220,000	84,000	12,000	56,000	30,000	183,000
2046	Dry	61,000	45,000	24,000	131,000	107,000	11,000	65,000	34,000	218,000

Groundwater Budget										
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Inflows				Outflows				
		Deep Percolation	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Inflows	Groundwater Pumping	Tile Drainage	Upper Aquifer Underflows	Lower Aquifer Underflows	Total Outflows
2047	Dry	70,000	*45,000*	*24,000*	139,000	*118,000*	*11,000*	*65,000*	*34,000*	229,000
2048	Average	75,000	*51,000*	*27,000*	154,000	*168,000*	*10,000*	*62,000*	*33,000*	273,000
2049	Average	108,000	*51,000*	*27,000*	187,000	*104,000*	*10,000*	*62,000*	*33,000*	209,000
2050	Wet	105,000	*73,000*	*38,000*	216,000	*90,000*	*12,000*	*56,000*	*30,000*	189,000
2051	Dry	61,000	*45,000*	*24,000*	131,000	*109,000*	*11,000*	*65,000*	*34,000*	220,000
2052	Dry	66,000	*45,000*	*24,000*	135,000	*104,000*	*11,000*	*65,000*	*34,000*	214,000
2053	Shasta Critical	68,000	*45,000*	*24,000*	138,000	*185,000*	*8,000*	*65,000*	*34,000*	292,000
2054	Shasta Critical	55,000	*45,000*	*24,000*	125,000	*194,000*	*8,000*	*65,000*	*34,000*	301,000
2055	Dry	91,000	*45,000*	*24,000*	161,000	*122,000*	*11,000*	*65,000*	*34,000*	233,000
2056	Wet	112,000	*73,000*	*38,000*	223,000	*116,000*	*12,000*	*56,000*	*30,000*	215,000
2057	Wet	127,000	*73,000*	*38,000*	239,000	*70,000*	*12,000*	*56,000*	*30,000*	169,000
2058	Average	90,000	*51,000*	*27,000*	168,000	*106,000*	*10,000*	*62,000*	*33,000*	212,000
2059	Wet	130,000	*73,000*	*38,000*	242,000	*69,000*	*12,000*	*56,000*	*30,000*	167,000
2060	Dry	73,000	*45,000*	*24,000*	143,000	*85,000*	*11,000*	*65,000*	*34,000*	196,000
2061	Wet	128,000	*73,000*	*38,000*	240,000	*68,000*	*12,000*	*56,000*	*30,000*	167,000
2062	Average	90,000	*51,000*	*27,000*	169,000	*106,000*	*10,000*	*62,000*	*33,000*	212,000
2063	Average	91,000	*51,000*	*27,000*	169,000	*105,000*	*10,000*	*62,000*	*33,000*	210,000
2064	Dry	76,000	*45,000*	*24,000*	145,000	*84,000*	*11,000*	*65,000*	*34,000*	195,000
2065	Average	94,000	*51,000*	*27,000*	172,000	*104,000*	*10,000*	*62,000*	*33,000*	210,000
2066	Wet	127,000	*73,000*	*38,000*	239,000	*70,000*	*12,000*	*56,000*	*30,000*	169,000
2067	Wet	130,000	*73,000*	*38,000*	241,000	*68,000*	*12,000*	*56,000*	*30,000*	166,000
2068	Dry	73,000	*45,000*	*24,000*	143,000	*82,000*	*11,000*	*65,000*	*34,000*	192,000
2069	Dry	75,000	*45,000*	*24,000*	145,000	*82,000*	*11,000*	*65,000*	*34,000*	193,000
2070	Wet	128,000	*73,000*	*38,000*	240,000	*68,000*	*12,000*	*56,000*	*30,000*	167,000
Projected Average		95,000	56,000	30,000	181,000	102,000	11,000	62,000	32,000	207,000

Table 5-34. Change in Storage, Projected Water Budget with Climate Change and Projects & Management Actions (AFY)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2014	Shasta Critical	(135,000)	(29,000)	(164,000)
2015	Shasta Critical	(123,000)	(26,000)	(148,000)
2016	Dry	(87,000)	(10,000)	(97,000)
2017	Wet	(17,000)	(6,000)	(23,000)
2018	Average	43,000	14,000	57,000
2019	Wet	9,000	9,000	18,000
2020	Dry	(112,000)	(17,000)	(129,000)
2021	Wet	22,000	10,000	31,000
2022	Wet	40,000	19,000	58,000
2023	Average	80,000	31,000	110,000
2024	Dry	(84,000)	(4,000)	(88,000)
2025	Wet	39,000	21,000	60,000
2026	Dry	(45,000)	2,000	(43,000)
2027	Dry	(39,000)	5,000	(35,000)
2028	Dry	(48,000)	0	(48,000)
2029	Dry	(60,000)	(7,000)	(67,000)
2030	Shasta Critical	(80,000)	(10,000)	(90,000)
2031	Shasta Critical	(73,000)	(8,000)	(81,000)
2032	Wet	57,000	12,000	69,000
2033	Dry	(63,000)	(13,000)	(75,000)
2034	Wet	52,000	10,000	62,000
2035	Wet	55,000	13,000	68,000
2036	Wet	65,000	18,000	83,000
2037	Wet	52,000	10,000	63,000
2038	Average	92,000	20,000	112,000
2039	Average	81,000	17,000	99,000
2040	Dry	(63,000)	(11,000)	(74,000)
2041	Dry	(68,000)	(13,000)	(81,000)
2042	Average	95,000	21,000	116,000
2043	Dry	(55,000)	(9,000)	(63,000)
2044	Wet	53,000	10,000	64,000
2045	Wet	31,000	6,000	37,000
2046	Dry	(79,000)	(16,000)	(96,000)

Groundwater Budget				
Simulated Water Year	Delta-Mendota Subbasin Water Year Type	Change in Storage		
		Upper Aquifer	Lower Aquifer	Total Change in Storage
2047	Dry	(63,000)	(11,000)	(75,000)
2048	Average	68,000	17,000	85,000
2049	Average	90,000	22,000	112,000
2050	Wet	37,000	6,000	43,000
2051	Dry	(82,000)	(17,000)	(100,000)
2052	Dry	(80,000)	(14,000)	(94,000)
2053	Shasta Critical	(94,000)	(15,000)	(109,000)
2054	Shasta Critical	(97,000)	(19,000)	(116,000)
2055	Dry	(69,000)	(7,000)	(76,000)
2056	Wet	43,000	11,000	55,000
2057	Wet	46,000	13,000	59,000
2058	Average	86,000	21,000	107,000
2059	Wet	51,000	13,000	65,000
2060	Dry	(71,000)	(10,000)	(80,000)
2061	Wet	51,000	14,000	64,000
2062	Average	86,000	21,000	108,000
2063	Average	89,000	22,000	110,000
2064	Dry	(64,000)	(8,000)	(73,000)
2065	Average	94,000	23,000	117,000
2066	Wet	46,000	13,000	59,000
2067	Wet	53,000	14,000	67,000
2068	Dry	(66,000)	(9,000)	(75,000)
2069	Dry	(63,000)	(8,000)	(71,000)
2070	Wet	50,000	13,000	63,000
Projected Average		(4,000)	3,000	(1,000)

5.4.7 Historic and Current Water Budgets

The historic water budget is a quantitative evaluation of historic hydrology, water supply, water demand, and land use information covering the 10-year period from WY2003 to WY2012. The current water budget (WY2013) quantifies the same information for current inflows and outflows for the Plan area using the most recent hydrology, water supply, water demand, and land use information. The goal of the water budget analysis is to characterize water supply and demand while summarizing hydrologic conditions and flows within the Plan area, including the movement of all primary sources of water such as rainfall, irrigation, streamflow, and subsurface flow.

Figure 5-122 and Figure 5-123, respectively, summarize the average annual historic and current land surface inflows and outflows in the Northern and Central Delta-Mendota Regions. Figure 5-124 shows the annual time series of historic and current land surface inflows and outflows.

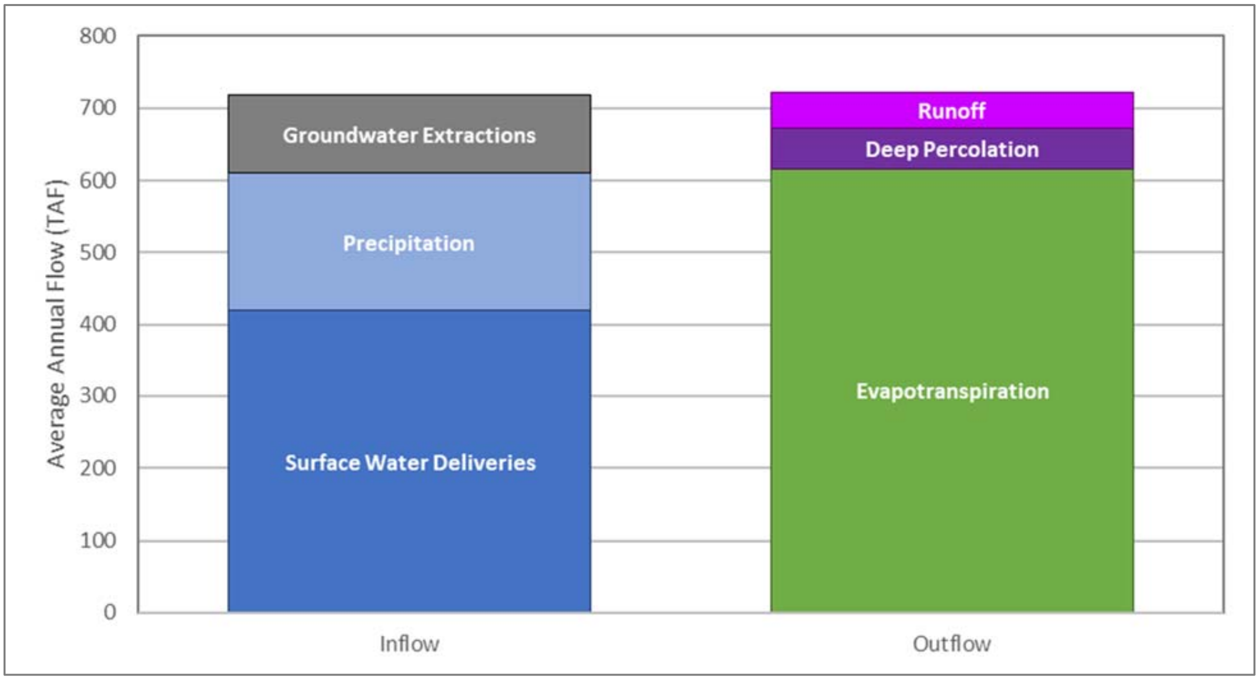

Figure 5-122. Average Historic Land Surface Budget (WY2003-2012)

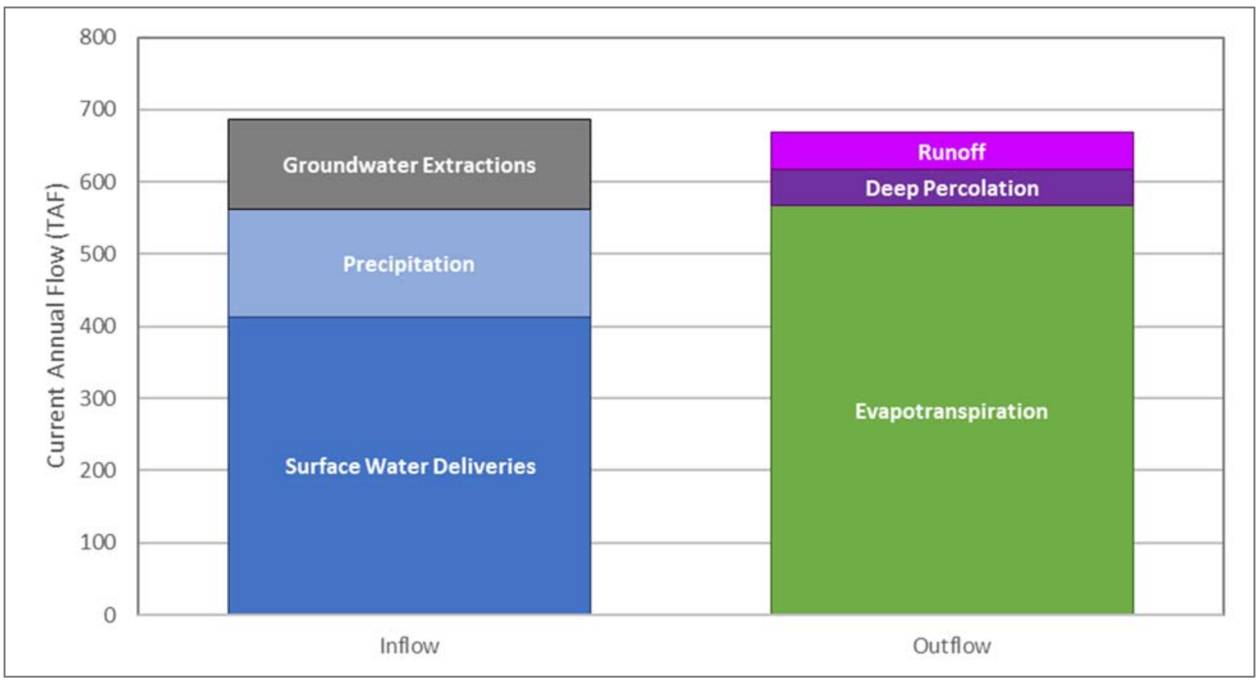

Figure 5-123. Current Land Surface Budget (WY2013)

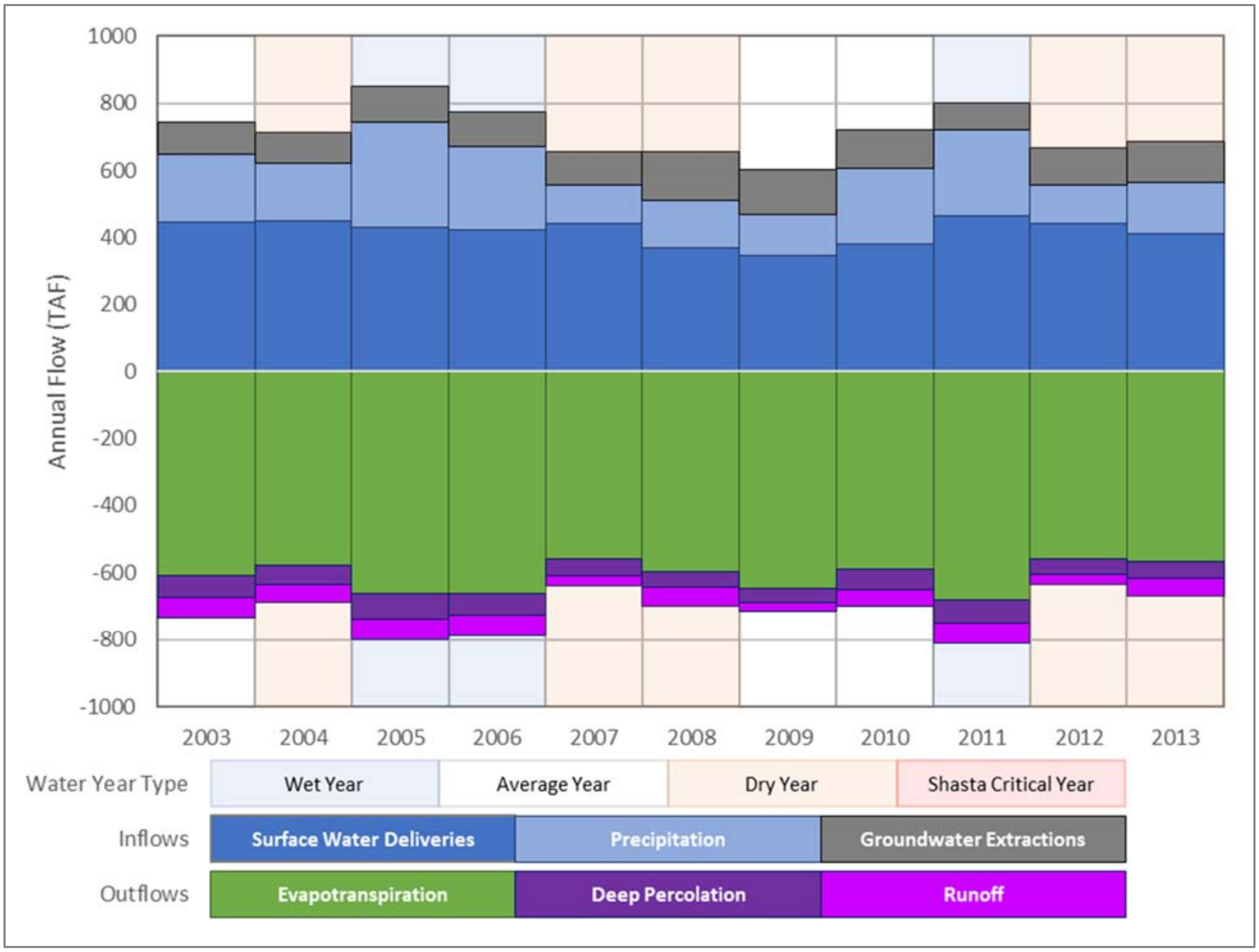

Figure 5-124. Annual Land Surface Budget Over Historic and Current Periods

The land surface budget estimated that the Northern and Central Delta-Mendota Regions experienced about 718,000 AFY of inflows on average between WY2003 and WY2012, including a combination of surface water deliveries (419,000 AFY), applied groundwater (pumped) (108,000 AFY), and precipitation (191,000 AFY) (Figure 5-122). Outflows from the land surface system were estimated to be similar in magnitude to inflows (722,000 AFY total) and are comprised of runoff (49,000 AFY), deep percolation (58,000 AFY), and evapotranspiration (615,000 AFY). Under current water year conditions (WY2013), total inflow to the land surface system was estimated to exceed outflows by approximately 16,000 acre-feet (AF) (685,000 AF and 669,000 AF, respectively) (Figure 5-123). During WY2013, inflows consisted of surface water deliveries (413,000 AF), applied groundwater (123,000 AF), and precipitation (149,000 AF), while outflows consisted of runoff (51,000 AF), deep percolation (50,000 AF) and evapotranspiration (568,000 AF).

Annual inflows and outflows in the land surface budget during the historic and current water budget period ranged from 602,000 AF (WY2009) to 848,000 AF (WY2005) and 634,000 AF (WY2012) to 811,000 AF (WY2011), respectively (Figure 5-124). The highest annual inflow and outflow were experienced during wet water years (WY2005, 2006, and 2011) when precipitation and surface water deliveries are highest. The least inflow and outflow from the land surface system was estimated to occur during dry years and years immediately following consecutive dry years as groundwater pumping increased but did not meet the entire surface water delivery deficit. Overall, inflows and outflows in the land surface budget were mostly balanced on an annual basis from WY2003 through WY2013.

Figure 5-125 and Figure 5-126, respectively, summarize the average annual historic and current groundwater inflows and outflows in the Northern and Central Delta-Mendota Regions. Figure 5-127 shows the annual time series of historic and current groundwater inflows and outflows.

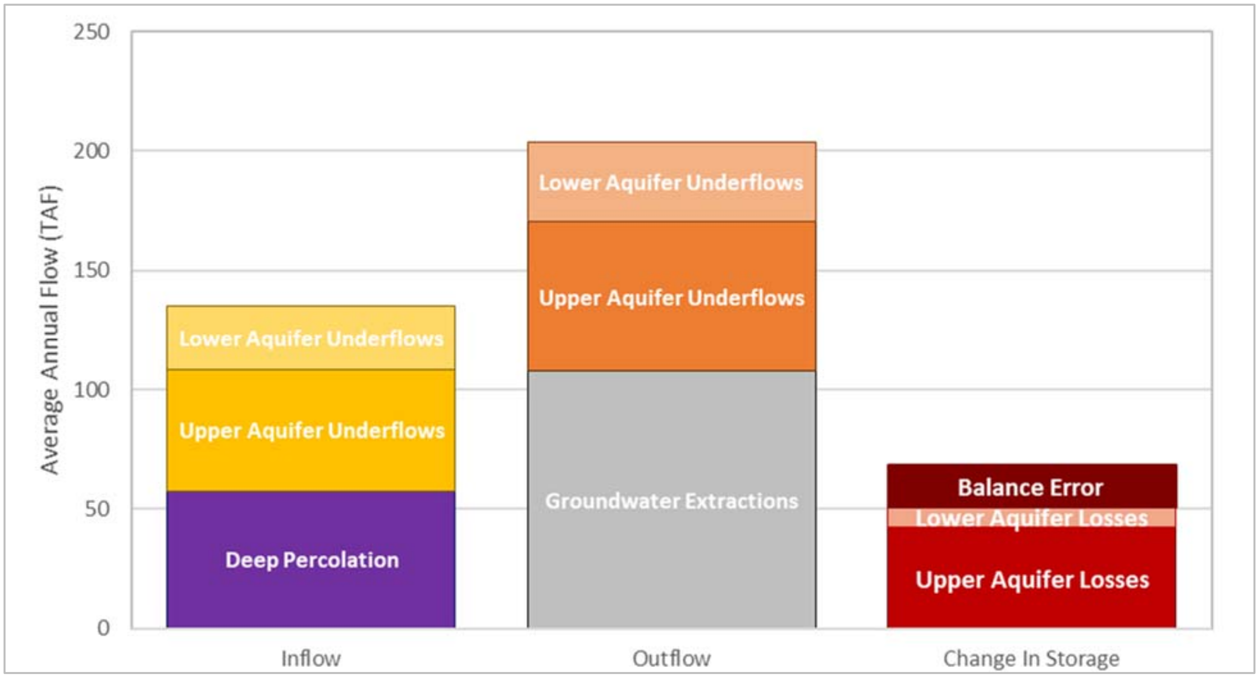

Figure 5-125. Average Historic Groundwater Budget (WY2003-2012)

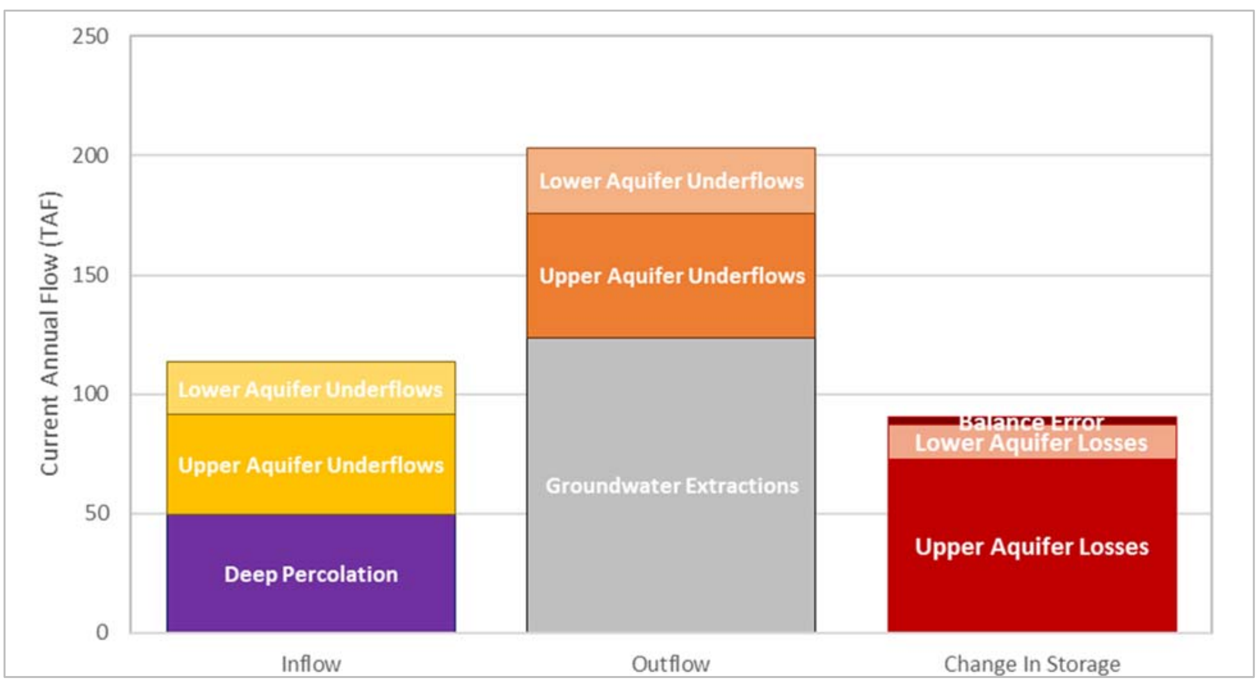

Figure 5-126. Current Groundwater Budget (WY2013)

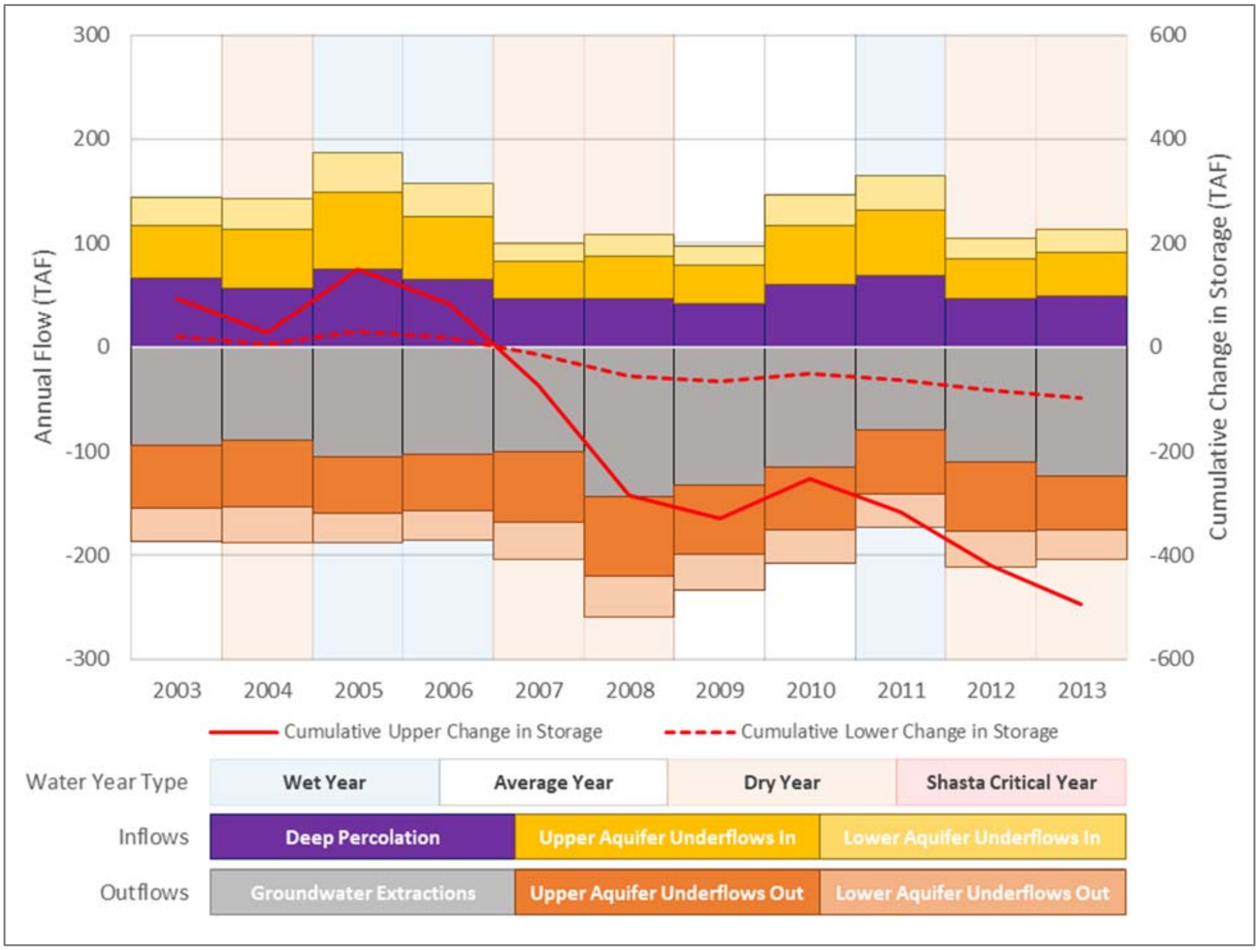

Figure 5-127. Historic and Current Annual Groundwater Budget

The groundwater budget estimated that the Northern and Central Delta-Mendota Regions experienced 136,000 AFY of total inflow on average during the historic water budget period, which includes 58,000 AFY of deep percolation, 51,000 AFY of Upper Aquifer underflows, and 27,000 AFY of Lower Aquifer underflows (Figure 5-125). Outflows from the groundwater system were estimated to be 204,000 AFY on average, which includes 108,000 AFY of groundwater pumping, 30 AFY of tile drainage, 63,000 AFY of Upper Aquifer underflows, and 33,000 AFY of Lower Aquifer underflow. In WY2013 (current condition), a total of 114,000 AF of inflow to the Northern and Central Delta-Mendota Regions was estimated to be comprised of 50,000 AF of deep percolation, 42,000 AF of Upper Aquifer underflows, and 22,000 AF of Lower Aquifer underflows (Figure 5-126). Estimated outflows from the groundwater system in WY2013 totaled 203,000 AF and was comprised of 124,000 AF of groundwater pumping, 30 AFY of tile drainage, 52,000 AF of Upper Aquifer underflows, and 27,000 AF of Lower Aquifer underflows. Overall, there is estimated to be 68,000 AFY and 89,000 AFY greater outflow than inflow under historic and current conditions, respectively. This includes balance error, Upper Aquifer losses, and Lower Aquifer losses.

On average, outflows were estimated to be greater than inflows throughout the historic and current water budget periods, meaning inflows did not meet the entire groundwater demand and resulted in decreased groundwater storage. This pattern is observed annually regardless of water year type, but the negative balance between inflows and outflows is less during wet years as compared to dry and normal years (Figure 5-127). Within the Northern and Central Delta-Mendota Regions, estimated average annual change in storage (i.e. overdraft) was -42,000 AFY in the Upper Aquifer and -8,000 AFY in the Lower Aquifer over the historic water budget period (50,000 AFY of total overdraft). During the current budget period, estimated Upper Aquifer storage decreased by 73,000 AF and Lower Aquifer storage decreased by 15,000 AF. Cumulative change in storage over the historic and current water budget periods in the Upper Aquifer and Lower Aquifer show overall downward trends (Figure 5-127). Between the beginning of WY2003 and WY2012, the estimated cumulative change in storage within the Upper Aquifer was -1.33 AF/acre, and -0.27 AF/acre in the Lower Aquifer (over the 316,000-acre Plan area). In WY2013, the estimated change in storage within the Upper Aquifer was -0.23 AF/acre and -0.05 AF/acre in the Lower Aquifer. Therefore, overdraft within the Northern and Central Delta-Mendota Regions is largely driven by conditions in the Upper Aquifer.

5.4.8 Projected Baseline Water Budget

The projected baseline water budget is used to estimate future (WY2014-2070) baseline conditions of supply, demand, and aquifer response to Plan implementation. More specifically, the baseline projected water budget was prepared to evaluate potential impacts from future changes in land use, cropping patterns, surface water supplies and groundwater demands, independent of climate change and mitigation measures (e.g. projects and management actions). Average annual historic hydrologic conditions were applied by water year type to each projected water year in correlation with the assigned representative water year.

Figure 5-128 summarizes the average annual projected baseline land surface inflows and outflows in the Northern and Central Delta-Mendota Regions. Figure 5-129 shows the annual time series of projected baseline land surface inflows and outflows.

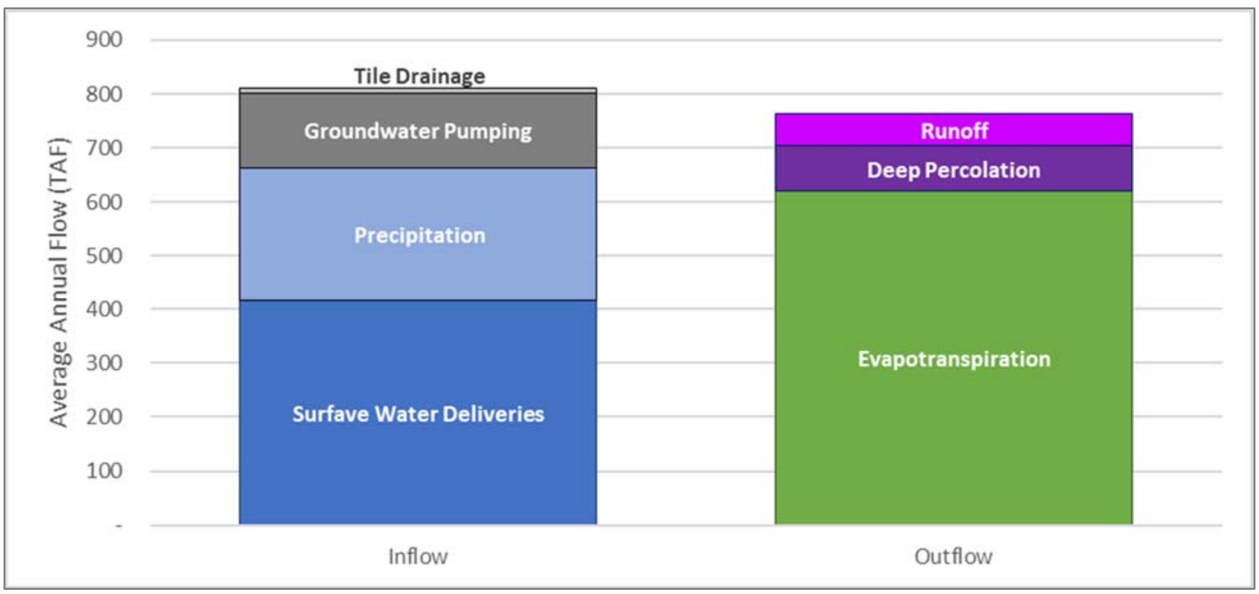

Figure 5-128. Projected Baseline Average Annual Land Surface Budget (WY2014-2070)

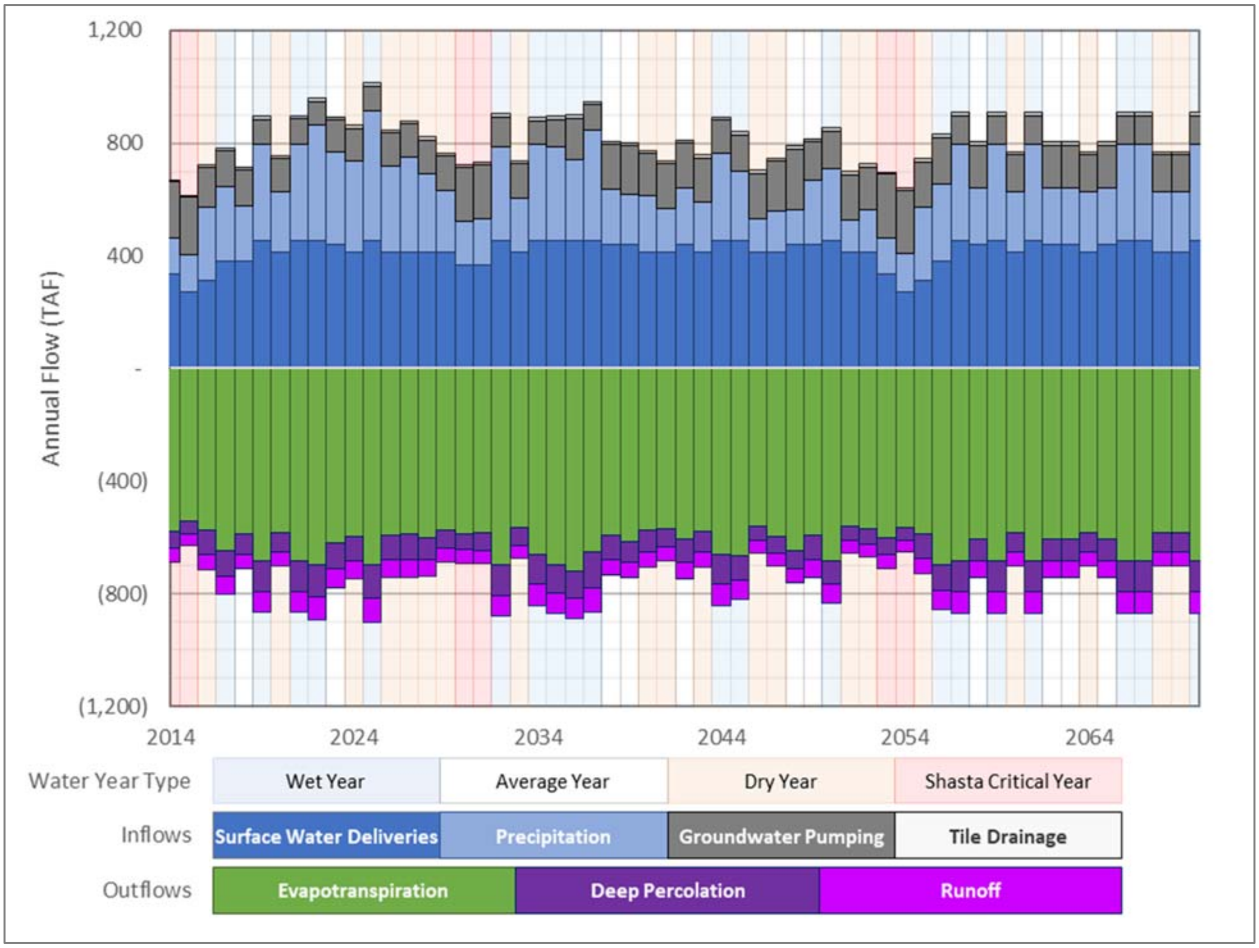

Figure 5-129. Projected Baseline Annual Land Surface Budget (WY2014-2070)

The land surface budget under projected baseline conditions shows inflows exceeding outflows on average by 53,000 AFY, where total average inflows and outflows are 817,000 AFY and 764,000 AFY, respectively (Figure 5-128). Inflows are comprised of surface water deliveries (422,000 AFY), applied groundwater (pumped) (138,000 AFY), tile drainage (11,000 AFY), and precipitation (246,000 AFY). Outflows are comprised of runoff (61,000 AFY), deep percolation (83,000 AFY), and evapotranspiration (620,000 AFY).

Annual inflows and outflows in the land surface budget during the projected baseline water budget period range from 615,000 AF (WY2015) to 1,012,000 AF (WY2025) and 628,000 AF (WY2015) to 902,000 AF (WY2025), respectively (Figure 5-129). Inflows and outflows from the land surface system are estimated to be largely balanced over the projected baseline water budget time period. Shasta Critical water years and dry water years preceding Shasta Critical water years show the least amount of inflow and outflow from the land surface system due to reduced surface water availability and precipitation. Figure 5-130 summarizes the average annual projected baseline groundwater inflows and outflows in the Northern and Central Delta-Mendota Regions. Figure 5-131 shows the annual time series of projected baseline inflows and outflows.

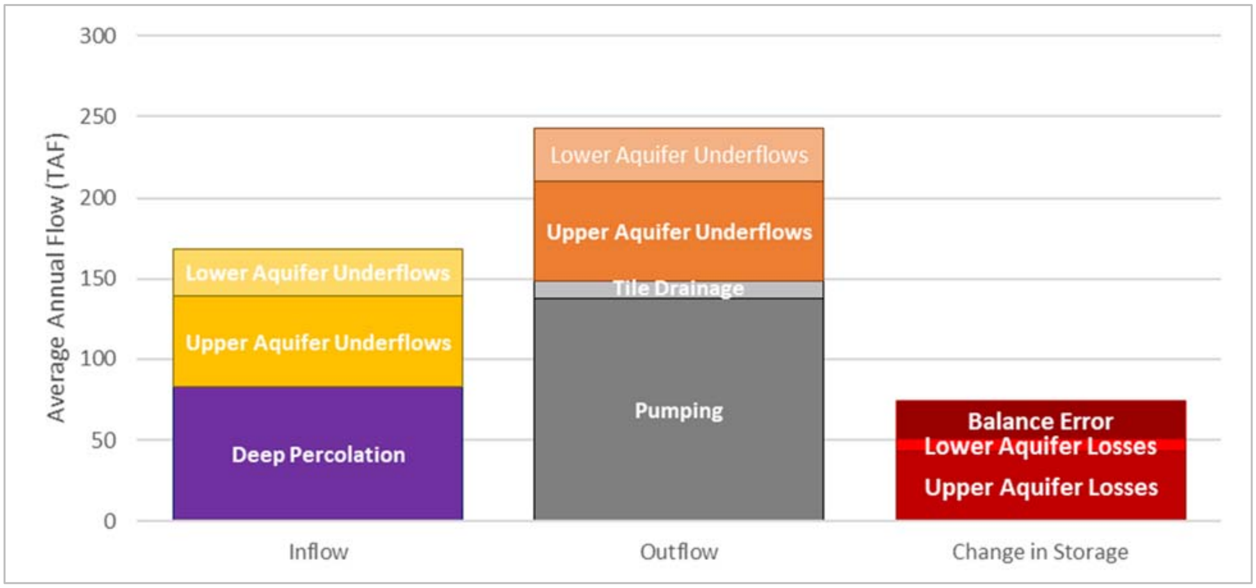

Figure 5-130. Projected Baseline Average Annual Groundwater Budget (WY2014-2070)

Figure 5-131. Projected Baseline Annual Groundwater Budget (WY2014-2070)

Under projected baseline conditions, the Northern and Central Delta-Mendota Regions are estimated to experience, on average, 169,000 AFY of inflow, of which 83,000 AFY is from deep percolation, 56,000 AFY is from Upper Aquifer underflows, and 30,000 AFY is from Lower Aquifer underflows (Figure 5-130). A total average annual outflow under the same conditions of 243,000 AFY consists of 138,000 AFY from groundwater pumping, 11,000 AFY from tile drainage, 62,000 AFY of Upper Aquifer underflows, and 32,000 AFY of Lower Aquifer underflows. Overall, there is 74,000 AFY greater outflow than inflow under projected baseline conditions that includes balance error, Upper Aquifer losses, and Lower Aquifer losses.

On average, outflows are estimated to be greater than inflows under projected baseline conditions, meaning continual declines in groundwater storage persist in the Northern and Central Delta-Mendota Regions. From WY2014 to WY2070, average annual change in storage is -43,000 AFY in the Upper Aquifer and -7,000 AFY in the Lower Aquifer (-50,000 AFY total). Cumulative change in storage in both the Upper and Lower Aquifer show overall declining trends over the baseline projected water budget period (Figure 5-131). By WY2070, cumulative change in storage in the Upper Aquifer and Lower Aquifer are -7.80 AF/acre and -1.24 AF/acre, respectively. Declines in groundwater storage in the Upper Aquifer continues to be dominant within the Northern and Central Delta-Mendota Regions over the projected baseline water budget period.

5.4.9 Projected Water Budget with Climate Change

The projected water budget with climate change is used to estimate future conditions of supply, demand, and aquifer response to Plan implementation without projects and management actions as precipitation, evapotranspiration, and streamflow patterns change. The projected water budget with CCF applied is used to evaluate projected baseline conditions with where applied climate change factors for precipitation and evapotranspiration provided by the California Department of Water Resources (DWR) (2018) and surface water delivery projections from local water purveyors were utilized from WY2014 through WY2070.

Figure 5-132 summarizes the average annual projected land surface inflows and outflows with CCF applied in the Northern and Central Delta-Mendota Regions. Figure 5-133 shows the annual time series of projected land surface inflows and outflows with climate change.

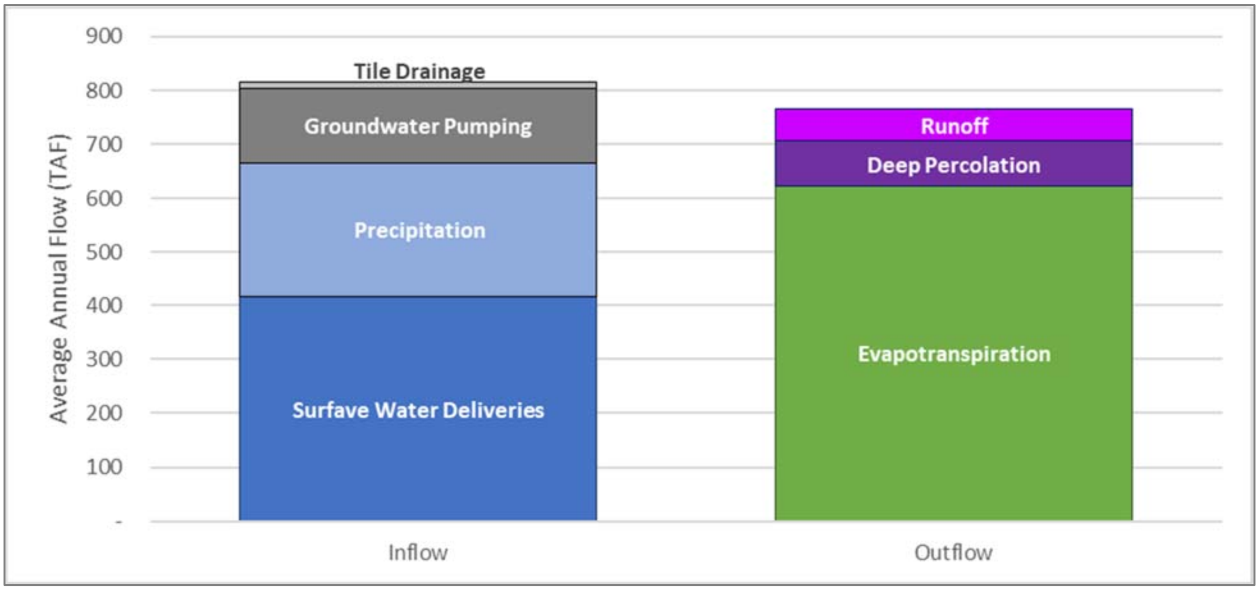

Figure 5-132. Projected Average Annual Land Surface Budget with Climate Change (WY2014-2070)

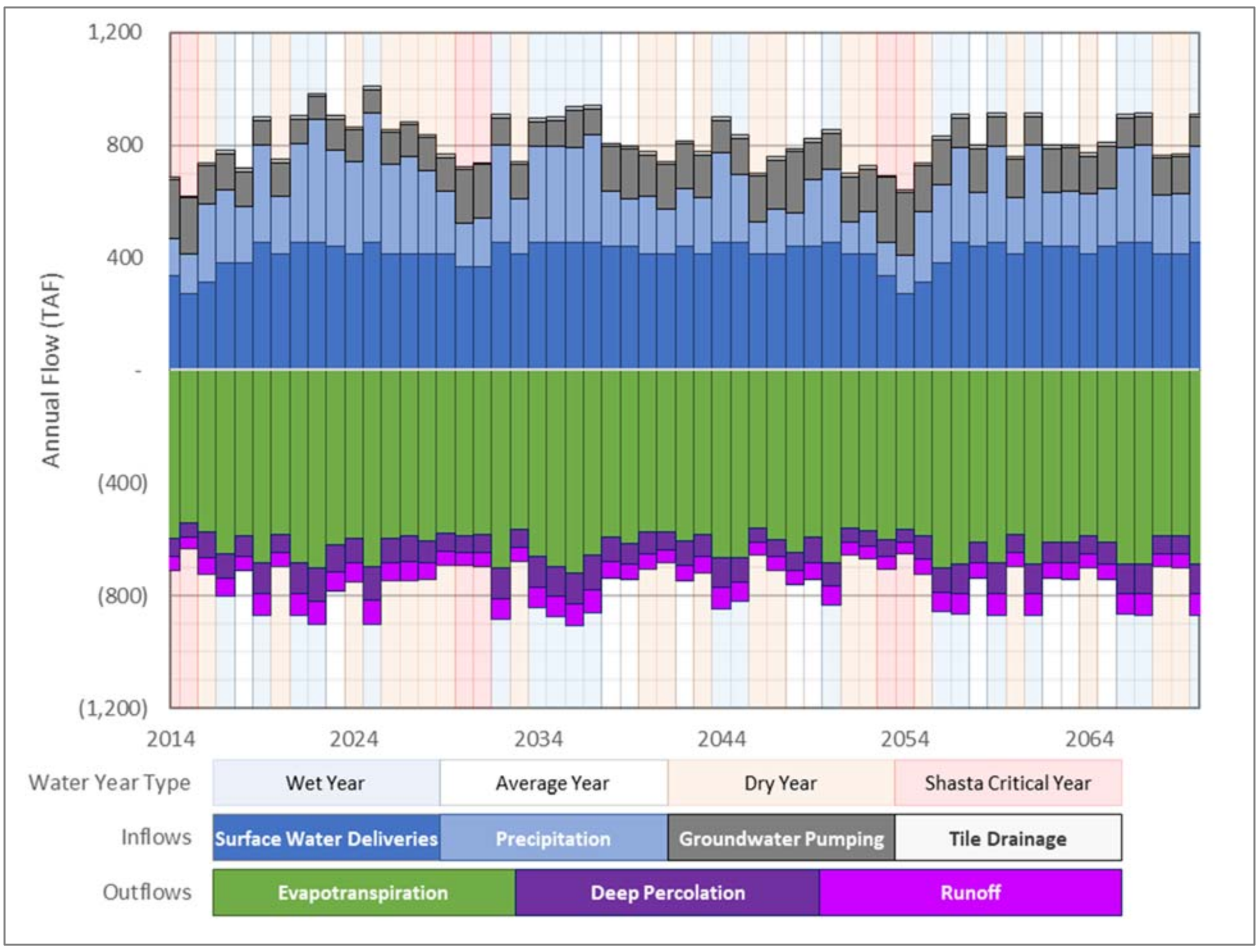

Figure 5-133. Projected Annual Land Surface Budget with Climate Change (WY2014-2070)

The land surface budget under projected conditions with climate change shows inflows exceeding outflows on average by 55,000 AFY, where total average inflows and outflows are 820,000 AFY and 765,000 AFY, respectively (Figure 5-132). Inflows are comprised of surface water deliveries (422,000 AFY), applied groundwater (pumped) (137,000 AFY), tile drainage (11,000 AFY), and precipitation (250,000 AFY). Outflows are comprised of runoff (60,000 AFY), deep percolation (83,000 AFY), and evapotranspiration (622,000 AFY).

Annual inflows and outflows in the land surface budget during the projected conditions with climate change water budget period range from 620,000 AF (WY2015) to 1,010,000 AF (WY2025) and 631,000 AF (WY 2015) to 908,000 AF (WY2036), respectively (Figure 5-133). Inflows and outflows from the land surface system are estimated to be largely balanced over the projected water budget time period under climate change. Shasta Critical water years and dry water years preceding Shasta Critical water years show the least amount of inflow and outflow from the land surface system due to reduced surface water availability.

Figure 5-134 summarizes the average annual projected conditions groundwater inflows and outflows with CCF applied in the Northern and Central Delta-Mendota Regions. Figure 5-135 shows the annual time series of projected conditions inflows and outflows with climate change.

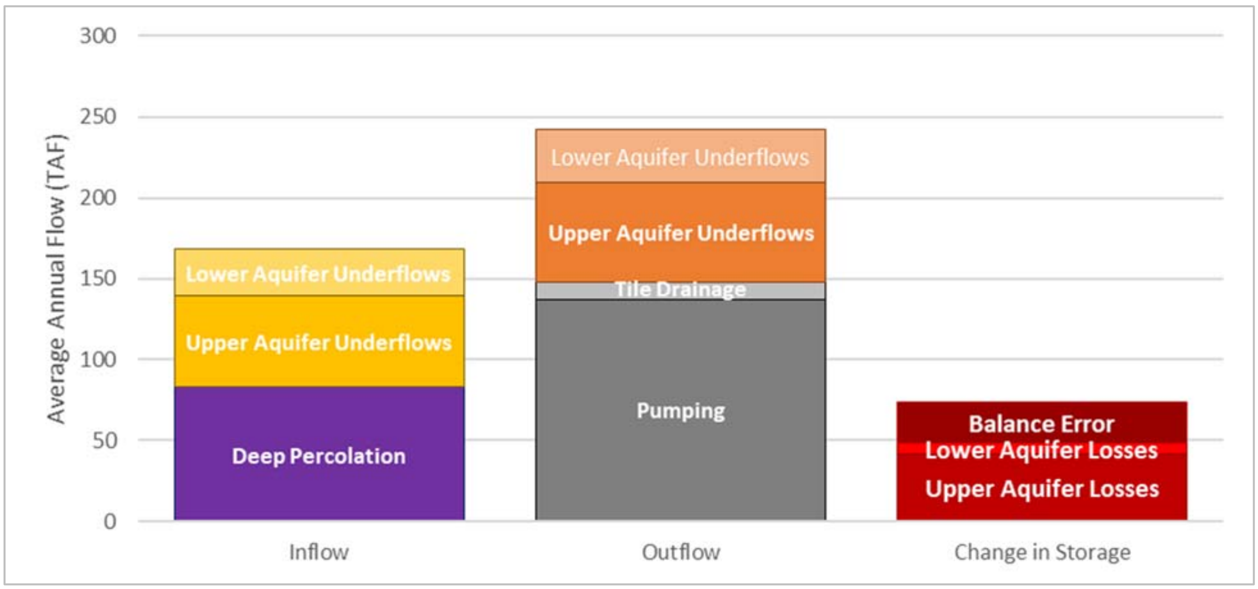

Figure 5-134. Projected Average Annual Groundwater Budget with Climate Change (WY2014-2070)

Figure 5-135. Projected Annual Groundwater Budget with Climate Change (WY2014-2070)

Under projected conditions with climate change, the Northern and Central Delta-Mendota Regions experiences, on average, 169,000 AFY of inflow of which 83,000 AFY is from deep percolation, 56,000 AFY is from Upper Aquifer underflows, and 30,000 AFY is from Lower Aquifer underflows (Figure 5-134). A total average annual outflow under the same conditions of 242,000 AFY consists of 137,000 AFY from groundwater pumping, 11,000 AFY from tile drainage, 62,000 AFY of Upper Aquifer underflows, and 32,000 AFY of Lower Aquifer underflows. Overall, there is 73,000 AFY greater outflow than inflow under projected conditions with climate change that includes balance error, Upper Aquifer losses, and Lower Aquifer losses.

On average, outflows are greater than inflows under projected conditions with climate change, meaning overdraft conditions persist in the Northern and Central Delta-Mendota Regions. From WY2014 to WY2070, average annual change in storage is -42,000 AFY in the Upper Aquifer and -6,000 AFY in the Lower Aquifer (-48,000 AFY total). Cumulative change in storage in both the Upper and Lower Aquifer show overall declining trends over the time period for the projected water budget with CCF applied (Figure 5-135). By WY2070, cumulative change in storage in the Upper Aquifer and Lower Aquifer are -7.51 AF/acre and -1.14 AF/acre, respectively. Compared to projected baseline conditions, cumulative change in storage under climate change conditions is 93,000 AF less in the Upper Aquifer and 33,000 AF less in the Lower Aquifer by WY2070. Overdraft in the Upper Aquifer continues to be the primary driver of overall overdraft within the Northern and Central Delta-Mendota Regions under projected conditions with climate change.

5.4.10 Projected Water Budget with Climate Change and Projects & Management Actions

The projected water budget with climate change is used to estimate future conditions of supply, demand, and aquifer response to Plan implementation as precipitation, evapotranspiration, and streamflow patterns change. The projected water budget with CCF applied and P&MAs is used to evaluate the projected baseline conditions with applied climate change factors provided by DWR from WY2014 through WY2070 as well as projects and management actions that will be implemented within the Plan area to help achieve sustainability by 2040. For more information regarding projects and management actions incorporated into this water budget, refer to Chapter 7 *Sustainability Implementation*, Section 7.1 *Projects & Management Actions*.

Figure 5-136 summarizes the average annual projected land surface inflows and outflows with CCF applied and P&MAs in the Northern and Central Delta-Mendota Regions. Figure 5-137 shows the annual time series of projected land surface inflows and outflows with CCF applied and P&MAs.

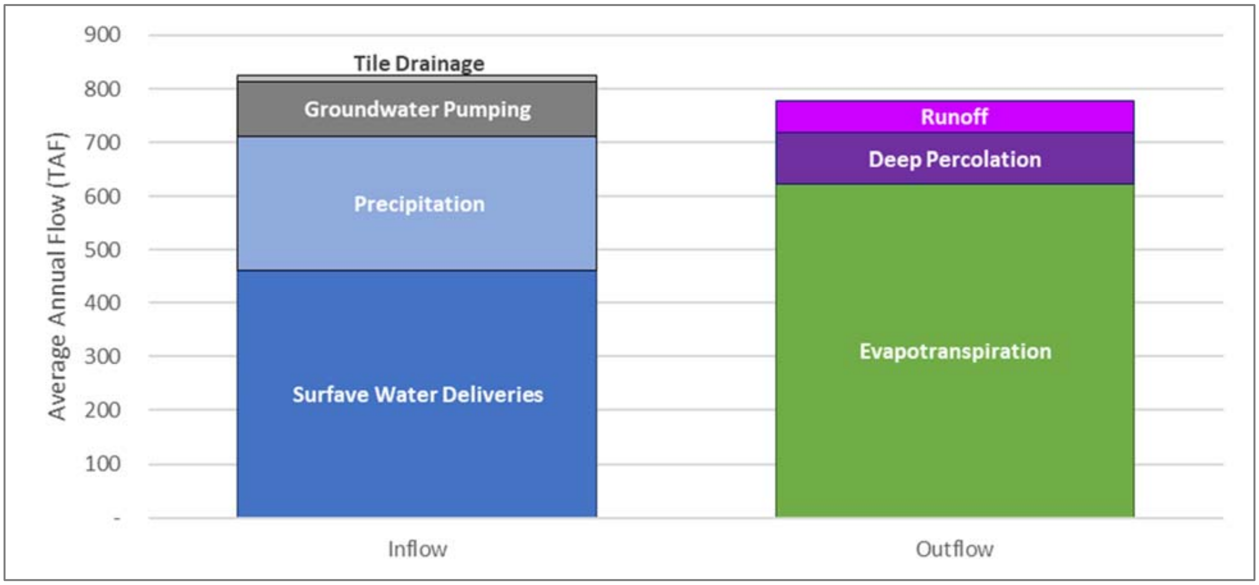

Figure 5-136. Projected Average Annual Land Surface Budget with Climate Change and Projects & Management Actions (WY2014-2070)

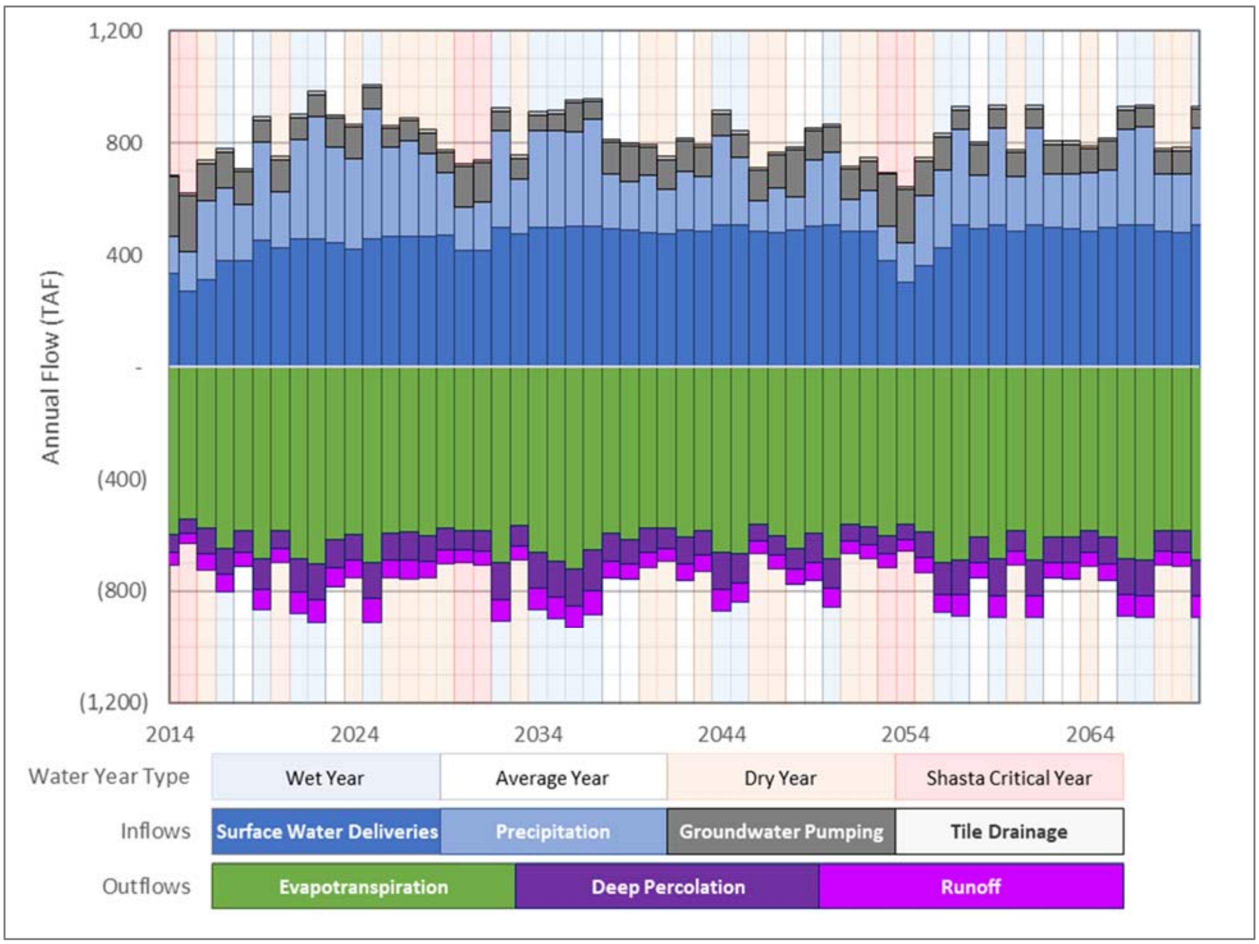

Figure 5-137. Projected Annual Land Surface Budget with Climate Change and Projects & Management Actions (WY2014-2070)

The land surface budget under projected conditions with CCF and P&MAs shows inflows exceeding outflows on average by 52,000 AFY, where total average inflows and outflows are 830,000 AFY and 778,000 AFY, respectively (Figure 5-136). Inflows are comprised of surface water deliveries (467,000 AFY), applied groundwater (pumped) (102,000 AFY), tile drainage (11,000 AFY), and precipitation (250,000 AFY). Outflows are comprised of runoff (61,000 AFY), deep percolation (95,000 AFY), and evapotranspiration (622,000 AFY).

Annual inflows and outflows in the land surface budget under projected conditions with CCF applied and P&MAs range from 620,000 AF (WY2015) to 1,010,000 AF (WY2025) and 631,000 AF (WY2015) to 931,000 AF (WY2036), respectively (Figure 5-137). Inflows and outflows from the land surface system are estimated to be largely balanced over the projected water budget with CCF applied and P&MAs time period. Shasta Critical water years and dry water years preceding Shasta Critical water years show the least amount of inflow and outflow from the land surface system due to reduced surface water availability and precipitation. Figure 5-138 summarizes the average annual projected conditions groundwater inflows and outflows with CCF applied and P&MAs in the Northern and Central Delta-Mendota Regions. Figure 5-139 shows the annual time series of projected conditions inflows and outflows with CCF applied and P&MAs.

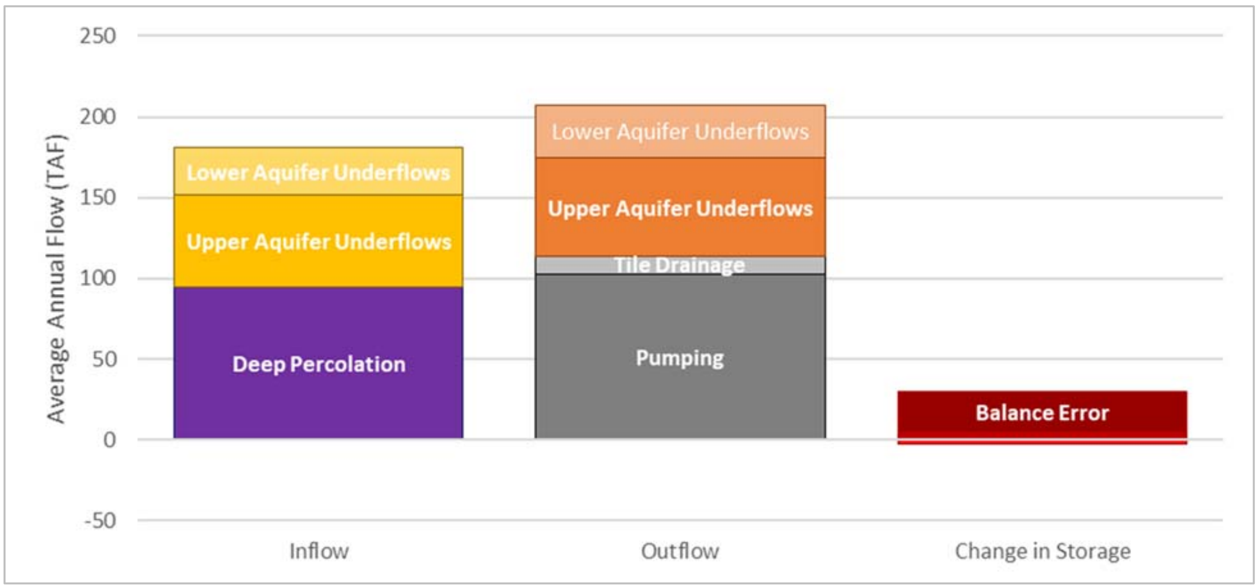

Figure 5-138. Projected Average Annual Groundwater Budget with Climate Change and Projects & Management Actions (WY2014-2070)

** Upper Aquifer Losses and Lower Aquifer Gains too small to label.*

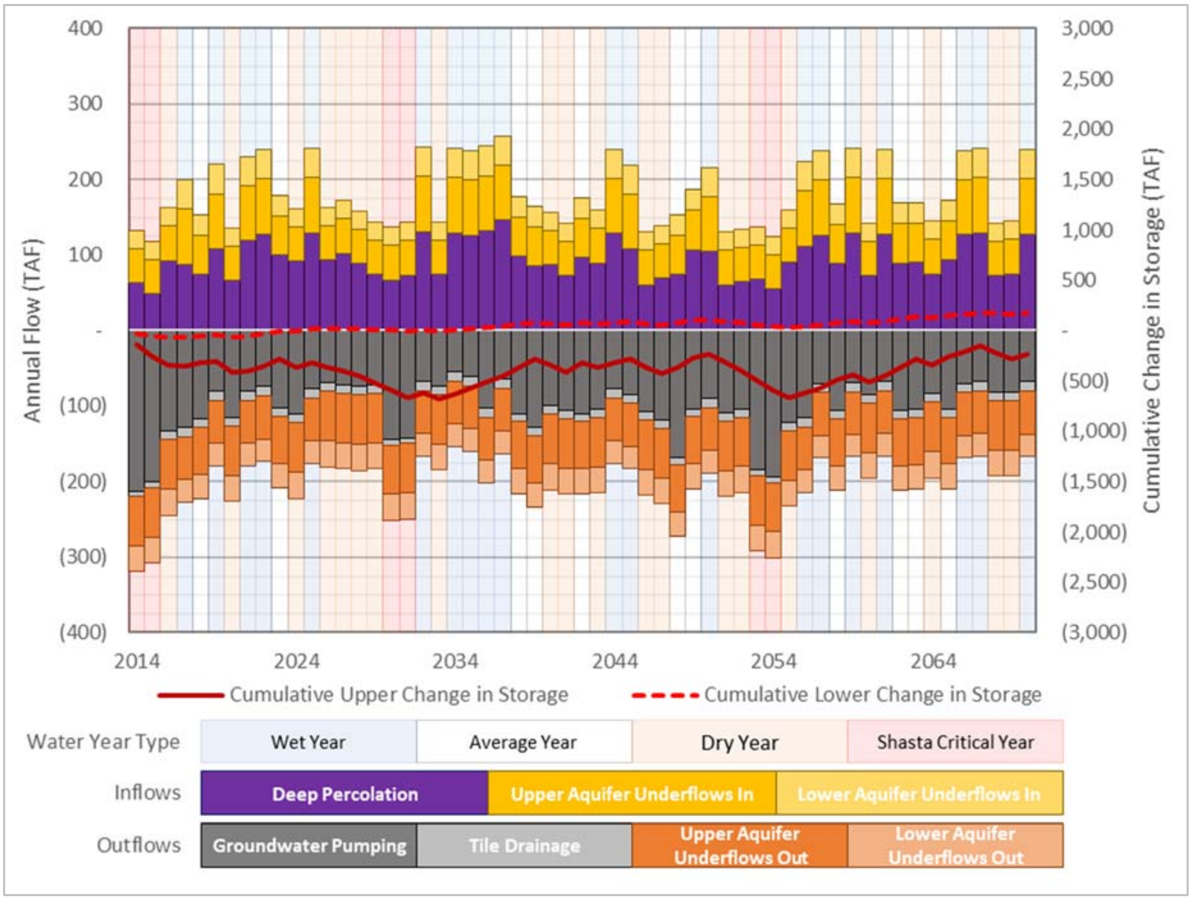

Figure 5-139. Projected Annual Groundwater Budget with Climate Change and Projects & Management Actions (WY2014-2070)

Under projected conditions with CCF and P&MAs, the Northern and Central Delta-Mendota Regions experience, on average, 181,000 AFY of inflow of which 95,000 AFY is from deep percolation, 56,000 AFY is from Upper Aquifer underflows, and 30,000 AFY is from Lower Aquifer underflows (Figure 5-138). A total average annual outflow under the same conditions of 207,000 AFY consists of 102,000 AFY from groundwater pumping, 11,000 AFY from tile drainage, 62,000 AFY of Upper Aquifer underflows, and 32,000 AFY of Lower Aquifer underflows. Overall, there is 26,000 AFY greater outflow than inflow under projected conditions with climate change factors applied and projects & management actions, including balance error, Upper Aquifer losses, and Lower Aquifer losses.

With the addition of CCF and P&MAs, projected long-term declines in groundwater storage are nearly reversed in both principal aquifers on an average annual basis in the Northern and Central Delta-Mendota Regions. From WY2014 to WY2070, average annual change in storage is -4,000 AFY in the Upper Aquifer and +3,000 AFY in the Lower Aquifer (-1,000 AFY total over the 316,000 acres comprising the Northern and Central Delta-Mendota Regions). From WY2034 onward, the Lower Aquifer no longer experiences overdraft conditions. Cumulative change in storage in both the Upper and Lower Aquifer show overall increasing trends over the projected water budget period with the addition of climate change and projects & management actions (Figure 5-139). By WY2070, cumulative change in storage in the Upper Aquifer and Lower Aquifer are -0.75 AF/acre and +0.55 AF/acre, respectively.

By WY2040, cumulative change in storage is -1.09 AF/acre in the Upper Aquifer and +0.22 AF/acre in the Lower Aquifer, for a total GSP-regional change in storage of approximately -0.87 AF/acre. By WY2040, the downward trend of cumulative change in storage has been corrected as compared to projected baseline conditions. However, these water budgets have been developed using approximate methodologies with a projected hydrology and land and water use patterns that are subject to change over the 20-year implementation period. It is anticipated that, as more data are collected and water budgets are refined, that projects and management actions will also be modified as needed to ensure that the sustainability goals for groundwater elevations and storage are achieved.

5.4.11 Sustainable Yield Estimates

Under SGMA, sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." (California Water Code [CWC] 10721(w)). Sustainable yield estimates for the Upper Aquifer and Lower Aquifer have been developed in a coordinated fashion for the entire Delta-Mendota Subbasin by Delta-Mendota Technical Working Group and approved by the Delta-Mendota Coordination Committee.

Upper Aquifer Sustainable Yield Estimate

Methodologies for calculating Upper Aquifer sustainable yield were discussed by both the Delta-Mendota Coordination Committee and an ad-hoc Technical Working Group of the Coordination Committee. During a workshop dedicated to this effort, several basic concepts and principles were discussed to calculate the Upper Aquifer sustainable yield estimate. Consideration was given to several potential options with increasing detail, including some combination of the following: total Subbasin Upper Aquifer pumping volumes, total Subbasin Upper Aquifer change in storage, and Subbasin Upper Aquifer subsurface inflows and outflows. Inflow from certain neighboring subbasins, based on groundwater flow direction, as well as subsurface inflow from the Coast Range at existing gradients (as part of the inflow to the Northern & Central Delta-Mendota Region GSP area) was considered. Outflow to neighboring subbasins at existing gradients was also considered in certain applicable areas along the Delta-Mendota Subbasin boundary based on groundwater flow characteristics.

Based on these considerations, the following formula was selected for estimating Upper Aquifer sustainable yield:

$$Upper\ Aquifer\ Sustainable\ Yield\ = (Pumping + Change\ in\ Storage)\ +\ (Outflow – Inflow)$$

Given existing Subbasin data gaps and uncertainties associated with the data used to develop the water budgets and this estimate, it was also decided that a +/- 10% factor should be applied to determine a range for the Upper Aquifer sustainable yield value. The +/- 10% factor is applied based on the percentage difference between the values from change in storage Subbasin contour mapping for the historic water budget period and reported changes in storage from the Subbasin consolidated historic water budgets (WY2003-2012) for the Upper Aquifer.

The formula for determining Upper Aquifer sustainable yield was applied to the following compiled Delta-Mendota Subbasin projected water budgets (WY2014-2070):

- *Projected Baseline values with Climate Change Factors*
- *Projected Baseline values with Climate Change Factors and Projects and Management Actions*

This analysis resulted in an Upper Aquifer Sustainable Yield estimate ranging from 325,000 AF to 480,000 AF, demonstrating the Subbasin's Upper Aquifer sustainable yield estimated without implementing any projects and management actions (low end of range) and how the Subbasin's Upper Aquifer sustainable yield will be impacted by implementing projects and management actions (high end of range).

The Upper Aquifer sustainable yield values, derived from calculations using the best available, but limited data, are considered to be preliminary estimations only and will be updated to an anticipated higher level of accuracy in future GSP updates. The intention of the Delta-Mendota Subbasin GSAs, following GSP submission in 2020, is to increase Subbasin-wide data collection efforts. Improved data, modeling results, and understanding of subsurface flows will allow the GSAs and each GSP Group to improve estimated sustainable yield values for future GSP updates.

The Upper Aquifer sustainable yield calculated range reflects the principle that the GSAs within the Delta-Mendota Subbasin reserve the right to claim or retain some portion of subbasin outflow generated by the lowering of groundwater levels from neighboring subbasins and the equitable portion of sources of recharge shared between two subbasins, by physical or non-physical means, in the future if the Delta-Mendota Subbasin GSAs determine that doing so will improve Subbasin sustainability or will prevent undesirable results due to chronic lowering of groundwater. Furthermore, intrabasin coordination during GSP development, followed by continuing interbasin coordination discussions and data collection after GSP adoption, will allow the GSAs to further refine these determinations.

<u>Lower Aquifer Sustainable Yield Estimate</u>

Currently, within the Delta-Mendota Subbasin, the distribution of known Lower Aquifer water level data and extraction volume data are not sufficient to allow for an accurate calculation of Lower Aquifer sustainable yield. Following discussions by both the Coordination Committee and the ad-hoc Technical Working Group of the Coordination Committee, a consensus was reached to establish a Lower Aquifer sustainable yield estimate for the Subbasin by evaluating other regional studies previously conducted in the San Joaquin Valley.

The Westlands Water District (WWD) GSA has completed a recent study using groundwater modeling, in conjunction with the Westside GSP development, to estimate sustainable yield for that subbasin. Based on an analysis of available data and an initial assumption of lower aquifer sustainable yield equivalent to approximately 0.35 acre-feet per acre within the Westside Subbasin (Westlands Water District GSA, Groundwater Management Strategy Concepts presentation to the WWD Board on October 16, 2018) the GSA estimates a sustainable yield of 230,000 to 250,000 AF, with historic conditions suggesting a range from 250,000 to 300,000 AF (Westlands Water District GSA, Westside Subbasin's Groundwater Model Forecast and Augmentation Strategies presentation to the WWD Board on April 3, 2019). Using Westlands Water District GSA's analysis, the Coordination Committee recommended a slightly more conservative sustainable yield value of one-third (0.33) an acre-foot per acre for the Delta-Mendota Subbasin. Using this more conservative value, the estimated sustainable yield is approximately 250,000 acre-feet per year over the approximately 750,000-acre subbasin. It should be noted that sustainable management of the Lower Aquifer is governed by significant and unreasonable subsidence rather than sustainable yield. Sustainable yield is not uniform throughout the Subbasin, and it will be the responsibility of each GSA in the Subbasin to manage Lower Aquifer pumping to prevent significant and unreasonable subsidence.

Because DWR classified the Delta-Mendota Subbasin as critically-overdraft due to subsidence issues, the more conservative acre-foot per acre value for a Lower Aquifer sustainable yield estimation is considered valid as a starting point for the Subbasin. Lower Aquifer groundwater extractions may be managed to a stricter criterion in some areas in order to reduce or eliminate the potential for future inelastic land subsidence.

The Lower Aquifer sustainable yield estimate will be refined in the future based on data collected and compiled for the Subbasin. This current sustainable yield approximation highlights the importance of an accepted Subbasin-level subsidence monitoring program concurrent with improved estimates of sub-Corcoran Clay groundwater extractions.

5.5 MANAGEMENT AREAS

This section describes the management areas established for the Northern and Central Regions of the Delta-Mendota Subbasin. The Groundwater Sustainability Plan (GSP) Emergency Regulations § 351(r) states that a "'management area' refers to an area within a basin for which the Plan [GSP] may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, and other factors." Management areas were identified and established pursuant to the requirements under Article 5: Plan Contents, Subarticle 2: Basin Setting, § 354.20 Management Areas of the GSP Emergency Regulations. When a management area is identified, the area must be evaluated based on the sustainability indicators for the Subbasin as a whole. Management area descriptions must include (1) the reason for the creation of each management area; (2) minimum thresholds and measurable objectives established for each management area and an explanation of the rationale for selecting those values, if different from the basin at large; (3) the level of monitoring analysis appropriate for each management area; and (4) an explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area for each sustainability indicators applicable to the Plan Area as a whole. Maps of established management areas for each sustainability indicator are also included within each description, where applicable.

5.5.1 Chronic Lowering of Groundwater Levels

No management areas are delineated for the purposes of managing the chronic lowering of groundwater levels sustainability indicator.

5.5.2 Reduction of Groundwater Storage

No management areas are delineated for the purposes of managing the long-term reduction of groundwater storage sustainability indicator.

5.5.3 Seawater Intrusion

Seawater intrusion is not applicable to the Delta-Mendota Subbasin as a whole, since the Subbasin is located inland from the Pacific Ocean and no known sources of seawater water are present within or surrounding the Subbasin. Therefore, this undesirable result is not applicable to the Delta-Mendota Subbasin and no management areas are delineated.

5.5.4 Degraded Water Quality

No management areas are delineated for the purposes of managing the degraded water quality sustainability indicator.

5.5.5 Land Subsidence

There are two management areas (MAs) established for land subsidence within the Plan Area: the West Stanislaus Irrigation District and Patterson Irrigation District (WSID-PID) MA and the Tranquillity Irrigation District (TRID) MA (Figure 5-140). The WSID-PID MA includes the entirety of the WSID and PID Groundwater Sustainability Agencies (GSAs), located primarily within Stanislaus County and extending into San Joaquin County. The TRID MA is located at the southeastern tip of the Delta-Mendota Subbasin and encompasses both the TRID and Fresno Slough Water District service areas. The following subsections describe the reason for these MAs, an explanation and rationale for selecting minimum thresholds and measurable objectives established for each MA, the level of monitoring and analysis appropriate for each MA, and an explanation of how the established MAs can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the MAs.

5.5.5.1 Reason for Management Areas

The WSID-PID and TRID MAs have been established to better manage progress toward sustainability through sustainable management criteria for the land subsidence sustainability indicator, as detailed in Chapter 6 *Sustainable Management Criteria*. Subsidence in the remaining Northern and Central Delta-Mendota Regions outside of the established MAs has the potential to impact water conveyance infrastructure of statewide importance, which includes the California Aqueduct and Delta-Mendota Canal (DMC) that run nearly the entire length of the remaining Plan Area. The WSID-PID and TRID MAs have been delineated to account for their respective unique, localized circumstances and conditions and to help facilitate implementation of the Plan to aid in achieving the sustainability goal for the Delta-Mendota Subbasin by 2040.

WSID and PID both hold appropriative water rights to divert from the San Joaquin River and contract with the U.S. Bureau of Reclamation for surface water deliveries from the Central Valley Project through diversions off the DMC. With adequate surface water supplies to meet demand within these districts, minimal groundwater pumping occurs from the Lower Aquifer (the primary cause of inelastic land subsidence in the Delta-Mendota Subbasin) within these district's boundaries. As a result, subsidence occurring within this MA is expected to be minimal and is not anticipated to have significant potential to impact water conveyance infrastructure of statewide importance. Impacts to the capacity of WSID's and PID's respective distribution systems as a result of potential increased groundwater pumping-related subsidence and the associated reduced ability to deliver surface water supplies diverted from the San Joaquin River (in addition to the DMC) would trigger an undesirable result or be considered "significant and unreasonable," and necessitates the establishment of this MA.

The TRID MA is established because it is geographically separated from the remainder of the Plan Area and distant from the DMC (Figure 5-140). Impacts from subsidence within the TRID MA are largely related to levees for flood protection and local water conveyance infrastructure, as the California Aqueduct and DMC do not run through the TRID MA. In 2017, the freeboard on the TRID levee system was raised approximately two (2) feet above the maximum flow condition as an emergency effort to counter inelastic land subsidence resulting from the prior drought period. This was done to both protect the local community and farmed lands from inundation and to ensure adequate channel capacity during subsequent wet years. As a result, sustainable management criteria have been established to manage this sustainability indicator according to the unique subsidence-related concerns within the TRID MA (see Chapter 6 *Sustainable Management Criteria* for more detail).

5.5.5.2 Minimum Thresholds and Measurable Objectives

Minimum thresholds and measurable objectives specific to each representative monitoring location within the WSID-PID and TRID MAs, as well as those for the remaining Plan Area, and the rationale for selecting values can be found in Chapter 6 *Sustainable Management Criteria*.

The minimum thresholds and measurable objectives specific to each representative monitoring site within the WSID-PID and TRID MAs are identified in Table 5-35. For monitoring sites within the WSID-PID MA, numeric values for minimum thresholds and measurable objectives will be developed following data collection efforts occurring between 2020 and 2025 and will be included in the first 5-Year Update to this GSP. Subsidence monitoring benchmarks were constructed within the WSID-PID MA due to subsidence impacts observed along the DMC in Stanislaus County. However, land surface elevation measurements at these benchmarks has not formally commenced and therefore data are limited in the respective MAs. Without available historical data to establish numeric minimum thresholds and measurable objectives, benchmark surveys will be performed within the first five (5) years of GSP implementation to develop numeric criteria to evaluate progress toward sustainability within the WSID-PID MA. As such, the minimum thresholds and measurable objectives for each representative monitoring site have been set as "to be determined" (TBD) until sufficient data are collected to establish these numeric values.

For the TRID MA, minimum thresholds and measurable objectives in ground surface elevation (in feet relative to the North American Vertical Datum of 1988 [NAVD88] or [ft ground surface elevation (GSE)]) at each representative monitoring site are identified in Table 5-35. These values have been established relative to the identified level of tolerance for additional subsidence relative to 2019 levee elevations. An additional two (2) feet of subsidence and an additional four (4) feet of subsidence relative to 2019 levee elevations have been set as the measurable objective and minimum threshold, respectively, for each land subsidence representative monitoring site within the TRID MA. These values for additional subsidence tolerance were established based on professional judgement, local knowledge, and the 2017 emergency levee freeboard increase.

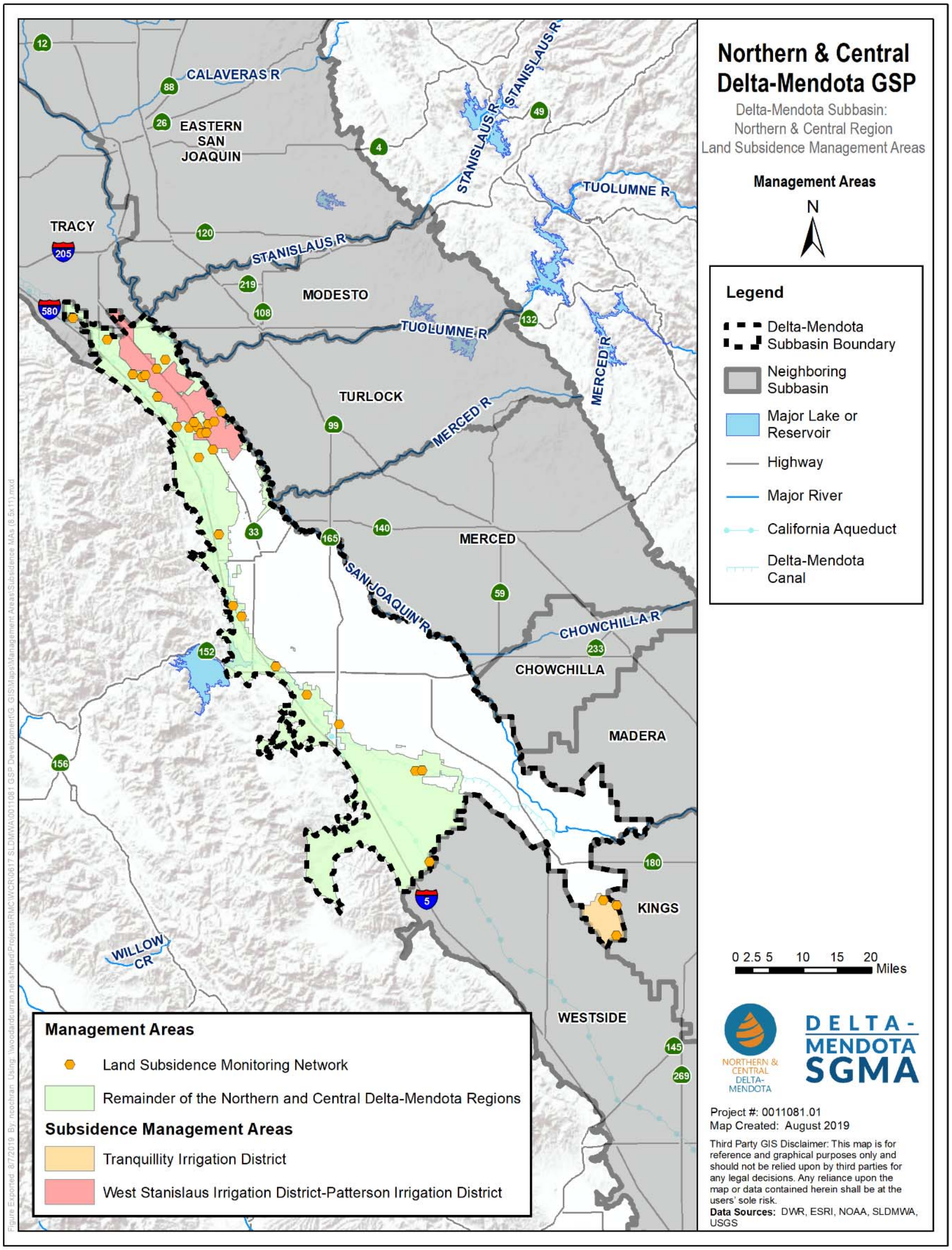

Figure 5-140. Subsidence Management Areas, Northern and Central Delta-Mendota Regions

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Table 5-35. Minimum Thresholds and Measurable Objectives for Subsidence Management Areas

Primary ID	Local ID	Agency	County	Management Area	Baseline Elevation [1]	Minimum Threshold	Measurable Objective
03-004	Locust Avenue Well	PID	Stanislaus	WSID-PID	TBD	TBD	TBD
03-005	Pumping Plant No. 2	PID	Stanislaus	WSID-PID	TBD	TBD	TBD
03-006	River Station	PID	Stanislaus	WSID-PID	TBD	TBD	TBD
04-002	WSID 1	WSID	Stanislaus	WSID-PID	TBD	TBD	TBD
04-003	WSID 11	WSID	Stanislaus	WSID-PID	TBD	TBD	TBD
04-004	WSID 21	WSID	Stanislaus	WSID-PID	TBD	TBD	TBD
07-019	AG-24	TRID	Fresno	TRID	157.77 ft GSE	153.77 ft GSE	155.77 ft GSE
07-025	TID A	TRID	Fresno	TRID	160.54 ft GSE	156.54 ft GSE	158.54 ft GSE
07-026	TID B	TRID	Fresno	TRID	169.22 ft GSE	165.22 ft GSE	167.22 ft GSE

TBD – To Be Determined
[1] Baseline elevation surveys will be performed for the monitoring sites in the WSID-PID MA by the end of calendar year 2019

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5.5.5.3 Monitoring and Analysis

GSP Emergency Regulations § 354.34(f) indicates: "If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area." For more information regarding the level of monitoring and analysis appropriate for each management area, refer to Section 7.2.5.5 *Land Subsidence Monitoring Network* of the *Sustainability Implementation* chapter.

The WSID-PID MA is approximately 58 square miles (mi^2) and the TRID MA is approximately 19 mi^2. The land subsidence monitoring network contains six (6) sites within the WSID-PID MA and three (3) sites within the TRID MA. Based on California Department of Water Resources' (DWR) recommendations as well as professional judgement, the selected number of monitoring sites within the WSID-PID and TRID MAs is sufficient to evaluate the land subsidence sustainability indicator relative to the sustainable management criteria established for each MA.

Each subsidence benchmark monitoring site will be surveyed and data will be analyzed and recorded annually within the TRID MA and during three (3) separate elevation surveys performed over the next five years within the WSID-PID MA. As there are no recorded issues related to conveyance capacity, stable groundwater levels, and substantial surface water supplies within this MA, subsidence is less of a concern in the WSID-PID MA compared to the remaining Plan Area. Baseline elevation measurements will be established in 2019 as reference for all representative monitoring sites within this MA, where subsequent elevation surveys at representative monitoring sites will be performed by the end of calendar year 2020 (in preparation for the 2021 Annual Report) and by the end of calendar year 2023 (in preparation for the 5-Year GSP Update in 2025). Measurements will be taken following seasonal high groundwater levels to capture the amount of inelastic subsidence occurring from the previous irrigation season(s). Monitoring frequency within the WSID-PID and TRID MAs will be reevaluated as part of the 5-Year GSP Update in 2025. For more detail regarding the level of monitoring and analysis appropriate for each management area, refer to Section 7.2.5.5 *Land Subsidence Monitoring Network* of the *Sustainability Implementation* chapter.

5.5.5.4 Operation and Outside Impacts

Due to ample surface water supplies available within the WSID-PID MA, it is unlikely that the minimal Lower Aquifer groundwater pumping currently occurring within this MA will significantly contribute to undesirable results related to inelastic land subsidence. The WSID-PID MA abuts the San Joaquin River Exchange Contractors (SJREC) GSP Group who, similarly, due to ample surface water supplies, is not currently experiencing significant levels of inelastic land subsidence from pumping within their Plan area. Due to the requirements that subbasins with multiple GSPs coordinate in the development and implementation of their GSPs, the Northern & Central Delta-Mendota Region and SJREC GSP Groups coordinated in the development of their land subsidence monitoring networks and data collection methodologies, as well as sustainable management criteria development, within and around the WSID-PID MA. The Northern & Central Delta-Mendota Region and SJREC GSP Groups will continue to coordinate as their respective GSPs are implemented to ensure land subsidence monitoring in the WSID-PID MA is adequate and necessary action is taken to prevent undesirable results outside the MA.

The TRID MA is geographically separate from the rest of the Northern & Central Delta-Mendota Region GSP Plan area. Therefore, based on professional judgement, it is unlikely that operation under different minimum thresholds and measurable objectives will cause undesirable results outside of the MA. The TRID MA abuts the Fresno County Management Area A & B (Fresno County) GSP Plan area. Due to the requirements that subbasins with multiple GSPs coordinate in the development and implementation of their GSPs, the Northern & Central Delta-Mendota Region and Fresno County GSP Groups coordinated in the development of their land subsidence monitoring networks and data collection methodologies, as well sustainable management criteria within and around the TRID MA. The Northern & Central Delta-Mendota Region and Fresno County GSP Groups will continue to coordinate as their respective GSPs are implemented to ensure land subsidence monitoring in the TRID MA is adequate and necessary actions are taken to prevent undesirable results outside the MA.

5.5.6 Depletion of Interconnected Surface Water

No management areas are delineated for the purposes of managing the depletions of interconnected surface water sustainability indicator.

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Section 6

Sustainable Management Criteria

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6. SUSTAINABLE MANAGEMENT CRITERIA

This chapter describes sustainable management criteria defining undesirable results in the Northern and Central Regions of the Delta-Mendota Subbasin and establishing the objectives by which Subbasin Groundwater Sustainability Agencies (GSAs) will obtain sustainable use of groundwater in Subbasin. Sustainability criteria defined herein include minimum thresholds and measurable objectives for each applicable sustainability indicator, pursuant to the Groundwater Sustainability Plan (GSP) Emergency Regulations Article 5 *Plan Contents*, Subarticle 3 *Sustainable Management Criteria* (§ 354.22 through 354.30).

The following criteria for each sustainability indicator applicable to the Plan area are described herein:

- Sustainability Goal
- Undesirable Results
- Minimum Thresholds
- Measurable Objectives
- Interim Milestones

The Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as “the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results” (California Water Code Section 10721). Sustainable Groundwater Management Criteria, or SMC, were developed using information presented in Chapter 5 *Basin Setting*. Input from Subbasin stakeholders was accepted and incorporated into the established SMC through discussion and presentation at public workshops and meetings of the following groups throughout the GSP development process: Northern and Central Delta-Mendota Technical Working Group, Northern and Central Delta-Mendota Region Management Committees, Delta-Mendota Subbasin Technical Working Group, and the Delta-Mendota Subbasin Coordination Committee.

The SMC developed for the Northern and Central Delta-Mendota Regions will be used to assess progress toward achieving the sustainability goal for the Delta-Mendota Subbasin. The Northern & Central Delta-Mendota Region GSP Group will continue to coordinate with the other GSP Groups in the Subbasin as each GSP is implemented to ensure actions of neighboring GSP Groups do not cause undesirable results for another GSP Group and that, collectively, progress is made towards achieving the Subbasin sustainability goal by 2040. Similarly, the Northern and Central Delta-Mendota Regions will continue to coordinate with adjacent subbasins (Tracy, Modesto, Turlock, Westside, and Kings) regarding SMC and ensuring activities within the Plan area do not cause undesirable results for adjacent subbasins.

6.1 USEFUL TERMS

A list and description of technical terms used throughout this section to discuss Sustainable Management Criteria are listed below. Figure 6-1 shows a graphic demonstrating the relationship between the Sustainable Management Criteria terms using groundwater elevation as an example. The terms and their descriptions are identified here to guide readers through this section and are not a definitive definition of each term.

- Undesirable Result – Significant and unreasonable negative impacts associated with each sustainability indicator, avoidance of which is used to guide development of GSP components.
- Minimum Threshold – Quantitative threshold for each sustainability indicator used to define the point at which undesirable results may begin to occur.
- Measurable Objective – Quantitative target that establishes a point above the minimum threshold that allows for a range of active management in order to prevent undesirable results.

- **Interim Milestones** – Targets set in increments of five years over the implementation period of the GSP to put the basin on a path to sustainability.
- **Margin of Operational Flexibility** – The range of active management between the measurable objective and the minimum threshold.

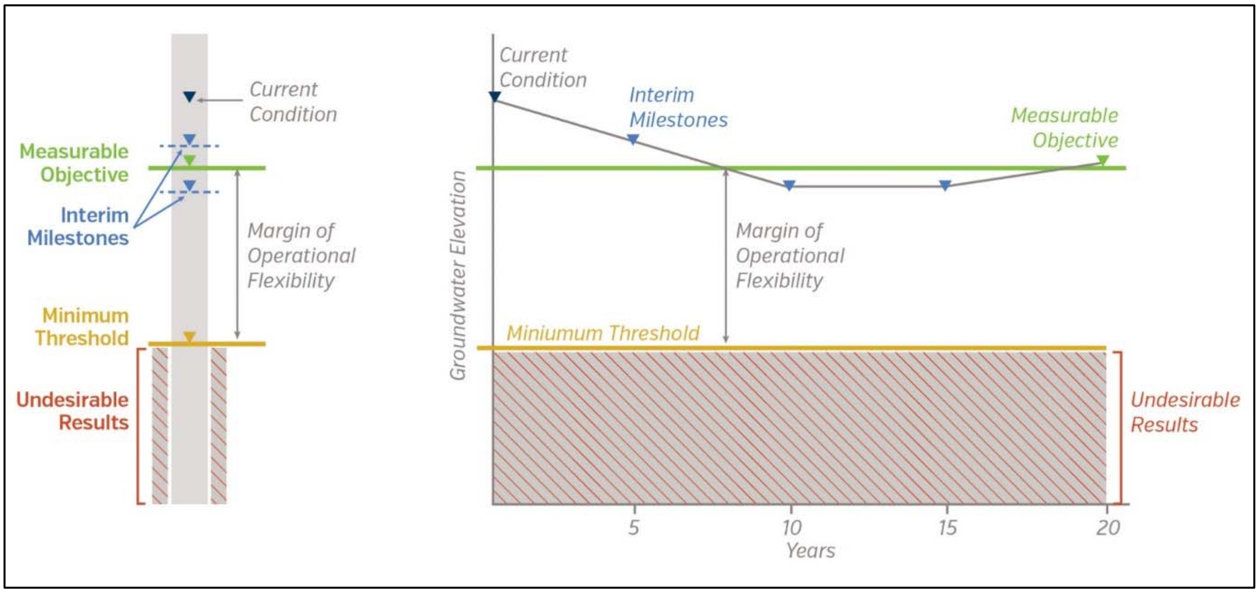

Figure 6-1. Sustainable Management Criteria Definitions Graphic (Groundwater Elevation Example)

6.2 SUSTAINABILITY GOAL

The sustainability goal for the Delta-Mendota Subbasin was established to succinctly state the objectives and desired conditions of the Subbasin that culminates in the absence of undesirable results by 2040. The sustainability goal for the Delta-Mendota Subbasin is as follows and was approved by the Delta-Mendota Coordination Committee:

> The Delta-Mendota Subbasin will manage groundwater resources for the benefit of all users of groundwater in a manner that allows for operational flexibility, ensures resource availability under drought conditions, and does not negatively impact surface water diversion and conveyance and delivery capabilities. This goal will be achieved through the implementation of the proposed projects and management actions to reach identified measurable objectives and milestones through the implementation of the GSP(s), and through continued coordination with neighboring subbasins to ensure the absence of undesirable results by 2040.

The sustainability goal described above was developed based on information presented in Chapter 5 *Basin Setting*. Conjunctive use of groundwater and surface water is prevalent throughout the Delta-Mendota Subbasin, where many water purveyors and private landowners pump groundwater and receive surface water deliveries from the San Joaquin River, the Kings River, the Central Valley Project (CVP) via the Delta-Mendota Canal, and the State Water Project (SWP) via the California Aqueduct. Operational flexibility is critical for many agencies within the Delta-Mendota Subbasin to allow for increased use of groundwater when surface water supplies are reduced or unavailable during prolonged dry periods. Additionally, operational flexibility allows for the storage of surface water supplies or groundwater recharge during wet periods for recovery and use during dry periods, as well as to manage other undesirable results such as inelastic land subsidence as a result of Lower Aquifer pumping.

In order to make progress in meeting the sustainability goal, locally-defined minimum thresholds and measurable objectives have been established for the Northern & Central Delta-Mendota Region GSP Group to define the 'operating range' of the groundwater subbasin. These criteria were developed in a coordinated fashion with the other

GSP Groups in the Subbasin, where definitions of undesirable results were developed and approved by all GSP Groups within the Subbasin for each sustainability indicator.

Each GSP Group is responsible for managing to locally-derived applicable sustainability indicators so conditions are improved as a whole and the Subbasin is sustainably managed by 2040. Projects and management actions, as detailed in Section 7.1 *Projects & Management Actions*, were selected to address adverse conditions and mitigate undesirable results within the Plan area. For more information about sustainable yield and the projects and management actions to be implemented during the 20-year implementation period, refer to Section 5.4.11 *Sustainable Yield* of the *Basin Setting* and Section 7.1.

Over the GSP planning and implementation horizon, Subbasin conditions are expected to fluctuate relative to minimum thresholds, measurable objectives, and interim milestones as projects and management actions are implemented and basin operations are modified to make progress toward sustainability. It is anticipated that, despite seasonal and short-term fluctuations, the Plan area and Subbasin will be managed to prevent undesirable results. Demonstration of the absence of undesirable results will support a determination that the Subbasin is operating within its sustainable yield and result in the conclusion that the sustainability goal has been achieved by 2040 and sustainability will be maintained beyond 2040.

6.3 SUSTAINABILITY THRESHOLDS

The following subsections present undesirable results, minimum thresholds, measurable objectives, and interim milestones for the following sustainability indicators:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage
- Degraded water quality
- Seawater intrusion (not applicable to the Delta-Mendota Subbasin)
- Land subsidence
- Depletions of interconnected surface water

6.3.1 Chronic Lowering of Groundwater Levels

Undesirable results, minimum thresholds, measurable objectives, and interim milestones for the chronic lowering of groundwater levels sustainability indicator are described in the subsequent subsections.

6.3.1.1 Undesirable Results

A description of undesirable results as defined under SGMA and by the Delta-Mendota Subbasin GSAs, identification of undesirable results, potential causes of undesirable results, and potential effects of undesirable results relative to the chronic lowering of groundwater levels sustainability indicator are detailed below.

6.3.1.1.1 Description of Undesirable Results

The undesirable result related to groundwater levels is defined under SGMA as:

> *Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods* (California Water Code [CWC] Section 10721(x)(1)).

An undesirable result for chronic lowering of groundwater levels in the Delta-Mendota Subbasin is experienced through *significant and unreasonable chronic change in water levels, as defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through intra- and/or inter-basin actions*. This Subbasin-wide definition of an undesirable result was agreed upon by all GSP Groups through the Delta-Mendota Subbasin Coordination Committee. Public feedback was considered in defining an undesirable result for the chronic lowering of groundwater levels based on stakeholder participation at public workshops held in May 2019.

6.3.1.1.2 Identification of Undesirable Results

An undesirable result for chronic lowering of groundwater levels is triggered, or conditions are deemed "significant and unreasonable," when groundwater elevations drop below the site-specific minimum threshold at 40 percent of representative monitoring wells in a principal aquifer in the Northern and Central Delta-Mendota Regions concurrently over a given year (7 out of 17 wells in the Upper Aquifer and/or 8 out of 18 wells in the Lower Aquifer). If these conditions were to occur, it is anticipated that shallow domestic wells in the same subregion as the representative monitoring points in exceedance of the minimum threshold would go dry and/or these conditions would result in higher pumping costs and/or the need to modify wells to obtain groundwater (for more information about monitoring network subregions, refer to Section 7.2 *Monitoring* of the *Sustainability Implementation* chapter).

6.3.1.1.3 Potential Causes of Undesirable Results

The Delta-Mendota Subbasin is currently designated as a critically overdrafted basin by the California Department of Water Resources (DWR). Potential causes of undesirable results resulting from the chronic lowering of groundwater levels could include insufficient pumping offsets or reductions that result in localized or Plan area-wide lowering of groundwater elevations. Delays in implementation of projects or management actions due to increased demands or regulatory, permitting or funding obstacles may also cause undesirable results. Additionally, regulatory requirements placed on CVP and SWP operations, as well as instream flow requirements on the San Joaquin River and its tributaries, have and will continue to have negative impacts on surface water supplies available to the Subbasin, resulting in increased reliance on groundwater resources within the Delta-Mendota Subbasin and potentially resulting in the chronic lowering of groundwater levels.

6.3.1.1.4 Potential Effects of Undesirable Results

If groundwater levels in either of the two principal aquifers (Upper Aquifer and Lower Aquifer) were to reach levels causing undesirable results, dewatering of wells could occur, beginning with shallow domestic wells where many residents and communities rely on groundwater as their sole potable water supply. Groundwater levels (piezometric head) in the Lower Aquifer could be reduced to the point where significant and unreasonable inelastic land subsidence is observed, thus impacting land use and water conveyance capacity. There are also parts of the Plan area where no groundwater pumping occurs, and thus GSAs have no control over groundwater levels. As such, there is the potential for undesirable results to occur in these areas of no groundwater pumping.

Reduced groundwater levels could result in surface water depletions that may impact beneficial uses of interconnected surface water within the Plan area. Similarly, significantly declining groundwater elevations could also impact productive agriculture. Municipal users of groundwater may be impacted where groundwater is the primary or sole supply source, such as for the City of Patterson and the communities of Grayson and Westley. Potable water supply costs for municipalities are likely to increase in the event of undesirable results due to a need to deepen wells, increased power-related costs to lift the water, a need for new wells, and/or if municipalities are forced to seek supplemental or alternative potable water supplies, such as surface water.

6.3.1.2 Minimum Thresholds

The minimum thresholds for the chronic lowering of groundwater levels sustainability indicator are set as the hydrologic low for wells perforated in the Upper Aquifer (above the Corcoran Clay) and 95 percent of the hydrologic low for wells perforated in the Lower Aquifer (below the Corcoran Clay) over the available hydrographs on record. It should be noted that for Upper Aquifer wells, minimum thresholds are based on the hydrologic lows comparable to the last drought period and at these levels, significant impacts are not anticipated to occur for drinking water users, including domestic well users. Figure 6-2 and Figure 6-3 show the locations of groundwater level representative monitoring wells in the Upper Aquifer and Lower Aquifer, respectively. Table 6-1 and Table 6-2 show the minimum thresholds at each representative monitoring site in the Upper Aquifer and Lower Aquifer, respectively, for the chronic lowering of groundwater levels sustainability indicator in feet above mean sea level (msl) relative to the North American Vertical Datum of 1988 (NAVD88). Hydrographs for all representative wells demonstrating the minimum threshold can be found in Appendix E.

To develop these minimum thresholds, the Northern and Central Delta-Mendota Technical Advisory Committee (TAC) examined available hydrographs throughout the Plan area. In 2015, groundwater levels in both the Upper Aquifer and Lower Aquifer were at or near historic lows. Groundwater levels in both primary aquifers were at or near historic highs in 2017, where in only two years groundwater levels increased from near historic lows at the height of the drought to near historic highs. Based on observations, technical understanding and local knowledge, it was concluded that groundwater levels in both the Upper Aquifer and Lower Aquifer have the potential to rebound after dry years, even if levels where undesirable results are observed are reached (e.g. post-2015). Therefore, the hydrologic low (Water Year [WY] 2015 in most cases) was deemed appropriate for setting the minimum threshold for the Upper Aquifer.

In the Lower Aquifer, undesirable results related to land subsidence were observed when comparing subsidence rates to 2015 groundwater levels, which were at or near historic lows. Subsidence rates were seen to decrease as Lower Aquifer groundwater elevations rose from the historic low groundwater elevations during the subsequent recovery period. As inelastic land subsidence is not recoverable, based on professional judgement and local knowledge, minimum thresholds of 95 percent of the hydrologic low was deemed appropriate as a starting point for the Lower Aquifer based on current information available. The Lower Aquifer minimum threshold will be reevaluated during the first GSP update and revised, as necessary, to determine if 95 percent of the hydrologic low provides an appropriate buffer to avoid an undesirable result for the chronic lowering of groundwater levels and land subsidence sustainability indicators.

The location of the Corcoran Clay layer, which subdivides the Upper Aquifer and Lower Aquifer, and inelastic land subsidence observed in correlation with Lower Aquifer pumping largely dictates the differences in characteristics and response of the two principal aquifers. This warrants different methodologies for setting minimum thresholds for representative monitoring points in the Upper Aquifer versus Lower Aquifer. As previously stated, by examining available hydrographs in both aquifers, similar trends were observed in aquifer response as conditions were at or near hydrologic lows in 2015 and rebounded to at or near hydrologic highs in 2017. Thus, it was deemed appropriate that the methodology for setting minimum thresholds is the same at each representative site for the Upper Aquifer and Lower Aquifer, respectively, but different based on principal aquifer. Minimum thresholds for groundwater levels have been set for the Lower Aquifer, where groundwater pumping from the Lower Aquifer is the primary cause of inelastic land subsidence, to avoid undesirable results by including a 5 percent buffer, resulting in thresholds set at 95 percent of the hydrologic low.

The subbasins adjacent to the Northern & Central Delta-Mendota Region GSP Group include the Tracy, Modesto, Turlock, Merced, Westside, and Kings subbasins. The GSPs for the Tracy, Modesto, and Turlock Subbasins are not due to DWR until January 2022, therefore evaluation of how minimum thresholds for chronic lowering of groundwater levels in the Northern and Central Delta-Mendota Regions affect the ability of these adjacent basins to achieve their sustainability goals will be evaluated in subsequent annual reports, during the GSP updates, and through on-going coordination efforts with these adjoining subbasins. Interbasin coordination has occurred to some extent with the Merced, Westside and Kings subbasins; however, time limitations have resulted in limited detailed discussions. As with the other three adjoining subbasins, ongoing coordination will occur during GSP implementation and will be reflected in the GSP updates.

Beneficial uses and users of groundwater, including domestic, municipal, agricultural and environmental use and their associated land uses and property interests, were considered in establishing minimum thresholds for the chronic lowering of groundwater levels sustainability indicator. Stakeholders, including the public, were invited to provide feedback on minimum thresholds during Working Group meetings and during public workshops centered around SMC held throughout the Delta-Mendota Subbasin in May 2019. Northern and Central Delta-Mendota regional representatives from the municipal and agricultural sectors are Working Group members and provided input in setting the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator throughout the development process. Municipal and agricultural representatives stated that setting the minimum thresholds as the hydrologic low for the Upper Aquifer and 95 percent of the hydrologic low for the Lower Aquifer were not likely to cause an undesirable result, based on observed conditions and impacts to operations during the most recent drought. Domestic wells are generally shallower than agricultural and municipal wells and thus more sensitive to undesirable results. Additionally, the loss of a domestic well usually results in a loss of water for consumption, cooking, and sanitary purposes, which can often have substantial impacts on the users of the water and can be financially difficult for the well owner to replace. Based on local knowledge and experience during the last drought, setting the minimum threshold for the Upper Aquifer as the hydrologic low (analogous to WY2015 groundwater elevations in most places) is protective of an undesirable result for chronic lowering of groundwater levels.

Currently, there are no other State, federal, or local standards within the Plan area that relate to the chronic lowering of groundwater levels sustainability indicator in the Northern and Central Delta-Mendota Regions. SGMA is the prevailing legislation dictating requirements and standards for the chronic lowering of groundwater levels sustainability indicator. Any future State, federal, or local standards that relate to the chronic lowering of groundwater levels sustainability indicator will be evaluated and considered in potential modifications to minimum thresholds during subsequent updates to this GSP.

For information regarding how minimum thresholds for the chronic lowering of groundwater levels will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to Section 7.2.5.1 *Groundwater Level Monitoring Network* of the *Sustainability Implementation* chapter.

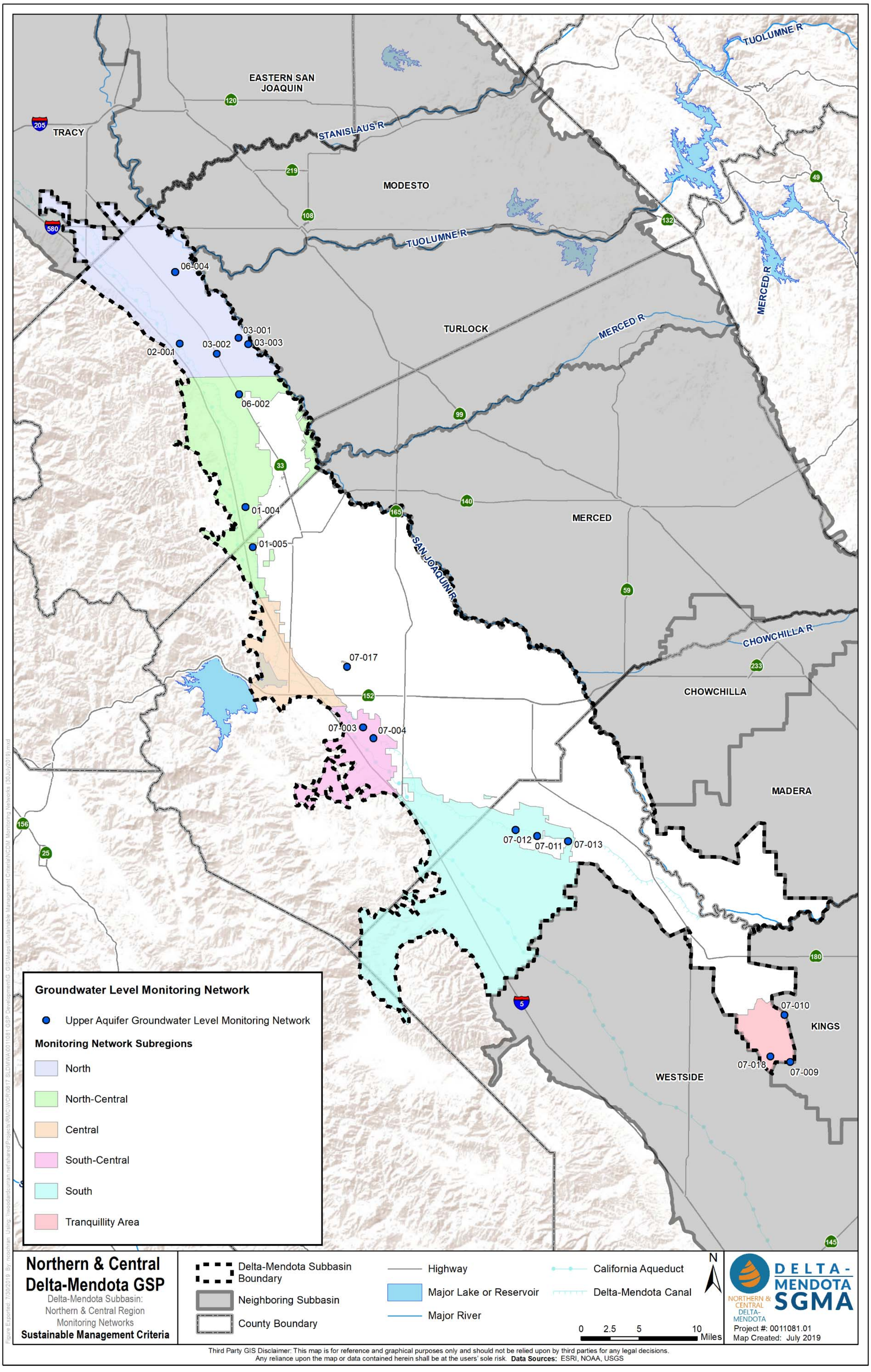

Figure 6-2. Location of Representative Monitoring Wells for Groundwater Levels, Upper Aquifer

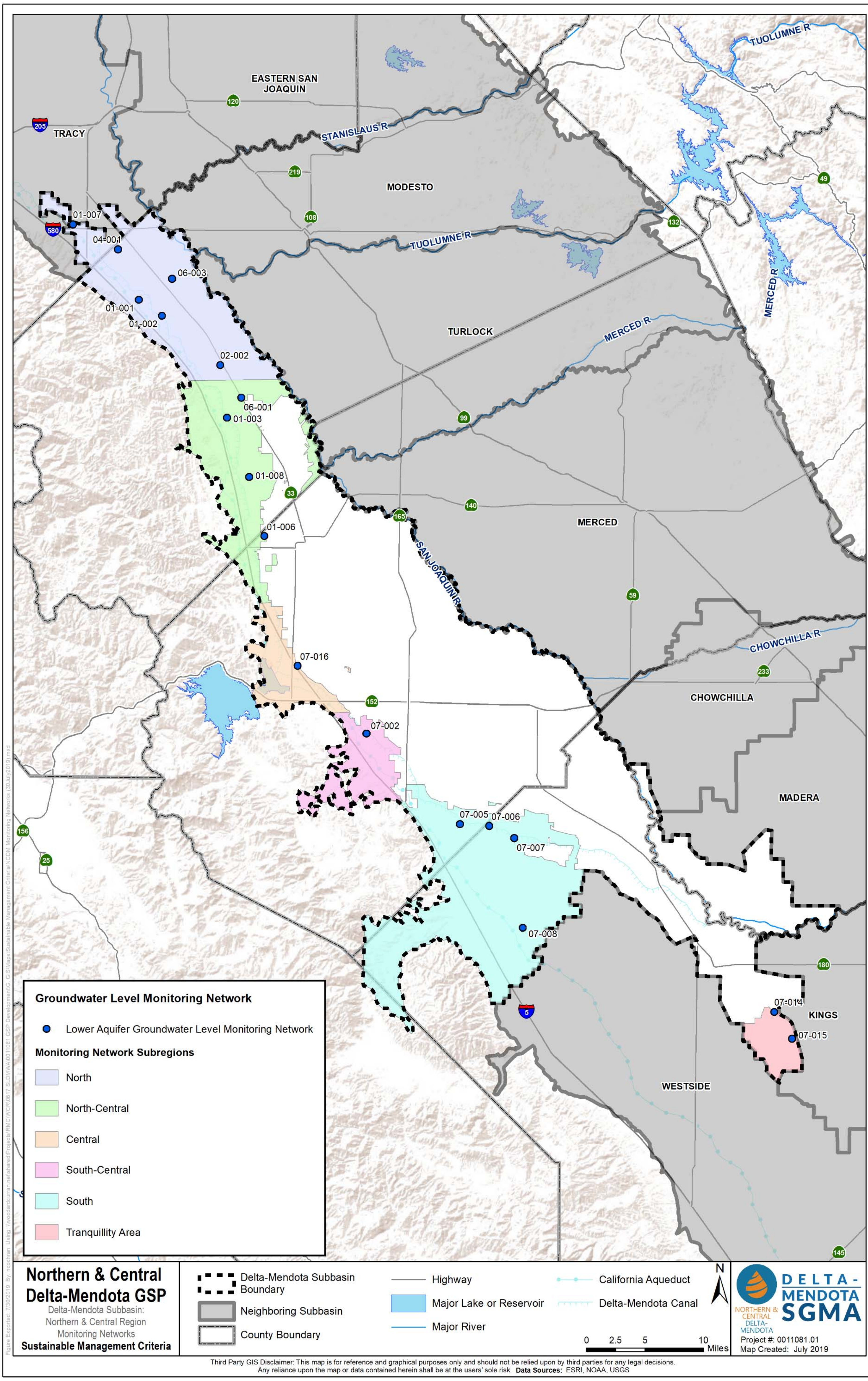

Figure 6-3. Location of Representative Monitoring Wells for Groundwater Levels, Lower Aquifer

Table 6-1. Minimum Thresholds for Chronic Lowering of Groundwater Levels, Upper Aquifer

Narrative Description				
The minimum threshold is the hydrologic low over the available hydrograph record.				
Numeric Minimum Thresholds – Chronic Lower of Groundwater Levels in Upper Aquifer				
Data Management System (DMS) ID	State Well Number	CASGEM ID (if applicable)	Local ID	Minimum Threshold (feet above msl NAVD88)
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	-49.1
06-004			MP031.31L1-L2Well1	14.8
03-001		375015N1211011W001	MW-2	25.40
03-002			MW-3	4.39
03-003	05S/08E-16R		WSJ003	30.7
06-002	06S08E09E003M	374316N1210994W003	P259-3	28.6
01-004	07S08E28R002M	372907N1210875W002	MC10-2	158.8
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	83.9
07-017			Well 1	9.4
07-003	10S10E32L002M	370173N1208999W002	MC15-2	62.4
07-004	11S10E04L001M		MP081.08R	58.2
07-011		368835N1206270W001	MP099.24L	-52.63
07-012	12S/12E-16B		GDA003	-41.1
07-013			MP102.04R	-15.9
07-010		366500N1202500W001	KRCDTID02	72.7
07-009		366000N1202300W001	KRCDTID03	60.3
07-018	15S/16E-20		WSJ001	60.3

Table 6-2. Minimum Threshold for Chronic Lowering of Groundwater Levels, Lower Aquifer

Narrative Description				
The minimum threshold is 95 percent of the hydrologic low for the available hydrograph record.				
Numeric Minimum Thresholds – Chronic Lower of Groundwater Levels in Lower Aquifer				
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Minimum Threshold (feet above msl NAVD88)
01-007			MP021.12L	-12.0
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	-16.3
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	-34.3
06-003		375774N1212096W001	WSID 3	-8.6
02-002			WELL 02 - NORTH 5TH STREET	-17.4
06-001	06S08E09E001M	374316N1210994W001	P259-1	-6.6
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	-20.7
04-001		376129N1212942W001	121	-6.1
01-008			MP051.66L	-42.6
01-006		372604N1210611W001	91	72.3
07-016			Well 01	-10.5
07-002	10S10E32L001M	370173N1208999W001	MC15-1	84.5
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	-80.4
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	-77.8
07-007	12S12E16E003M	368896N1206702W001	MC18-1	-50.8
07-008	13S12E22F001M	367885N1206510W001	PWD 48	-87.4
07-014			TW-4	-126.8
07-015			TW-5	-146.8

6.3.1.3 Measurable Objectives and Interim Milestones

Measurable objectives are quantitative goals that reflect the desired Plan area conditions and allow the Subbasin to achieve the sustainability goal. The measurable objective is set to allow a reasonable margin of operational flexibility (Margin) between the measurable objective and minimum threshold for the active management of the groundwater basin. The Margin is intended to accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities. The purpose of establishing measurable objectives is to define specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions, thereby defining the range of operational flexibility for basin management.

For the chronic lowering of groundwater levels sustainability indicator, the measurable objective is set as the lowest value of three possible parameters – the average of historic seasonal highs over the available hydrograph, Spring 2012 seasonal high, or Spring 2017 seasonal high (where seasonal high and Spring are synonymous and defined as measurements taken between February and April). Table 6-3 and Table 6-4 list the measurable objectives for each representative monitoring well in the Upper Aquifer and Lower Aquifer, respectively, in feet above msl NAVD88. Hydrographs for each representative monitoring site, when available, that show the minimum threshold and measurable objective for that location are located in Appendix E.

To assist the Plan area in reaching the measurable objectives for groundwater levels by 2040, interim milestones are established for 2025, 2030, and 2035 as a means of assessing progress towards the Regions' sustainability goal. In cases where the measurable objective has been achieved (as was the case in 2017, the most recent dataset reviewed for the Northern and Central Delta-Mendota Regions), the interim goals reflect overall objective of maintaining those water levels. The interim milestones for chronic lowering of groundwater levels are therefore set as follows:

- Year 5 (2025): Maintain groundwater elevations comparable to 2012/2017 hydrologic highs and lows
- Year 10 (2030): Maintain groundwater elevations comparable to 2012/2017 hydrologic highs and lows
- Year 15 (2035): Maintain groundwater elevations comparable to 2012/2017 hydrologic highs and lows

The established measurable objectives and interim milestones will aid in achieving the sustainability goal within 20 years of Plan implementation.

Table 6-3. Measurable Objective for Chronic Lowering of Groundwater Levels, Upper Aquifer

Narrative Description				
The measurable objective is set at the lowest value of three parameters: the average historic seasonal high over the available hydrograph, Spring 2012 seasonal high, or Spring 2017 seasonal high.				
Numeric Measurable Objectives – Chronic Lower of Groundwater Levels in Upper Aquifer				
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Measurable Objective (feet above msl, NAVD88)
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	22.0
06-004			MP031.31L1-L2Well1	38.9
03-001		375015N1211011W001	MW-2	-29.90
03-002			MW-3	23.89
03-003	05S/08E-16R		WSJ003	29.90
06-002	06S08E09E003M	374316N1210994W003	P259-3	40.3
01-004	07S08E28R002M	372907N1210875W002	MC10-2	160.8
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	108.5
07-017			Well 1	79.7
07-003	10S10E32L002M	370173N1208999W002	MC15-2	71.6
07-004	11S10E04L001M		MP081.08R	90.1
07-011		368835N1206270W001	MP099.24L	12.1
07-012	12S/12E-16B		GDA003	24.7
07-013			MP102.04R	34.9
07-010		366500N1202500W001	KRCDTID02	96.3
07-009		366000N1202300W001	KRCDTID03	70.5
07-018	15S/16E-20		WSJ001	70.5

Table 6-4. Measurable Objective for Chronic Lowering of Groundwater Levels, Lower Aquifer

Narrative Description				
The measurable objective is set at the lowest value of three parameters: the average historic seasonal high over the available hydrograph, Spring 2012 seasonal high, or Spring 2017 seasonal high.				
Numeric Measurable Objectives – Chronic Lower of Groundwater Levels in Lower Aquifer				
Primary Well ID	State Well Number	CASGEM ID (if applicable)	Local ID	Measurable Objective (feet above msl, NAVD88)
01-007			MP021.12L	15.5
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	16.5
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	6.6
06-003		375774N1212096W001	WSID 3	31.3
02-002			WELL 02 - NORTH 5TH STREET	24.7
06-001	06S08E09E001M	374316N1210994W001	P259-1	45.7
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	63.8
04-001		376129N1212942W001	121	7.8
01-008			MP051.66L	8.5
01-006		372604N1210611W001	91	84.4
07-016			Well 01	71.7
07-002	10S10E32L001M	370173N1208999W001	MC15-1	126.7
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	-34.3
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	-28.8
07-007	12S12E16E003M	368896N1206702W001	MC18-1	-2.0
07-008	13S12E22F001M	367885N1206510W001	PWD 48	-49.0
07-014			TW-4	-28.2
07-015			TW-5	-27.2

6.3.2 Reduction of Groundwater Storage

Undesirable results, minimum thresholds, measurable objectives, and interim milestones for the reduction in groundwater storage sustainability indicator are described in the subsequent subsections.

6.3.2.1 Undesirable Results

A description of undesirable results as defined under SGMA and by the Delta-Mendota Subbasin GSAs, identification of undesirable results, potential causes of undesirable results, and potential effects of undesirable results relative to the reduction in groundwater storage sustainability indicator are detailed below.

6.3.2.1.1 Description of Undesirable Results

The undesirable result related to groundwater storage is defined under SGMA as:

Significant and unreasonable reduction of groundwater storage (CWC Section 10721(x)(2)).

An undesirable result for reduction of groundwater storage in the Delta-Mendota Subbasin is experienced through *significant and unreasonable chronic decrease in groundwater storage, as defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through either intra- and/or inter-basin actions*. This definition of an undesirable result was agreed upon by all GSP Groups through the Delta-Mendota Subbasin

Coordination Committee. Public feedback was considered in defining an undesirable result for reduction in groundwater storage based on stakeholder participation at public workshops held in May 2019.

Depletion of groundwater storage appears to have occurred over the historic and current period established in the water budgets for the Northern and Central Delta-Mendota Regions; however, based on existing data, this trend appears to have been reversed as a result of recent wet years, and are not anticipated to occur in the future with the implementation of projects and management actions to promote long-term subbasin sustainability. Groundwater pumping from the Upper Aquifer is largely limited by poorer quality water compared to the Lower Aquifer, particularly in the Stanislaus County portion of the Plan area, and areas with shallow groundwater within the southwestern portion of the Subbasin indicate that Upper Aquifer water supplies are abundant, where shallow groundwater is drained from the root zone to allow for agricultural production. The Lower Aquifer extends from the bottom of the Corcoran Clay layer to the top of the base of freshwater, which is located around -2,000 feet above mean sea level, as defined by Page (1973) (see Section 5.2 *Hydrogeologic Conceptual Model* of the *Basin Setting* chapter for more information about the base of freshwater). Based on the definition of the base of freshwater for the Delta-Mendota Subbasin, a large volume of groundwater is available in storage within the Lower Aquifer. Extractions from the Lower Aquifer are dictated by other sustainability indicators, such as inelastic land subsidence, rather than by available storage.

6.3.2.1.2 Identification of Undesirable Results

The same trigger for an undesirable result for the chronic lowering of groundwater levels is applicable to the long-term reduction of groundwater storage (see Section 6.3.1.1.2 for more detail). Long-term reductions in storage are not anticipated for either principal aquifer so long as groundwater levels are managed above minimum thresholds. Through coordination with the other GSP Groups in the Delta-Mendota Subbasin, additional projects and/or management actions will be implemented to prevent long-term decline in groundwater storage.

6.3.2.1.3 Potential Causes of Undesirable Results

Although the Subbasin has enough fresh groundwater in both principal aquifers to sustain groundwater pumping with the addition of projects and management actions, dramatic increases in reliance on groundwater, severe drought, or other major changes in groundwater management over time would cause the volume of fresh groundwater in storage to decline to a significant and unreasonable level. Additionally, regulatory requirements placed on CVP and SWP operations, as well as instream flow requirements on the San Joaquin River and its tributaries, have and will continue to have negative impacts on surface water supplies available to the Subbasin, resulting in increased reliance on groundwater resources within the Delta-Mendota Subbasin and potentially resulting in the long-term reduction in groundwater storage.

This undesirable result is driven by the chronic lowering of groundwater levels sustainability indicator, and minimum thresholds set for the chronic lowering of groundwater levels sustainability indicator, combined with identified projects and management actions, will also be protective of possible undesirable results for the long-term reduction in groundwater storage.

6.3.2.1.4 Potential Effects of Undesirable Results

If groundwater levels were to reach the point where undesirable results are observed, undesirable effects could include encroachment on the groundwater reserved as a drought buffer, increased cost of pumping as deeper wells are required to access groundwater, and reduction in beneficial uses. Groundwater pumping from the Lower Aquifer is known to cause inelastic land subsidence. Therefore, increased pumping from the Lower Aquifer could result in undesirable results for the land subsidence sustainability indicator.

6.3.2.2 Minimum Thresholds

This GSP uses groundwater levels minimum thresholds as a proxy for the reduction of groundwater storage sustainability indicator. As such, the minimum thresholds for the reduction of groundwater storage sustainability indicator are consistent with the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator.

GSP regulations allow GSAs to use groundwater levels as a proxy metric for any sustainability indicator, provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics. In order to rely on groundwater levels as a proxy, one approach suggested by DWR is to:

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site* (DWR, 2017).

Minimum thresholds for groundwater levels will effectively avoid undesirable results for reduction of groundwater storage by ensuring that groundwater elevations (and therefore the volume of groundwater in storage) does not chronically decline in the future and has a demonstrated ability to rebound in subsequent normal and wet years following a drought. Minimum thresholds and measurable objectives for groundwater levels can therefore be used as a proxy for reduction in groundwater storage because groundwater levels are sufficiently protective against occurrences of significant and unreasonable reductions in groundwater storage.

6.3.2.3 Measurable Objectives and Interim Milestones

Since the chronic lowering of groundwater levels is used as a proxy for reduction in groundwater storage, the measurable objectives and interim milestones for the reduction in groundwater storage sustainability indicator are consistent with the measurable objectives and interim milestones for the chronic lowering of groundwater levels sustainability indicator as set forth in Section 6.3.1.3 and will utilize the same monitoring networks and data sets for the evaluating performance and sustainability metrics.

6.3.3 Degraded Water Quality

Undesirable results, minimum thresholds, measurable objectives, and interim milestones for the degraded water quality sustainability indicator are described in the subsequent subsections.

6.3.3.1 Undesirable Results

A description of undesirable results as defined under SGMA and by the Delta-Mendota Subbasin GSAs, identification of undesirable results, potential causes of undesirable results, and potential effects of undesirable results relative to the degraded water quality sustainability indicator are detailed below.

6.3.3.1.1 Description of Undesirable Results

The undesirable result related to degraded water quality is defined under SGMA as:

> *Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies* (CWC Section 10721(x)(4).

An undesirable result for degraded water quality in the Delta-Mendota Subbasin is experienced through *significant and unreasonable degradation of groundwater quality, defined by each GSP Group, that has an impact on the beneficial users of groundwater in the Subbasin through intra- and/or inter-basin actions and/or activities*. This definition of an undesirable result was agreed upon by all GSP Groups through the Delta-Mendota Subbasin Coordination Committee. Public feedback was considered in defining an undesirable result for degraded water quality based on stakeholder participation at public workshops held in May 2019.

As described in Section 5.3 *Groundwater Conditions* of the *Basin Setting* chapter, groundwater quality concerns within the Plan area are largely related to non-point sources and/or naturally-occurring constituents. Total dissolved solids (TDS), nitrate (discussed herein as nitrogen or N), and boron have been identified as constituents of concern related to groundwater levels or other SGMA-related groundwater quality management activities and were selected based on available data, the potential to impact existing or future groundwater use, the ability to address groundwater quality impacts through projects and/or management actions, and the source of the constituent. Based on publicly available datasets, there are no known groundwater contamination sites or plumes within the Northern and Central Delta-Mendota Regions. While other constituents of concern are known to exist in the Delta-Mendota Subbasin (such as arsenic, selenium, and hexavalent chromium), concentrations of these constituents do not appear to be linked to groundwater elevations or other groundwater-related management activities. The groundwater quality monitoring network developed for this GSP will continue to collect data relative to ongoing groundwater concentrations for these constituents for future assessment in coordination with other existing and anticipated future regulatory programs.

6.3.3.1.2 Identification of Undesirable Results

An undesirable result for degraded water quality is triggered, or considered “significant and unreasonable,” when:

- Groundwater quality exceeds Maximum Contaminant Levels (MCLs) or water quality objectives (WQOs) for TDS, nitrate, or boron over three (3) consecutive sampling events in non-drought years, or additional degradation of current groundwater quality where current groundwater quality exceeds the MCLs or WQOs.
- Water quality degradation due to recharge projects that exceeds 20 percent of the aquifer’s assimilative capacity for one or more constituents without justification of a greater public benefit achieved.

6.3.3.1.3 Potential Causes of Undesirable Results

As previously stated, TDS, nitrate as N, and boron have been identified as constituents of concern and are largely the result of non-point sources. Elevated TDS and boron concentrations are primarily a result of a combination of land use practices, the geochemistry of the Coast Range rocks, recharge derived from the Coast Range streams, dissolvable materials within the alluvial fan complexes, and the naturally poor-draining conditions which tends to result in accumulation of these constituents. Elevated nitrate as N is largely the result of agricultural applications of fertilizer along with leaching from naturally-occurring alluvium in the southwestern portion of the Subbasin. Similarly, elevated boron concentrations are also the result of applied pesticides and accumulation in areas of poor drainage. For more information about groundwater water quality in the Plan area, refer to Section 5.2.8 *Water Quality* and Section 5.3.5 *Groundwater Quality* of the *Basin Setting* chapter.

6.3.3.1.4 Potential Effects of Undesirable Results

If an undesirable result for the degraded water quality sustainability indicator were to occur, the overarching impact would be a reduction in usable groundwater supply for all beneficial users of groundwater within the Plan area and/or an increased need for groundwater treatment prior to use. Wellhead or distribution system treatment would be necessary before domestic, municipal, or agricultural use or alternative supplies might be sought out, with small domestic users most impacted financially by these potential imposed costs. For agricultural groundwater users, degraded water quality may cause potential changes in irrigation practices, crops grown, agricultural efficiencies, adverse effects on property values, and other economic impacts, with the potential to adversely impact the larger economy throughout the Subbasin.

6.3.3.2 Minimum Thresholds

The minimum thresholds for the degraded water quality sustainability indicator are set as the upper Secondary MCL for TDS (1,000 mg/L) (State of California, 2006), the Primary MCL for nitrate (10 mg/L as N) (SWRCB, March 2018), and the agricultural WQO for irrigation for boron (0.7 mg/L) (Ayers and Westcot, 1985) or current groundwater quality as of December 2018 for both the Upper Aquifer and Lower Aquifer if the listed MCL or WQO is already exceeded. For more information regarding current water quality as of December 2018 within the Plan area in the Upper Aquifer and Lower Aquifer, refer to Figure 5-86 and Figure 5-87, respectively, in Section 5.3 *Groundwater Conditions* of the *Basin Setting* chapter. Figure 6-4 and Figure 6-5 show the locations of groundwater quality representative monitoring wells in the Upper Aquifer and Lower Aquifer, respectively. Table 6-5 and Table 6-6 show the minimum thresholds at each representative monitoring site in the Upper Aquifer and Lower Aquifer, respectively, for the degraded water quality sustainability indicator.

In developing the minimum thresholds for groundwater quality, State, federal, and local standards were evaluated to ensure consistency with existing water quality standards within the Plan area. Under the Central Valley Regional Water Quality Control Board's (CV-RWQCB) *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (or Basin Plan) (SWRCB, May 2018), the Delta-Mendota Subbasin is given a municipal (MUN) beneficial use designation, which dictates the WQOs for ambient water quality consistent with drinking water standards. The Statewide Recycled Water Policy regulations were also incorporated into the minimum thresholds for degraded water quality as recycled water-related projects are currently planned to aid in GSP implementation (see Section 7.1 *Projects & Management Actions* for more information about recycled water projects in the Plan area). Resolution 68-16 (SWRCB, 1968), also known as the California Anti-Degradation Policy, was also used to inform the minimum thresholds for the degraded water quality sustainability indicator where existing groundwater will be maintained to ensure the highest water quality to the maximum benefit to the people of the State. The Basin Plan, Statewide Recycled Water Policy, and Resolution 68-18, combined with the requirement to establish existing baseline conditions under SGMA, were relied upon to establish and justify the minimum thresholds for the degraded water quality sustainability indicator.

Water quality in the Delta-Mendota Subbasin varies both by principal aquifer and by location within the Subbasin. The Upper Aquifer is considered a semi-confined aquifer and elevated concentrations detected in groundwater are mostly associated with anthropogenic activities, such as through irrigation water and fertilizer application. The Lower Aquifer, as a confined aquifer, generally has good water quality (as the Corcoran Clay acts as a barrier to the downward migration of constituents), but is impacted to some extent along the western margin of the Subbasin (where the Corcoran Clay does not exist) or where composite wells are screened across the Corcoran Clay and have the potential to act as a conduit for constituent migration within and between primary aquifers.

TDS, nitrate, and boron are also naturally-occurring in both the Upper Aquifer and Lower Aquifer. Water quality conditions were evaluated based on aquifer designation and the range of conditions present within each monitoring network subregion. Therefore, differences in vertical and horizontal spatial patterns of elevated constituent concentrations warrants the differences in minimum threshold values at representative monitoring sites by monitoring network subregion and principal aquifer for the degraded water quality sustainability indicator. Across sustainability indicators, the constituents of concern that will be monitored under this GSP in coordination with groundwater levels to support groundwater management operations, providing future insight into potential links between groundwater levels and water quality. Management of the chronic lowering of groundwater levels relative to minimum thresholds for groundwater levels is anticipated to avoid an undesirable result for degraded water quality based on professional judgement and local knowledge of concentrations of constituents of concern observed at hydrologic low conditions (as supported by historical changes in groundwater quality during periods of low groundwater elevations). It should be noted that minimum thresholds for the degraded water quality sustainability indicator are established for ambient groundwater quality, where treatment may be required prior to the intended beneficial use of groundwater.

Similar to the establishment of sustainability indicators for groundwater elevations, limited interbasin coordination has been conducted relative to establishing the minimum thresholds and measurable objectives for groundwater quality. As previously noted, three of the adjoining subbasins (Tracy, Modesto, Turlock Subbasins) are not required to submit their GSPs to DWR until January 2022, and due to time constraints in preparing the GSPs, limited coordination was conducted with the Merced, Westside and Kings Subbasins. As such, ongoing interbasin coordination between the subbasins will be conducted during GSP implementation, and the annual reports and GSP updates will contain evaluations of how minimum thresholds for degraded water quality in the Northern and Central Delta-Mendota Regions may affect the ability of these adjacent basins to meet achieve their sustainability goals.

The beneficial uses and users of groundwater, as well as land uses and property interests, were considered when establishing minimum thresholds for the degraded water quality sustainability indicator. Stakeholders, including the public, were invited to provide feedback on minimum thresholds during Working Group meetings (publicly noticed per Brown Act requirements) and during public workshops centered around SMC held throughout the Delta-Mendota Subbasin in May 2019. Representatives from the municipal sector (primarily the City of Patterson and Santa Nella County Water District) and agricultural sector are Working Group members and provided input in setting the minimum thresholds for the degraded water quality sustainability indicator throughout the development process. Agricultural sector representatives indicated that ambient groundwater quality consistent with the Secondary MCL for TDS, the Primary MCL for nitrate, and the WQO for irrigation for boron were sufficiently protective of the agricultural beneficial use of groundwater as they are consistent with State regulations and the agricultural WQOs described in the *Delta-Mendota Canal Non-Project Water Pump-in Program Monitoring Plan* (USBR, 2018). Input was also provided by agricultural representatives where current water quality as of December 2018 was in excess of the described objectives to determine that an undesirable result for degraded water quality was not already occurring.

For information regarding how minimum thresholds for the degraded water quality sustainability indicator will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to Section 7.2.5.4 *Degraded Water Quality Monitoring Network* of the *Sustainability Implementation* chapter.

Table 6-5. Minimum Thresholds for Degraded Water Quality, Upper Aquifer

Narrative Description						
The minimum threshold is set as the upper Secondary MCL for TDS, Primary MCL for nitrate as N, and WQO for irrigation for boron or the current groundwater quality where it exceeds the afore-mentioned criteria as of December 2018.						
Numeric Minimum Thresholds – Degraded Water Quality in Upper Aquifer						
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Minimum Threshold (mg/L)		
				TDS	Nitrate as N	Boron
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	4,000	80	3.0
06-004			MP031.31L1-L2Well1	4,000	80	3.0
03-001		375015N1211011W001	MW-2	4,000	80	3.0
03-002			MW-3	4,000	80	3.0
03-003	05S/08E-16R		WSJ003	4,000	80	3.0
06-002	06S08E09E003M	374316N1210994W003	P259-3	2,500	60	1.7
01-004	07S08E28R002M	372907N1210875W002	MC10-2	2,500	60	1.7
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	2,500	60	1.7
07-017			Well 1	1,000	60	0.9
07-003	10S10E32L002M	370173N1208999W002	MC15-2	2,700	90	1.0
07-004	11S10E04L001M		MP081.08R	2,700	90	1.0
07-011		368835N1206270W001	MP099.24L	3,500	13	6.0
07-012	12S/12E-16B		GDA003	3,500	13	6.0
07-013			MP102.04R	3,500	13	6.0
07-010		366500N1202500W001	KRCDTID02	1,000	10	2.2
07-009		366000N1202300W001	KRCDTID03	1,000	10	2.2
07-018	15S/16E-20		WSJ001	1,000	10	2.2

Table 6-6. Minimum Thresholds for Degraded Water Quality, Lower Aquifer

Narrative Description						
The minimum threshold is set as the upper Secondary MCL for TDS, Primary MCL for nitrate as N, and WQO for irrigation for boron or the current groundwater quality where it exceeds the afore-mentioned criteria as of December 2018.						
Numeric Minimum Thresholds – Degraded Water Quality in Lower Aquifer						
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Minimum Threshold (mg/L)		
				TDS	Nitrate as N	Boron
01-007			MP021.12L	2,000	50	3.0
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	2,000	50	3.0
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	2,000	50	3.0
06-003		375774N1212096W001	WSID 3	2,000	50	3.0
02-002			WELL 02 - NORTH 5TH STREET	2,000	50	3.0
06-001	06S08E09E001M	374316N1210994W001	P259-1	4,000	70	0.7
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	4,000	70	0.7
04-001		376129N1212942W001	121	4,000	70	0.7
01-008			MP051.66L	4,000	70	0.7
01-006		372604N1210611W001	91	4,000	70	0.7
07-016			Well 01	1,000	17	0.7
07-002	10S10E32L001M	370173N1208999W001	MC15-1	1,200	18	0.8
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	2,600	10	6.0
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	2,600	10	6.0
07-007	12S12E16E003M	368896N1206702W001	MC18-1	2,600	10	6.0
07-008	13S12E22F001M	367885N1206510W001	PWD 48	2,600	10	6.0
07-014			TW-4	1,000	10	1.1
07-015			TW-5	1,000	10	1.1

6.3.3.3 Measurable Objectives and Interim Milestones

The measurable objective for degraded water quality is set as current water quality conditions for TDS, nitrate, and boron as established for each monitoring network subregion (see Section 7.2 *Monitoring* of the *Sustainability Implementation* chapter for more information on the monitoring network subregions). The upper limit of the concentration range presented for the Upper Aquifer and Lower Aquifer in Figure 5-86 and Figure 5-87, respectively, in Section 5.3 *Groundwater Conditions* in the *Basin Setting* chapter were used to set the measurable objective at each monitoring site. Table 6-7 and Table 6-8 reflect the measurable objectives for degraded water quality for the Upper Aquifer and Lower Aquifer, respectively. Measurable objective values were set based on water quality data from existing water quality monitoring programs and evaluating concentrations for TDS, nitrate as N, and boron between 2000 and 2018. Local input and professional judgement were also applied in setting the measurable objectives. The selected minimum thresholds reflect input from local drinking water purveyors, as well as the local agricultural community, and is expected to maintain beneficial uses of groundwater for both drinking water and agricultural users. It should be noted that concentrations presented for measurable objectives reflect ambient groundwater quality, where additional treatment may be necessary to meet State and federal MCLs for drinking water.

To assist the Plan area in reaching the measurable objective for degraded water quality, interim milestones are established for 2025, 2030, and 2035 as a means of assessing progress towards the Regions' sustainability goal. In cases where the measurable objective has been achieved, the interim goals reflect overall objective of maintaining existing groundwater quality. Therefore, the interim milestones for degraded water quality are set as follows:

- Year 5 (2025): Maintain current groundwater quality
- Year 10 (2030): Maintain current groundwater quality
- Year 15 (2035): Maintain current groundwater quality

Table 6-7. Measurable Objective for Degraded Water Quality, Upper Aquifer

Narrative Description						
The measurable objective is set as the current groundwater quality conditions by GSP subregion.						
Numeric Measurable Objectives – Degraded Water Quality in Upper Aquifer						
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Measurable Objective (mg/L)		
				TDS	Nitrate as N	Boron
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	4,000	80	3.0
06-004			MP031.31L1-L2Well1	4,000	80	3.0
03-001		375015N1211011W001	MW-2	4,000	80	3.0
03-002			MW-3	4,000	80	3.0
03-003	05S/08E-16R		WSJ003	4,000	80	3.0
06-002	06S08E09E003M	374316N1210994W003	P259-3	2,500	60	1.7
01-004	07S08E28R002M	372907N1210875W002	MC10-2	2,500	60	1.7
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	2,500	60	1.7
07-017			Well 1	1,000	60	0.9
07-003	10S10E32L002M	370173N1208999W002	MC15-2	2,700	90	1.0
07-004	11S10E04L001M		MP081.08R	2,700	90	1.0
07-011		368835N1206270W001	MP099.24L	3,500	13	6.0
07-012	12S/12E-16B		GDA003	3,500	13	6.0
07-013			MP102.04R	3,500	13	6.0
07-010		366500N1202500W001	KRCDTID02	800	1	2.2
07-009		366000N1202300W001	KRCDTID03	800	1	2.2
07-018	15S/16E-20		WSJ001	800	1	2.2

Table 6-8. Measurable Objective for Degraded Water Quality, Lower Aquifer

Narrative Description						
The measurable objective is set as the current groundwater quality conditions by GSP subregion.						
Numeric Measurable Objectives – Degraded Water Quality in Lower Aquifer						
DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Measurable Objective (mg/L)		
				TDS	Nitrate as N	Boron
01-007			MP021.12L	2,000	50	3.0
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	2,000	50	3.0
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	2,000	50	3.0
06-003		375774N1212096W001	WSID 3	2,000	50	3.0
02-002			WELL 02 - NORTH 5TH STREET	2,000	50	3.0
06-001	06S08E09E001M	374316N1210994W001	P259-1	4,000	70	0.6
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	4,000	70	0.6
04-001		376129N1212942W001	121	4,000	70	0.6
01-008			MP051.66L	4,000	70	0.6
01-006		372604N1210611W001	91	4,000	70	0.6
07-016			Well 01	1,000	17	0.2
07-002	10S10E32L001M	370173N1208999W001	MC15-1	1,200	18	0.8
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	2,600	10	6.0
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	2,600	10	6.0
07-007	12S12E16E003M	368896N1206702W001	MC18-1	2,600	10	6.0
07-008	13S12E22F001M	367885N1206510W001	PWD 48	2,600	10	6.0
07-014			TW-4	775	1	1.1
07-015			TW-5	775	1	1.1

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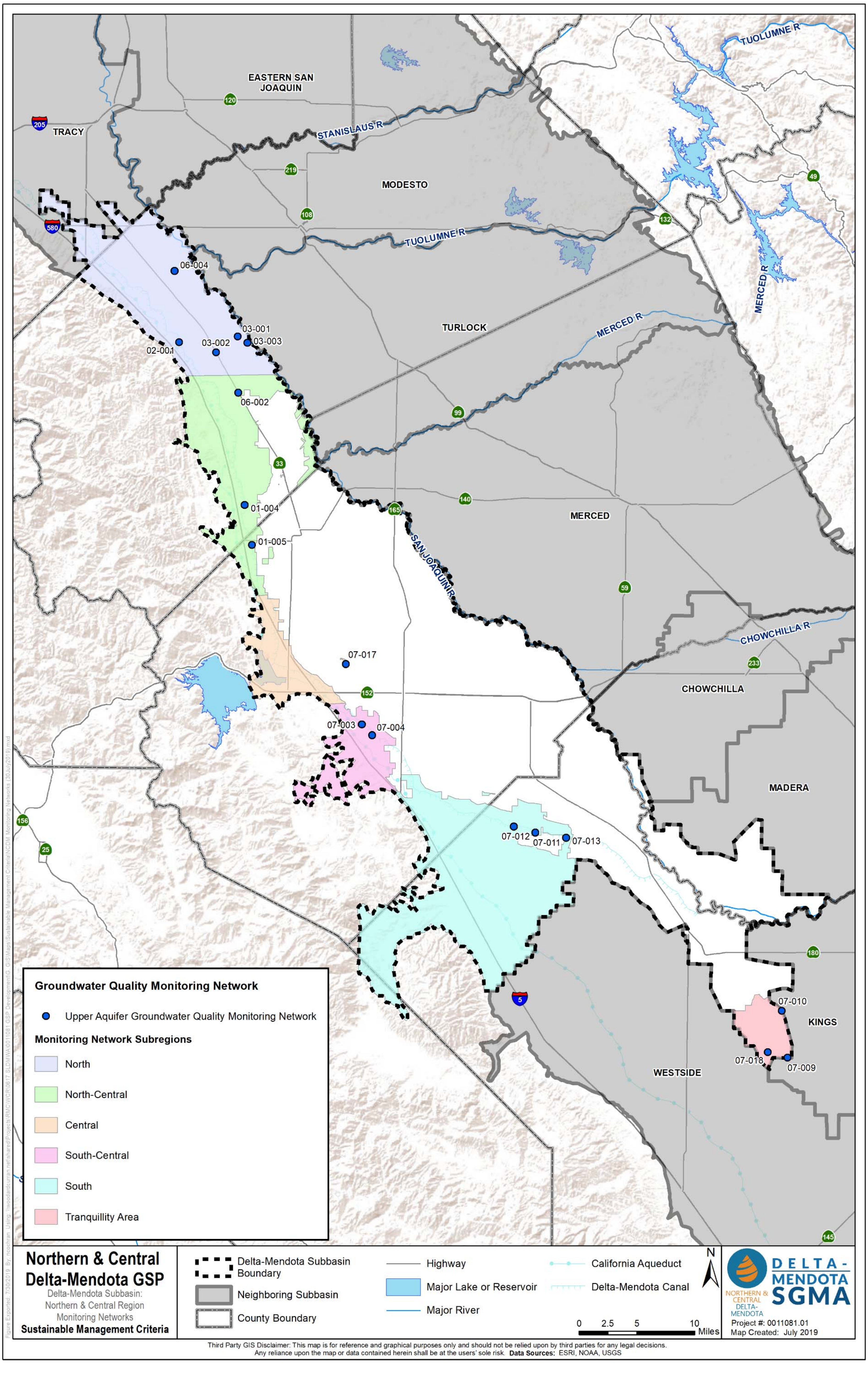

Figure 6-4. Locations of Representative Monitoring Wells for Degraded Water Quality, Upper Aquifer

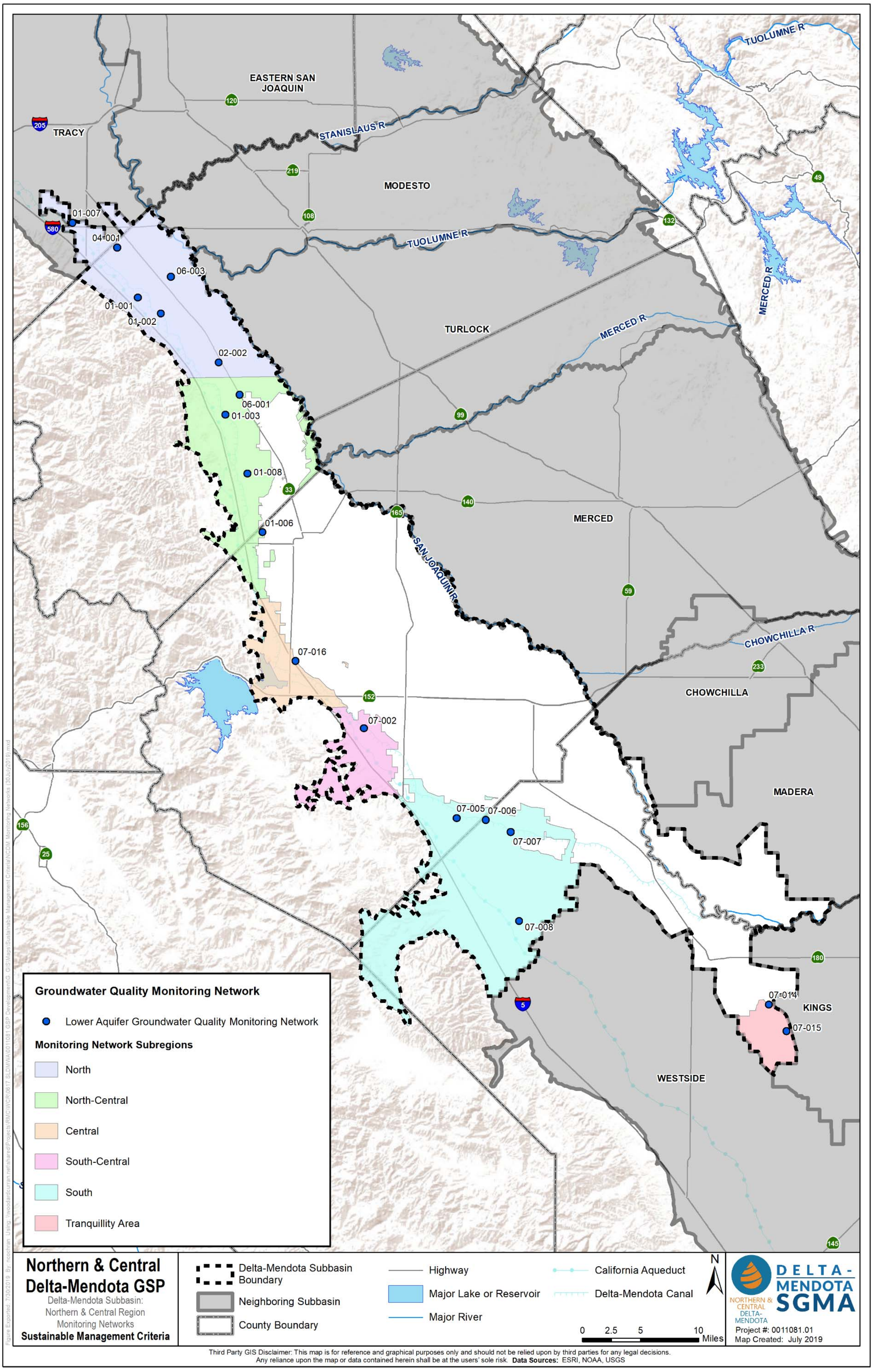

Figure 6-5. Locations of Representative Monitoring Wells for Degraded Water Quality, Lower Aquifer

6.3.4 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Delta-Mendota Subbasin as the Subbasin is located inland from the Pacific Ocean. Therefore, sustainable management criteria for seawater intrusion will not be set for the Plan area.

6.3.5 Land Subsidence

Undesirable results, minimum thresholds, measurable objectives, and interim milestones for the land subsidence sustainability indicator are described in the subsequent subsections.

6.3.5.1 Undesirable Results

A description of undesirable results as defined under SGMA and by the Delta-Mendota Subbasin, identification of undesirable results, potential causes of undesirable results, and potential effects of undesirable results relative to the land subsidence sustainability indicator are detailed below.

6.3.5.1.1 Description of Undesirable Results

The undesirable result related to land subsidence is defined under SGMA as:

> *Significant and unreasonable land subsidence that substantially interferes with surface land uses* (CWC Section 10721(x)(5).

An undesirable result for land subsidence in the Delta-Mendota Subbasin is experienced through *changes in ground surface elevation that cause damage to critical infrastructure that would cause significant and unreasonable reductions of conveyance capacity, damage to personal property, impacts to natural resources, or create conditions that threaten public health and safety*. This definition of an undesirable result was agreed upon by all GSP Groups through the Delta-Mendota Subbasin Coordination Committee. Public feedback was considered in defining an undesirable result for land subsidence based on stakeholder participation at public workshops held in May 2019.

6.3.5.1.2 Identification of Undesirable Results

As previously described in Section 5.5 *Management Areas* of the *Basin Setting* chapter, two management areas (MAs) have been established for the land subsidence sustainability indicator within the Plan area: West Stanislaus Irrigation District-Patterson Irrigation District (WSID-PID) MA and Tranquillity Irrigation District (TRID) MA. Definitions triggering an undesirable result have been established for each land subsidence MA, as well as for the Plan area as a whole. An undesirable result for land subsidence is triggered, or considered "significant and unreasonable," for each management area and remaining Plan area when:

- WSID-PID MA: Significant impacts occur to laterals from differential settlement that reduces the ability to deliver surface water supplies.
- TRID MA: Inadequate freeboard exists on the levee system to retain flood flows in wet years as a result of significant additional land subsidence.
- Remaining Plan area: Significant increases in 2014-2016 subsidence rates due to groundwater pumping in two or more subregions that result in 50 percent loss of standup capacity (where standups are defined as vertical stand concrete pipes at Delta-Mendota Canal [DMC] turnouts) and/or 75 percent overtopping of lining in the Delta-Mendota Canal as a result of inelastic land subsidence.

Minimum thresholds established for this sustainability indicator have been established to reflect these undesirable results.

6.3.5.1.3 Potential Causes of Undesirable Results

Land subsidence in the Delta-Mendota Subbasin typically is the result of over-extraction of groundwater. Inelastic land subsidence throughout the Subbasin is largely occurs from Lower Aquifer groundwater pumping resulting in the compaction of clays below the Corcoran Clay layer as a result of the loss of piezometric head. Generally poor water quality within the Upper Aquifer and transitions from pasture or fallowed land to irrigated land uses has resulted in increased groundwater demand from the Lower Aquifer. Conjunctive use of surface water and groundwater is prevalent throughout the Plan area as supplies from the San Joaquin River, Kings River, CVP, and SWP are utilized and supplemented with groundwater when surface water deliveries are reduced or non-existent. As a result, groundwater extractions increase during periods of drought or as the result of regulatory constraints, when surface water supplies are inadequate to meet agricultural demand, resulting in higher rates of inelastic land subsidence.

6.3.5.1.4 Potential Effects of Undesirable Results

Undesirable results related to land subsidence could potentially cause unrecoverable loss of groundwater storage and differential changes in land surface elevation, resulting in damage to water conveyance infrastructure, flood control facilities and other infrastructure, and causing decreased capacity to convey water or control flood waters. This could impact the ability to deliver surface water within the Subbasin as well as throughout California, as the DMC and California Aqueduct run the nearly the entire length of the Northern and Central Delta-Mendota Regions. The cost to convey surface water or control flood waters would likely increase as gradients of gravity-driven conveyance structures would require repair and modification or increased energy to pump and move surface or flood water. These potential effects could result in significant economic costs and adversely impact property value as well as public safety.

6.3.5.2 Minimum Thresholds

The minimum thresholds for the land subsidence sustainability indicator are set as follows for the two established management areas and the remaining Plan area:

- WSID-PID MA: Acceptable loss in distribution capacity (as based on a future capacity study) due to inelastic land subsidence resulting from groundwater pumping. Numerical values for this criterion to be determined based on data collection between 2020 and 2025.
- TRID MA: Four (4) feet additional subsidence compared to 2019 benchmark elevations.
- Remaining Plan area: Target rate/goal by monitoring network subregion, based on the average 2014-2016 elevation change from recent DMC surveys.

Figure 6-6 shows the locations of land subsidence representative monitoring sites. Table 6-9 includes the minimum thresholds at each representative monitoring site for the land subsidence sustainability indicator.

To develop minimum thresholds for the land subsidence sustainability indicator, different information and data were evaluated for the two MAs (WSID-PID and TRID) and the remaining Plan area. Minimal land subsidence has previously been observed in the WSID-PID MA. Both WSID and PID receive sufficient surface water supplies via the San Joaquin River and the CVP to meet demands within the districts, meaning Lower Aquifer groundwater pumping (which results in inelastic land subsidence) within this MA is minimal. Therefore, the established minimum threshold for the WSID-PID MA described above is protective of beneficial uses of surface water in WSID and PID should land subsidence be observed as a results of a future capacity study.

Within the TRID MA, the locally-owned levee operated by TRID was raised in 2017 to approximately two (2) feet above the maximum flow condition to provide sufficient freeboard as a flood control measure due to wet conditions observed in 2017. Local representatives from TRID indicated that the additional cost and loss of productive agricultural land to raise the levee an additional four (4) feet compared to the 2019 levee elevation have already been planned for and would not cause an undesirable result for this MA. For the remaining Plan area, the average 2014-2016 elevation from recent DMC surveys and analyses performed by the United States Bureau of Reclamation were used to establish minimum thresholds outside the designated management areas. The subsidence rates from the 2014 and 2016 surveys were used because they encompass the largest portion of the recent drought period where significant subsidence was observed. These thresholds were established using the best available data and will be reevaluated following a capacity analysis and bathymetric survey of the DMC.

The minimum thresholds within the two MAs and the remaining Plan area were established to be protective of water conveyance infrastructure and surface water delivery capabilities specific to these areas to avoid an undesirable result. Within the WSID-PID MA, impacts related to subsidence would be considered “significant and unreasonable” if impacts to laterals from differential settlement reduced the ability to deliver surface water supplies from the San Joaquin River and Central Valley Project. These conditions would likely result in increased groundwater extractions to replace undelivered surface water, thereby potentially exacerbating the subsidence conditions.

Within the TRID MA, impacts would be considered “significant and unreasonable” if inadequate freeboard on TRID’s levee system during flood releases of the Kings River are observed as a result of significant additional land subsidence resulting from groundwater extractions. Throughout the remaining Plan area, the DMC is the primary infrastructure of concern as it is the primary means of conveying surface water to irrigated lands in the Subbasin. Land subsidence rates for each pool along the DMC, presented in Table 5-8 (Section 5.3 *Groundwater Conditions* of the *Basin Setting* chapter), were assigned to each monitoring network subregion and an average of the pool 2014-2016 average elevation changes within a given subregion was established as the minimum threshold for all monitoring sites within a subregion. In setting minimum thresholds based on these land subsidence rates, professional judgement deems that an undesirable result for land subsidence will be avoided as a “significant and unreasonable” loss in standup capacity or overtopping of lining is unlikely to occur due to land subsidence.

The minimum thresholds for land subsidence within the two MAs and the remaining Plan area do not directly impact any of the other applicable sustainability indicators. As previously stated, the land subsidence and chronic lowering of groundwater levels sustainability indicators are linked as groundwater pumping from the Lower Aquifer results in deeper groundwater levels and causes inelastic subsidence.

Similar to the establishment of sustainability indicators for groundwater elevations, limited interbasin coordination has been conducted relative to establishing the minimum thresholds and measurable objectives for inelastic land subsidence. As previously noted, three of the adjoining subbasins (Tracy, Modesto, Turlock Subbasins) are not required to submit their GSPs to DWR until January 2022, and due to time constraints in preparing the GSPs, limited coordination was conducted with the Merced, Westside and Kings Subbasins. As such, ongoing interbasin coordination between the subbasins will be conducted during GSP implementation, and the annual reports and GSP updates will contain evaluations of how minimum thresholds for land subsidence in the Northern and Central Delta-Mendota Regions may affect the ability of these adjacent basins to meet achieve their sustainability goals

The beneficial uses and users of groundwater, as well as land uses and property interests, were considered when establishing minimum thresholds for the land subsidence sustainability indicator. Stakeholders, including the public, were invited to provide feedback on minimum thresholds during Working Group meetings (publicly noticed per Brown Act requirements) and during public workshops centered around SMC held throughout the Delta-Mendota Subbasin in May 2019. Representatives from the municipal sector (primarily the City of Patterson and Santa Nella County Water District) and agricultural sector are Working Group members and provided input in setting the minimum thresholds for the land subsidence sustainability indicator throughout the development process. Many agricultural water users within the Plan area conjunctively use groundwater and surface water and therefore provided feedback in setting minimum thresholds for the land subsidence sustainability indicator related to both surface water and groundwater. An undesirable result for land subsidence throughout the Plan area relates to damage of critical infrastructure for conveying surface water through reductions in conveyance capacity, damage to personal property, impacts to natural resources, or creating conditions that threaten public health and safety as a result of Lower Aquifer groundwater pumping. Based on the above described communication with beneficial users of groundwater, it was deemed that the minimum thresholds set for the land subsidence and chronic lowering of groundwater levels sustainability indicators would avoid undesirable results for both sustainability indicators.

Currently, there are no other State, federal, or local standards within the Plan area that relate to the land subsidence sustainability indicator. SGMA is the prevailing legislation dictating requirements and standards for the land subsidence sustainability indicator. Since the California Aqueduct runs nearly the entire length of the Plan area and is managed by DWR, the Northern and Central Delta-Mendota Regions met with representatives from DWR and coordinated with DWR in regards to land subsidence throughout the development of this GSP. As this GSP was being developed, DWR was conducting an on-going evaluation of land subsidence relative to the California Aqueduct, which is expected to be complete and released in late 2019. Discussions and coordination with DWR involved DWR's tolerance for additional land subsidence along the California Aqueduct within the Delta-Mendota Subbasin to ensure minimum thresholds set in this GSP are compatible with DWR's projected operations of the California Aqueduct. DWR did not, however, opt to participate in GSP development prior to the release of the Public Draft GSP.

For information regarding how minimum thresholds for the land subsidence sustainability indicator will be quantitatively measured, including monitoring protocols as well as frequency and timing of measurement, refer to Section 7.2.5.5 *Land Subsidence Monitoring Network* of the *Sustainability Implementation* chapter.

6.3.5.3 Measurable Objectives and Interim Milestones

The measurable objectives for land subsidence are set as followed for the WSID-PID and TRID MAs, as well as the remaining Plan area:

- WSID-PID MA: No loss in distribution capacity as a result of subsidence resulting from groundwater pumping. Numerical value for this criterion to be determined based on data collection between 2020 and 2025.
- TRID MA: Two (2) feet additional subsidence compared to 2019 benchmark elevation.
- Remaining Plan area: Target rate/goal by monitoring network subregion, based on the average 2016-2018 elevation change from recent DMC surveys.

Table 6-10 reflects the measurable objectives for land subsidence at each representative monitoring site. As previously noted, undesirable results for land subsidence relate to conveyance capacity of water conveyance or flood control infrastructure as significant and unreasonable rates of land subsidence occur. By managing the Lower Aquifer according to the chronic lowering of groundwater levels measurable objectives, as well as the measurable objectives set forth for the land subsidence sustainability indicator, it is anticipated that an undesirable result for land subsidence will be avoided and therefore the sustainability goal will be met by 2040.

To assist the Plan area in reaching the measurable objective for land subsidence, interim milestones are established for 2025, 2030, and 2035 as a means of assessing progress towards the Regions' sustainability goal. For this sustainability indicator, interim milestones are based on achieving the sustainability goal within the 20-year time period provided under SGMA. The interim milestones for land subsidence are shown in Table 6-11.

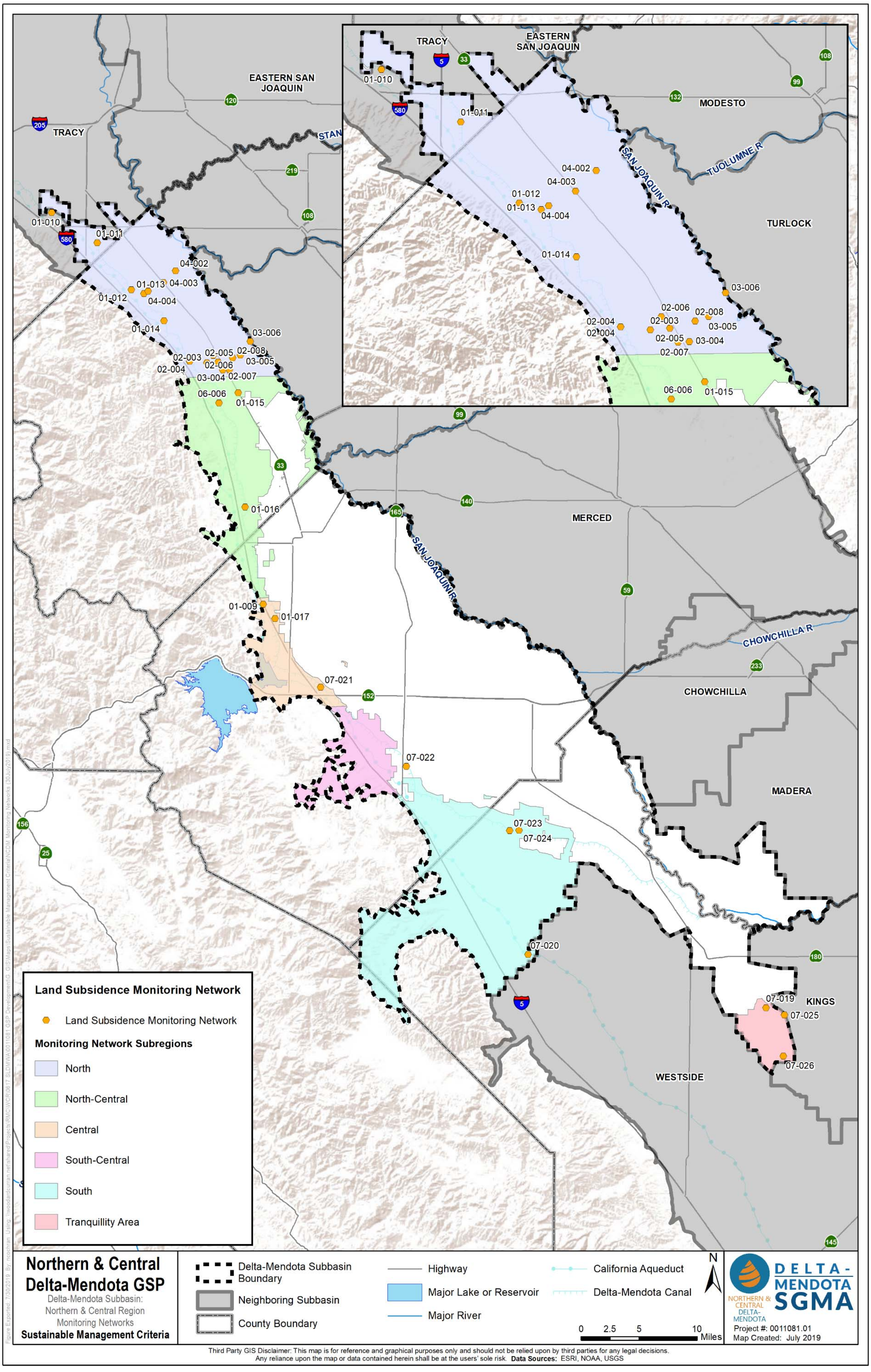

Figure 6-6. Location of Representative Monitoring Sites for Land Subsidence

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Table 6-9. Minimum Thresholds for Land Subsidence

Narrative Description				
WSID-PID Management Area: The minimum threshold is set as the acceptable loss in distribution capacity as a result of subsidence resulting from groundwater pumping as based on future capacity study. **TRID Management Area:** The minimum threshold is set as four (4) feet additional subsidence compared to 2019 benchmark elevation. **Remaining Plan Area:** The minimum threshold is set as target rate/goal by monitoring subregion, based on the average 2014-2016 elevation change from recent DMC surveys.				
Numeric Minimum Thresholds – Inelastic Land Subsidence				
DMS ID	Local ID	Management Area	Minimum Threshold[1,2]	Units[1,2]
02-003	Floragold Well	N/A	-0.13	ft/year
02-008	Well 11	N/A	-0.13	ft/year
02-005	Well 2	N/A	-0.13	ft/year
02-006	Well 4	N/A	-0.13	ft/year
02-007	Well 6	N/A	-0.13	ft/year
03-004	Locust Avenue Well	WSID-PID	TBD	TBD
03-005	Pumping Plant No. 2	WSID-PID	TBD	TBD
03-006	River Station	WSID-PID	TBD	TBD
01-010	Subsidence Monitoring Point #1	N/A	-0.13	ft/year
01-011	Subsidence Monitoring Point #2	N/A	-0.13	ft/year
01-012	Subsidence Monitoring Point #3	N/A	-0.13	ft/year
01-013	Subsidence Monitoring Point #4	N/A	-0.13	ft/year
01-014	Subsidence Monitoring Point #5	N/A	-0.13	ft/year
02-004	Subsidence Monitoring Point #6	N/A	-0.13	ft/year
04-002	WSID 1	WSID-PID	TBD	TBD
04-003	WSID 11	WSID-PID	TBD	TBD
04-004	WSID 21	WSID-PID	TBD	TBD
01-015	Subsidence Monitoring Point #7	N/A	-0.26	ft/year
06-006	Subsidence Monitoring Point #8	N/A	-0.26	ft/year
01-016	Subsidence Monitoring Point #9	N/A	-0.26	ft/year
01-017	Subsidence Monitoring Point #10	N/A	-0.21	ft/year
07-021	Subsidence Monitoring Point #11	N/A	-0.21	ft/year
01-009	P252	N/A	-0.21	ft/year
07-022	Subsidence Monitoring Point #12	N/A	-0.15	ft/year
07-023	Subsidence Monitoring Point #13	N/A	-0.15	ft/year
07-020	104.20-R	N/A	-0.18	ft/year
07-024	Subsidence Monitoring Point #14	N/A	-0.18	ft/year
07-025	Subsidence Monitoring Point #15	N/A	-0.18	ft/year
07-019	AG-24	TRID	153.77	ft GSE
07-026	TID A	TRID	156.54	ft GSE
07-027	TID B	TRID	165.22	ft GSE

[1] TBD = To be determined
[2] ft GSE = feet ground surface elevation (NAVD88)

Table 6-10. Measurable Objective for Land Subsidence

Narrative Description				
WSID-PID Management Area: The measurable objective is set as no loss in distribution capacity as a result of subsidence resulting from groundwater pumping. Numerical values for this criterion to be determined based on data collection between 2020 and 2025. **TRID Management Area:** The measurable objective is set as two (2) feet additional subsidence compared to 2019 benchmark elevation. **Remaining Plan Area:** The measurable objective is set as target rate/goal by monitoring subregion, based on the average 2016-2018 elevation change from recent Delta-Mendota Canal survey.				
Numeric Measurable Objectives – Inelastic Land Subsidence				
DMS ID	Local ID	Management Area	Measurable Objective[1,2]	Units[1,2]
02-003	Floragold Well	N/A	-0.11	ft/year
02-008	Well 11	N/A	-0.11	ft/year
02-005	Well 2	N/A	-0.11	ft/year
02-006	Well 4	N/A	-0.11	ft/year
02-007	Well 6	N/A	-0.11	ft/year
03-004	Locust Avenue Well	WSID-PID	TBD	TBD
03-005	Pumping Plant No. 2	WSID-PID	TBD	TBD
03-006	River Station	WSID-PID	TBD	TBD
01-010	Subsidence Monitoring Point #1	N/A	-0.11	ft/year
01-011	Subsidence Monitoring Point #2	N/A	-0.11	ft/year
01-012	Subsidence Monitoring Point #3	N/A	-0.11	ft/year
01-013	Subsidence Monitoring Point #4	N/A	-0.11	ft/year
01-014	Subsidence Monitoring Point #5	N/A	-0.11	ft/year
02-004	Subsidence Monitoring Point #6	N/A	-0.11	ft/year
04-002	WSID 1	WSID-PID	TBD	TBD
04-003	WSID 11	WSID-PID	TBD	TBD
04-004	WSID 21	WSID-PID	TBD	TBD
01-015	Subsidence Monitoring Point #7	N/A	0.01	ft/year
06-006	Subsidence Monitoring Point #8	N/A	0.01	ft/year
01-016	Subsidence Monitoring Point #9	N/A	0.01	ft/year
01-017	Subsidence Monitoring Point #10	N/A	-0.03	ft/year
07-021	Subsidence Monitoring Point #11	N/A	-0.03	ft/year
01-009	P252	N/A	-0.03	ft/year
07-022	Subsidence Monitoring Point #12	N/A	-0.01	ft/year
07-023	Subsidence Monitoring Point #13	N/A	-0.01	ft/year
07-020	104.20-R	N/A	-0.08	ft/year
07-024	Subsidence Monitoring Point #14	N/A	-0.08	ft/year
07-025	Subsidence Monitoring Point #15	N/A	-0.08	ft/year
07-019	AG-24	TRID	155.77	ft GSE
07-026	TID A	TRID	158.54	ft GSE
07-027	TID B	TRID	167.22	ft GSE

[1] TBD = To be determined
[2] ft GSE = feet ground surface elevation (NAVD88)

Table 6-11. Interim Milestones for Land Subsidence

Narrative Description

WSID-PID Management Area
- Year 5 (2025): Establish minimum threshold and measurable objective for land subsidence sustainability indicator
- Year 10 (2030): To be determined in 5-Year GSP update in 2025 based on additional data analysis
- Year 15 (2035): To be determined in 5-Year GSP update in 2025 based on additional data analysis

TRID Management Area
- Year 5 (2025): Minimal additional subsidence
- Year 10 (2030): Minimal additional subsidence
- Year 15 (2035): Minimal additional subsidence

Remaining Plan Area
- Year 5 (2025): Minimal additional subsidence
- Year 10 (2030): Minimal additional subsidence
- Year 15 (2035): Minimal additional subsidence

Numeric Interim Milestones – Inelastic Land Subsidence

DMS ID	Local ID	Management Area	Year 5 (2025) [1,2]	Year 10 (2030) [1,2]	Year 15 (2035) [1,2]	Units[1,2]
02-003	Floragold Well	N/A	-0.12	-0.12	-0.11	ft/year
02-008	Well 11	N/A	-0.12	-0.12	-0.11	ft/year
02-005	Well 2	N/A	-0.12	-0.12	-0.11	ft/year
02-006	Well 4	N/A	-0.12	-0.12	-0.11	ft/year
02-007	Well 6	N/A	-0.12	-0.12	-0.11	ft/year
03-004	Locust Avenue Well	WSID-PID	TBD	TBD	TBD	TBD
03-005	Pumping Plant No. 2	WSID-PID	TBD	TBD	TBD	TBD
03-006	River Station	WSID-PID	TBD	TBD	TBD	TBD
01-010	Subsidence Monitoring Point #1	N/A	-0.12	-0.12	-0.11	ft/year
01-011	Subsidence Monitoring Point #2	N/A	-0.12	-0.12	-0.11	ft/year
01-012	Subsidence Monitoring Point #3	N/A	-0.12	-0.12	-0.11	ft/year
01-013	Subsidence Monitoring Point #4	N/A	-0.12	-0.12	-0.11	ft/year
01-014	Subsidence Monitoring Point #5	N/A	-0.12	-0.12	-0.11	ft/year
02-004	Subsidence Monitoring Point #6	N/A	-0.12	-0.12	-0.11	ft/year
04-002	WSID 1	WSID-PID	TBD	TBD	TBD	TBD
04-003	WSID 11	WSID-PID	TBD	TBD	TBD	TBD
04-004	WSID 21	WSID-PID	TBD	TBD	TBD	TBD
01-015	Subsidence Monitoring Point #7	N/A	-0.18	-0.09	-0.01	ft/year
06-006	Subsidence Monitoring Point #8	N/A	-0.18	-0.09	-0.01	ft/year
01-016	Subsidence Monitoring Point #9	N/A	-0.18	-0.09	-0.01	ft/year
01-017	Subsidence Monitoring Point #10	N/A	-0.15	-0.09	-0.03	ft/year
07-021	Subsidence Monitoring Point #11	N/A	-0.15	-0.09	-0.03	ft/year
01-009	P252	N/A	-0.15	-0.09	-0.03	ft/year
07-022	Subsidence Monitoring Point #12	N/A	-0.1	-0.06	-0.01	ft/year
07-023	Subsidence Monitoring Point #13	N/A	-0.1	-0.06	-0.01	ft/year
07-020	104.20-R	N/A	-0.15	-0.11	-0.08	ft/year
07-024	Subsidence Monitoring Point #14	N/A	-0.15	-0.11	-0.08	ft/year
07-025	Subsidence Monitoring Point #15	N/A	-0.15	-0.11	-0.08	ft/year
07-019	AG-24	TRID	< -0.5	< -0.5	< -0.5	ft GSE
07-026	TID A	TRID	< -0.5	< -0.5	< -0.5	ft GSE
07-027	TID B	TRID	< -0.5	< -0.5	< -0.5	ft GSE

[1] TBD = To be determined
[2] ft GSE = feet ground surface elevation (NAVD88)

6.3.6 Depletions of Interconnected Surface Water

Undesirable results, minimum thresholds, measurable objectives, and interim milestones for the depletions of interconnected surface water sustainability indicator are described in the subsequent subsections.

6.3.6.1 Undesirable Results

A description of undesirable results as defined under SGMA and by the Delta-Mendota Subbasin, identification of undesirable results, potential causes of undesirable results, and potential effects of undesirable results relative to the depletions of interconnected surface water sustainability indicator are detailed below.

6.3.6.1.1 Description of Undesirable Results

The undesirable result related to depletions of interconnected surface water is defined under SGMA as:

> *Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water* (CWC Section 10721(x)(6)).

An undesirable result for depletions of interconnected surface water in the Delta-Mendota Subbasin is experienced through *depletions of interconnected surface water, as defined by each GSP Group, that have significant and unreasonable adverse impacts on the beneficial uses of surface water*. This definition of an undesirable result was agreed upon by all GSP Groups through the Delta-Mendota Subbasin Coordination Committee. Public feedback was considered in defining an undesirable result for depletions of interconnected surface water based on stakeholder participation at public workshops held in May 2019.

6.3.6.1.2 Identification of Undesirable Results

An undesirable result for depletions of interconnected surface water is triggered, or considered “significant and unreasonable,” when where interconnected stretches of surface water are identified and a significant increase in the depletions of surface water is occurring as a result of groundwater pumping. The percent increase in depletions considered significant, identified herein as ‘X,’ is to be determined from monitoring data to be collected between 2020 and 2025 and associated analysis of these data.

6.3.6.1.3 Potential Causes of Undesirable Results

The potential causes of undesirable results for the depletions of interconnected surface water includes increased groundwater demand along interconnected corridors. The portion of the San Joaquin River bordering the Northern Delta-Mendota Region has been identified as the only interconnected surface water body in the Plan area, based on information available during development of this GSP as described in Section 5.3.7 *Interconnected Surface Water Systems* of the *Basin Setting* chapter.

6.3.6.1.4 Potential Effects of Undesirable Results

If depletions of interconnected surface water were to reach levels causing undesirable results, adverse effects could include reduced flow and stage within the San Joaquin River to the extent that insufficient surface water flows would be available to support diversions for agricultural uses or to support regulatory environmental requirements. This could result in increased groundwater production, changes in irrigation practices and crops grown, and could cause adverse effects to property values and the subbasin-wide economy. Such impacts could also be tied to the inability to meet minimum flow requirements, which are defined for the San Joaquin River and are managed by upstream dams and reservoir releases.

6.3.6.2 Minimum Thresholds

At the time of GSP development, there are insufficient data available to set numeric values for minimum thresholds for the depletions of interconnected surface water sustainability indicator in a manner that is not subjective. A qualitative statement of minimum thresholds has been developed in the interim for this sustainability indicator as follows:

> *An X percent increase in surface water depletions along interconnected stretches of surface water as a result of groundwater pumping, where 'X' is the present increase in depletions to be determined from monitoring data collected between 2020 and 2025 and associated analyses of these data.*

Data collected from wells within the depletions of interconnected surface water monitoring network and stream gauges located along the San Joaquin River between 2020 and 2025 will be analyzed to determine the location, timing, and quantity of depletions over reaches of interconnected surface water within and/or adjoining the Northern and Central Delta-Mendota Regions. Data and assessments gathered during this time period will be used to establish numeric minimum thresholds for inclusion in the first 5-Year GSP Update. Figure 6-7 shows the representative monitoring locations for the depletions of interconnected surface water sustainability indicator.

6.3.6.3 Measurable Objectives and Interim Milestones

At the time of GSP development, there are insufficient data available to set numeric values for measurable objectives and interim milestones for the depletions of interconnected surface water sustainability indicator. Data collected from wells within the depletions of interconnected surface water monitoring network and stream gauges located along the San Joaquin River between 2020 and 2025 will be analyzed to determine the location, timing, and quantity of depletions. Data and assessments gathered between this time period will be used to establish numeric measurable objectives and interim milestones for inclusion in the first the 5-Year GSP Update.

In the interim, a qualitative statement has been developed for the measurable objective for depletions of interconnected surface water as follows:

> *No increased depletions of surface water as a result of groundwater pumping.*

Since the 2025 interim goal is to establish measurable objectives for this sustainability indicator (in addition to subsequent interim goals), numeric measurable objectives and 2030 and 2035 interim goals will be included in the first 5-Year GSP Update based on additional data collected and analyses performed.

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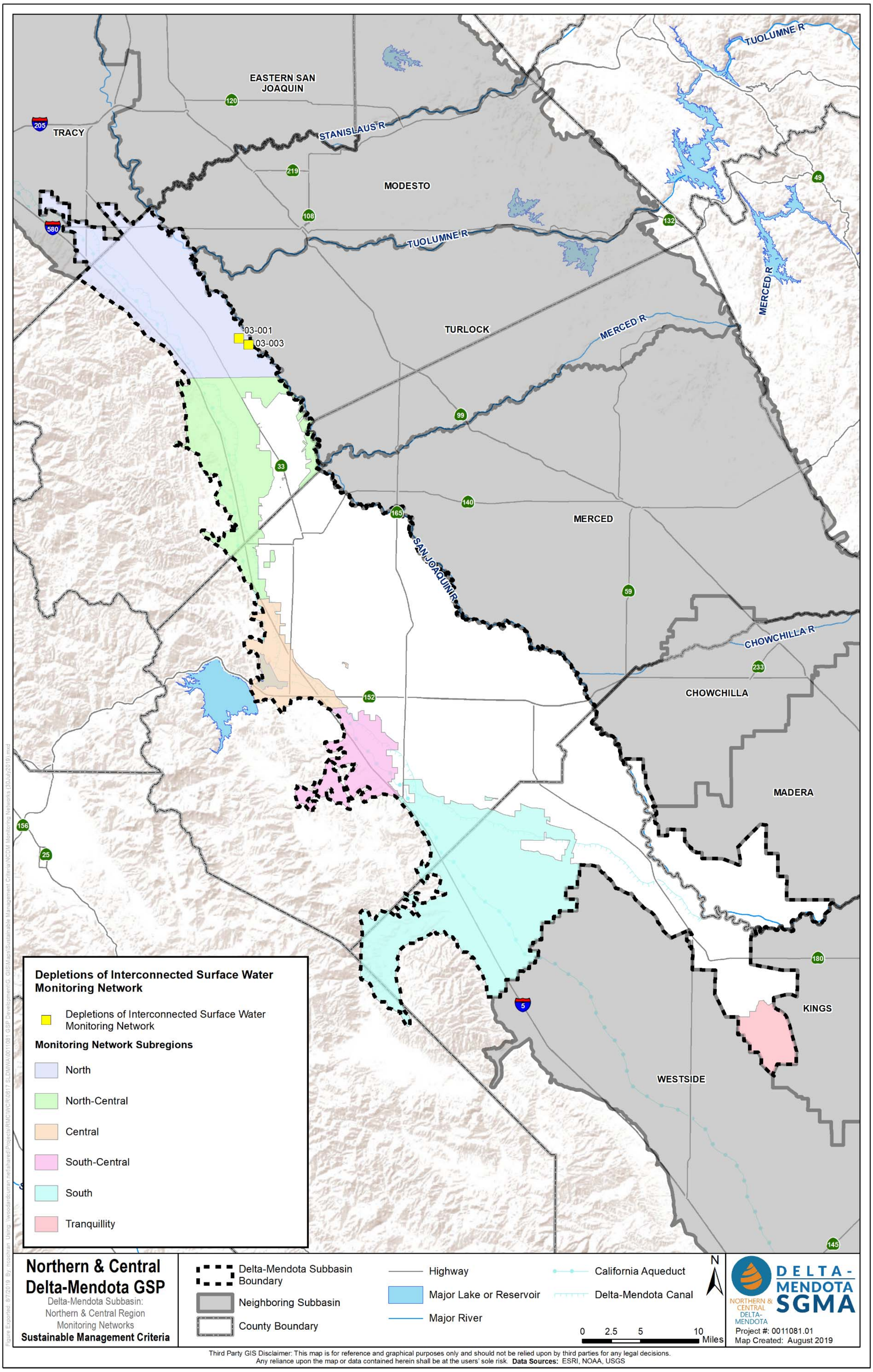

Figure 6-7. Locations of Representative Monitoring Wells for Depletions of Interconnected Surface Water

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6.4 REFERENCES

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Section 7

Sustainability Implementation

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7. SUSTAINABILITY IMPLEMENTATION

7.1 PROJECTS AND MANAGEMENT ACTIONS

The projects and management actions detailed in this section have been identified for implementation to support groundwater sustainability in the Northern and Central Regions of the Delta-Mendota Subbasin and to respond to projected changing conditions in the Subbasin over the planning and implementation horizon, as required by the Groundwater Sustainability Plan (GSP) Emergency Regulations Article 5 Plan Contents, Subarticle 5 Projects and Management Actions (§354.42 - §354.44). Pursuant to Section 354.44, each project and management action description included herein contains the following information:

- A description of the measurable objective that is expected to benefit from the project or management action;
- Criteria for implementation;
- Quantification of demand reduction for overdraft mitigation;
- A summary of permitting and regulatory processes required for each project and management action;
- The status of each project and management action;
- An explanation of benefits expected to be realized and how benefits will be evaluated;
- An explanation of how the project or management action will be accomplished;
- The legal authority required for each project and management action;
- Estimated cost and how costs will be met; and
- A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.

Projects selected for inclusion in the projected water budget for the Northern and Central Delta-Mendota Regions were based on several criteria including:

- The status of project development;
- The feasibility of quantifying anticipated benefits at the time of GSP development; and
- The ability of projects and management actions to help meet the Subbasin sustainability goal.

It is anticipated that projects and management actions identified herein will change during the implementation process as more information is learned about the Delta-Mendota Subbasin and how the Subbasin reacts to implemented projects and management actions. Implementation of projects identified herein is contingent upon the availability of funding for construction, operation and maintenance. Projects and management actions not implemented during the first five years of the GSP implementation period will be re-evaluated based on data collection efforts through 2025. Additional projects and management actions will also be evaluated for inclusion in subsequent 5-Year Plan updates to ensure Subbasin sustainability is achieved by 2040.

The projects and management actions contained herein were divided into three tiers based on design and funding status and anticipated timeframe of implementation:

- Tier 1 – Near-term projects and management actions that the Groundwater Sustainability Agencies (GSAs) are committed to implementing at this time. These projects and management actions are either currently in the process of being implemented or could be implemented in the near future (constructed and operational) within the next five years (by 2025).

- **Tier 2 –** Projects and management actions that have been identified and require further development before implementation can occur. It is anticipated that these projects and management actions could be developed over the next five years and implemented beginning in 2026 or later, pending re-evaluation prior to the 5-Year GSP Update in 2025.

- **Tier 3 –** Longer-term projects and management actions that may be implemented in the future as needed. Many of these projects are outside of the GSAs' control but could have implications on surface water availability and/or are additional projects/management actions that could be implemented under an adaptive management approach.

The projects and management actions selected for implementation are summarized in Table 7-1 and described in more detail in the following subsections. The project proponents (or implementing agencies) are also shown in Table 7-1. Generally, management actions do not have a specific project proponent, but rather would be implemented by a single GSA, all of the GSAs in the Plan area or Subbasin, and/or a proponent/manager for the management action would be identified prior to implementation. Table 7-2 includes a summary of how projects and management actions described herein address each sustainability indicator applicable to the Plan Area. It should be noted that projects related to the use of surplus surface water, stormwater or flood flow for groundwater recharge will be required to obtain proper water rights prior to project construction.

The projected water budget, with applied climate change factors and anticipated projects and management actions, contained in Section 5.4 *Water Budget* of the *Basin Setting* chapter was completed assuming implementation of Tier 1 projects, Tier 2 projects, and Tier 2 management actions. Because Tier 3 projects are longer term and/or are outside the direct control of the Northern and Central Delta-Mendota Regions GSAs and project details have not yet been determined, these projects were not included in the projected water budget. For details regarding how each of the Tier 1 and Tier 2 projects and Tier 2 management actions were incorporated into the projected water budget, refer to Appendix D *Water Budgets Model Development Technical Memorandum*.

Table 7-1. Northern & Central Delta-Mendota Region GSP Projects and Management Actions

Tier	Category	Project / Management Action	Project Proponent
Tier 1	Projects	Los Banos Creek Recharge and Recovery Project	San Luis Water District
		Orestimba Creek Recharge and Recovery Project	Del Puerto Water District
		North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years	Del Puerto Water District
		City of Patterson Percolation Ponds for Stormwater Capture and Recharge	City of Patterson
		Kaljian Drainwater Reuse Project	San Luis Water District
		West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	West Stanislaus Irrigation District
		Revision to Tranquillity Irrigation District Lower Aquifer Pumping	Tranquillity Irrigation District
	Management Actions	Lower Aquifer Pumping Rules for Minimizing Subsidence	N/A
		Maximize Use of Other Water Supplies	N/A
		Increasing GSA Access to and Input on Well Permits	N/A
		Drought Contingency Planning in Urban Areas	N/A
		Fill Data Gaps	N/A
Tier 2	Projects	Del Puerto Canyon Reservoir Project	Del Puerto Water District
		Little Salado Creek Groundwater Recharge and Flood Control Basin	Stanislaus County
		Patterson Irrigation District Groundwater Bank and/or Flood-Managed Aquifer Recharge (MAR)-type Project	Patterson Irrigation District
		West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	West Stanislaus Irrigation District
		Ortigalita Creek Groundwater Recharge and Recovery Project	San Luis Water District
	Management Action	Develop Program to Incentivize Use of Surface Water and Reduce Groundwater Demand	N/A
Tier 3	Projects	Pacheco Reservoir Expansion	Santa Clara Valley Water District
		Raising San Luis Reservoir	U.S. Bureau of Reclamation (USBR)
		Sites Reservoir	Sites Project Authority
		Los Vaqueros Expansion Phase 2	Contra Costa Water District
	Management Actions	Groundwater Extraction Fee with Land Use Modifications	N/A
		City of Patterson Reduced Groundwater Use Portfolio	City of Patterson
		Rotational Fallowing of Crop Lands	N/A

N/A – Not applicable; no specific project proponent identified. In most cases, management action will be implemented by a single GSA, all of the GSAs, and/or a proponent/manager for the management action will be identified prior to implementation.

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Table 7-2. Summary of How Northern & Central Delta-Mendota Region GSP Projects and Management Actions Address Sustainability Indicators

Activity	Sustainability Indicator				
	Chronic Lowering of Groundwater Levels	Reduction of Groundwater Storage	Degraded Water Quality	Land Subsidence	Depletions of Interconnected Surface Water
Tier 1 Projects					
Los Banos Creek Recharge and Recovery Project	Increased groundwater recharge; directly contributing to increased groundwater levels in the Upper Aquifer.	Increased groundwater recharge; directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	This project does not address this sustainability indicator.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
Orestimba Creek Recharge and Recovery Project	Increased groundwater recharge during wet periods; directly contributing to increased groundwater levels in the Upper Aquifer. Provides an alternative source of water during dry/critically dry periods for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Increased groundwater recharge; directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge during wet periods, reducing groundwater quality degradation associated with declining groundwater levels. Provides an alternative source of water during dry periods for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations that potentially lead to reduced groundwater quality degradation.	As water demand is met by water in the Upper Aquifer, reliance on Lower Aquifer pumping decreases, which results in a reduced risk of inelastic land subsidence.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations potentially leading to reduced groundwater quality degradation associated with declining groundwater levels.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in Lower Aquifer piezometric head, resulting in a reduced risk of inelastic land subsidence.	Provide an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations and associated potential impacts to interconnected surface water.
City of Patterson Percolation Ponds for Stormwater Capture and Recharge	Increased groundwater recharge; directly contributing to increased groundwater levels in the Upper Aquifer.	Increased groundwater recharge; directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	Increased recharge in the Upper Aquifer will allow the City to utilize this aquifer in lieu of pumping the Lower Aquifer, which will result in reduced risk of inelastic land subsidence.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
Kaljian Drainwater Reuse Project	Provides a new source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Provides new source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Provides a new source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations potentially leading to reduced groundwater quality degradation associated with declining groundwater levels.	Provides a new source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in Lower Aquifer piezometric head, resulting in a reduced risk of inelastic land subsidence.	Provides a new source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations and associated potential impacts to interconnected surface water.
West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations potentially leading to reduced groundwater quality degradation associated with declining groundwater levels.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in Lower Aquifer piezometric head, resulting in a reduced risk of inelastic land subsidence.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations and associated potential impacts to interconnected surface water.
Revision to Tranquillity Irrigation District Lower Aquifer Pumping	Modifies the way in which Lower Aquifer groundwater is extracted, reducing declines in Lower Aquifer piezometric head.	Modifies the way in which Lower Aquifer groundwater is extracted, reducing declines in Lower Aquifer piezometric head and overall groundwater extractions from the Lower Aquifer.	This project does not address this sustainability indicator.	Modifies the way in which Lower Aquifer groundwater is extracted, reducing declines in Lower Aquifer piezometric head resulting in a reduced risk of inelastic land subsidence.	This project does not address this sustainability indicator.
Tier 1 Management Actions					

Activity	Sustainability Indicator				
	Chronic Lowering of Groundwater Levels	Reduction of Groundwater Storage	Degraded Water Quality	Land Subsidence	Depletions of Interconnected Surface Water
Lower Aquifer Pumping Rules for Minimizing Subsidence	Provides an additional buffer to keep groundwater levels above minimum thresholds at representative monitoring locations in the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and avoiding undesirable results for this sustainability indicator.	Reduced declines in Lower Aquifer piezometric head as a result reduces overall groundwater extractions from the Lower Aquifer.	This management action does not address this sustainability indicator.	Providing an additional buffer to keep groundwater levels above the minimum thresholds at representative monitoring locations for Chronic Lowering of Groundwater Levels reduces declines in Lower Aquifer piezometric head, resulting in reduced risk of inelastic land subsidence.	This management action does not address this sustainability indicator.
Maximize Use of Other Water Supplies	Increased use of water supplies other than groundwater offsets groundwater pumping from each principal aquifer, thus reducing declines in groundwater elevations in each principal aquifer.	Increased use of water supplies other than groundwater offsets groundwater pumping and reduces declines in groundwater storage.	Groundwater quality could improve with the increased use of other water supplies to offset groundwater pumping, particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels may demonstrate decreased concentrations of certain constituents of concern).	Increased use of other water supplies can offset groundwater pumped from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	Increased use of other water supplies can offset groundwater pumped from areas where surface water-groundwater interaction is known or suspected to occur, thus reducing the risk of depletions of interconnected surface waters.
Increasing GSA Access to and Input on Well Permits	Input from GSAs regarding new well locations may avoid undesirable results related to this sustainability indicator within the GSA's jurisdictional area, where groundwater extractions can also be metered or measured.	Input from GSAs regarding new well locations may avoid undesirable results related to this sustainability indicator within the GSA's jurisdictional area, where groundwater extractions can also be metered or measured.	Input from GSAs regarding new well locations may aid in avoiding areas where groundwater pumping is expected to cause increased concentrations of constituents of concern.	Input from GSAs regarding new well locations may also include proposed depth and screened intervals for a new well, where such input may reduce the number of new wells pumping from the Lower Aquifer resulting in reduced risk of inelastic land subsidence.	Input from GSAs regarding new well locations may aid in avoiding installation of wells located where pumping has the potential to cause depletions of interconnected surface water.
Drought Contingency Planning in Urban Areas	Drought contingency planning may result in the ability to prepare for and respond to water shortage during times of drought by increasing efficiency of use of available groundwater resources or seeking alternative or supplemental water supply sources, thus reducing declines in groundwater elevations in each principal aquifer.	Drought contingency planning may result in the ability to prepare for and respond to water shortage during times of drought by increasing efficiency of use of available groundwater resources or seeking alternative or supplemental water supply sources, thus reducing declines in groundwater storage.	This management action does not address this sustainability indicator.	Drought contingency planning may result in the ability to prepare for and respond to water shortages during times of drought by utilizing other water supplies as opposed to continued pumping from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	This management action does not address this sustainability indicator.
Fill Data Gaps	Filling in data gaps related to this sustainability indicator will aid in refining water budgets, improve the representative monitoring network, and provide additional data for setting/refining numeric minimum thresholds and measurable objectives.	Filling in data gaps related to this sustainability indicator will aid in refining water budgets, improve the representative monitoring network, and provide additional data for setting/refining numeric minimum thresholds and measurable objectives.	Filling in data gaps related to this sustainability indicator will aid in refining water budgets, improve the representative monitoring network, and provide additional data for setting/refining numeric minimum thresholds and measurable objectives.	Filling in data gaps related to this sustainability indicator will aid in refining water budgets, improve the representative monitoring network, and provide additional data for setting/refining numeric minimum thresholds and measurable objectives.	Filling in data gaps related to this sustainability indicator will aid in refining water budgets, improve the representative monitoring network, and provide additional data for setting/refining numeric minimum thresholds and measurable objectives.
Tier 2 Projects					
Del Puerto Canyon Reservoir Project	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations potentially leading to	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in Lower Aquifer	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations and associated potential impacts to interconnected surface water.

Activity	Sustainability Indicator				
	Chronic Lowering of Groundwater Levels	Reduction of Groundwater Storage	Degraded Water Quality	Land Subsidence	Depletions of Interconnected Surface Water
			reduced groundwater quality degradation associated with declining groundwater levels.	piezometric head, resulting in a reduced risk of inelastic land subsidence.	
Little Salado Creek Groundwater Recharge and Flood Control Basin	Increased groundwater recharge, directly contributing to increased groundwater levels in the Upper Aquifer.	Increased groundwater recharge, directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	This project does not address this sustainability indicator.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
Patterson Irrigation District Groundwater Bank and/or Flood-MAR-type Project	Increased groundwater recharge, directly contributing to increased groundwater levels in the Upper Aquifer.	Increased groundwater recharge, directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	This project does not address this sustainability indicator.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations potentially leading to reduced groundwater quality degradation associated with declining groundwater levels.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in Lower Aquifer piezometric head, resulting in a reduced risk of inelastic land subsidence.	Provides an alternative source of water for irrigation, thereby offsetting groundwater pumping and reducing declines in groundwater elevations and associated potential impacts to interconnected surface water.
Ortigalita Creek Groundwater Recharge and Recovery Project	Increased groundwater recharge, directly contributing to increased groundwater levels in the Upper Aquifer.	Increased groundwater, directly contributing to increased storage in the Upper Aquifer.	Contributes to increased groundwater levels through increased recharge, reducing groundwater quality degradation associated with declining groundwater levels.	This project does not address this sustainability indicator.	Increased groundwater recharge reduces the potential for groundwater levels to decline and negatively impact interconnected surface water flows.
Tier 2 Management Actions					
Develop Program to Incentivize Use of Surface Water and Reduce Groundwater Demand	Incentivizing the use of surface water supplies offsets groundwater pumping from each principal aquifer, thus reducing declines in groundwater elevations in each principal aquifer.	Incentivizing the use of surface water supplies offsets groundwater pumping and reduces declines in groundwater storage.	Groundwater quality could improve by incentivizing the use of surface water supplies to offset groundwater pumping, particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels may demonstrate decreased concentrations of certain constituents of concern).	Incentivizing the use of surface water supplies can offset groundwater pumped from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	Incentivizing the use of surface water can offset groundwater pumped from areas where surface water-groundwater interaction is known or suspected to occur, thus reducing the risk of depletions of interconnected surface waters.
Tier 3 Projects					
Pacheco Reservoir Expansion	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, thereby reducing declines in groundwater elevations in each principal aquifer.	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing declines in groundwater storage.	Increased reliability of surface water supplies (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing degradation of groundwater quality particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels may demonstrate decreased concentrations of certain constituents of concern).	Increased water supply reliability (directly and indirectly) and operational flexibility can offset groundwater pumping from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	This project does not address this sustainability indicator.
Raising San Luis Reservoir	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, thereby reducing declines in	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing declines in groundwater storage.	Increased reliability of surface water supplies and operational flexibility offsets groundwater pumping, reducing degradation of groundwater quality particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels	Increased water supply reliability (directly and indirectly) and operational flexibility can offset groundwater pumping from the Lower Aquifer, thus reducing declines in Lower Aquifer	This project does not address this sustainability indicator.

Activity	Sustainability Indicator				
	Chronic Lowering of Groundwater Levels	Reduction of Groundwater Storage	Degraded Water Quality	Land Subsidence	Depletions of Interconnected Surface Water
	groundwater elevations in each principal aquifer.		may demonstrate decreased concentrations of certain constituents of concern).	piezometric head and resulting in reduced risk of inelastic land subsidence.	
Sites Reservoir	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, thereby reducing declines in groundwater elevations in each principal aquifer.	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing declines in groundwater storage.	Increased reliability of surface water supplies (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing degradation of groundwater quality particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels may demonstrate decreased concentrations of certain constituents of concern).	Increased water supply reliability (directly and indirectly) and operational flexibility can offset groundwater pumping from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	This project does not address this sustainability indicator.
Los Vaqueros Expansion Phase 2	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, thereby reducing declines in groundwater elevations in each principal aquifer.	Increased water supply reliability (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing declines in groundwater storage.	Increased reliability of surface water supplies (directly and indirectly) and operational flexibility offsets groundwater pumping, reducing degradation of groundwater quality particularly for constituents of concern that are correlated with groundwater levels (where increased groundwater levels may demonstrate decreased concentrations of certain constituents of concern).	Increased water supply reliability (directly and indirectly) and operational flexibility can offset groundwater pumping from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	This project does not address this sustainability indicator.
Tier 3 Management Actions					
Groundwater Extraction Fee with Land Use Modifications	Collection of groundwater extraction fees incentivizes the use of supplemental or alternative water supplies where fees can also fund activities/projects that increase groundwater supplies, such as groundwater recharge, thus reducing declines in groundwater elevations.	Collection of groundwater extraction fees incentivizes the use of supplemental or alternative water supplies where fees can also fund activities/projects that increase groundwater supplies, such as groundwater recharge, thereby offsetting groundwater pumping and reducing declines in groundwater storage.	Collection of groundwater extraction fees incentivizes the use of supplemental or alternative water supplies where fees can also fund activities/projects that reduce degradation of groundwater quality, such as the proper construction and destruction of wells to prevent groundwater contamination.	Collection of groundwater extraction fees incentivizes the use of supplemental or alternative water supplies that offset Lower Aquifer pumping, reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	Collection of groundwater extraction fees can incentivize the use of supplemental or alternative water supplies over groundwater pumping from areas where surface water-groundwater interaction is known or suspected to occur, thus reducing the risk of depletions of interconnected surface water.
City of Patterson Reduced Groundwater Use Portfolio	Increased use of water supplies other than groundwater and easier implementation of water supply projects offsets groundwater pumping, thus reducing declines in groundwater elevations.	Increased use of water supplies other than groundwater and easier implementation of water supply projects offsets groundwater pumping and reduces declines in groundwater storage.	This management action does not address this sustainability indicator.	Increased use of other water supplies and easier implementation of water supply projects can offset groundwater pumped from the Lower Aquifer, thus reducing declines in Lower Aquifer piezometric head and resulting in reduced risk of inelastic land subsidence.	This management action does not address this sustainability indicator.
Rotational Fallowing of Crop Lands	Rotational fallowing of crop lands can temporarily reduce agricultural water use, thereby increasing groundwater levels.	Rotational fallowing of crop lands can temporarily reduce agricultural water uses, thereby reducing declines in groundwater storage.	Rotational fallowing of crop lands can temporarily reduce agricultural water use, thereby improving groundwater quality.	Rotational fallowing of crop lands can temporarily reduce agricultural water use, thereby reducing the risk of inelastic land subsidence.	This management action does not address this sustainability indicator.

7.1.1 Description of Projects and Management Actions

The following subsections describe the projects and management actions associated with each tier as summarized above. A full vetting of projects described herein, including required permitting, environmental review (as required for compliance with California Environmental Quality Act [CEQA] and/or National Environmental Policy Act [NEPA]) and funding, is not within the scope of this GSP and may lead to identified projects being rendered infeasible. Further assessments of feasibility will be conducted by the individual project proponents. Subsequent 5-Year GSP Updates will include revisions to or removal of projects described in this GSP and the addition of other projects as necessary in order to achieve Subbasin sustainability by 2040.

7.1.1.1 Tier 1 Projects

Tier 1 projects are anticipated to be implemented, or begin to be implemented, in the first five years of GSP implementation (between 2020 and 2025). These projects are at various points in development and operation but are anticipated to begin to provide benefits to the Plan area prior to the first 5-Year GSP Update in 2025.

7.1.1.1.1 Los Banos Creek Recharge and Recovery Project

The Los Banos Creek Recharge and Recovery Project is located in and adjacent to Los Banos Creek, which is south of the City of Los Banos between the San Luis Canal and Central California Irrigation District's (CCID) Outside Canal. The project will develop a recharge basin, convert three rock quarry pits to temporary storage/recharge basins, construct three storage recovery sump pumps, six shallow groundwater recovery wells, a bridge crossing of Los Banos Creek, and a weir located just downstream of the Outside Canal. Project flood waters and surplus irrigation supply will be temporarily stored in the pits/basin for beneficial use and flood mitigation purposes with surplus waters percolated into the Upper Aquifer. Project beneficiaries include San Luis Water District (SLWD), CCID, Grassland Water District, and regional groundwater users (including the City of Los Banos). A hydrogeologic study conducted by Kenneth D. Schmidt and Associates in 2017 concluded that the local geology and aquifer are likely suitable for groundwater recharge and recovery operations.

The recharge portion of the project will increase groundwater elevations in the Upper Aquifer, along with the volume of water stored above the Corcoran Clay. Utilization of water stored in the local aquifer in surplus years for irrigation supply in drought years offsets deficit groundwater pumping and/or a portion of the need to acquire open market water, much of which is acquired through the Sacramento-San Joaquin Delta (Delta) or from sources which would otherwise contribute to Delta flows. It is estimated 200 acre-feet per year (AFY) of groundwater recharge will be achieved within the first year of operation.

The project is currently at 30% design. It is anticipated that Final Design and permitting can be completed within two years with recharge beginning in 2020. It is anticipated this project will require an Environmental Impact Report (EIR) with a Mitigated Negative Declaration to comply with the CEQA and NEPA along with Waste Discharge Requirement permits for the recharge portion of the project and well permits for the recovery portion of the project. Environmental documentation has not yet begun. It is anticipated that all required environmental documentation work can be completed within two years of start. Construction and project completion would be achieved within three years. Project advancement is ready to proceed as soon as funding becomes available.

7.1.1.1.2 Orestimba Creek Recharge and Recovery Project

The Orestimba Creek Recharge and Recovery Project (OCRRP), led by Del Puerto Water District (DPWD) and CCID, is designed to capture flood flows, excess winter flows, and Section 215 contract water (non-storable flows authorized by the United States Bureau of Reclamation [USBR]) from Orestimba Creek and the Delta-Mendota Canal (DMC) for groundwater recharge and later use during dry periods. Phase 1 of the project includes the construction of two 10-acre recharge ponds, enlargement of the existing canal to convey 10 cubic feet per second (cfs) of flows, construction of five monitoring wells (two 250-feet deep wells and three 150-feet deep wells), and construction of one production well. Phase 2 of the project includes the construction of 60 acres of additional recharge ponds, a diversion point out of Orestimba Creek, pipelines from Orestimba Creek and the DMC to the recharge facilities, five recovery wells, and associated appurtenances and pipelines along the project site between the DMC and the Eastin Water District boundary and along the CCID Main Canal. The project will receive flood flows from both the San Joaquin and Kings Rivers together with surface water from Orestimba Creek, CCID and/or DPWD. The DMC, as well as a proposed pipeline from Orestimba Creek, will be used to convey water to the project site. It is anticipated that 7,500 AFY of benefits will be actualized from this project within the Northern Delta-Mendota Region.

The initial 20 acres of recharge ponds and the monitoring wells under Phase 1 have been constructed. The production well will be constructed based on the results of the initial monitoring. Depending on the results of Phase 1, Phase 2 of the project will be designed and constructed. A Mitigated Negative Declaration to comply with CEQA and NEPA was prepared for Phase 1, and it is assumed that the same would be completed for the potential expansion of the ponds. Design and environmental documentation will not be completed until a determination that an expansion would be pursued by the project proponents, likely in 2019.

The proposed project will help support elevated groundwater levels and increased storage in the Upper Aquifer by banking excess water, thus accelerating the rate of groundwater recharge for the underlying aquifer. Monitoring or observation wells will be installed at key locations to monitor the rate of groundwater recharge. Data collected from these wells will also be used to determine the volume of water allowed to be extracted so that the rate of recharge will always exceed extraction. It was anticipated that DPWD (and their project partners) will store up to 7,500 AFY of water as a result of the OCRRP beginning in 2020. During Below Normal Water Years (WYs) [San Joaquin River WY Index], DPWD could withdraw 3,750 acre-feet (AF), less a 10% leave behind. In Dry and Critical WYs, DPWD could withdraw 7,500 AF, less a 10% leave behind. Both DPWD and CCID rely on the Delta for their water supply. The OCRRP provides a means to capture flood flows and excess surface water flows for later use during dry periods, thereby reducing demands on the Delta and improving the sustainability of the Upper Aquifer during these critical dry periods.

7.1.1.1.3 North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years

The North Valley Regional Recycled Water Program (NVRRWP) conveys tertiary-treated recycled water from the cities of Modesto and Turlock to the DMC for conveyance to growers in the DPWD service area, as well as south-of-the-Delta wildlife refuges. With the development of conveyance capability, at buildout, up to 59,000 AFY of tertiary-treated recycled water produced from municipal wastewater and stormwater collected from the cities of Ceres, Turlock, and Modesto will be delivered DPWD growers and wildlife refuges. Recycled water is conveyed to DPWD lands to supplement Central Valley Project (CVP) supplies and offset groundwater pumping that has been occurring to make up for delivery shortages. Recycled water delivered by this project is also conveyed by USBR to supplement water supplies to wildlife refuges.

DPWD provides water to approximately 45,000 acres of productive farmland in western San Joaquin, Stanislaus, and Merced Counties. DPWD's current sole source of water is via a contract with USBR that provides up to 140,210 AFY of CVP water. However, DPWD's annual CVP water allocation has been significantly reduced since the 1990s, sometimes receiving 0% allocation in recent years. During periods of surface water delivery shortages, groundwater extraction from private wells is used to meet crop demands. Utilizing this new water supply provided by the NVRRWP, DPWD's dependence on highly unreliable CVP supplies is reduced, its surface water supply resiliency improved, and a resultant reduction in groundwater pumping realized.

An Environmental Impact Report / Environmental Impact Statement (EIR/EIS) was prepared for the NVRRWP in 2015 to comply with CEQA and NEPA. Modesto has completed its portion of the NVRRWP (consisting of a pipeline from Modesto's wastewater treatment plant to the DMC) and recycled water deliveries to DPWD customers began in

December 2017. Turlock completed design of its components in 2018 and began construction in August 2018. Turlock's recycled water will be delivered to the DMC, and ultimately the growers in DPWD's service area, in 2020. Additional recycled water supplies are expected to increase from 10,000 AFY in 2020 to 30,000 AFY in 2040 and onward as the cities grow.

7.1.1.1.4 City of Patterson Percolation Ponds for Stormwater Capture and Recharge

The City of Patterson Percolation Ponds for Stormwater Capture and Recharge project consists of constructing percolation ponds to capture and infiltrate stormwater from Del Puerto Creek. The ponds will cover roughly 14 acres. Sizing of the percolation ponds is based on existing infiltration rate data and will be updated when field investigations are completed. Implementation of this project may be phased such that the ponds are constructed over a number of years. The project is anticipated to result in 1,700 AFY of direct groundwater recharge using stormwater runoff captured within the City and conveyed to recharge locations beginning in 2020. At present, the project is in the conceptual stage and environmental (CEQA) documentation has not yet started; however, project design and associated environmental documentation can be completed within a two-year period pending available funding.

7.1.1.1.5 Kaljian Drainwater Reuse Project

The Kaljian Drainwater Reuse Project is located within SLWD's service area, approximately nine miles from the City of Los Banos. Project improvements include re-grading and/or installing lift pumps within the drainage ditches; construction of a turnout pipeline; modification of the Kaljian pump structure; and restoration of the Fitji and Kaljian pump stations, Kaljian pipeline, and 1st Lift Canal. The project will reclaim tile drain water from Charleston Drainage District for blending and permit conveyance of other supplies for beneficial use. The project will augment SLWD's supply and increase reliability, enable the conveyance of flood water for beneficial use, reduce poor quality drain water discharges to the San Joaquin River, and free up capacity in the San Joaquin River Water Quality Improvement Project.

The project will allow SLWD to wheel San Joaquin and Kings River flood waters and utilize that water for recharge. Of the 2,700 AFY average yield, it is estimated that up to 500 AFY can be available for recharge, where a portion of this water may be directly recharged in the Los Banos Creek Recharge Project. This project will reduce dependence on imported water coming from the Delta by increasing local supply in utilizing the local tile drain water to augment irrigation supplies (including offset groundwater pumping to meet crop demand not met by surface water supplies).

The project has completed a feasibility study report and 30% design plans. Further progress can be made on design, permitting, and environmental documentation when funding becomes available. It is anticipated that these items could be completed within one to 1½ years and that construction could begin within six months of completing design and permitting, with construction is anticipated to be complete in 2020. A Mitigated Negative Declaration will be prepared to comply with CEQA and NEPA. Environmental documentation is not yet started.

7.1.1.1.6 West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir

The West Stanislaus Irrigation District (WSID) Lateral 4-North Recapture and Recirculation Reservoir project will be implemented by WSID. This project consists of a reservoir on a 7-acre parcel currently not in production. The reservoir, once complete, will collect operational spill from two distribution laterals and irrigation tailwater on the north side of WSID's service area and store those waters for reliable use downstream. This project will also provide two additional benefits: First, the project will allow flexible water delivery service to users during times of drought or capture constraints; and second, the project will improve water quality to downstream users by mixing water from the DMC with surface water of lesser quality from the San Joaquin River. This project is estimated to result in roughly 1,800 AFY of recapture, of which approximately 270 AFY will percolate through the reservoir bottom and recharge the underlying Upper Aquifer helping to offset groundwater extractions in other locations of the Subbasin.

The project is currently in the conceptual stage. Design is expected to take eight months. A Mitigated Negative Declaration is expected to be required to comply with CEQA, which would be completed in parallel with design. The anticipated date of full buildout is 2020.

7.1.1.1.7 Revision to Tranquillity Irrigation District Lower Aquifer Pumping

Tranquillity Irrigation District (TRID) maintains and operates 28 wells that extract water from the Lower Aquifer and two wells from the Upper Aquifer. At times, depending on the water year, the 30 wells have pumped from the two aquifers continuously. Based on historic records, the most groundwater pumped in a single year was 24,000 AF. Beginning in 2017, TRID revised the pumping regime from the Lower Aquifer within district boundaries, allowing roughly only 10 wells to be operational at a time and shutting the wells off at night to allow for drawdown to recover. In addition, under this revised pumping regime, the most water to be pumped within a year will be 8,000 AF. During Average and Wet WYs, an estimated 1,000 AF could be pumped from the Lower Aquifer (see Section 5.4 *Water Budget* for more information about Delta-Mendota Subbasin WY designations). During Dry WYs, up to 8,000 AF could be pumped from the Lower Aquifer (see Section 5.4 *Water Budget* for more information about Delta-Mendota Subbasin WY designations). TRID began implementing this revised pumping regime in 2017, with actual Lower Aquifer groundwater extractions totaling 200 AFY each in 2017 and 2018.

7.1.1.2 Tier 1 Management Actions

It is assumed that all of the Tier 1 management actions may be implemented beginning in February 2020. What is described below are not projects that would be constructed, but rather strategies that will be developed and applied to benefit the Plan area. GSAs may implement all, some, or none of the Tier 1 management actions under their individual discretion and authority as necessary to meet the objectives of this GSP within their individual areas. Coordination among the GSAs and agencies throughout the Northern and Central Delta-Mendota Regions will be required prior to implementing the following management actions.

7.1.1.2.1 Lower Aquifer Pumping Rules for Minimizing Subsidence

In Chapter 6 *Sustainable Management Criteria*, minimum thresholds and measurable objectives associated with each representative monitoring location in the Lower Aquifer have been developed. Entities extracting groundwater from the Lower Aquifer in the Northern and Central Delta-Mendota Regions will be required to comply with these sustainable management criteria. Specifically, during groundwater extraction, if groundwater elevations approach or reach the minimum threshold of the nearest representative monitoring well(s), actions must be implemented in order to avoid undesirable results.

7.1.1.2.2 Maximizing Use of Other Water Supplies

Maximizing the use of water supplies other than groundwater can improve the quality and volume of groundwater in storage in each principal aquifer. Where possible, surface water, recycled water, stormwater, and tile drain water will be used to offset groundwater deficits. In order to implement this management action, the GSAs will develop a program to incentivize the use of alternative supplies over groundwater when possible. This program may also include, but is not limited to, taking advantage of available surplus surface water for groundwater recharge in order to increase groundwater levels in the Upper Aquifer. Surplus surface water is typically available during Wet and Above Normal WYs (San Joaquin River WY Index) when surface water supplies exceed demand. If a GSA or GSA member agency has rights to surface water and all demands have been met, the surplus water can be used for recharge through an existing groundwater recharge project or fallowed lands and/or sold to entities without surface water rights to offset groundwater pumping. As less groundwater is pumped, groundwater levels and storage could remain the same or increase, overall groundwater quality could improve, and subsidence could be reduced or eliminated in certain areas.

7.1.1.2.3 Increasing GSA Access to and Input on Well Permits

Counties in the Delta-Mendota Subbasin with well construction permit authority include Stanislaus, Merced, and Fresno Counties. Under this management action, the Counties would develop and/or change internal policies associated with well permitting to include consultation with and consideration of input from GSAs relative to if and where a proposed well would be located. This will be done to determine if the pumping associated with a new well will cause undesirable results in the GSA's jurisdictional area and to ensure that groundwater extractions are metered or measured in some fashion. These policies will also make GSAs aware of new wells such that they can be incorporated into any management programs that may be implemented as a result of Sustainable Groundwater Management Act (SGMA) compliance. Additionally, GSAs are able to develop policies regarding groundwater use, which may impact future well permitting by the Counties.

7.1.1.2.4 Drought Contingency Planning in Urban Areas

Under this management action, GSAs or GSA member agencies responsible for municipal supplies dependent on groundwater for some or all of their supplies will develop and implement drought contingency planning in urban areas in order to prepare for and respond to water shortages during times of drought. Urban water suppliers are already required to address water shortage contingency planning in their Urban Water Management Plans prepared every five years. These planning strategies can be expanded upon, if necessary, and applied in order to minimize impacts to groundwater storage and water levels when supplies become limited.

7.1.1.2.5 Fill Data Gaps

SGMA-related data gaps are identified and summarized in **Section 5.3** *Groundwater Conditions* of this GSP. In order to refine water budgets, improve the monitoring network, and provide additional data necessary for setting/refining numeric values associated with minimum thresholds and/or measurable objectives, efforts will be made to fill the identified data gaps as funding permits.

7.1.1.3 Tier 2 Projects

Tier 2 projects are projects currently in preliminary or conceptual design that will require additional time for development and implementation. For the most part, it is anticipated that Tier 2 projects will be developed over the next five years with the intent of bringing them online by 2026 or later.

7.1.1.3.1 Del Puerto Canyon Reservoir Project

The Del Puerto Canyon Reservoir Project will construct a 270-foot tall earthen dam at the mouth of Del Puerto Canyon providing 85,000 AF of storage for DPWD and the member agencies of the San Joaquin River Exchange Contractors Water Authority (SJRECWA). Water would be pumped into the reservoir from the DMC when excess water is available and discharged back to the DMC when necessary. Minimal seasonal storm flows through Del Puerto Canyon would be captured by the reservoir and discharged perennially to Del Puerto Creek for downstream use.

~~DPWD is the lead participant for both this project and the NVRRWP. DPWD will be receiving water from the NVRRWP throughout the year where NVRRWP water can be stored in the reservoir. The Del Puerto Canyon Reservoir Project will provide a reliable place of storage for NVRRWP supplies and the NVRRWP would provide a consistent supply source for the reservoir. Additionally, other partnering districts~~The districts ~~hold senior surface water rights or similar~~ would be storing CVP supplies~~, most of which comes through the Delta~~ from their annual entitlements when excess to their immediate needs. Thus, this project would benefit the ~~Delta~~ Region ~~by providing operational flexibility and~~ allowing the districts to store water south of the Delta when excess water is available to them and utilize that water during dry periods when ~~Delta~~ supplies may be limited.

An initial feasibility study and preliminary economic feasibility assessment were prepared for the Del Puerto Canyon Reservoir. Design and environmental documentation began in February 2019. It is anticipated that an EIR/EIS will be prepared over the next two years to comply with CEQA and NEPA with completion scheduled in August 2020. It is assumed water would be available for storage in the reservoir every year beginning in 2030. On average, 2,756 AFY from Del Puerto Creek would be captured and stored in the reservoir. During Wet WYs (San Joaquin River WY Index), up to 35,570 AFY of creek flows could be stored for later use in the reservoir.

The Del Puerto Canyon Reservoir project will assist the Northern and Central Delta-Mendota Regions with water supply reliability, both allowing for better ~~conjunctive~~ management of supplies and providing for storage of additional CVP surface water supplies that can be used to offset groundwater pumping in drier years. This will help the Regions maintain sustainable groundwater elevations and storage in both principal aquifers.

7.1.1.3.2 Little Salado Creek Groundwater Recharge and Flood Control Basin

The Little Salado Creek Groundwater Recharge and Flood Control Basin project, proposed by Stanislaus County, consists of constructing a stormwater detention basin to partially divert, retain, and percolate up to 270 cfs of flow from Little Salado Creek. Little Salado Creek has a drainage of 874 AFY. It was assumed the detention basin would recharge 489 AFY in Wet WYs (San Joaquin River WY Index). The basin would be located in the future Crows Landing Industrial Business Park and would have a capacity of 380 AF. The project will provide flood relief to the downstream City of Patterson and the Upper Aquifer recharge will offset groundwater pumping required to supply the new development, thereby limiting impacts on Upper Aquifer groundwater elevations and storage due to this project's development.

A drainage study was completed in November 2016 to define preliminary storm drain system infrastructure improvements necessary to accommodate the development of the Crows Landing Industrial Business Park. A Draft EIR was completed in January 2018 and was released for public review from January 22, 2018 to March 12, 2018. Stanislaus County is ready to proceed with design once funding is secured, with 2032 as the estimated date of full buildout.

7.1.1.3.3 Patterson Irrigation District Groundwater Bank and/or Flood-Managed Aquifer Recharge (MAR)-type Project

Within Patterson Irrigation District's (PID) service area, there are currently approximately 800 to 900 acres fallow each year. The University of California at Davis' Soil Agricultural Groundwater Banking (SAGBI) index was used to assess the range of potential groundwater recharge volumes that could be achieved given those fallow acres. The SAGBI index is a suitability index for groundwater recharge on agricultural land based on five major factors that are critical to successful agricultural groundwater banking: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition.

Based on the analysis conducted, the PID service area has the potential to recharge between 3,000 AFY and 9,700 AFY on the fallowed land. As a pre-1914 water rights holder, PID has access to surplus surface water from the San Joaquin River that can be used for Upper Aquifer recharge. It is assumed 3,000 AFY could be percolated in Average WYs with a larger volume during Wet WYs (see **Section 5.4** *Water Budget* for more information about Delta-Mendota Subbasin WY designations). Recharge would occur over a 120-day period from January through March. The project is currently in the conceptual phase and additional feasibility studies, pilot studies, and project design are required with an anticipated buildout date of 2032.

7.1.1.3.4 West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir

WSID is implementing the WSID Lateral 4-North Recapture and Recirculation Reservoir project in the north side of the District's service area as described in **Section 7.1.1.1** *Tier 1 Project*~~*Tier 1 Project*~~. The WSID Lateral 4-South

Recirculation Reservoir project would be a similar project, but on the south side of the District's service area. WSID would identify a parcel to construct a new reservoir to collect operational spill from distribution laterals and irrigation tailwater on the south side of the District and store those waters for reliable use downstream. For planning purposes, it is assumed 1,800 AFY could be recaptured and reused. Like the recapture and recirculation reservoir project on the northern end of the District, this project would also improve water supply reliability during droughts or in times of capture constraints. It is assumed 270 AFY of water would percolate through the reservoir bottom and recharge the underlying Upper Aquifer, helping to offset groundwater extractions in other locations of the Subbasin.

The project is currently in the conceptual stage. Design is expected to take eight months. A Mitigated Negative Declaration is expected to be required to comply with CEQA and would be completed in parallel with design. The anticipated date of full buildout is 2026.

7.1.1.3.5 Ortigalita Creek Groundwater Recharge and Recovery Project

The Ortigalita Creek Groundwater Recharge and Recover Project is a conceptual project that will be implemented by SLWD. Similar to other storm water capture recharge and recovery projects in the Tier 1 project list, this project would capture storm water runoff and/or use surplus surface water available to SLWD to recharge the Upper Aquifer. Based on local experience and knowledge, during wet years, an estimated 3,000 AFY of water could be recharged into the Upper Aquifer near Ortigalita Creek. During dry years when water is needed, a portion of this (volume yet to be determined) would be recovered from the Upper Aquifer for use by SLWD to offset surface water supply shortages.

As previously noted, this project is currently in the conceptual stage. It is anticipated that, over the next five years, project feasibility studies will be conducted and a preliminary design of the project developed. CEQA compliance documentation would then be prepared in coordination with further project design. It is assumed that this project would recharge water during Wet WYs (San Joaquin River WY Index) beginning in 2026. As with similar Tier 1 projects, this project will help support elevated groundwater levels and increased storage in the Upper Aquifer by banking excess water, thus accelerating the rate of groundwater recharge for the underlying aquifer.

7.1.1.4 Tier 2 Management Actions

The following Tier 2 management actions have been identified and require further development before implementation can occur. It is anticipated that these management actions could be developed over the next five years and implemented beginning in 2026 or later, pending re-evaluation prior to the 5-Year GSP Update in 2025.

7.1.1.4.1 Develop Program to Incentivize Use of Surface Water and Reduce Groundwater Demand

When groundwater extraction is less expensive than other water supplies, economics dictate that customers may sometimes choose to pump groundwater rather than purchase the more-costly surface water supply. To reduce groundwater demand to allow and encourage the recovery of the groundwater aquifers, especially when other supplies such as surface water are available, the use of surface water will be incentivized. Programs that could incentivize the use of surface water over groundwater could include, but are not limited to, groundwater extraction fees, a groundwater accounting framework, and rules that allow growers to sell 'groundwater credits.' It is assumed that this management action will be developed over the next five years with input from the GSAs and participating growers and would be implemented beginning in January 2026.

7.1.1.5 Tier 3 Projects

Tier 3 projects are those that have the potential to substantially affect the conjunctive use of surface water and groundwater supplies in the Northern and Central Delta-Mendota Regions by increasing water supply reliability south of the Delta, in turn impacting CVP and State Water Project (SWP) operations. As the Delta-Mendota Subbasin is dependent upon water from the CVP and SWP, Tier 3 projects have the potential to impact overall basin management. However, GSAs have little to no control over the implementation of these projects, which may be required to help achieve sustainability in the Subbasin by 2040. As such, these projects do not have specific deadlines identified herein by which it is anticipated that these projects will (if ever) be implemented.

Listed below are several projects of this nature that have the ability to directly and/or indirectly affect the availability of surface water in the Delta-Mendota Subbasin. This is not intended to be an exhaustive list; other projects are currently being considered on a regional and statewide basis that also fall into this Tier 3 category.

7.1.1.5.1 Pacheco Reservoir Expansion

The Pacheco Reservoir Expansion Project, proposed by Santa Clara Valley Water District (SCVWD) in partnership with San Benito County Water District (SBCWD) and Pacheco Pass Water District (PPWD), would raise the existing dam on Pacheco Creek to increase reservoir capacity from 5,500 AF to 140,000 AF. Pacheco Reservoir is located 60 miles southeast of San Jose on the north fork of Pacheco Creek. The project would construct a new earthen dam made of rock and other soil materials within the footprint of the existing reservoir. The project would improve water supply reliability, increase flood protection, and enhance fish habitat (SCVWD, n.d.). In July 2018, the California Water Commission (CWC) announced that the project would receive a $484.55 million grant through the Prop 1 Water Storage Investment Program (WSIP), contributing to half of the funds needed for the $969 million project. SBCWD and PPWD also plan to pursue federal funds. Remaining project costs would be paid through local water rates over multiple decades (Santa Clara Valley Water News, July 2018).

7.1.1.5.2 Raising San Luis Reservoir

The existing San Luis Reservoir has a capacity of 2 million (MAF). San Luis Reservoir was created on San Luis Creek by USBR's B.F. Sisk Dam (Sisk Dam), approximately 12 miles west of Los Banos. Water is lifted from the O'Neill Forebay into the reservoir by the Gianelli Pumping-Generating Plant, where water is stored and then released for future use. Since 2001, USBR has studied alternatives for improving delivery reliability issues that result when the reservoir storage drops to a "low point" below 300,000 AF as part of its San Luis Low Point Improvement Project (SLLPIP). In 2008, the SLLPIP identified raising the Sisk Dam as one alternative. It was later eliminated from the study after a subsequent report identified more cost-effective solutions that seemed viable at the time. In 2006, it was determined that Sisk Dam is at risk for seismic failure. Alternatives were evaluated to reduce the seismic risk of the dam, one of which included raising the dam. In December 2013, USBR prepared the *San Luis Reservoir Expansion – Appraisal Report* (USBR, December 2013) to further evaluate raising the dam to address the "low point" issue and seismic risk. Modifications to the dam were found to be technically feasible. The alternative evaluated in the report consists of raising the reservoir water surface by 10 feet, raising the dam crest by 20 feet, and increasing reservoir capacity by approximately 130,000 AF. Based on the conceptual design, construction was estimated to cost $360 million. Additional studies and project development would be needed to further refine project details, costs, and schedule.

7.1.1.5.3 Sites Reservoir

Sites Reservoir would be a new 1.8 MAF offstream reservoir located in a valley west of the City of Williams along the Glenn-Colusa County line. The reservoir would store water conveyed via 14 miles of pipeline from the Sacramento River. The reservoir would be operated to allow other reservoirs in California to hold more water into summer months and increase operational flexibility. Sites Reservoir will increase Sacramento Valley water storage by 15% and add up to 500,000 AFY to California's water system (Sites Water Authority, August 2018). The project is estimated to cost $4.4 billion (in 2015 dollars).

In 2018, CWC awarded the project $816 million of grant funding from WSIP. The remainder of the project costs would come from participating water agencies. Project implementation is led by the Sites Project Authority with a board currently comprised of representatives from Reclamation District 108, Placer County Water Agency, City of Roseville, Colusa County, Glenn County, Glenn-Colusa Irrigation District, City of Sacramento, Sacramento County

Water Agency, Tehama-Colusa Canal Authority, Westside Water District, USBR, and the California Department of Water Resources (DWR). Many other participants have been identified. Design and environmental documentation are currently underway. It is anticipated that project construction could begin in 2022 with full operations beginning in 2029.

7.1.1.5.4 Los Vaqueros Expansion Phase 2

Los Vaqueros Reservoir, located 17 miles south of the City of Antioch, was completed in 1998 and expanded from 100,000 AF to 160,000 AF in 2012 (Phase 1 Expansion). The EIS/EIR for the expansion also evaluated further expansion up to 275,000 AF (Phase 2). In July 2018, CWC announced that the Phase 2 Expansion would receive a $459 million WSIP grant. There are 15 agencies interested in partnering on the project and contributing to the local cost share. Some of these include Contra Costa Water District (CCWD), Alameda County Water District, Byron-Bethany Irrigation District, Bay Area Water Supply and Conservation Agency, City of Brentwood, DPWD, East Bay Municipal Utility District, Grassland Water District, San Luis & Delta-Mendota Water Authority, SCVWD, and Westlands Water District. Design, permitting, and environmental documentation are underway with expected completion in 2021 (CCWD, n.d.).

7.1.1.6 Tier 3 Management Actions

After implementation of the Tier 1 and Tier 2 projects and management actions, Tier 3 management actions would be implemented if additional measures are required to reduce undesirable results in the Plan area. These are long-term actions and do not have an assumed start date, but rather would be implemented as needed sometime after 2026 following reevaluation during the 5-Year GSP Update in 2025.

7.1.1.6.1 Groundwater Extraction Fee with Land Use Modifications

A groundwater extraction fee or groundwater production charge could be collected from entities that own or operate a water-producing well. Revenue from these fees could then be used to pay for a variety of activities such as the construction of water infrastructure, protection of groundwater, proper construction and destruction of wells to prevent contamination, groundwater recharge and recovery projects, purchase of imported water or other supplies to replenish the groundwater basin, and/or purchasing and permanent fallowing of marginally-productive agricultural lands dependent on groundwater. Several agencies in California have already implemented such a program and have seen success in utilizing revenue to benefit the local groundwater basin. A similar methodology could be applied by various agencies within the Northern and Central Delta-Mendota Regions.

7.1.1.6.2 City of Patterson Reduced Groundwater Use Portfolio

The City of Patterson's 2018 *Water Master Plan* evaluated various water supply portfolios to meet anticipated future supply gaps (i.e., the City's existing supply subtracted from future demands). The two most relevant portfolios include the Patterson Control Portfolio and Low Reliance on Groundwater (2) Portfolio. The preferred portfolio, Patterson Control Portfolio, provides the City independent control of its water supply and easier implementation of water supply projects. The Low Reliance on Groundwater (2) Portfolio would diversify the City's water supply portfolio to reduce the City's groundwater use with the addition of a long-term surface water transfer in which the City negotiates a long-term contract to purchase water from another entity. As a Tier 3 management action, the City could explore a long-term water transfer and move forward towards the Low Reliance on Groundwater (2) Portfolio to further reduce groundwater extractions from the Lower Aquifer, if needed.

7.1.1.6.3 Rotational Fallowing of Crop Lands

Agricultural water use can be temporarily reduced by fallowing crop lands. While this can have economic impacts to a region, the benefits can include improved water supply reliability, improved groundwater quality, increased groundwater levels, reduced subsidence, and operational flexibility. Rotational fallowing of crop lands reduces the economic impacts to any one area by rotating the areas of fallowing. This management action could be combined with a recharge project through the application of surplus water supplies to the fallowed lands resulting in in-lieu groundwater recharge.

This management action could be implemented, if needed, after 2026 to help the Northern and Central Delta-Mendota Regions work towards interim sustainability goals. However, the rules by which this management action would be implemented will have to be developed by the GSAs within the Plan area.

7.1.2 Legal Authority

All of the project proponents for the Tier 1 and 2 projects and management actions are water districts, irrigation districts, counties, cities, GSAs with specific authorities granted under SGMA or part of the agency-enabling act. As such, all have legal authority over water management decisions within their boundaries. In addition, the cities and counties in the Delta-Mendota Subbasin have legal authority in the form of land use planning and decision making.

7.1.3 Costs

Costs that have been estimated for the Tier 1 and Tier 2 projects are summarized in Table 7-3. Some costs have yet to be determined due to unknown or uncertain project status as indicated by "TBD" (To Be Determined). Costs for management actions were not developed since they are more strategies to be applied rather than construction of facilities and will vary based on GSA-specific implementation. Similarly, Tier 3 projects and management actions are too conceptual or long-term to estimate costs at this time; therefore, such costs are not included in the table. Also summarized are the potential funding sources for financing project implementation. Financing for project and Plan implementation is also described in more detail in Section 8.2 *Implementation Costs and Funding Sources*.

Table 7-3. Project Costs

Tier	Project	Project Proponent	Estimated Capital Cost [1]	Potential Funding Source(s) [2]
Tier 1	Los Banos Creek Recharge and Recovery Project	San Luis Water District	$9,116,374	Office of Emergency Services (FEMA); Local funds
	Orestimba Creek Recharge and Recovery Project	Del Puerto Water District	$7,923,450	Hazard Mitigation Grant Program (HMGP); Local funds
	North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years	Del Puerto Water District	$96,000,000	Clean Water State Revolving Fund; Water Recycling Funding Program; Title XVI Water Infrastructure Improvements for the Nation (WIIN) Grant Program; Integrated Regional Water Management (IRWM) Grant Program
	City of Patterson Percolation Ponds for Stormwater Capture and Recharge	City of Patterson	$7,800,000	State grant funds (TBD); Local funds
	Kaljian Drainwater Reuse Project	San Luis Water District	$16,500,000	USBR grant funds; Local funds
	West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	West Stanislaus Irrigation District	$1,120,000	IRWM Grant Program
	Revision to Tranquillity Irrigation District Lower Aquifer Pumping	Tranquillity Irrigation District	$0 [3]	Not Applicable
Tier 2	Del Puerto Canyon Reservoir Project	Del Puerto Water District	$491,300,000	WIIN; Local funds
	Little Salado Creek Groundwater Recharge and Flood Control Basin	Stanislaus County	$7,710,000	State grant funds (TBD); Local funds
	Patterson Irrigation District Groundwater Bank and/or Flood-MAR-type Project	Patterson Irrigation District	TBD	TBD
	West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	West Stanislaus Irrigation District	$1,500,000	State grant funds (TBD)
	Ortigalita Creek Groundwater Recharge and Recovery Project	San Luis Water District	TBD	State grant funds (TBD); Local funds

TBD – To be determined

Notes:

1. Tier 2 costs are estimated or yet to be determined based on project design.
2. State grant and low-interest loan projects, such as the Integrated Regional Water Management (IRWM) grant program, Storm Water Resources Program (SWRP) grant program, and State Revolving Fund (SRF) programs may be utilized to provide funding for any of the afore-mentioned projects or management actions, as available.
3. No direct cost as this is a revision to pumping operations within the District.

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7.1.4 Public Noticing

The Northern and Central Delta-Mendota Regions GSAs understand the benefits of an open and transparent GSP development, project planning and implementation process. While there is no formal requirement for public noticing of a project by the project proponent as part of the Northern & Central Delta-Mendota Region GSP prior to or during implementation, project proponents are encouraged to keep the public informed about project development, status, and implementation. Public noticing is often required as part of the funding, environmental, and/or permitting processes. Each project and project proponent will comply with public noticing requirements as applicable. For example, if a project proponent is preparing an EIR for a project to comply with CEQA, the project proponent would publish a Notice of Preparation, Notice of Availability, Notice of Completion, and/or Notice of Adoption. In addition, public noticing prior to public meetings, such as a scoping meeting or the meeting conducted by the governing body to adopt the EIR, would be required.

Program details for management actions implemented as part of this GSP will be developed by individual GSAs or jointly by the GSAs comprising the Northern and Central Delta-Mendota Regions. As part of management action implementation, public noticing and outreach will be conducted to provide the goals and details for each management action and to provide stakeholders with information regarding implementation and potential outcomes or impacts.

7.1.5 Permitting

Every project identified in this GSP will acquire project-specific permits prior to and during construction and/or operation. It will be the responsibility of the project proponent to ensure that these permits are secured. The permitting and regulatory approval process will be coordinated by and be the responsibility of the project proponent. This may not apply to management actions as these typically are not projects that would involve construction and thus, permits would not be needed.

Permits needed for a project are usually identified during the design and environmental review phases and are dependent upon, among other things, site characteristics, construction methods, and timelines. The types of permits that may generally be needed for the projects summarized below:

- California State Water Resources Control Board (SWRCB) Water Rights Permitting and Licensing – required to establish a riparian, overlying and/or appropriative water right. An appropriative water right license may be necessary for recharge and recovery projects as well as stormwater capture projects.

- Encroachment permits - required when a facility or construction will take place within the jurisdiction of another entity (e.g., an encroachment permit from the California Department of Transportation is required when construction will be within any portion of the State highway right-of-way). Encroachment permits may be needed for county, irrigation district, or other jurisdictional entities.

- U.S. Army Corps of Engineers 401 Permit and 404 Permit – required when construction will take place within or the project will result in the fill of any wetland or water of the United States.

- California Department of Fish and Wildlife (CDFW) Streambed Alteration Agreement – required if a pipeline or project facility will cross a stream.

- California Waste Discharge Requirement or National Pollutant Discharge Elimination System (NPDES) Permit – required when a project will discharge wastewaters (including recycled water) to land or surface waters.

- Grading permits – usually acquired at the county level and required when excavation or fill volumes meet certain parameters.

- Authority to Construct / Permit to Operate – required from certain entities (e.g., air pollution control boards) prior to construction and/or operation to manage air emissions associated with project construction and/or operation.
- Well permits – permits acquired from the county prior to the construction or destruction of a well.
- Building permits – an approval from a local governmental agency allowing the contractor to proceed with construction.

7.1.6 Benefits and Evaluation of Benefits

Projects of the same type tend to have similar benefits, which can generally be evaluated in the same way. Table 7-4 summarizes the benefits that are anticipated to be realized by project type. Table 7-5 is a crosswalk table that identifies the project type for the projects included in this GSP.

Table 7-4. Project Type and Benefits

Project Type	Benefits	Evaluation of Benefits
Recharge and Recovery	Increased groundwater storage / recharge Improved water supply reliability Improved groundwater quality Reduced land subsidence and/or fissuring	Acre-feet of water stored (directly or in-lieu) Groundwater elevations Water quality monitoring data Estimates of water in storage
Recycled Water	Improved water supply reliability Increased groundwater levels through in-lieu recharge and decreased groundwater pumping	Acre-feet of recycled water delivered Acre-feet of groundwater offset
Reservoir Creation / Expansion	Improved water supply reliability Improved groundwater quality (through reduced pumping) In-lieu groundwater recharge through seepage Increased groundwater storage / recharge (through reduced pumping)	Acre-feet of water stored Acre-feet of surface water delivered in-lieu of groundwater pumped
Pumping Changes	Reduced groundwater pumping	Acre-feet of groundwater pumped

Table 7-5. Project Types

Tier	Project	Project Type
Tier 1	Los Banos Creek Recharge and Recovery Project	Recharge and Recovery
	Orestimba Creek Recharge and Recovery Project	Recharge and Recovery
	North Valley Regional Recycled Water Program (NVRRWP) – Modesto and Early Turlock Years	Recycled Water
	City of Patterson Percolation Ponds for Stormwater Capture and Recharge	Recharge and Recovery
	Kaljian Drainwater Reuse Project	Recycled Water
	West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	Reservoir Creation / Expansion
	Revision to Tranquillity Irrigation District Lower Aquifer Pumping	Pumping Changes
Tier 2	Del Puerto Canyon Reservoir Project	Reservoir Creation / Expansion
	Little Salado Creek Groundwater Recharge and Flood Control Basin	Recharge and Recovery
	Patterson Irrigation District Groundwater Bank and/or Flood-MAR-type Project	Recharge and Recovery
	West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	Reservoir Creation / Expansion
	Ortigalita Creek Groundwater Recharge and Recovery Project	Recharge and Recovery
Tier 3	Pacheco Reservoir Expansion	Reservoir Creation / Expansion
	Raising San Luis Reservoir	Reservoir Creation / Expansion
	Sites Reservoir	Reservoir Creation / Expansion
	Los Vaqueros Expansion Phase 2	Reservoir Creation / Expansion

7.2 MONITORING

This section documents the monitoring networks and protocols developed to assess progress toward sustainability within the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan (GSP) Plan area. Comprehensive monitoring networks have been established for each applicable sustainability indicator within the Plan area: chronic lowering of groundwater levels, reduction of groundwater storage, degraded water quality, land subsidence, and depletions of interconnected surface water. (Note, seawater intrusion is not applicable to the Delta-Mendota Subbasin.) Sustainable management criteria, including minimum thresholds, measurable objectives, and interim milestones, have been set for each applicable sustainability indicator at each individual monitoring location and are discussed in further detail in Chapter 6 *Sustainable Management Criteria*.

The monitoring networks described herein were developed to coordinate with existing monitoring programs to the extent possible while providing the coverage necessary for assessing groundwater sustainability within the Delta-Mendota Subbasin. This section includes a description of the monitoring objectives, monitoring protocols, and data reporting requirements.

The monitoring networks shown herein promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related interconnected surface water conditions in the Plan Area and to evaluate changing conditions that occur through implementation of the Plan (GSP Emergency Regulations § 352.2 and § 354.32 through § 354.38). Data gaps, and a plan to fill data gaps, are also identified for each monitoring network (GSP Emergency Regulations § 354.38). For more information on existing water resources monitoring and management programs within the Delta-Mendota Subbasin, refer to Chapter 2 *Plan Area*.

7.2.1 Useful Terms

A list and description of technical terms used throughout this section to discuss groundwater wells, water quality indicators, subsidence measurements, and other monitoring characteristics are listed below. Figure 7-1 shows a schematic of a standard monitoring well with key measurements and terms identified. The terms and their descriptions are identified here to guide readers through this section and are not a definitive definition of each term.

- Best Available Science – Refers to the use of sufficient and credible information and data, specific to the decision being made and the time frame available for making that decision, that is consistent with scientific and engineering professional standards of practice (California [CA] Code of Regulations 351).
- Best Management Practice – Refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science (CA Code of Regulations, Title 23, Article 2).
- Constituent – Refers to a water quality parameter measured to assess groundwater quality.
- Data Gap – Refers to a lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of [GSP] implementation and could limit the ability to assess whether a basin is being sustainably managed (CA Code of Regulations, Title 23, Article 2).
- Depth to Bottom Perforation – The distance to the bottom of the perforated (or screen) interval of a well from the ground surface.
- Depth to Top Perforation – The distance to the top of the perforated (or screen) interval in a well from the ground surface.
- Depth to Water – The distance from the ground surface elevation (or reference point) to water surface elevation.

- Ground Surface Elevation – The elevation of the land surface in feet at the monitoring site location. Elevation is commonly expressed as feet above mean sea level (msl) and is reported relative to the North American Vertical Datum of 1988 (NAVD88) in this document per Sustainable Groundwater Act (SGMA) regulations.
- Inelastic Subsidence – Refers to the permanent sinking or downward settling of the Earth's surface. In the context of this GSP, it is primarily due to the unsustainable extraction of groundwater.
- Interconnected Surface Water – Refers to surface water that is hydraulically connected at any point in time or space by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.
- Lower Aquifer – The alluvial aquifer below the Corcoran Clay (or E-clay) layer.
- Measurable Objectives – Refers to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin.
- Minimum Threshold – Refers to a numeric value for each sustainability indicator used to define significant and unreasonable undesirable results.
- NAVD88 – Refers to the North American Vertical Datum of 1988 computed by the National Geodetic Survey, or as modified.
- Plan Implementation – Refers to an Agency's exercise of the powers and authorities described in the Sustainable Groundwater Management Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities.
- Principal Aquifers – Refers to aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. For the purpose of this GSP, the two principal aquifers discussed and referenced are the Upper Aquifer and Lower Aquifer.
- Representative Monitoring - Refers to a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin (CA Code of Regulations, Title 23, Article 2).
- Reference Point – Refers to a permanent, stationary, and readily identifiable mark or point on a well, such as the top of casing, from which groundwater level measurements are taken, or other monitoring site (CA Code of Regulations, Title 23, Article 2). Reference point elevation is reported relative to NAVD88 and is used to convert depth to water measurements into water surface elevation values.
- Screen Interval – The portion(s) of a well casing that is screened to allow water from the surrounding aquifer into the well pipe. Screen interval is usually reported in feet below ground surface for both the upper-most limit and lower-most limit of the screen.
- Seasonal High – Refers to the highest annual static groundwater elevation that is typically measured in the Spring and associated with stable aquifer conditions following a period of lowest annual groundwater demand.
- Seasonal Low – Refers to the lowest annual static groundwater elevation that is typically measured in the Summer or Fall and associated with a period of stable aquifer conditions following a period of highest annual groundwater demand.
- Sustainability Goal – The existence and implementation of one or more Groundwater Sustainability Plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield.

- Sustainability Indicator – Refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x).
- Sustainable Groundwater Management – The management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.
- Total Well Depth – The depth that a well is installed to, measured from the ground surface. This depth is often deeper than the bottom of the deepest screen interval.
- Undesirable Result – One or more of the following effects caused by groundwater conditions occurring throughout the basin:
  1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon.
  2) Significant and unreasonable reduction of groundwater storage.
  3) Significant and unreasonable seawater intrusion.
  4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
  5) Significant and unreasonable inelastic land subsidence that substantially interferes with surface land uses.
  6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.
- Upper Aquifer – The alluvial aquifer above the Corcoran Clay (or E-clay) layer.
- Water Surface Elevation – The elevation in feet relative to NAVD88 that groundwater is encountered inside the well. Elevation is commonly expressed as feet above mean sea level (msl) and is reported relative to the North American Vertical Datum of 1988 (NAVD88) in this document per SGMA regulations.

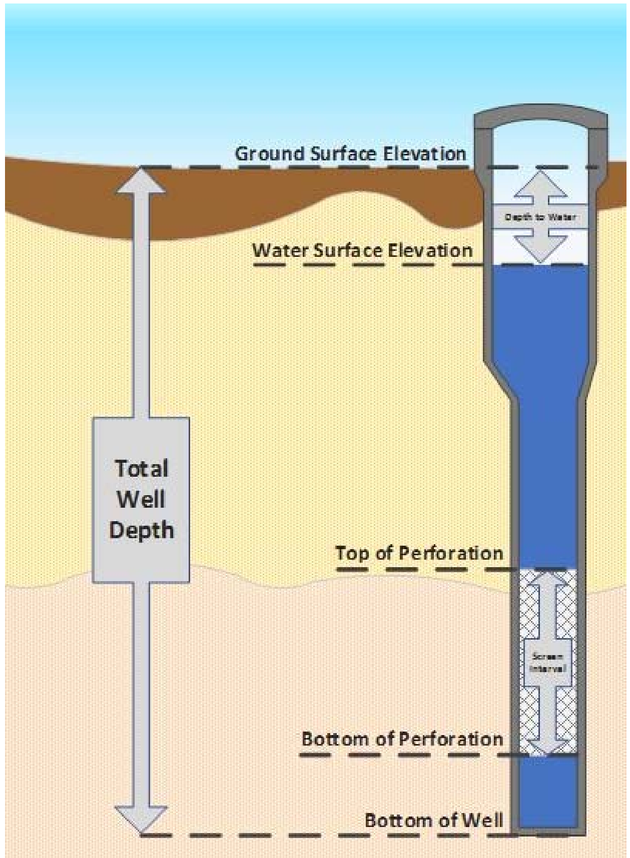

Figure 7-1. Diagram of Key Groundwater Monitoring Well Measurements

7.2.2 Monitoring Network Objectives

This section describes the Northern & Central Delta-Mendota Region GSP representative monitoring networks for the five sustainability indicators applicable to the Delta-Mendota Subbasin. The objective of these monitoring networks is to detect undesirable results in the Plan Area using the sustainability management criteria described in Chapter 6 *Sustainable Management Criteria*. Other related objectives of the monitoring networks, as defined by the GSP Emergency Regulations, are as follows:

- Demonstrate progress toward achieving measurable objectives described in the GSP;
- Monitor impacts to the beneficial uses or users of groundwater;
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds; and
- Quantify annual changes in water budget components.

The monitoring network plan for the Northern & Central Delta-Mendota Region GSP is intended to monitor for the:

- Chronic lowering of groundwater levels
- Long-term reduction in groundwater storage
- Degradation of water quality
- Inelastic land subsidence
- Depletions of interconnected surface water

The monitoring networks described herein were developed by evaluating monitoring locations and data available through existing monitoring programs within the Northern and Central Delta-Mendota Regions along with information available for accessible monitoring sites. Sites selected for inclusion in the monitoring networks for this GSP were considered based on criteria described herein.

7.2.2.1 Conditions Relevant to Monitoring Network Development

This section summarizes key conditions that influence the development of monitoring networks in the Northern and Central Delta-Mendota Regions. These key conditions include hydrogeology, land use, and water conveyance infrastructure.

The Delta-Mendota Subbasin, as described in Section 5.2 *Hydrogeologic Conceptual Model*, is generally composed of two principal aquifers divided by a regional aquitard referred to as the Corcoran Clay or E-clay layer. The semi-confined Upper Aquifer overlies the Corcoran Clay, while the confined Lower Aquifer is below the Corcoran Clay. Local variation in hydrogeology does exist throughout the Delta-Mendota Subbasin; for example, shallow clay layers known as the A- and C-clay layers exist in the southern portion of the Subbasin. The monitoring networks described herein account for these local variations as appropriate while considering the general formations comprising the Delta-Mendota Subbasin.

The largest land use by volume of groundwater within the Northern and Central Delta-Mendota Regions is irrigated agriculture. Cities and communities reliant on groundwater, in whole or in part, for their water supply include the City of Patterson and the communities of Grayson, Westley, Crows Landing, Santa Nella, and Tranquillity as well as unincorporated communities within Oro Loma Water District's service area. Groundwater use is described in greater detail in Chapter 2 *Plan Area* of this GSP.

Water conveyance infrastructure of statewide importance, including the Delta-Mendota Canal (DMC) and California Aqueduct, runs the length of the Delta-Mendota Subbasin, mostly through the Northern and Central Delta-Mendota Regions. Historic inelastic land subsidence has resulted in reduced capacity of the DMC and California Aqueduct by uneven decline in ground surface elevations along the canals, decreasing flow velocity and reducing freeboard resulting in erosion along the canal walls. Further detail on major water-related infrastructure within the Northern and Central Delta-Mendota Regions is contained in Chapter 2 *Plan Area*.

7.2.3 Representative Monitoring

The monitoring networks contained herein are the representative monitoring networks for the Northern and Central Delta-Mendota Regions, as defined in GSP Emergency Regulations § 354.36. Groundwater levels are being used to monitor the chronic lowering of groundwater levels sustainability indicator as well as a proxy for data collection and analyses relative to the reduction of groundwater storage and depletions of interconnected surface water sustainability indicators. Land surface elevation is used for assessing sustainability relative to the land subsidence sustainability indicator, while groundwater quality data are used for assessing sustainability relative to the degraded water quality sustainability indicator.

7.2.4 Scientific Rationale for Monitoring Site Selection

The monitoring networks described herein were developed to ensure they can provide the data necessary to detect changes in conditions within the Plan area such that the Northern and Central Delta-Mendota Regions can manage the Plan area and ensure sustainability criteria are met. It is anticipated that these monitoring networks will be refined in future updates to this GSP, with the intent of ensuring that no undesirable results are present after 20 years of Subbasin sustainable management (e.g. post-2040) and, if undesirable results do occur, ensure that conditions will improve and begin trending toward the established measurable objective.

The monitoring networks herein were developed to detect short-term, seasonal, and long-term trends for all sustainability indicators applicable to the Northern and Central Delta-Mendota Regions. The monitoring networks were also developed to include information about temporal frequency and spatial density so the Northern and Central Delta-Mendota Regions can evaluate information, both independently and in cooperation with the other five Subbasin GSPs, regarding how groundwater conditions change spatially and temporally as projects and management actions are implemented to aid in reaching subbasin-wide sustainability by 2040.

7.2.4.1 Monitoring Site Selection Criteria

Monitoring site selection criteria specific to the monitoring networks for each applicable sustainability indicator is described in detail in Section 7.2.5 *Monitoring Networks*.

7.2.4.2 Monitoring Network Subregions

The Northern & Central Delta-Mendota Region GSP Plan area was divided into six subregions, as depicted in Figure 7-2, for the purpose of assessing current conditions within the Plan area and for selecting monitoring sites for the groundwater level and groundwater water quality monitoring networks:

- North Subregion
- North-Central Subregion
- Central Subregion
- South-Central Subregion
- South Subregion
- Tranquillity Subregion

These subregions <u>are not management areas</u>. These subregions were established to qualifying spatial differences in groundwater levels and groundwater quality conditions throughout the Plan area and to aid in establishing minimum thresholds, measurable objectives, and interim milestones at each representative monitoring site (see Chapter 6 *Sustainable Management Criteria* for more detail). A minimum of two sites were selected per subregion for the groundwater level and groundwater quality monitoring networks for each principal aquifer to ensure adequate spatial coverage of monitoring sites throughout the Plan Area.

7.2.4.3 Existing Monitoring Programs

Existing monitoring programs were evaluated and utilized to develop the Northern & Central Delta-Mendota Region GSP monitoring networks with the ultimate goal of coordinating required monitoring efforts in the Subbasin for all relative programs. Further detail regarding existing monitoring programs can be found in Section 2.3.3 (*Plan Area* chapter).

7.2.4.4 Data and Reporting Standards

The following data and reporting standards apply to all categories of information required of a GSP, unless otherwise indicated (DWR, 2016c):

1. Water volumes shall be reported in acre-feet.
2. Surface water flow shall be reported in cubic feet per second.
3. Groundwater flow shall be reported in acre-feet per year.

4. Field measurements of elevations of groundwater, surface water, and land surface shall be measured and reported in feet to an accuracy of at least 0.1 feet relative to the North American Vertical Datum of 1988 (NAVD88), or another national standard that is convertible to NAVD88, and the method of measurement described.

5. Reference point (RP) elevations shall be measured and reported in feet to an accuracy of 0.1 feet, or the best available information, relative to NAVD88 or another national standard that is convertible to NAVD88, and the method of measurement described.

6. Geographic locations shall be reported in Global Positioning System (GPS) coordinates by latitude and longitude in decimal degree to a minimum accuracy of 30 feet relative to NAD83 or another national standard that is convertible to NAD83.

Monitoring Sites

The following protocols will be applied to all monitoring sites included in the Northern & Central Delta-Mendota Region GSP monitoring networks for all sustainability indicators (DWR, 2016c):

1. Long-term access agreements that include year-round site access to allow for increased monitoring frequency.

2. A unique site identification number and narrative description of the site location.

3. A description of the type of monitoring, type of measurement taken, and monitoring frequency shall be documented.

4. Location, elevation of the ground surface, and identification and description of the reference point shall be documented.

5. A description of the standards used to install the monitoring site. Sites that do not conform to Best Management Practices (BMPs) shall be identified and the nature of the divergence from BMPs described in the monitoring site file.

6. A modification log is to be kept in order to track all modifications to the monitoring site.

Wells

The following standards apply to wells (DWR, 2016c):

1. Wells used to monitor groundwater conditions shall be constructed according to applicable construction standards, and the following information shall be provided in both tabular and geodatabase-compatible shapefile form:

    a. California Statewide Groundwater Elevation Monitoring (CASGEM) well identification number, if available. If a CASGEM well identification number has not been issued, appropriate well information shall be entered on forms made available by the California Department of Water Resources (DWR).

    b. Well location, elevation of the ground surface and reference point, including a description of the reference point.

    c. A description of the well use (such as public supply, irrigation, domestic, monitoring, or other type of well), whether the well is active or inactive, and whether the well is a single, clustered, nested, or other type of well.

d. Casing perforations, borehole depth, and total well depth.

e. Well completion reports, if available, from which the names of private owners have been redacted.

f. Geophysical logs, well construction diagrams, or other relevant information, if available.

g. Identification of principal aquifers monitored.

h. Other relevant well construction information, such as well capacity, casing diameter, or casing modifications, as available.

2. If an agency relies on wells that lack casing perforations, borehole depth, or total well depth information to monitor groundwater conditions as part of a GSP, the agency shall describe a schedule for acquiring monitoring wells with the necessary information or demonstrate to the DWR that such information is not necessary to understand and manage groundwater in the basin.

Maps

Maps submitted by the Northern and Central Delta-Mendota Regions' Groundwater Sustainability Agencies (GSAs) will meet the following requirements (DWR, 2016c):

1. Data layers, shapefiles, geodatabases, and other information provided with each map shall be submitted electronically to the DWR.
2. Maps shall be clearly labeled and contain a level of detail to ensure that the map is informative and useful.
3. The datum shall be clearly identified on the maps or in an associated legend.

Hydrographs

Hydrographs submitted by the Northern and Central Delta-Mendota Regions' GSAs shall meet the following requirements (DWR, 2016c):

1. Hydrographs shall be submitted electronically to the Department in accordance with the procedures described in Article 4, Procedures of the GSP Regulations.
2. Hydrographs shall include a unique site identification number and the ground surface elevation for each site.
3. Hydrographs shall use the same datum and scaling to the greatest extent practical.

Groundwater and Surface Water Models

Groundwater and surface water models used shall meet the following standards (DWR, 2016c):

1. The model shall include publicly available supporting documentation.
2. The model shall be based on field or laboratory measurements, or equivalent methods that justify the selected values, and calibrated against site-specific field data.
3. Groundwater and surface water models developed in support of a GSP after the effective date of the GSP regulations shall consist of public domain open-source software.

Data Management System

The Northern and Central Delta-Mendota Regions' GSAs have developed and will maintain a data management system (DMS) that is capable of storing and reporting information relevant to the development or implementation of the coordinated GSP and monitoring of the Delta-Mendota Subbasin (DWR, 2016c). For more information about the Delta-Mendota Subbasin DMS, refer to Section 8.3.4 of the *Plan Implementation* chapter.

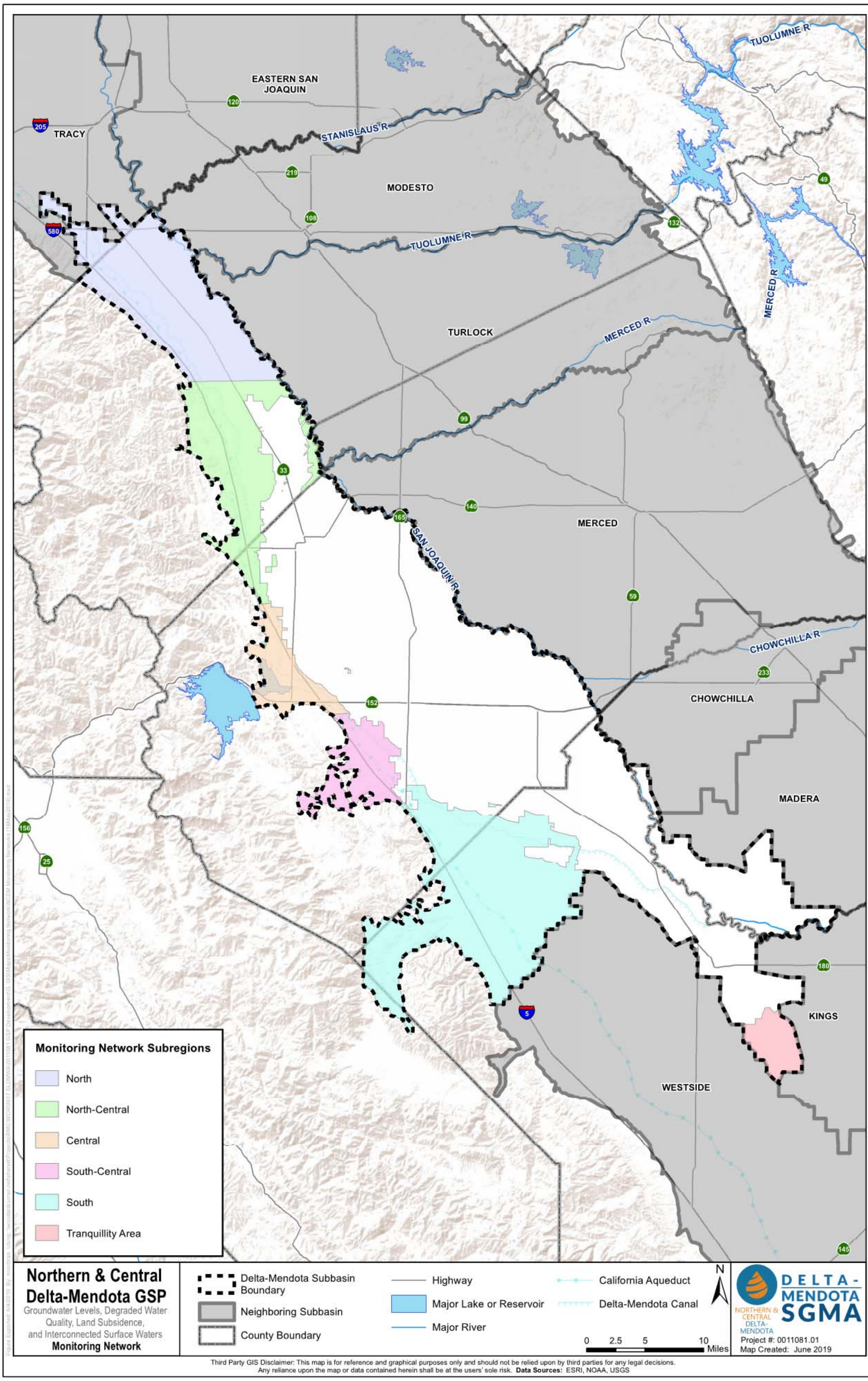

Figure 7-2. Monitoring Network Subregions

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7.2.5 Monitoring Networks

A description of each monitoring network within the Plan area is included herein. Each monitoring network was established for collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions as well as yield representative information about groundwater conditions as necessary to evaluate Plan implementation. Selected monitoring sites are presented on maps and in tabular form. Monitoring protocols and data reporting requirements, frequency and timing of monitoring events, and spatial density are briefly described in this section with more specific information on monitoring protocols found in Appendix F (*Quality Assurance Program Plan for Northern & Central Delta-Mendota Region GSP Monitoring Protocol*). Existing data gaps are identified and described, as well as plans to assess and improve the monitoring networks in future GSP updates. A more detailed plan for addressing identified data gaps will be developed by the Regions in 2020, detailing work efforts to be conducted and scheduling. This plan will be available upon request following completion.

Monitoring frequency and density of monitoring sites will be adjusted over time through periodic assessment and refinements to ensure an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under the following circumstances:

1. Minimum threshold exceedances;
2. Highly variable spatial or temporal conditions;
3. Adverse impacts to beneficial uses and users of groundwater; and
4. The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

7.2.5.1 Groundwater Level Monitoring Network

Groundwater level monitoring networks for each principal aquifer are established to demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and interconnected surface water features by the following methods:

1. A sufficient density of monitoring wells to collect representative groundwater elevation measurements through depth-discrete perforated (or screened) intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.
2. Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

Groundwater level monitoring is conducted through a groundwater well monitoring network. The following subsections provide information about how the groundwater level monitoring network for each principal aquifer was developed, criteria for selecting monitoring wells, summary of protocols, monitoring frequency and timing, spatial density, and identification and strategies to fill data gaps.

7.2.5.1.1 Selected Monitoring Sites

Wells identified and summarized in Table 7-6 and Table 7-7 were selected to evaluate short-term, seasonal, and long-term trends in groundwater levels in the Upper Aquifer and Lower Aquifer, respectively. The overall groundwater level monitoring network is comprised of 17 wells perforated in the Upper Aquifer (Figure 7-3) and 18 wells in the Lower Aquifer (Figure 7-4).

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Table 7-6. Groundwater Level Monitoring Network, Upper Aquifer

DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Status	Well Use	Monitoring Agency	Monitoring Program	County	Subregion	Depth (ft)	Screen Intervals (ft)	First Measurement Year	Last Measurement Year	Measurement Count
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (United States Bureau of Reclamation [USBR]); CASGEM (Mandatory)	Stanislaus	North	360	150-360	1995	2019	51
06-004			MP031.31L1-L2Well1	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Stanislaus	North	Unknown	140-160; 200-240	2009	2019	27
03-001		375015N1211011W001	MW-2	Active	Monitoring	Patterson Irrigation District	CASGEM (Mandatory)	Stanislaus	North	250	220 - 250	2010	2018	21
03-002			MW-3	Unknown	Monitoring	Patterson Irrigation District	Local agency	Stanislaus	North	260	220 - 250	2010	2018	16
03-003	05S/08E-16R		WSJ003	Unknown	Irrigation	Westside San Joaquin River Watershed Coalition	Groundwater Quality Trend Monitoring Program (Irrigated Lands Regulatory Program [ILRP])	Stanislaus	North	255	130 - 250	Not available	Not available	Not available
06-002	06S08E09E003M	374316N1210994W003	P259-3	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	North-Central	115	95 - 115	2012	2019	81
01-004	07S08E28R002M	372907N1210875W002	MC10-2	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	North-Central	135	115 - 135	2012	2019	81
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Merced	North-Central	170	120 - 150	1995	2019	54
07-017			Well 1	Unknown	Public Supply	Volta Community Services District	Local agency	Merced	Central	Unknown	170-253	Not available	Not available	Not available
07-003	10S10E32L002M	370173N1208999W002	MC15-2	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	South-Central	160	150 - 160	2012	2019	81
07-004	11S10E04L001M		MP081.08R	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Merced	South-Central	Unknown	140-200 (assumed)	2010	2019	29
07-011		368835N1206270W001	MP099.24L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Voluntary)	Fresno	South	405	300-390	1995	2019	69
07-012	12S/12E-16B		GDA003	Unknown	Irrigation	Grassland Drainage Area Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Fresno	South	410	270 - 390	1995	2019	84
07-013			MP102.04R	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Fresno	South	600	220-240; 280-340	1995	2019	86
07-010		366500N1202500W001	KRCDTID02	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	Tranquillity	540	295-535	2014	2018	9
07-009		366000N1202300W001	KRCDTID03	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	Tranquillity	543	434-510	2014	2018	9
07-018	15S/16E-20		WSJ001	Unknown	Domestic	Westside San Joaquin River Watershed Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Fresno	Tranquillity	205	165 - 205	Not available	Not available	Not available

Table 7-7. Groundwater Level Monitoring Network, Lower Aquifer

DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Status	Well Use	Agency	Program	County	Depth (ft)	Screen Intervals (ft)	Subregion	First Measurement Year	Last Measurement Year	Measurement Count
01-007			MP021.12L	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	San Joaquin	Unknown	400-570 (assumed)	North	1995	2019	63
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	475	230 - 475	North	1995	2019	83
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	510	235 - 475	North	1995	2019	72
06-003		375774N1212096W001	WSID 3	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	400	280 - 380	North	2009	2018	19
02-002			WELL 02 - NORTH 5TH STREET	Unknown	Public Supply	City of Patterson	Local agency	Stanislaus	360	170-356	North	2003	2019	55
06-001	06S08E09E001M	374316N1210994W001	P259-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	430	390 - 410	North-Central	2012	2019	81
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	721	218 - 242; 290 - 346; 353 - 358; 418 - 480; 490 - 538; 562 - 550; 600 - 595; 658 - 610	North-Central	1995	2019	83
04-001		376129N1212942W001	121	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	600	400 - 570	North-Central	2016	2018	5
01-008			MP051.66L	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Stanislaus	Unknown	290-470 (assumed)	North-Central	1995	2019	62
01-006		372604N1210611W001	91	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	260	120 - 210	North-Central	2016	2019	5
07-016			Well 01	Unknown	Public Supply	Santa Nella County Water District	Local agency	Merced	Unknown	185-225	Central	Not available	Not available	Not available
07-002	10S10E32L001M	370173N1208999W001	MC15-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	355	335 - 355	South-Central	2012	2019	81
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Merced	615	425 - 455; 495 - 615	South	1995	2019	94
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Fresno	840	440 - 600; 640 - 720	South	1995	2019	84
07-007	12S12E16E003M	368896N1206702W001	MC18-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	550	530 - 550	South	2011	2019	78
07-008	13S12E22F001M	367885N1206510W001	PWD 48	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	1,002	542 - 982	South	2009	2019	10
07-014			TW-4	Unknown	Monitoring	Tranquillity Irrigation District	Local agency	Fresno	690	650-690	Tranquillity	2015	2019	38
07-015			TW-5	Unknown	Nested Monitoring	Tranquillity Irrigation District	Local agency	Fresno	630	630-670	Tranquillity	2015	2019	38

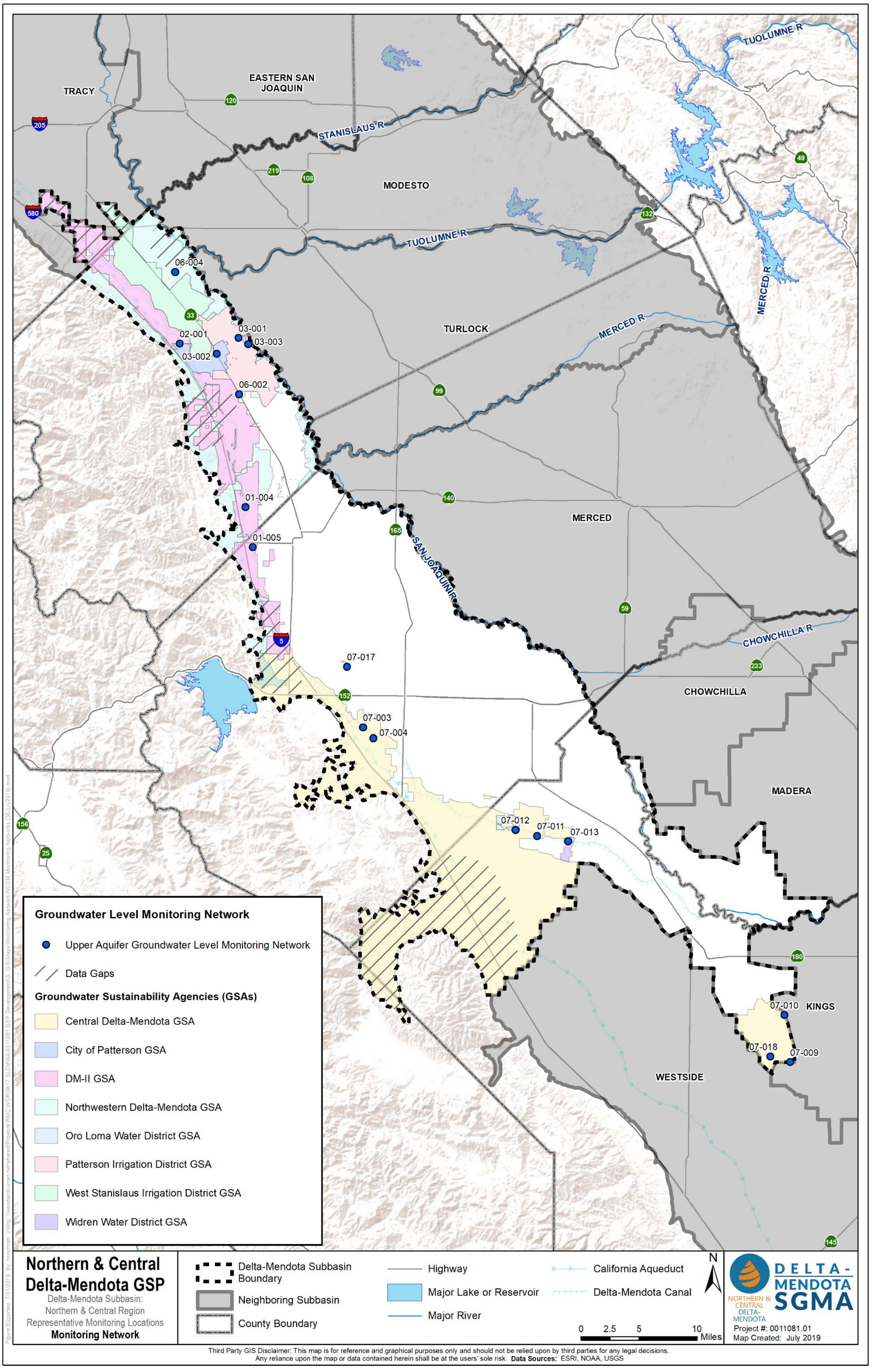

Figure 7-3. Groundwater Level Monitoring Network, Upper Aquifer

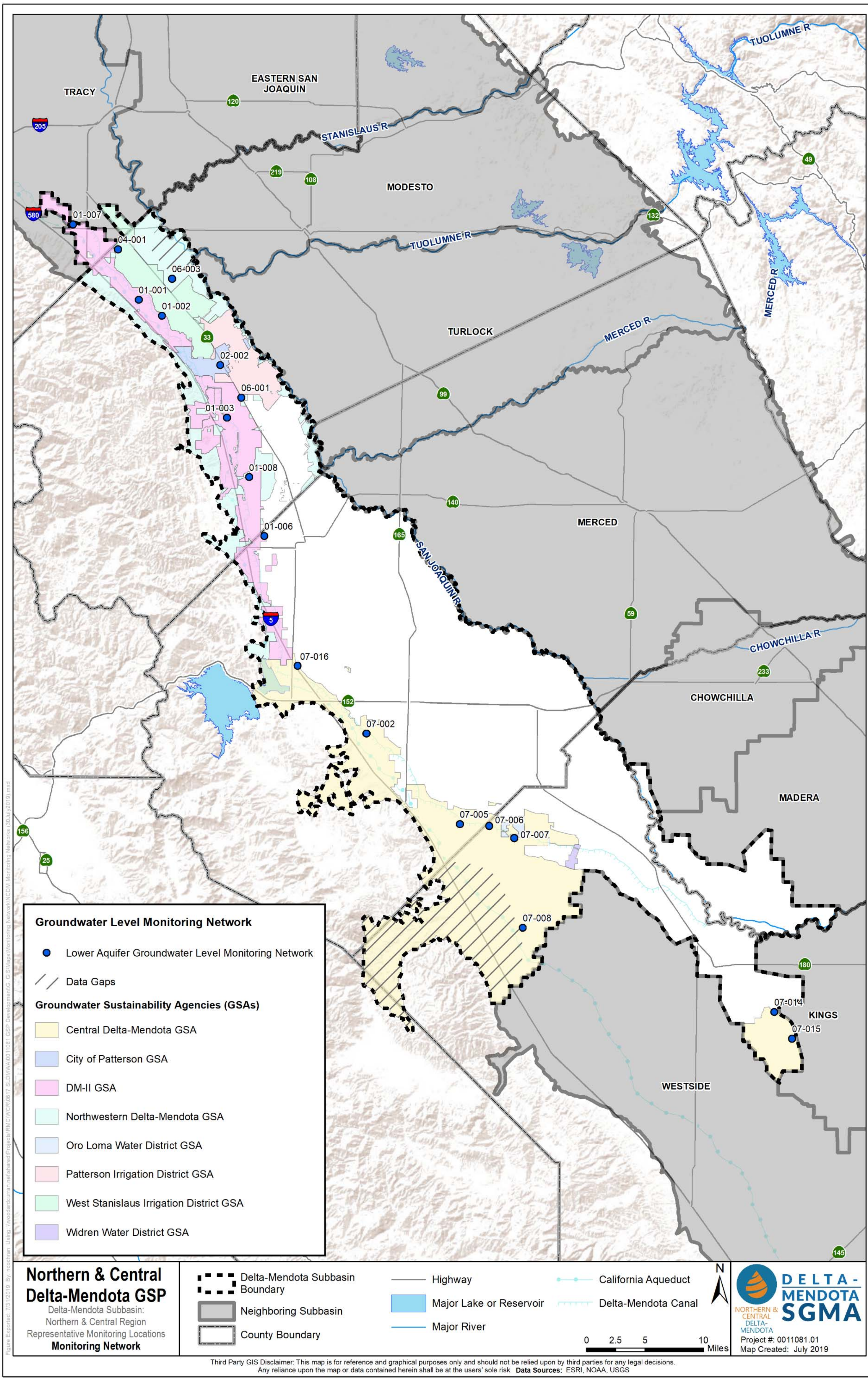

Figure 7-4. Groundwater Level Monitoring Network, Lower Aquifer

Wells were selected for the groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer based on the following criteria:

1. Existing Monitoring Program – Wells within existing, on-going monitoring program networks were preferred since access to wells for monitoring purposes have previously been granted, construction information is available, and a historical record of groundwater levels exists.

2. Adequate Construction Information – Well information such as screen intervals, construction date, and well depth was considered when evaluating existing well sites.

3. Confirmed Well Access – Access to all wells included in the monitoring networks have been confirmed along with the ability to temporary shut down pumping from wells currently being used prior to data collection (per BMPs for data collection).

4. Screened Exclusively within a Single Principal Aquifer – Only wells screened exclusively within either the Upper Aquifer or Lower Aquifer (i.e. not across the Corcoran Clay layer) were considered for inclusion in the groundwater level monitoring network. This is consistent with the BMPs published by DWR for establishing monitoring networks (DWR, 2016a).

5. Robust and Extensive Historical Data – Existing monitoring sites with longer, more robust historical datasets provide insight into long-term trends and indicate aquifer response under various climate conditions as well as anthropogenic effects regarding groundwater use patterns and were preferred over those without historic records.

6. Consistency with Best Management Practices – Using published BMPs provided by DWR ensures consistency across all basins and compliance with established regulations.

7. Adequate Spatial Distribution – As described in Section 7.2.4.2 (*Monitoring Network Subregions*), a minimum of two sites were selected per subregion to ensure adequate spatial coverage of monitoring sites throughout the Plan area. This criterion was applied along with the other criteria listed where greater or fewer than two sites within each subregion may be selected.

8. Local Knowledge – Representatives from local agencies and the public were invited to provide any information and insight related to well location, construction, or historical record through each iteration of the groundwater level monitoring network.

9. Professional Judgment and Best Available Science – Professional judgement and best available science were used to make the final decision about each well, particularly when more than one suitable well exists in an area of interest.

The criteria detailed herein used to develop the groundwater level monitoring network does not indicate any particular ranking or order of importance of each criterion. Rather, all criteria were considered collectively to create the groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer.

7.2.5.1.2 Monitoring Protocols and Data Reporting Requirements

Monitoring protocols and data reporting requirements for the groundwater level monitoring networks have been developed in accordance with DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b). Monitoring protocols applicable to all Northern & Central Delta-Mendota Region GSP monitoring networks are detailed in Section 7.2.4.4. Additional details regarding monitoring protocols and data reporting requirements can be found in Appendix F (*Quality Assurance Program Plan [QAPP] for Northern & Central Delta-Mendota GSP Monitoring Protocol*). Monitoring networks, protocols, and data reporting requirements established for the groundwater level monitoring networks will be reviewed every five years and refined as necessary, where any modifications to the monitoring protocols will be documents in detail within future GSP updates.

Measuring Groundwater Elevation

The following guidelines were adopted from DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b):

- Well construction, anticipated groundwater level measuring equipment, field conditions, and well operations will be considered prior to collection of the groundwater level measurement. Depth to water measurements will use procedures appropriate for the measuring device and equipment must be operated and maintained in accordance with manufacturer instructions.
- Depth to groundwater must be measured relevant to an established RP on the well casing, usually identified with a permanent market, paint spot, or notch in the lip of the well casing. Depth to groundwater must be measured to an accuracy of 0.1 foot and should be measured to NAVD88. An accuracy of 0.01 foot below the RP is preferable, if possible.
- For measuring wells that are under pressure, a period of time after uncapping will occur during which groundwater levels in the well will equilibrate and stabilize. In these cases, multiple measurements will be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value will be appropriately qualified as a questionable measurement. Record the dimension of the extension and document measurements and configuration.
- The sampler will calculate the groundwater elevation as:

  $$GWE = RPE - DTW$$

  Where:

  GWE = Groundwater Elevation
  RPE = Reference Point Elevation
  DTW = Depth to Water

  The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.
- The sampler will replace any well caps or plugs and lock any well buildings or covers prior to departing the monitoring location.

Recording Groundwater Levels

Prior to collecting semiannual field measurements and before going to the field, the sampling personnel will assemble the following equipment and supplies (SLDMWA, 2015):

- Semiannual Groundwater Level form
- Well sounding location details
- Steel measuring tape and chalk or electric water level sounder
- Clean rags and gloves
- Cell phone
- First aid kit
- Watch or stopwatch
- Ballpoint pen and clipboard

In general, the sampler will record the following for each well in a field notebook:

- Well identifier
- Date and time of measurements (24-hour format)
- RP elevation
- Height of RP above or below ground surface
- Depth to water
- Groundwater elevation (as calculated from RP and depth to water)
- Comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, or well condition.

If there is a questionable measurement or the measurement cannot be obtained, it will be noted. Standardized field forms will be used for all data collection.

Data Reduction, Validation, and Reporting

After field personnel have completed their work, data should be cross-checked and submitted to the GSP Lead for compilation with other Regional data collection efforts. All monitoring locations in the Northern & Central Delta-Mendota Region GSP monitoring networks have been assigned a unique well identification (ID), and information associated with wells, such as well characteristics and historical hydrologic observations, will be compiled and maintained within the DMS.

Agencies will collect groundwater level measurements during the designated seasonal high and seasonal low time periods (as identified in Section 7.2.5.1.3). Each GSA member agency is responsible for collecting groundwater level measurements and supplying those data to the GSA Lead for compilation and a quality assurance/quality control (QA/QC) review to avoid data entry mistakes. The GSA Lead then submits the compiled data to the GSP Representative for compilation at the GSP level. The GSP Representative will compile the GSA-level data into standard forms for uploading to the Subbasin DMS using import wizards and checks that data has been uploaded correctly. All data is to be updated by October 31 each year for inclusion in the annual report. San Luis & Delta-Mendota Water Authority (SLDMWA), as Plan Administrator, then reviews data uploaded by all six Delta-Mendota GSP Groups prior to compilation at the Subbasin level for annual reporting. Should a measurement appear suspicious, a confirmation reading shall be obtained.

7.2.5.1.3 Frequency and Timing of Monitoring

GSP Emergency Regulations § 354.34(c)(1)(b) indicate that static groundwater elevation measurements shall be collected at least two times per year to represent seasonal low and seasonal high groundwater conditions. Seasonal high groundwater level measurements occur between February and April (classified as “Spring”) and seasonal low groundwater level measurements occur between September and October (classified as “Fall”) within the Delta-Mendota Subbasin. All GSP Groups within the Delta-Mendota Subbasin are responsible for collecting and reporting seasonal high and seasonal low measurements for compilation and reporting to the State.

Coordination with existing monitoring entities will take place regarding the frequency and timing of monitoring events to ensure access to the well site and ensure proper protocols are followed to ensure static groundwater level readings.

7.2.5.1.4 Spatial Density

The goal of the groundwater level monitoring network is to provide adequate spatial coverage of the Plan area for each principal aquifer. This includes the ability to monitor and identify changes in groundwater conditions across the Plan area over time to assess progress toward the sustainability goal by 2040 and beyond. Consideration of the spatial location of monitoring wells included well accessibility, availability of well construction information, proximity to other monitoring wells, and ensuring adequate coverage where undesirable results are occurring or are likely to occur.

The well density of the current monitoring network for the Northern and Central Delta-Mendota Regions is within the range recommended by DWR's *Monitoring Networks and Identifications of Data Gaps BMP* (2016a), where spatial density may be higher in areas where local agencies deem necessary. Spatial density of the groundwater level monitoring networks for both the Upper Aquifer and Lower Aquifer will be reevaluated during future GSP updates and revised as deemed necessary.

7.2.5.1.5 Data Gaps

Groundwater level monitoring data gaps exist in areas where data are limited both spatially and temporally. The lack of available well construction information to determine principal aquifer designation is also a data gap within the Northern and Central Delta-Mendota Regions and throughout the Delta-Mendota Subbasin. Unavailable or inaccurate construction information eliminated the majority of wells with known coordinates from inclusion within the groundwater level monitoring network.

Figure 7-3 and Figure 7-4 reflect the spatial data gaps in groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer within the Delta-Mendota Subbasin. Data gap areas were identified using professional judgement and localized knowledge. The location, reason, and local issues and circumstances that limit or prevent monitoring of these identified data gap areas located within the Northern and Central Delta-Mendota Regions are described below:

1. Portions of the DM-II and West Stanislaus Irrigation District (WSID) GSA neighboring the Tracy Subbasin (Upper Aquifer only) – There are no known wells located within this area with known and verified construction within the Upper Aquifer, therefore monitoring is currently limited in this area.

2. Portion of Northwestern Delta-Mendota GSA neighboring the Modesto Subbasin (Upper Aquifer and Lower Aquifer) - There are no known wells located within this area with known and verified construction within the Upper Aquifer or Lower Aquifer, therefore monitoring is currently limited in this area.

3. Oak Flat Water District area (DM-II GSA) (Upper Aquifer only) – Wells thought to be located in this area are limited to private wells where location, construction, and historical record are unknown and access is limited, thus currently limiting monitoring in this area.

4. Santa Nella County Water District and area surrounding O'Neill Forebay (Upper Aquifer only) - There are no known wells located within this area with known and verified construction within the Upper Aquifer, therefore monitoring is currently limited in this area.

5. Southwestern portion of the Central Delta-Mendota Multi-Agency GSA (Upper and Lower Aquifer) – Local water managers indicate there is *de minimis* or no groundwater use in this area within the Upper and Lower Aquifer and borings for groundwater exploration in the recent drought failed to encounter groundwater at economic quantities and depths, thus monitoring is largely unnecessary.

Temporal data gaps exist at individual well sites and across wells throughout the Delta-Mendota Subbasin. This is due to a multitude of reasons including historical differences in the timing of collected measurement, well construction date, and ability to access the well site.

7.2.5.1.6 Plan to Fill Data Gaps

Data gaps identified in the above section for the groundwater level monitoring networks for each principal aquifer will be filled through a combination of video surveying well boreholes to identify screen intervals and constructing new dedicated monitoring wells as funding allows (including through Technical Support Services [TSS] funding provided by DWR, future grant funding, and GSA funding) (Figure 7-5 and Figure 7-6). Within the Northern and Central Delta-Mendota Regions, a total of 14 wells will be video logged to identify screen intervals and determine aquifer designation, and one multi-completion well will be installed near Panoche Creek within the Central Delta-Mendota Subbasin GSA through DWR's TSS program. Additionally, four nested wells will be installed with tentative locations between the boundaries of Del Puerto Water District (DM-II GSA), Patterson Irrigation District, and West Stanislaus Irrigation District utilizing future grant funding. For the purpose of monitoring depletions of interconnected surface water, where groundwater levels are used as a proxy, four additional wells with tentative locations have been identified that would also be included in the groundwater level monitoring network. These wells are located within three miles of the San Joaquin River within the Northwestern Delta-Mendota GSA and Patterson Irrigation District GSA. As wells with unknown construction are video surveyed and new wells are installed, professional judgement will be used to determine if each well meets the criteria for inclusion in the groundwater level monitoring network for each principal aquifer. Any new monitoring wells will be installed in accordance with guidance provided in DWR's *Monitoring Networks and Identifications of Data Gaps BMP* (2016a) and with the State's well standards.

While past temporal data gaps cannot be rectified, future temporal data gaps can be prevented or reduced by ensuring proper sampling and data management protocols are followed, as detailed in Sections 7.2.5.1.2 and 7.2.5.1.3.

Current uses for each well within the groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer are identified in Table 7-6 and Table 7-7. Not all wells included in these networks are dedicated monitoring wells, as recommended by DWR's *Monitoring Networks and Identifications of Data Gaps BMP* (2016a). A concerted effort will be made to convert or replace production wells with dedicated monitoring wells over time as funding allows. The use of dedicated monitoring wells is important because such wells have known construction, where screened intervals can be restricted to a single aquifer, do not require the cessation of pumping before measurement, and allow for static measurements that more accurately reflect conditions of single aquifers. As production wells are replaced by dedicated monitoring wells, GSA member agencies will provide input regarding converting existing monitoring wells to a dedicated monitoring wells, selecting an alternative well to convert to a dedicated monitoring well, or selecting the location to install a new dedicated monitoring well.

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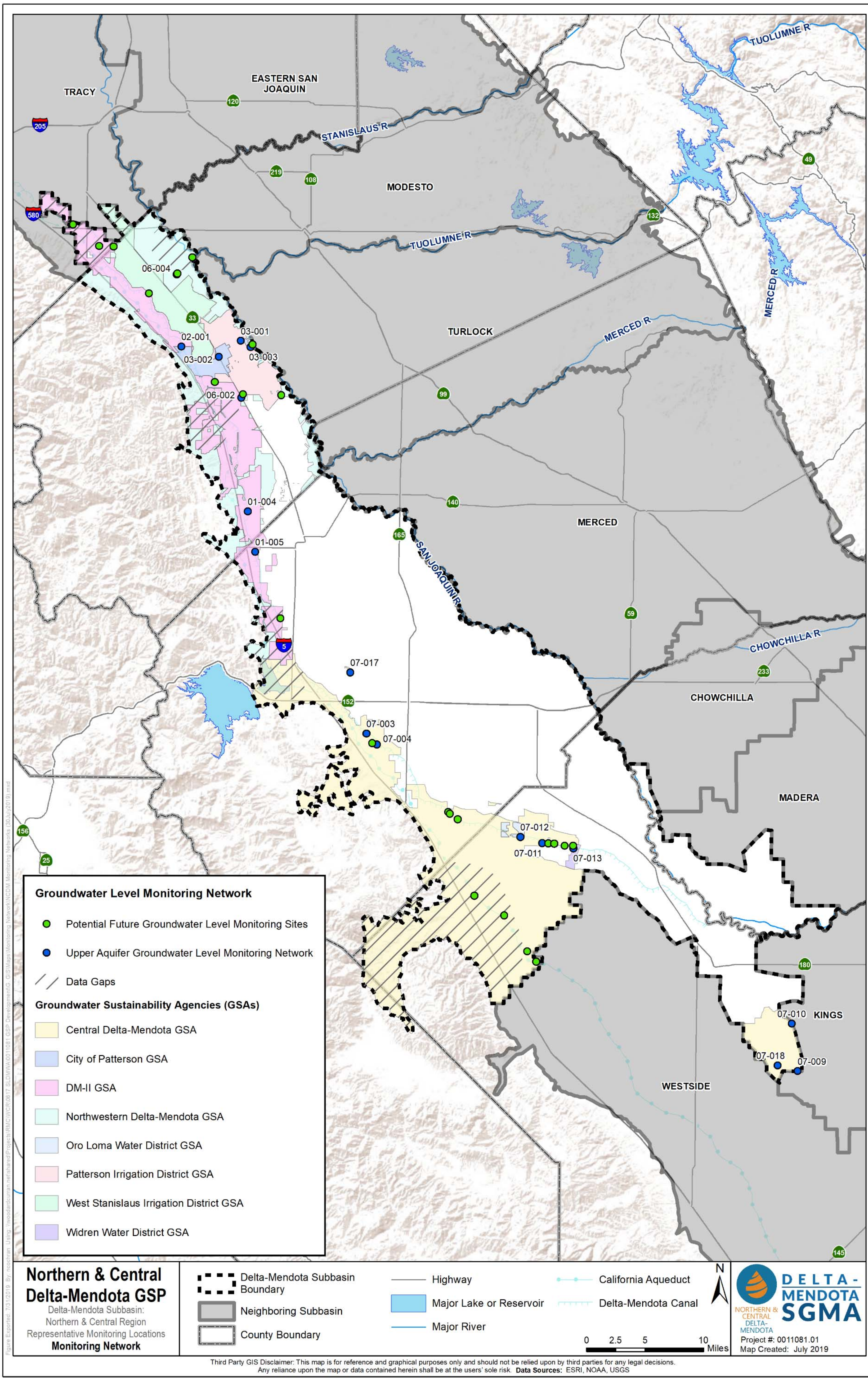

Figure 7-5. Potential Future Groundwater Level Monitoring Sites, Upper Aquifer

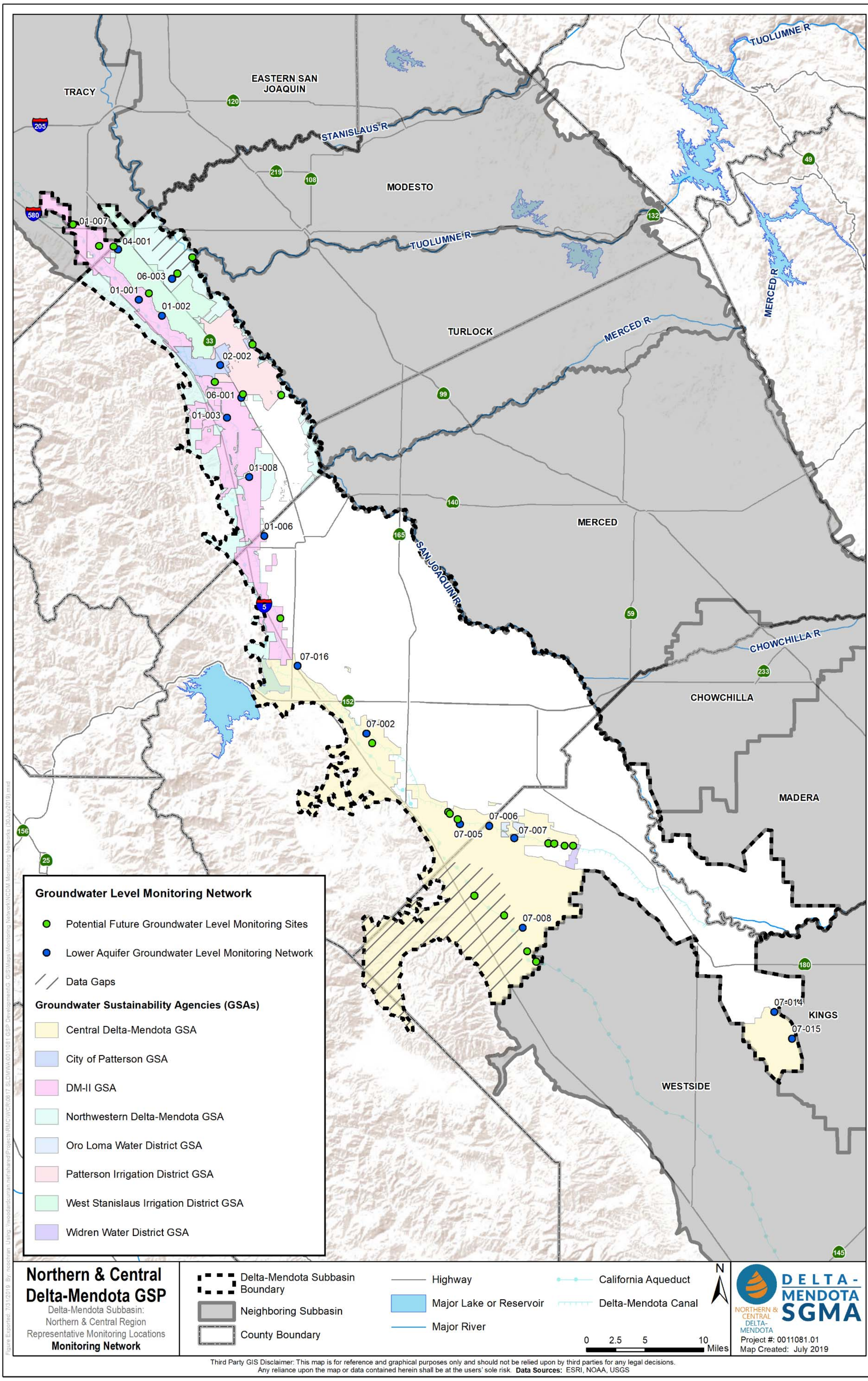

Figure 7-6. Potential Future Groundwater Level Monitoring Sites, Lower Aquifer

7.2.5.2 Groundwater Storage Monitoring Network

Groundwater levels will be used as a proxy for the reduction of groundwater storage sustainability indicator. Therefore, the groundwater storage monitoring network is analogous to the groundwater level monitoring network for both the Upper Aquifer and Lower Aquifer. Refer to Section 7.2.5.1 (*Groundwater Level Monitoring Network*) for more detail on the groundwater level monitoring network and Chapter 6 *Sustainable Management Criteria* for more detail regarding minimum thresholds, measurable objectives, and interim milestones related to groundwater storage.

7.2.5.3 Seawater Intrusion Monitoring Network

Seawater intrusion is not an applicable sustainability indicator for the Delta-Mendota Subbasin as a whole, as the Subbasin is located inland from the Pacific Ocean and any other large source of seawater. As a result, the Plan Area is not at risk of seawater intrusion and a monitoring network will not be established for this sustainability indicator (GSP Emergency Regulations § 354.34(j)). Total Dissolved Solids (TDS), which is a water quality constituent commonly associated with salinity, will be monitored as part of the groundwater quality network but the primary naturally occurring TDS in the Delta-Mendota Subbasin is due to the geochemistry of the Coast Range rocks, rather than seawater intrusion.

7.2.5.4 Degraded Water Quality Monitoring Network

Groundwater quality monitoring networks for each principal aquifer are designed to collect sufficient spatial and temporal data to determine groundwater quality trends to address known water quality issues. TDS, nitrate as N, and boron have been identified by the Northern and Central Delta-Mendota Regions as water quality constituents of concern within the Plan Area.

This section provides information about how the groundwater quality monitoring network for each principal aquifer was developed, criteria for selecting monitoring wells, summary of protocols, monitoring frequency and timing, spatial density, and identification and strategies to fill data gaps.

7.2.5.4.1 Selected Monitoring Sites

The groundwater quality monitoring network is analogous to the groundwater level monitoring network presented in Section 7.2.5.1. Wells identified and summarized in Table 7-8 and Table 7-9 were selected to evaluate short-term, seasonal, and long-term trends in groundwater quality in the Upper Aquifer and Lower Aquifer, respectively, as well as for trends in groundwater elevations. The overall groundwater quality monitoring network is comprised of 17 wells perforated in the Upper Aquifer (Figure 7-7) and 18 wells in the Lower Aquifer (Figure 7-8).

Since the groundwater quality monitoring network and groundwater level monitoring network include identical sets of wells for the Upper Aquifer and Lower Aquifer, the well selection criteria described in Section 7.2.5.1.1 are also applicable to the groundwater quality monitoring network.

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Table 7-8. Groundwater Quality Monitoring Network, Upper Aquifer

DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Status	Well Use	Monitoring Agency	Monitoring Program	County	Subregion	Depth (ft)	Screen Intervals (ft)	Constituent(s)	First Measurement Year	Last Measurement Year	Measurement Count
02-001	05S07E15N002M	374934N1211934W001	MP037.32L	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	North	360	150-360	Not available	Not available	Not available	Not available
06-004			MP031.31L1-L2Well1	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Stanislaus	North	Unknown	140-160; 200-240	Not available	Not available	Not available	Not available
03-001		375015N1211011W001	MW-2	Active	Monitoring	Patterson Irrigation District	CASGEM (Mandatory)	Stanislaus	North	250	220 - 250	Not available	Not available	Not available	Not available
03-002			MW-3	Unknown	Monitoring	Patterson Irrigation District	Local agency	Stanislaus	North	260	220 - 250	Not available	Not available	Not available	Not available
03-003	05S/08E-16R		WSJ003	Unknown	Irrigation	Westside San Joaquin River Watershed Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Stanislaus	North	255	130 - 250	Not available	Not available	Not available	Not available
06-002	06S08E09E003M	374316N1210994W003	P259-3	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	North-Central	115	95 - 115	TDS and Nitrate as N	2010	2012	8 (TDS), 4 (Nitrate as N)
01-004	07S08E28R002M	372907N1210875W002	MC10-2	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	North-Central	135	115 - 135	TDS and Nitrate as N	2011	2012	8 (TDS), 4 (Nitrate as N)
01-005	08S08E15G001M	372424N1210754W001	MP058.28L	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Merced	North-Central	170	120 - 150	TDS, Nitrate as N, and Boron	2001	2017	5 (TDS), 6 (Nitrate as N), 5 (Boron)
07-017			Well 1	Unknown	Public Supply	Volta Community Services District	Local agency	Merced	Central	Unknown	170-253	TDS, Nitrate as N, and Boron	2002	2017	8 (TDS), 16 (Nitrate as N), 2 (Boron)
07-003	10S10E32L002M	370173N1208999W002	MC15-2	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	South-Central	160	150 - 160	Not available	Not available	Not available	Not available
07-004	11S10E04L001M		MP081.08R	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Merced	South-Central	Unknown	140-200 (assumed)	TDS, Nitrate as N, and Boron	2007	2008	3 (TDS), 1 (Nitrate as N), 2 (Boron)
07-011		368835N1206270W001	MP099.24L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Voluntary)	Fresno	South	405	300-390	Not available	Not available	Not available	Not available
07-012	12S/12E-16B		GDA003	Unknown	Irrigation	Grassland Drainage Area Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Fresno	South	410	270 - 390	Not available	Not available	Not available	Not available
07-013			MP102.04R	Active	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Fresno	South	600	220-240; 280-340	Not available	Not available	Not available	Not available
07-010		366500N1202500W001	KRCDTID02	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	Tranquillity	540	295-535	Not available	Not available	Not available	Not available
07-009		366000N1202300W001	KRCDTID03	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	Tranquillity	543	434-510	Not available	Not available	Not available	Not available
07-018	15S/16E-20		WSJ001	Unknown	Domestic	Westside San Joaquin River Watershed Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Fresno	Tranquillity	205	165 - 205	Not available	Not available	Not available	Not available

Table 7-9. Groundwater Quality Monitoring Network, Lower Aquifer

DMS ID	Primary Well ID	CASGEM ID (if applicable)	Local ID	Status	Well Use	Agency	Program	County	Depth (ft)	Screen Intervals (ft)	Subregion	Constituent(s)	First Measurement Year	Last Measurement Year	Measurement Count
01-007			MP021.12L	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	San Joaquin	Unknown	400-570 (assumed)	North	TDS, Nitrate as N, and Boron	2008	2016	7 (TDS), 14 (Nitrate as N), 7 (Boron)
01-001	04S06E36C001M	375509N1212609W001	MP030.43R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	475	230 - 475	North	TDS, Nitrate as N, and Boron	2013	2016	5 (TDS), 7 (Nitrate as N), 3 (Boron)
01-002	05S07E05F001M	375313N1212242W001	MP033.71L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	510	235 - 475	North	TDS, Nitrate as N, and Boron	2001	2013	5 (TDS), 8 (Nitrate as N), 6 (Boron)
06-003		375774N1212096W001	WSID 3	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	400	280 - 380	North	Not available	Not available	Not available	Not available
02-002			WELL 02 - NORTH 5TH STREET	Unknown	Public Supply	City of Patterson	Local agency	Stanislaus	360	170-356	North	TDS, Nitrate as N, and Boron	2000	2016	12 (TDS), 23 (Nitrate as N), 8 (Boron)
06-001	06S08E09E001M	374316N1210994W001	P259-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	430	390 - 410	North-Central	TDS and Nitrate as N	2010	2010	8 (TDS), 4 (Nitrate as N)
01-003	06S08E20D002M	374061N1211212W001	MP045.78R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Stanislaus	721	218 - 242; 290 - 346; 353 - 358; 418 - 480; 490 - 538; 562 - 550; 600 - 595; 658 - 610	North-Central	Not available	Not available	Not available	Not available
04-001		376129N1212942W001	121	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Stanislaus	600	400 - 570	North-Central	Not available	Not available	Not available	Not available
01-008			MP051.66L	Unknown	Unknown	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR)	Stanislaus	Unknown	290-470 (assumed)	North-Central	TDS, Nitrate as N, and Boron	2007	2016	7 (TDS), 10 (Nitrate as N), 5 (Boron)
01-006		372604N1210611W001	91	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	260	120 - 210	North-Central	Not available	Not available	Not available	Not available
07-016			Well 01	Unknown	Public Supply	Santa Nella County Water District	Local agency	Merced	Unknown	185-225	Central	TDS and Nitrate as N	2000	2017	10 (TDS), 17 (Nitrate as N)
07-002	10S10E32L001M	370173N1208999W001	MC15-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Merced	355	335 - 355	South-Central	Not available	Not available	Not available	Not available
07-005	12S11E03Q001M	369097N1207554W001	MP091.68R	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Merced	615	425 - 455; 495 - 615	South	TDS	1994	1994	1 (TDS)
07-006	12S12E07E001M	369044N1207092W001	MP094.26L	Inactive	Irrigation	San Luis & Delta-Mendota Water Authority	Delta-Mendota Canal Pump-in Program (USBR); CASGEM (Mandatory)	Fresno	840	440 - 600; 640 - 720	South	TDS and Boron	2007	2007	1 (TDS), 1 (Boron)

DMS ID	Primary Well ID	CASGEM ID (if applicable)	Local ID	Status	Well Use	Agency	Program	County	Depth (ft)	Screen Intervals (ft)	Subregion	Constituent(s)	First Measurement Year	Last Measurement Year	Measurement Count
07-007	12S12E16E003M	368896N1206702W001	MC18-1	Active	Monitoring	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	550	530 - 550	South	TDS and Boron	2010	2010	1 (TDS), 1 (Boron)
07-008	13S12E22F001M	367885N1206510W001	PWD 48	Active	Irrigation	San Luis & Delta-Mendota Water Authority	CASGEM (Mandatory)	Fresno	1,002	542 - 982	South	Not available	Not available	Not available	Not available
07-014			TW-4	Unknown	Monitoring	Tranquillity Irrigation District	Local agency	Fresno	690	650-690	Tranquillity	Not available	Not available	Not available	Not available
07-015			TW-5	Unknown	Nested Monitoring	Tranquillity Irrigation District	Local agency	Fresno	630	630-670	Tranquillity	Not available	Not available	Not available	Not available

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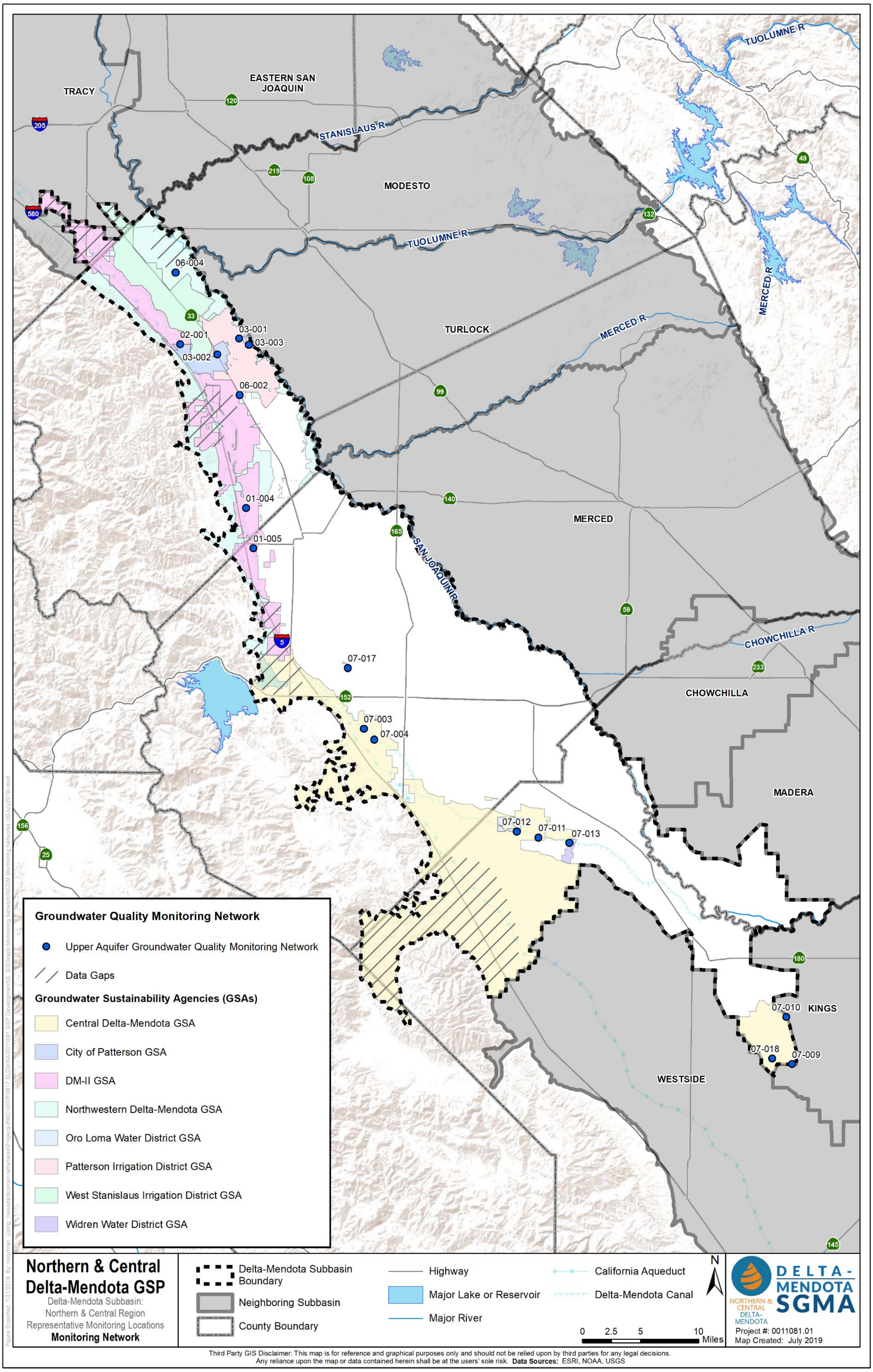

Figure 7-7. Groundwater Quality Monitoring Network, Upper Aquifer

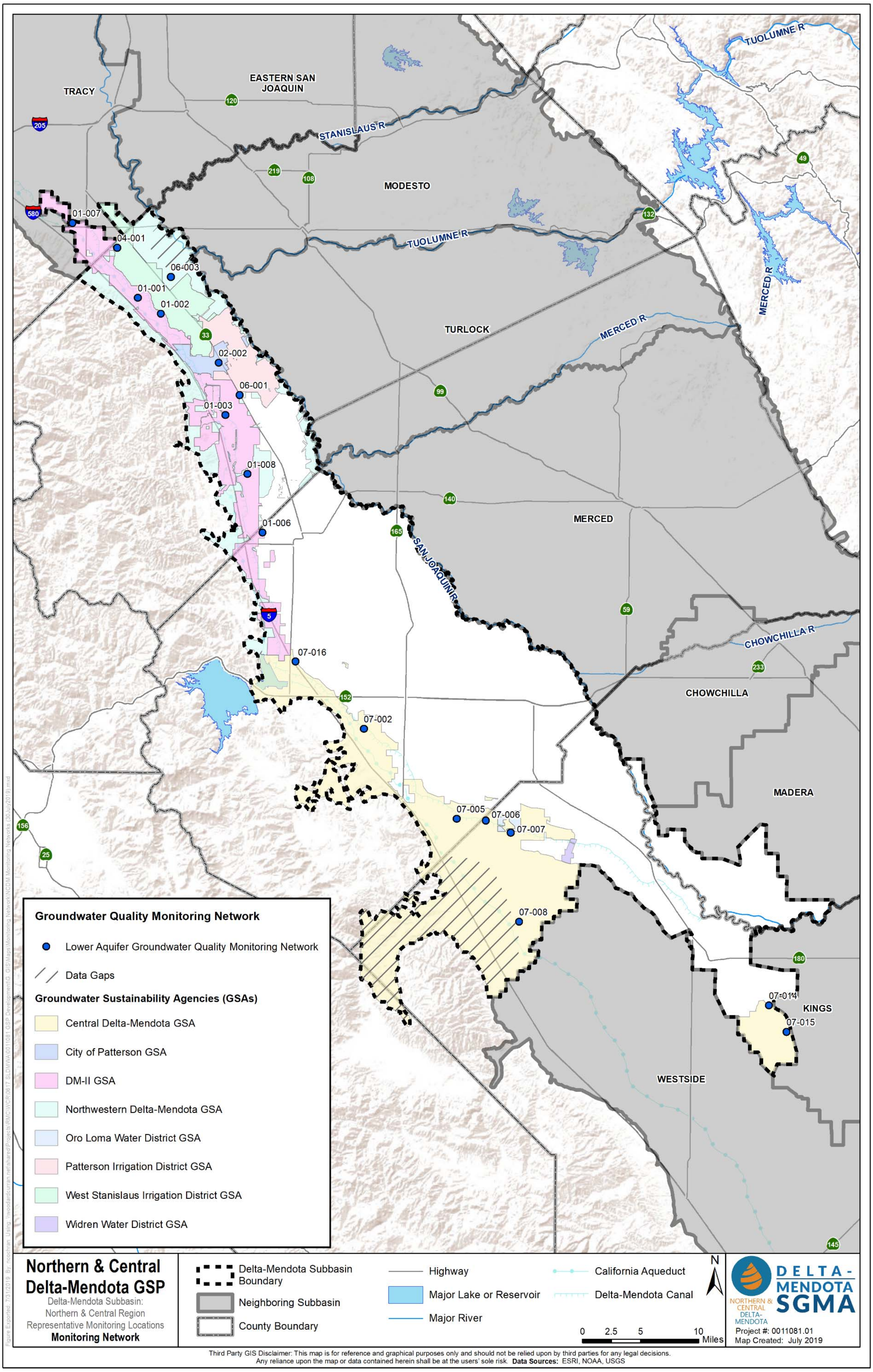

Figure 7-8. Groundwater Quality Monitoring Network, Lower Aquifer

7.2.5.4.2 Monitoring Protocols and Data Reporting Requirements

Monitoring protocols and data reporting requirements for the groundwater quality monitoring network have been developed in accordance with DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b). Monitoring protocols applicable to all Northern & Central Delta-Mendota Region GSP monitoring networks are detailed in Section 7.2.4.4. Additional details for the monitoring protocols and data reporting requirements can be found in Appendix F (*QAPP for Northern & Central Delta-Mendota Region GSP Monitoring Protocol*). Monitoring protocols established for the groundwater quality monitoring network will be reviewed every five years and modified as necessary, particularly as new methods or technology are developed, where any modifications to the monitoring protocols will be documents in detail within future GSP updates.

<u>Sampling Water Quality Data</u>

The following guidelines were adopted from DWR's *Standardized [Groundwater Quality Sampling] Protocols* (DWR, 2016b):

- Prior to sampling, the sampler must contact the State-certified analytical laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.
- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.
- The sampler will clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.
- The groundwater elevation in the well will be measured following appropriate protocols described above in the groundwater level measuring protocols.
- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water will be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment will be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), the condition will be documented and the well allowed to recover to within 90% of original level prior to sampling. Professional judgment should be exercised as to whether the sample will meet the data quality objective (DQOs) and adjusted as necessary.
- Field parameters of pH, electrical conductivity (EC), and temperature will be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Measurements of pH will only be measured in the field; lab pH analysis are typically unachievable due to short hold times. All field instruments will be calibrated daily and evaluated for drift throughout the day.
- Sample containers will be labeled prior to sample collection. The sample label must include sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.
- Samples will be collected under laminar flow conditions when possible with the goal of reducing turbulence. This may require reducing pumping rates prior to sample collection.

- Samples should be collected according to appropriate standards such as those listed in the *Standard Methods for the Examination of Water and Wastewater*, United States Geological Survey (USGS) *National Field Manual for the Collection of Water Quality Data,* or other appropriate guidance. The specific sample collection procedure should reflect the type of analysis to be performed and DQOs.
- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. The sampler will ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals will be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.
- Samples will be maintained at a temperature in accordance with the laboratory's Quality Assurance Management Plan's chilling and shipping requirements.
- Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.
- The laboratory will be instructed to use reporting limits that are equal to or less than the applicable DQOs or regional water quality objectives/screening levels.

Analytical Methods

Wells in the groundwater quality monitoring network will be sampled in coordination with other ongoing water quality sampling programs and the Quality Assurance Program Plan (QAPP) included in Appendix F of this GSP. Wells will be appropriately purged in accordance with their type and operational history to ensure that a representative groundwater sample is collected from the well. Wells will be purged for a sufficient time (see basic purging below) to evacuate water held in casing storage before collecting the water sample. This is important to ensure that water collected from a well is representative of groundwater in the aquifer formation outside the well bore.

Prior to sampling of a well, the depth to the water in the well will be measured, if possible, and recorded. It may not be possible to measure the water level due to wellhead accessibility or because the well is actively pumping. The well operational status prior to and at the time of sampling will be noted and any other observations at a well site that may potentially relate to the well or groundwater sampling will be described. Field water quality parameters, including EC, pH, and temperature, will be tested and recorded during sampling. Observed characteristics of the water during sampling, such as color, smell, or other visual observations, will be documented in a field notebook. All instruments used to measure field conditions during sampling will be calibrated on a regular basis in accordance with manufacturer guidelines and recommendations.

Water samples collected for laboratory analytical testing will be collected in appropriate laboratory-approved sample containers and stored in accordance with recommended sample handling procedures indicated by the laboratory and established in the QAPP (Appendix F). The sample identification, time, date, and any other informational fields indicated on the sample container label will be clearly provided. The associated laboratory chain of custody (COC) for samples will be completed and signed and provided with the samples at the time of delivery of samples to the laboratory for analysis.

Basic Purging. If possible, three casing volumes will be purged from the well prior to sample collection. Larger-capacity wells may not need purging (or may need more pumping) depending on their operational history. For smaller-capacity wells, such as domestic wells, achieving a three-casing volume purge may not be practical because of operational constraints relating to the well and water distribution system. In cases where a three-casing volume purge is not achievable, field parameters (EC, pH, temperature, etc.) of the water will be monitored during pumping/purging and a sample will not be collected until the field parameters have sufficiently stabilized. Field parameters will be monitored and recorded at least three times during well pumping/purging.

Low Flow. In addition to the protocols listed above, sampling using low-flow sample equipment should adopt the protocols set forth in the USEPA's *Low-flow (minimal drawdown) ground-water sampling procedures* (Puls and Barcelona, 1996). These protocols are not intended for bailers and apply to low-flow sampling equipment that generally pumps between 0.026 and 0.13 gallons per minute [0.1 and 0.5 liters per minute] (DWR, 2016b).

No Flow. For wells lacking pumping equipment and with casing volumes that make well purging difficult or impractical, a no-purge sampling device, such as a HydraSleeve, may be utilized to collect the sample. No-purge sampling methods should be conducted in accordance with recommended guidelines for the sample collection specific to the sampling device. When using a no-purge sampling method, a sufficient water sample should be collected for measuring field parameters and filling all necessary laboratory sample bottles.

For monitoring wells with installed pumping systems, groundwater samples will be collected from a point in the distribution system as near to the wellhead as possible and prior to any filtration or pressure tank, if possible.

Data Reduction, Validation, and Reporting

Chain of custody documentation will be used to document sample collection, shipping, storage, preservation, and analysis. All individuals transferring and receiving samples will sign, date, and record the time on the COC that the samples are transferred. Laboratory COC procedures are described in each laboratory's Quality Assurance Program Manual. Laboratories must receive the COC documentation submitted with each batch of samples and sign, date, and record the time the samples are transferred. Laboratories will also note any sample discrepancies (e.g., labeling, breakage). After generating the laboratory data report for the client, samples will be stored for a minimum of 30 days in a secured area prior to disposal.

Water quality samples should be delivered and tested at a state accredited analytical laboratory. A list of approved laboratories is provided in the USBR's *2013 Delta-Mendota Canal Groundwater Pump-in Program Water Quality Monitoring Plan* (USBR, 2013) or on the SWRCB Environmental Laboratory Accreditation Program (ELAP) website at https://www.waterboards.ca.gov/drinking_water/certlic/labs/.

Data generated or acquired as part of the Northern & Central Delta-Mendota Region GSP monitoring networks will be uploaded to the coordinated DMS as soon as possible. All monitoring locations in the GSP monitoring networks of the Delta-Mendota Subbasin will be assigned a unique ID and information associated with each monitoring location, such as well characteristics and historical hydrologic observations, will be compiled and maintained within the DMS. The structure of the DMS will be compatible with Geographic Information System (GIS) and other data formats and to facilitate future uploading of data to a state GSP database. Care should be taken to avoid data entry mistakes and electronic data transfers from the analytical laboratory should be used whenever possible.

Each GSA member agency is responsible for collecting groundwater quality samples and supplying the resultant data to the GSA Lead for compilation and a QA/QC review to avoid data entry mistakes. The GSA Lead then submits the compiled data to the GSP Representative for compilation at the GSP level. The GSP Representative will compile the GSA-level data into standard forms for uploading to the Subbasin DMS using import wizards and checks that data has been uploaded correctly. All data is to be updated by October 31 each year for inclusion in the annual report. SLDMWA, as Plan Administrator, then reviews data uploaded by all six Delta-Mendota GSP Groups prior to compilation at the Subbasin level for annual reporting. Should a result appear suspicious, a second sample shall be obtained as soon as possible for confirmation of the analytical result.

7.2.5.4.3 Frequency and Timing of Monitoring

Groundwater quality sampling will occur once per year during irrigation season, typically between May and July. The frequency and timing for groundwater quality monitoring were agreed upon by the Northern and Central Delta-Mendota Management Committee as well as the Delta-Mendota Subbasin Coordination Committee and deemed sufficient for evaluating the long-term trends in water quality. The frequency and timing of water quality monitoring will be continuously evaluated and modified as necessary prior to the 5-Year GSP Update.

7.2.5.4.4 Spatial Density

According to DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a), "the spatial distribution [of wells] should be adequate to map or supplement mapping of known contaminants." The goal of the groundwater quality monitoring network is to adequately cover the Plan area to accurately characterize concentrations and trends of constituents of concern. This includes both spatial and temporal coverage in order to identify changes in ambient groundwater quality over time. As such, professional judgement was used along with available well construction and groundwater quality data to identify the appropriate spatial density for the groundwater quality monitoring network for each principal aquifer.

Since the groundwater quality monitoring networks for the Upper Aquifer and Lower Aquifer contain identical sets of wells to the groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer, the spatial density of wells is also the same. Refer to Section 7.2.5.1.4 for more detail regarding spatial density of the groundwater levels and groundwater quality monitoring networks for each principal aquifer.

7.2.5.4.5 Data Gaps

Groundwater quality monitoring data gaps include both temporal and spatial gaps. Since the groundwater level monitoring networks and groundwater quality monitoring networks for the Upper Aquifer and Lower Aquifer are analogous, all data gaps identified and described in Section 7.2.5.1.5 are applicable to the groundwater quality monitoring networks.

7.2.5.4.6 Plan to Fill Data Gaps

The groundwater quality monitoring networks for the Upper Aquifer and Lower Aquifer contain identical sets of wells as the groundwater level monitoring networks for the Upper Aquifer and Lower Aquifer, respectively. Refer to Section 7.2.5.1.6 for the plan to fill data gaps in the groundwater levels and groundwater quality monitoring networks for both principal aquifers. As more data are collected regarding ambient groundwater quality in the Northern and Central Delta-Mendota Regions, the groundwater quality monitoring networks for the Upper Aquifer and Lower Aquifer will be evaluated and refined, and data gaps reexamined to determine if this monitoring network continues to provide adequate spatial coverage to monitor and manage groundwater quality according to the established sustainable management criteria.

While past temporal data gaps cannot be rectified, future temporal data gaps can be prevented or reduced by ensuring proper sampling and data management protocols are followed, as detailed in Sections 7.2.5.4.2 and 7.2.5.4.3.

Well use for each monitoring well within the groundwater quality monitoring networks for the Upper Aquifer and Lower Aquifer is identified in Table 7-8 and Table 7-9. Not all wells included in these networks are dedicated monitoring wells, as recommended by DWR's *Monitoring Networks and Identifications of Data Gaps BMP* (2016a). A concerted effort will be made to convert or replace production wells with dedicated monitoring wells over time as funding allows. As production wells are replaced by dedicated monitoring wells, GSA member agencies will provide input regarding converting existing monitoring wells to dedicated monitoring wells, selecting an alternative well to convert to a dedicated monitoring well, or selecting the location to install a new dedicated monitoring well.

7.2.5.5 Land Subsidence Monitoring Network

A land subsidence monitoring network for the Northern and Central Delta-Mendota Regions has been established to identify the rate and extent of inelastic land subsidence, which may be measured by extensometers, land surveying, remote sensing technology, or other appropriate method. Selection of land surface elevation monitoring sites were considered in relation to major water conveyance infrastructure, geographically separated areas, and areas with adequate surface water supplies available to develop a network for managing conditions in relation to each sustainability goal set for each land subsidence management area (see Section 5.5 *Management Areas* of the *Basin Setting* chapter for more detail regarding management areas).

This section provides information about management areas established for the land subsidence sustainability indicator, how the land subsidence monitoring network was developed, criteria for selecting monitoring locations, summary of protocols, monitoring frequency and timing, spatial density, and identification and strategies to fill data gaps.

7.2.5.5.1 Management Areas

Two management areas (MAs) have been established for the inelastic land subsidence sustainability indicator within the Northern and Central Delta-Mendota Regions: the West Stanislaus Irrigation District-Patterson Irrigation District (WSID-PID) MA and the Tranquillity Irrigation District (TRID) MA. Refer to Section 5.5 *Management Areas* of the *Basin Setting* chapter for more detail regarding the reasons these management areas were established. The land subsidence monitoring network has been established in consideration of sufficient quantity and density of monitoring sites to evaluate conditions of the basin setting and sustainable management criteria specific to the designated management areas.

7.2.5.5.2 Selected Monitoring Sites

Land subsidence monitoring sites are identified and summarized in Table 7-10. A total of 30 benchmarks and one (1) continuous Global Positioning System (CGPS) station comprise the land subsidence monitoring network, where there are six (6) benchmarks located within the WSID-PID MA and three (3) benchmarks located within the TRID MA. Figure 7-9 shows the locations of each land subsidence monitoring location within the Plan Area.

Land subsidence monitoring locations were selected based on the following criteria:

1. Existing Monitoring Program – Monitoring sites within existing, on-going monitoring program networks were preferred since access to land subsidence monitoring sites have previously been granted and a historical record of subsidence measurements likely exists.

2. Historical Data Available – Existing monitoring sites with longer, more robust historical datasets provide insight into long-term trends regarding subsidence rates and extents related to groundwater pumping patterns.

3. Management Area Coverage – For established MAs, a sufficient quantity and density of monitoring sites were selected to evaluate conditions and manage land subsidence relative to the sustainable management criteria established for each MA.

4. Adequate Spatial Distribution – Land subsidence monitoring sites were selected to provide adequate spatial distribution to evaluate conditions relative to sustainable management criteria throughout the Plan Area and established MAs.

5. Local Knowledge – Representatives from local agencies as well as the public were invited to provide any information and insight related to subsidence and historical record through each iteration of the land subsidence monitoring network.

6. Professional Judgement and Best Available Science – Professional judgement and best available science were used to make the final decision about each land subsidence monitoring location, particularly when more than one suitable site exists in an area of interest.

The criteria detailed herein used to develop the land subsidence monitoring network does not indicate any particular ranking or order of importance of each criterion. Rather, all criteria were considered collectively to create the land subsidence monitoring network for the Northern & Central Delta-Mendota Region GSP.

Table 7-10. Land Subsidence Monitoring Network

DMS ID	Local ID	Monitoring Agency	Site Type	County	Subregion	Management Area	First Measurement Year	Last Measurement Year	Measurement Frequency
02-003	Floragold Well	City of Patterson	Benchmark	Stanislaus	North	N/A	2006	2019	Periodic
02-008	Well 11	City of Patterson	Benchmark	Stanislaus	North	N/A	2006	2019	Periodic
02-005	Well 2	City of Patterson	Benchmark	Stanislaus	North	N/A	2006	2019	Periodic
02-006	Well 4	City of Patterson	Benchmark	Stanislaus	North	N/A	2006	2019	Periodic
02-007	Well 6	City of Patterson	Benchmark	Stanislaus	North	N/A	2006	2019	Periodic
03-004	Locust Avenue Well	Patterson Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	2019	Periodic
03-005	Pumping Plant No. 2	Patterson Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	2019	Periodic
03-006	River Station	Patterson Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	2019	Periodic
01-010	Subsidence Monitoring Point #1	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
01-011	Subsidence Monitoring Point #2	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
01-012	Subsidence Monitoring Point #3	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
01-013	Subsidence Monitoring Point #4	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
01-014	Subsidence Monitoring Point #5	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
02-004	Subsidence Monitoring Point #6	San Luis & Delta-Mendota Water Authority, City of Patterson	Benchmark	Stanislaus	North	N/A	1984	2018	Periodic
04-002	WSID 1	West Stanislaus Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	Unknown	Periodic
04-003	WSID 11	West Stanislaus Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	Unknown	Periodic
04-004	WSID 21	West Stanislaus Irrigation District	Benchmark	Stanislaus	North	WSID-PID	Unknown	Unknown	Periodic
01-015	Subsidence Monitoring Point #7	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North-Central	N/A	1984	2018	Periodic
06-006	Subsidence Monitoring Point #8	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North-Central	N/A	1984	2018	Periodic
01-016	Subsidence Monitoring Point #9	San Luis & Delta-Mendota Water Authority	Benchmark	Stanislaus	North-Central	N/A	1984	2018	Periodic
01-017	Subsidence Monitoring Point #10	San Luis & Delta-Mendota Water Authority	Benchmark	Merced	Central	N/A	1984	2018	Periodic
07-021	Subsidence Monitoring Point #11	San Luis & Delta-Mendota Water Authority	Benchmark	Merced	Central	N/A	1984	2018	Periodic
01-009	P252	University NAVSTAR Consortium (UNAVCO)	CGPS	Merced	Central	N/A	2005	2019	Daily
07-022	Subsidence Monitoring Point #12	San Luis & Delta-Mendota Water Authority	Benchmark	Merced	South-Central	N/A	1984	2018	Periodic
07-023	Subsidence Monitoring Point #13	San Luis & Delta-Mendota Water Authority	Benchmark	Merced	South-Central	N/A	1984	2018	Periodic
07-020	104.20-R	San Luis Water District	Benchmark	Fresno	South	N/A	1967	2019	Periodic
07-024	Subsidence Monitoring Point #14	San Luis & Delta-Mendota Water Authority	Benchmark	Fresno	South	N/A	1984	2018	Periodic
07-025	Subsidence Monitoring Point #15	San Luis & Delta-Mendota Water Authority	Benchmark	Fresno	South	N/A	1984	2018	Periodic
07-019	AG-24	Tranquillity Irrigation District	Benchmark	Fresno	Tranquillity	TRID	2013	2019	Annual
07-026	TID A	Tranquillity Irrigation District	Benchmark	Fresno	Tranquillity	TRID	2013	2019	Annual
07-027	TID B	Tranquillity Irrigation District	Benchmark	Fresno	Tranquillity	TRID	2013	2019	Annual

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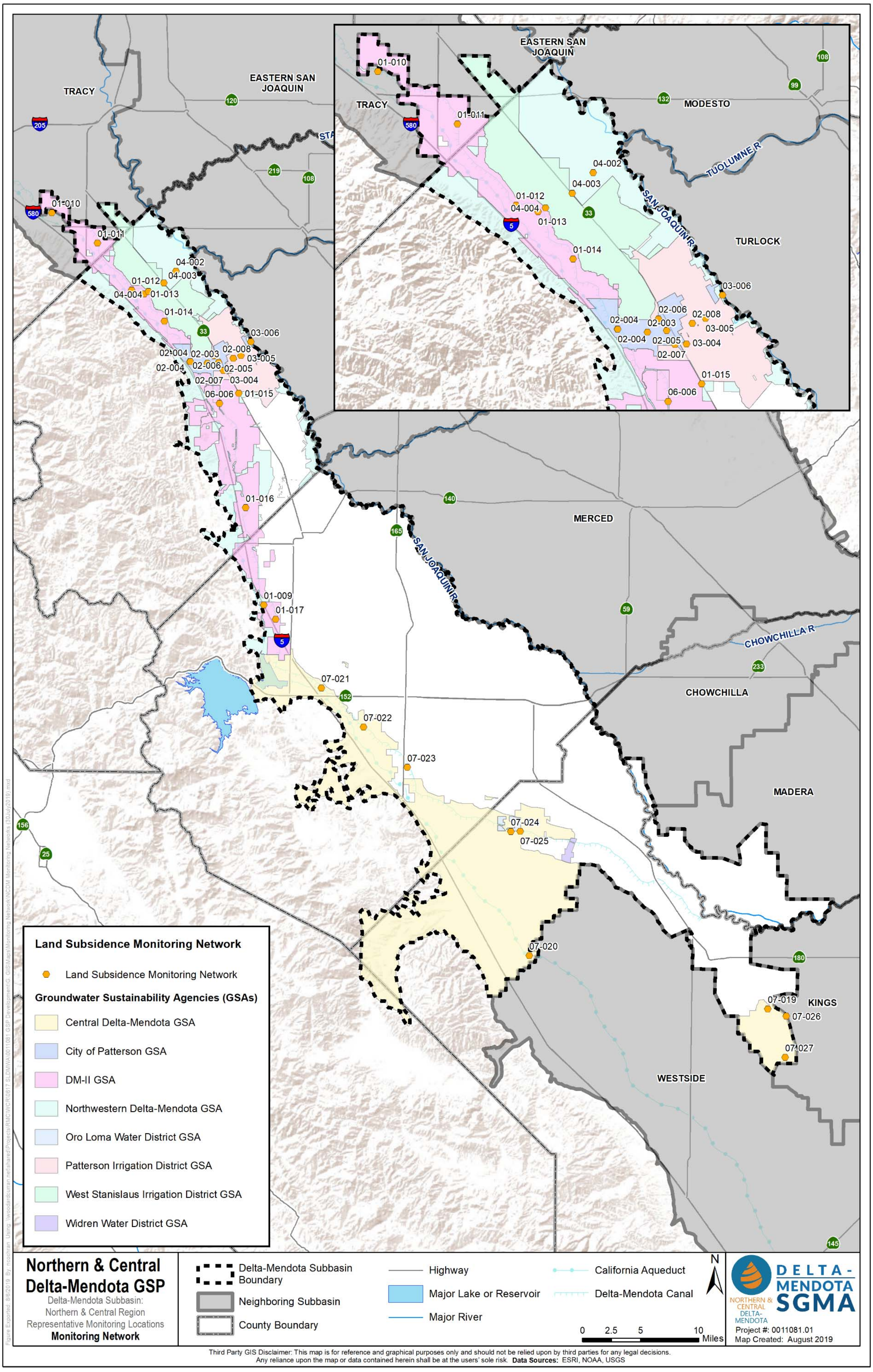

Figure 7-9. Land Subsidence Monitoring Network

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7.2.5.5.3 Monitoring Protocols and Data Reporting Requirements

Monitoring protocols and data reporting requirements for the land subsidence monitoring network have been developed in accordance with DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b). Monitoring protocols applicable to all Northern & Central Delta-Mendota Region GSP monitoring networks are detailed in Section 7.2.4.4. Additional details regarding monitoring protocols and data reporting requirements can be found in Appendix F (*QAPP for Northern & Central Delta-Mendota Region GSP Monitoring Protocol*). Monitoring protocols established for the land subsidence monitoring network will be reviewed every five years and modified as necessary, where any modifications to the monitoring protocols will be documented in detail in future GSP updates.

<u>Land Surveying Procedures</u>

The following guidelines for conducting ground surface elevations measurements via land surveying were adopted from the United States Department of Agriculture, Natural Resources Conservation Service *Engineering Field Handbook* (2008):

- All surveys will be conducted by a California licensed land surveyor and will tie into established benchmarks.
- Prior to taking the first measurement at a given representative monitoring location, the established benchmark for the monitoring site will be identified and information will be obtained from the appropriate entity prior to field work.
- Maps and photographs of the monitoring site will be made available to the surveyor.
- Proper protocols and procedures will be followed to set up and level the surveying equipment.
- Before taking a reading, ensure the measurement rod is in the vertical position and no foreign material prevents clear contact between the rod and the point to be read.
- The leveling bubble on the surveying equipment will be checked regularly during use by the surveyor to make sure no inadvertent movement has occurred. If necessary, proper protocols and procedures to re-level the surveying equipment will be followed to begin measuring again. Adjustments to the level should never be made part way through a circuit.
- All vertical elevation measurements will be collected relative to NAVD88.
- Field notes will, at a minimum, contain the following information:
    - Location of survey (including coordinates and written description)
    - Date and time of survey
    - Instruments and technique used
    - Established benchmark tied to the monitoring site
    - Monitoring site ID
    - Measured benchmark elevation (to 0.1-foot accuracy)
    - Measured elevation at monitoring site relative to the established benchmark (to 0.1-foot accuracy)
    - Description of any modifications to the monitoring site

<u>Data Reduction, Validation, and Reporting</u>

Data generated or acquired as part of the Northern & Central Delta-Mendota Region GSP monitoring networks will be uploaded to the Subbasin coordinated DMS as soon as possible following validation. All representative monitoring sites will be assigned a unique ID number and information associated with monitoring site, such as such as location descriptions and associated photographs, will be compiled and maintained within the DMS. The structure of the DMS will be compatible with GIS and other data formats to facilitate future uploading of data to external databases.

Each GSA member agency is responsible for collecting land survey measurements and supplying the resultant data to the GSA Lead for compilation and a QA/QC review to avoid data entry mistakes. The GSA Lead then submits the compiled data to the GSP Representative for compilation at the GSP level. The GSP Representative will compile the GSA-level data into standard forms for uploading to the Subbasin DMS using import wizards and checks that data has been uploaded correctly. All data is to be updated by October 31 each year for inclusion in the annual report. SLDMWA, as Plan Administrator, then reviews data uploaded by all six Delta-Mendota GSP Groups prior to compilation at the Subbasin level for annual reporting. Should a measurement appear suspicious, a second confirmation reading shall be obtained as soon as possible.

In addition to data collected directly by the Northern and Central Delta-Mendota Regions' GSAs, subsidence data will be downloaded from publicly available sources such as UNAVCO and DWR's SGMA Data Viewer for assessment with local data. All data will be maintained in the Subbasin coordinated DMS.

7.2.5.5.4 Frequency and Timing of Monitoring

Land subsidence monitoring sites will be surveyed, and data will be analyzed and recorded at differing frequencies within the established MAs and the remaining Plan Area. In the WSID-PID MA, baseline land surface elevation measurements will be performed during calendar year 2019, and two subsequent surveys will be performed between 2020 and 2025. Elevation surveys will be performed at representative monitoring sites in the WSID-PID MA by the end of calendar year 2020 (in preparation for the 2021 Annual Report) and by the end of calendar year 2023 (in preparation for the 2025 GSP Update). In the TRID MA, elevation surveys will take place annually. Elevation surveys in the WSID-PID and TRID MAs will be performed during the month of May. Refer to Section 5.5 *Management Areas* of the *Basin Setting* chapter for more information about monitoring frequency deemed appropriate for each established MA. Within the remaining Plan area, elevation surveys will be performed every other year with surveys taking place during even years. Elevation surveys within the remaining Northern & Central Region GSP Plan area will be performed either by the United States Bureau of Reclamation or the San Luis & Delta-Mendota Water Authority during the month of July.

Benchmark monitoring sites will be surveyed during the same period (e.g. Spring or Fall) to ensure measurements represent the same condition related to subsidence. Data collected from publicly available sources (such as UNAVCO and DWR's SGMA Data Viewer) will also be downloaded and used to supplement survey data. Coordination with existing monitoring entities will take place regarding the frequency and timing of monitoring events to ensure access to the monitoring site and ensure proper protocols are followed.

7.2.5.5.5 Spatial Density

Guidance related to the spatial density of land subsidence monitoring sites is not provided in DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a). It is noted that the land subsidence monitoring network "should be established to observe the sustainability indicator such that the sustainability goal can be met" (DWR, 2016a). Professional judgement, along with historical survey data, existing survey benchmarks and local experience, to establish the appropriate spatial density of land subsidence monitoring networks within the Plan area and the two established MAs.

7.2.5.5.6 Data Gaps

There are no known spatial data gaps identified for the land subsidence monitoring network within the Northern and Central Delta-Mendota Regions. Professional judgement and local knowledge were used in the development of the land subsidence monitoring network determined that there is adequate spatial distribution of benchmark sites to collect subsidence data relative to management areas and their respective sustainable management criteria going forward.

Temporal data gaps exist at individual monitoring sites and across monitoring sites throughout the Delta-Mendota Subbasin. This is due to a multitude of reasons including historical differences in the timing of collected measurement, monitoring site construction date, and ability to access the monitoring site. Future land surveys, coordinated amongst the GSAs and combined with publicly available land survey datasets, will eliminate these temporal data gaps in the future.

7.2.5.5.7 Plan to Fill Data Gaps

While there are currently no known spatial data gaps within the land subsidence monitoring network, a concerted effort will be made to continually assess the land subsidence monitoring network for data gaps and to refine the network through the process outlined in DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a). Such efforts will take place prior to updates to this GSP.

While past temporal data gaps cannot be rectified, future temporal data gaps can be prevented or reduced by ensuring proper sampling and data management protocols are followed, as detailed in Sections 7.2.5.5.3 and 7.2.5.5.4.

7.2.5.6 Depletions of Interconnected Surface Water Monitoring Network

A monitoring network for the depletions of interconnected surface water sustainability indicator is designed to monitor surface water and groundwater conditions at locations where interconnected surface water conditions exist to characterize the spatial and temporal relationship between surface water stage and Upper Aquifer groundwater elevations. This monitoring network is also designed to provide the necessary data for calculating depletions of surface water caused by groundwater extractions. The monitoring network is intended to characterize the following:

1. Flow conditions in interconnected surface water bodies, including surface water discharge, surface water stage, and baseflow contribution.
2. The approximate data and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
3. Temporal change in conditions due to variations in stream discharge and regional groundwater extractions.
4. Other factors that may be necessary to identify adverse impacts on beneficial uses of surface water.

This section provides information about how the depletions of interconnected surface water monitoring network was developed, criteria for selecting monitoring wells, summary of protocols, monitoring frequency and timing, spatial density, and identification and strategies to fill data gaps.

7.2.5.6.1 Selected Monitoring Sites

The monitoring network for the depletions of interconnected surface water sustainability indicator includes a subset of wells from the groundwater level monitoring network for the Upper Aquifer. Therefore, the criteria for selecting wells for the depletions of interconnected surface water monitoring network is the same as the criteria applied in developing the groundwater level monitoring network (detailed in Section 7.2.5.1.1).

Proximity to the portion of the San Joaquin River located within the Northern Delta-Mendota Region, approximately within three miles of the river, was an additional criterion considered in establishing this monitoring network. A distance of three miles was selected based on DWR's *Monitoring Networks and Identification of Data Gaps* BMP (2016a) document, where future data collection and analyses will determine the appropriate distance from the river for monitoring this sustainability indicator. Table 7-11 and Figure 7-10 summarize the two existing representative monitoring locations identified to evaluate short-term, seasonal, and long-term trends in groundwater levels and potential changes in gradient between the wells and the San Joaquin River. Table 7-12 shows the selected stream gauges for use in monitoring for potential changes in gradient between the representative monitoring sites and San Joaquin River head.

7.2.5.6.2 Monitoring Protocols and Data Reporting Requirements

Depletions of interconnected surface water will be assessed using groundwater levels as a proxy. As such, the monitoring protocols for the groundwater level monitoring network are also applicable for collecting information relevant to the monitoring network for the depletions of interconnected surface water sustainability indicator.

Monitoring protocols for the groundwater level monitoring network have been developed in accordance with DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b). Monitoring protocols applicable to all Northern & Central Delta-Mendota Region GSP monitoring networks are detailed in Section 7.2.4.4. Greater detail regarding monitoring protocols and data reporting requirements can be found in Appendix F (*QAPP for Northern & Central Delta-Mendota Region GSP Monitoring Protocol*). Monitoring protocols established for the groundwater level monitoring network will be reviewed every five years and modified as necessary, where any modifications to the monitoring protocols will be documents in detail in each future GSP update.

For the analysis of future management of interconnected surface waters, streamflow and/or surface water stage data will be downloaded from publicly available databases and/or obtained from local sources and combined with groundwater elevation data for assessing the status of this sustainability criterion. Specifically, future data collection efforts will attempt to link groundwater elevations and gradients with river stage, groundwater pumping data and hydrologic conditions to establish a relationship between groundwater use and interconnected surface water. All data collected and utilized will be uploaded to the Subbasin coordinated DMS.

Protocols for Measuring Streamflow

The following guidelines were adopted from DWR's *Monitoring Protocols, Standards, and Sites* BMP (DWR, 2016b):

- The use of existing streamflow monitoring locations will be incorporated to the greatest extent possible.
- Establishment of new streamflow monitoring sites should consider existing representative monitoring networks and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any surface water monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.
- To establish a new streamflow monitoring station, special consideration must be made in the field to select an appropriate location for measuring flows and/or stage. Once a site is selected, development of a relationship between stream stage and discharges will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages may be necessary to develop the ratings curve correlating stage to discharge. Following development of the ratings curve, a simple stilling well and pressure transducer with data logger can be used to evaluate state on a frequent basis.
- Streamflow measurements will be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175, *Volume 1. – Measurement of Stage Discharge* (Rantz et al., 1982a) and *Volume 2. – Computation of Discharge* (Rantz et al., 1982b). This methodology is currently being used by both USGS and DWR for existing streamflow monitoring throughout the State.

Table 7-11. Depletions of Interconnected Surface Water Monitoring Network

DMS ID	State Well Number	CASGEM ID (if applicable)	Local ID	Status	Well Use	Monitoring Agency	Monitoring Program	County	Subregion	Depth (ft)	Screen Intervals (ft)	First Measurement Year	Last Measurement Year	Measurement Count
03-001		375015N1211011W001	MW-2	Active	Monitoring	Patterson Irrigation District	CASGEM (Mandatory)	Stanislaus	North	250	220 - 250	2010	N/A – Continuous Monitoring	21
03-003	05S/08E-16R		WSJ003	Unknown	Irrigation	Westside San Joaquin River Watershed Coalition	Groundwater Quality Trend Monitoring Program (ILRP)	Stanislaus	North	255	130 - 250	Not available	Not available	Not available

Table 7-12. Selected Stream Gauges

Stream Gauge ID	Description	Agency	River Discharge			River Stage		
			First Measurement Year	Last Measurement Year	Measurement Frequency	First Measurement Year	Last Measurement Year	Measurement Frequency
SMN	San Joaquin River above Merced River near Newman	United States Geological Survey	2010	present	15-minute intervals (computed)	2010	present	15-minute intervals
NEW	San Joaquin River near Newman	United States Geological Survey	1995	present	15-minute intervals (computed)	1984	present	15-minute intervals
SCL	San Joaquin River near Crows Landing	United States Geological Survey	2004	present	15-minute intervals (computed)	2004	present	15-minute intervals
SJP	San Joaquin River near Patterson	California Data Exchange Center (DWR)	1997	present	15-minute intervals	1997	present	15-minute intervals
MRB	San Joaquin River near Maze Rd Bridge	California Data Exchange Center (DWR)	2006	present	15-minute intervals (computed)	2006	present	15-minute intervals
VNS	San Joaquin River near Vernalis	California Data Exchange Center (DWR) and United States Geological Survey	1984	present	15-minute intervals	1995	present	15-minute intervals
PID Transducer		Patterson Irrigation District	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
WSID Pumping Plant 1 Intake Level Sensors	At end of gravity-fed canal, two miles inland from San Joaquin River.	West Stanislaus Irrigation District	Not measured	Not measured	Not measured	2013	present	15-second intervals

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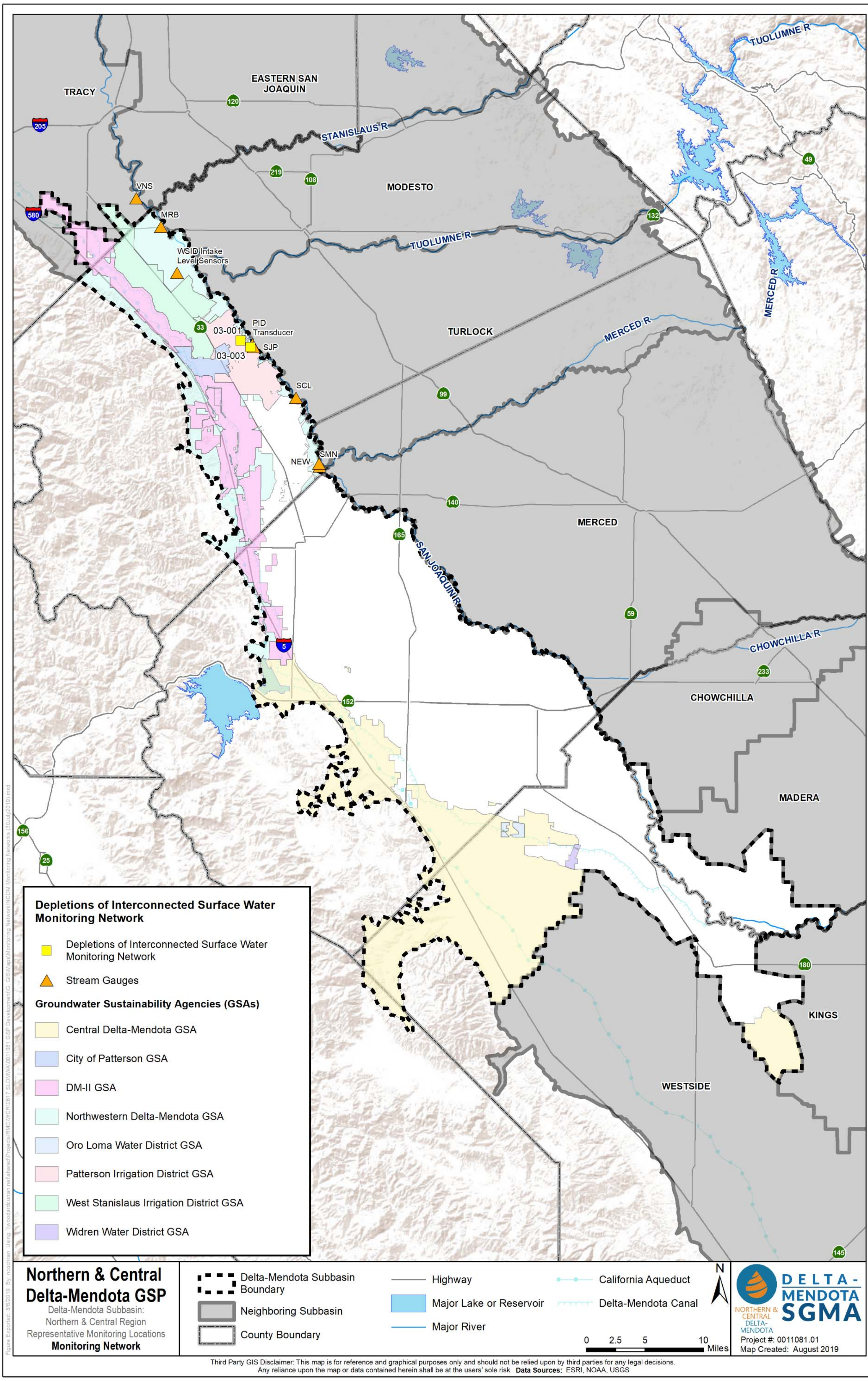

Figure 7-10. Depletions of Interconnected Surface Water Monitoring Network

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Data Reduction, Validation, and Reporting

After field personnel have completed collection of groundwater level measurements and river stage (if appropriate), data should be entered into the Delta-Mendota Subbasin coordinated DMS as soon as possible. Each GSA member agency is responsible for collecting the appropriate groundwater and surface water level data during the designated seasonal high and seasonal low time periods (as designated in Section 7.2.5.1.3) and supplying the resultant data to the GSA Lead for compilation and a QA/QC review to avoid data entry mistakes. The GSA Lead then submits the compiled data to the GSP Representative for compilation at the GSP level. The GSP Representative will compile the GSA-level data into standard forms for uploading to the Subbasin DMS using import wizards and checks that data has been uploaded correctly. All data is to be updated by October 31 each year for inclusion in the annual report. SLDMWA, as Plan Administrator, then reviews data uploaded by all six Delta-Mendota GSP Groups prior to compilation at the Subbasin level for annual reporting. Should a measurement appear suspicious, a second confirmation reading shall be obtained as soon as possible.

For river discharge and stage data collected from publicly available sources as well as local gauges, a visual check of the data will be performed to ensure that the reported value matches stream conditions. The same protocol will be taken to enter stream-related data into the Subbasin coordinated DMS as for groundwater level data.

7.2.5.6.3 Frequency and Timing of Monitoring

Since groundwater levels are being used as a proxy for monitoring depletions of interconnected surface water, the frequency and timing of monitoring events can be found in Section 7.2.5.1.3. Publicly available stream gauge data, such as from the USGS's National Water Information System (NWIS) and DWR's California Data Exchange Center (CDEC), will be paired with groundwater level and extraction data to evaluate for any significant and sustained change in gradient between monitoring wells and the San Joaquin River, potentially indicating a significant and unreasonable loss of interconnected surface water as a result of groundwater extractions.

As described in Chapter 6 *Sustainable Management Criteria*, the first 5-year interim goal is to establish numeric minimum thresholds, measurable objectives, and subsequent interim milestones for the depletion of interconnected surface water sustainability indicator. Prior to the 5-Year GSP Update, the frequency and timing of depletion of interconnected surface water monitoring will be evaluated and refined to better understand the timing and quantity of depletions (if any) from the San Joaquin River.

7.2.5.6.4 Spatial Density

In the absence of spatial density guidelines or recommendations contained within DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a) for the depletions of interconnected surface water monitoring network, professional judgement was used along with available data and monitoring locations to determine the appropriate density of monitoring sites. Only two well sites were available for inclusion in the monitoring network based on the groundwater level well criteria described in Section 7.2.5.1.1 and located within approximately three miles of the river or as appropriate for the flow regime. DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a) recommends GSPs identify and quantify both timing and volume of groundwater pumping within approximately three miles of the stream or as appropriate for the flow regime.

Stream gauge data to be paired with groundwater elevation data will be collected from publicly available data sources, such as USGS's NWIS and DWR's CDEC, and local data as available. Future efforts will be made to evaluate the spatial density and location of stream gauges for assessing the depletions of interconnected surface water sustainability indicator, and a plan to fill this data gap will be evaluated during the five-year GSP updates.

7.2.5.6.5 Data Gaps

Depletions of interconnected surface water data gaps exist in areas where data are limited both spatially and temporally. The entire area along the San Joaquin River within the Northern Delta-Mendota Region is considered to be a data gap for the depletions of interconnected surface water monitoring network. The absence of known well locations within approximately three miles of the San Joaquin River is the primary driver currently limiting monitoring of the depletions of interconnected surface water sustainability indicator, as groundwater levels and potential changes in gradient between wells and the stream stage are used as proxy for monitoring this sustainability indicator.

Temporal data gaps exist at individual and across well sites throughout the Northern Delta-Mendota Region. This is due to a multitude of reasons including limited monitoring locations, historical differences in the timing of collected measurements, well or stream gauge construction date, and ability to access the well site or stream gauge.

7.2.5.6.6 Plan to Fill Data Gaps

For the purpose of monitoring for depletions of interconnected surface water where groundwater levels are used as a proxy, the locations of four (4) clustered or nested wells with tentative locations have been identified (Figure 7-11). These wells are located within three miles of the San Joaquin River within the Northwestern Delta-Mendota GSA and Patterson Irrigation District GSA. Any new monitoring wells will be installed in accordance with guidance provided in DWR's *Monitoring Networks and Identifications of Data Gaps BMP* (2016a) and will be paired with a nearby stream gauge where possible. While there are no current plans to include supplemental stream gauges beyond those available through publicly available data sets or local gauges currently identified in Table 7-12, an assessment will be made prior to the 5-Year Update to this GSP to determine if data gaps exist within existing stream gauge networks and guidance provided in DWR's *Monitoring Networks and Identification of Data Gaps BMP* (2016a) will be used to install additional gauges, if required.

While past temporal data gaps cannot be rectified, future temporal data gaps can be prevented or reduced by ensuring proper sampling and data management protocols are followed, as detailed in Sections 7.2.5.6.2 and 7.2.5.6.3 and in DWR's *Monitoring Protocols, Standards, and Sites* BMP (2016b) for streamflow measuring protocols.

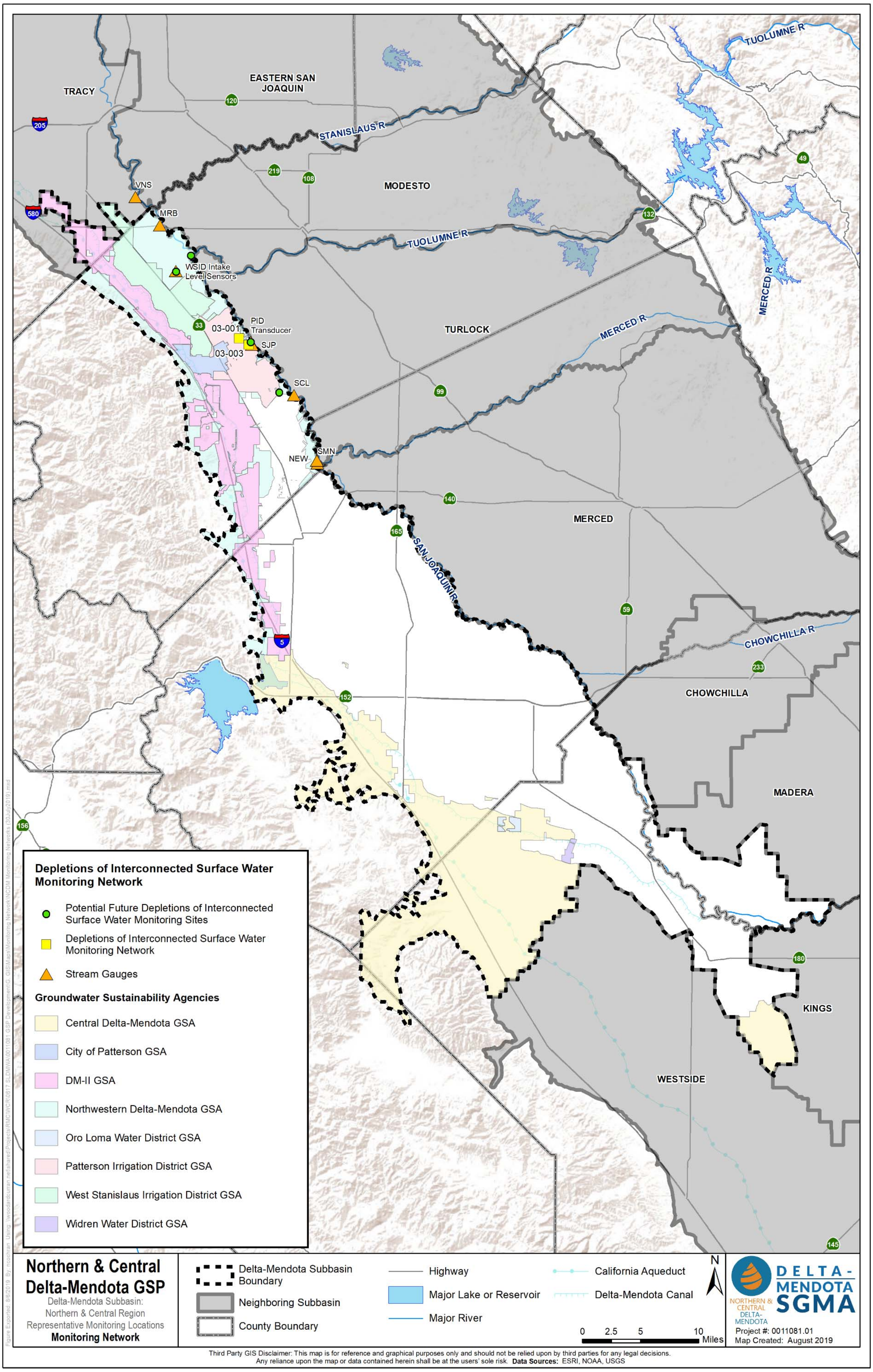

Figure 7-11. Potential Future Depletions of Interconnected Surface Water Monitoring Sites

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7.3 REFERENCES

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Section 8

Plan Implementation

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8. PLAN IMPLEMENTATION

8.1 PLAN IMPLEMENTATION

Implementation of this Groundwater Sustainability Plan (GSP) includes implementation of the projects and management actions included in Chapter 7, as well as the following:

- Groundwater Sustainability Plan implementation, administration, and management
- Implementation of the monitoring program described in Chapter 7 of this GSP
- Annual Reporting
- Five-year assessment reports, also referred to as 5-Year Updates to this GSP

This chapter also describes the contents of both the annual reports and five-year assessment reports that must be provided to the California Department of Water Resources (DWR) as required by Sustainable Groundwater Management Act (SGMA) regulations.

8.1.1 Implementation Schedule

Figure 8-1 illustrates the implementation schedule for this GSP through 2025. Included in the chart are activities necessary for ongoing GSP monitoring and updates, as well as tentative schedules for the anticipated projects and management actions, to the first interim goal. Additional details about the activities included in the schedule are provided in the respective sections of this GSP. Adaptive management actions will only be implemented if the GSP interim goals, as described in Chapter 6 *Sustainable Management Criteria*, are not being met.

8.2 IMPLEMENTATION COSTS AND FUNDING SOURCES

Northern and Central Delta-Mendota Regions Groundwater Sustainability Agencies (GSAs) operations and GSP implementation will incur costs which will require funding by the individual entities comprising the GSAs. The five primary activities that will incur costs include:

- Implementing the GSP
- Implementing GSP-related projects and management actions
- GSA and Plan Administrator operations
- Annual data collection, analysis, and reporting
- Developing five-year assessment reports

Table 8-1 summarizes these activities and their estimated costs, where some costs and associated activities will be undertaken by each Northern and Central Delta-Mendota Regions GSAs as well as San Luis & Delta-Mendota Water Authority (SLDMWA). Costs are subject to change based on whether GSAs, SLDMWA, or consulting staff conduct each activity. Costs associated with implementing GSP-related projects and management actions are included in Section 7.1 *Projects and Management Actions* of the *Sustainability Implementation* chapter.

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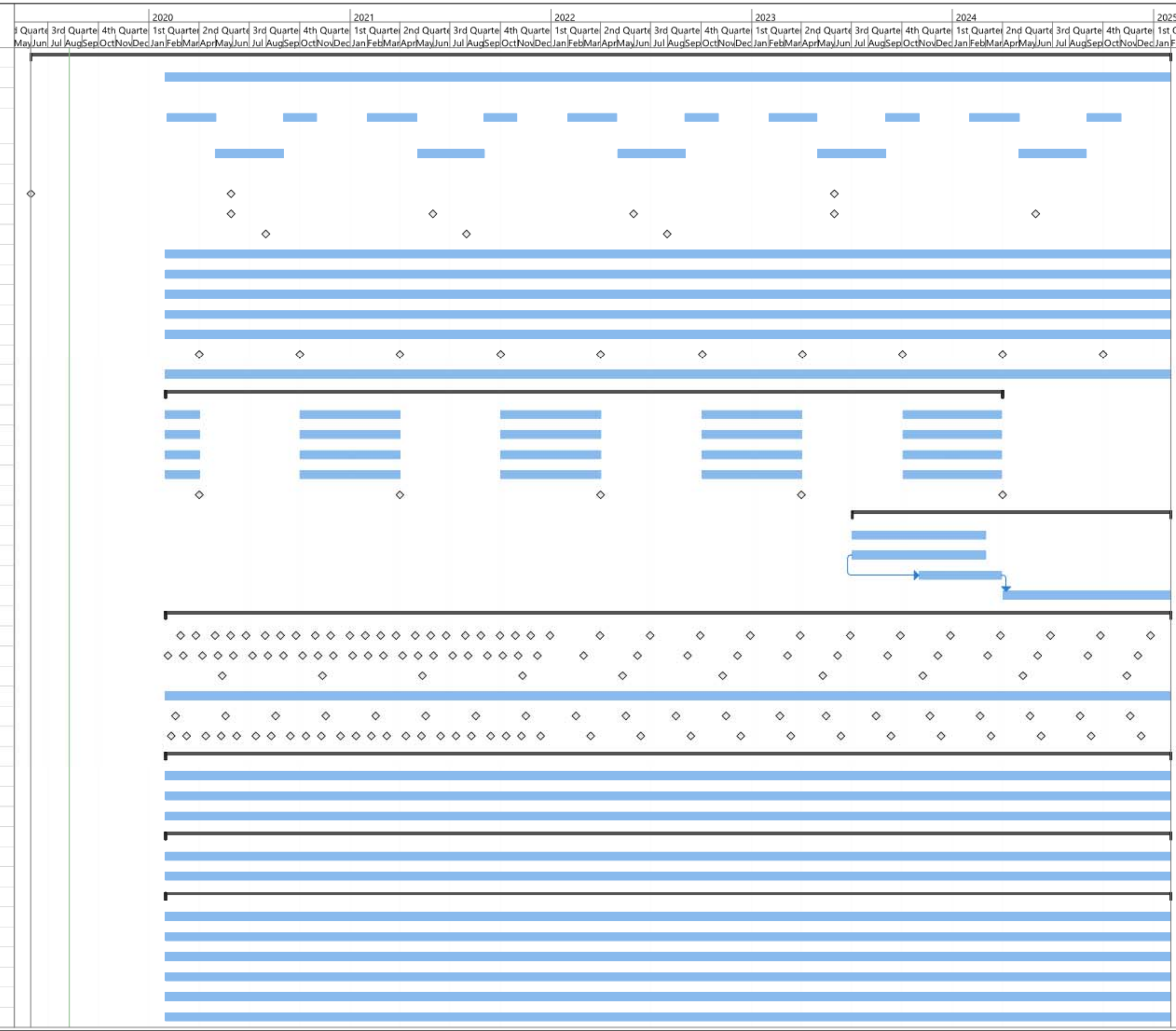
Task Name	Duration	Start	Finish
Task 1: Monitoring Program	**1481 days**	**Fri 5/31/19**	**Fri 1/31/25**
Coordination with Monitoring Entities	1306 days	Fri 1/31/20	Fri 1/31/25
Data Field Collection	1416 days	Fri 5/31/19	Fri 11/1/24
Groundwater Levels and Interconnected Surface Water	1240 days	Mon 2/3/20	Fri 11/1/24
Groundwater Quality	1131 days	Fri 5/1/20	Fri 8/30/24
Subsidence	1305 days	Fri 5/31/19	Fri 5/31/24
WSID-PID Management Area	1043 days	Fri 5/31/19	Wed 5/31/23
TRID Management Area	1045 days	Fri 5/29/20	Fri 5/31/24
Remaining GSP Area	521 days	Fri 7/31/20	Sun 7/31/22
Monitoring Data Quality Control and Analysis	1306 days	Fri 1/31/20	Fri 1/31/25
Oversight and Coordination of Monitoring	1306 days	Fri 1/31/20	Fri 1/31/25
Monitoring Network Maintenance	1306 days	Fri 1/31/20	Fri 1/31/25
Data Gap Tracking	1306 days	Fri 1/31/20	Fri 1/31/25
Local Monitoring	1306 days	Fri 1/31/20	Fri 1/31/25
Lab Testing	1174 days	Wed 4/1/20	Tue 10/1/24
Training	1306 days	Fri 1/31/20	Fri 1/31/25
Task 2: Annual Reporting and Analysis	**1086 days**	**Fri 1/31/20**	**Mon 4/1/24**
Water Levels	1086 days	Fri 1/31/20	Fri 3/29/24
Change in Storage	1086 days	Fri 1/31/20	Fri 3/29/24
Water Quality	1086 days	Fri 1/31/20	Fri 3/29/24
Subsidence	1086 days	Fri 1/31/20	Fri 3/29/24
Annual Report Documentation	1043 days	Wed 4/1/20	Mon 4/1/24
Task 3: 5-Year Update	**415 days**	**Mon 7/3/23**	**Fri 1/31/25**
Threshold Evaluation and Updating	174 days	Mon 7/3/23	Thu 2/29/24
Numerical Model Updates and Coordination	174 days	Mon 7/3/23	Thu 2/29/24
Evaluation of Intial GSP Effectiveness	108 days	Wed 11/1/23	Fri 3/29/24
Plan to Improve GSP	219 days	Tue 4/2/24	Fri 1/31/25
Task 4: Coordination	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**
Advisory Committee Meeting Support	1260 days	Thu 2/27/20	Thu 12/26/24
GSA Board Meeting Support	1260 days	Tue 2/4/20	Tue 12/3/24
Public Outreach	1175 days	Wed 5/13/20	Wed 11/13/24
Website Maintenance	1306 days	Fri 1/31/20	Fri 1/31/25
Interbasin Coordination	1240 days	Tue 2/18/20	Tue 11/19/24
Intrabasin Coordination	1260 days	Mon 2/10/20	Mon 12/9/24
Task 5: Data Management System Maintenance	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**
Data Quality Control	1306 days	Fri 1/31/20	Fri 1/31/25
Data Management System Cleanup/Maintenance	1306 days	Fri 1/31/20	Fri 1/31/25
Task 6: Budget Schedule and Monitoring	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**
Task 7: Grant Tracking and Administration	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**
Grant Tracking and Pursuit	1306 days	Fri 1/31/20	Fri 1/31/25
Grant Administration	1306 days	Fri 1/31/20	Fri 1/31/25
Task 8: General Administration	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**
Accounting	1306 days	Fri 1/31/20	Fri 1/31/25
Auditing	1306 days	Fri 1/31/20	Fri 1/31/25
Document Management	1306 days	Fri 1/31/20	Fri 1/31/25
General Staff Oversight	1306 days	Fri 1/31/20	Fri 1/31/25
Contract Management	1306 days	Fri 1/31/20	Fri 1/31/25
Task 9: Legal Support	**1306 days**	**Fri 1/31/20**	**Fri 1/31/25**



Project: Implementation Schedule,
Northern & Central Delta-Mendota GSP
Date: 2020-2025

Task | Summary | Milestone ◇

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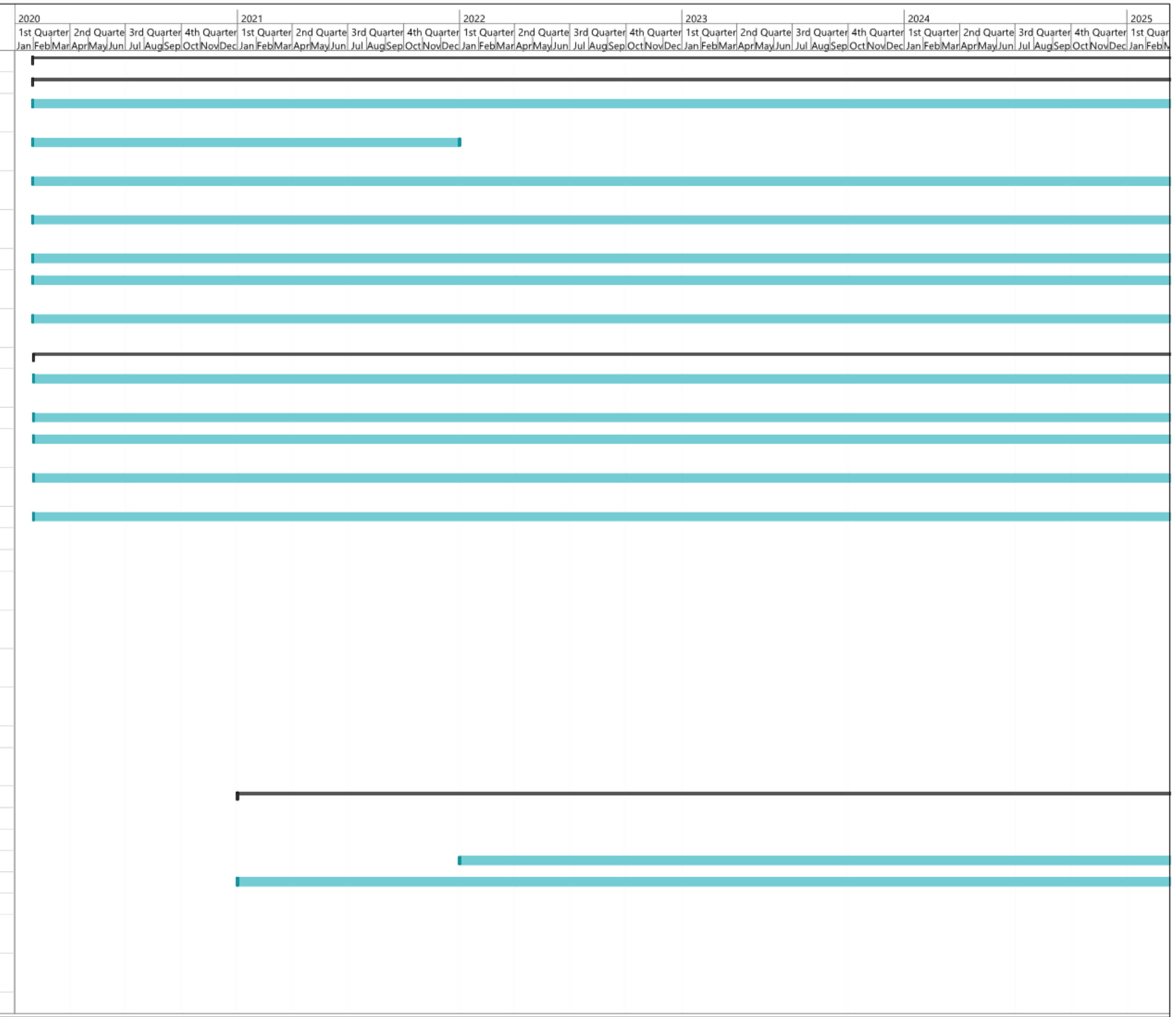
Figure 8-1. Implementation Schedule

Task Name	Duration	Start	Finish
Projects and Management Actions	**5457 days**	**Fri 1/31/20**	**Mon 12/31/40**
Tier 1 Projects	**1544 days**	**Fri 1/31/20**	**Wed 12/31/25**
Los Banos Creek Recharge and Recovery Project	1544 days	Fri 1/31/20	Wed 12/31/25
Orestimba Creek Recharge and Recovery Project	501 days	Fri 1/31/20	Fri 12/31/21
North Valley Regional Recycled Water Program (NVRRWP)	1544 days	Fri 1/31/20	Wed 12/31/25
City of Patterson Percolation Ponds for Stormwater Capture and Recharge	1544 days	Fri 1/31/20	Wed 12/31/25
Kaljian Drainwater Reuse Project	1544 days	Fri 1/31/20	Wed 12/31/25
West Stanislaus Irrigation District Lateral 4-North Recapture and Recirculation Reservoir	1544 days	Fri 1/31/20	Wed 12/31/25
Revision to Tranquillity Irrigation District Lower Aquifer Pumping	1544 days	Fri 1/31/20	Wed 12/31/25
Tier 1 Management Actions	**1543 days**	**Sat 2/1/20**	**Wed 12/31/25**
Lower Aquifer Pumping Rules for Minimizing Subsidence	1544 days	Sat 2/1/20	Wed 12/31/25
Maximize Use of Other Water Supplies	1544 days	Sat 2/1/20	Wed 12/31/25
Increasing GSA Access to and Input on Well Permits	1544 days	Sat 2/1/20	Wed 12/31/25
Drought Contingency Planning in Urban Areas	1544 days	Sat 2/1/20	Wed 12/31/25
Fill Data Gaps	1544 days	Sat 2/1/20	Wed 12/31/25
Tier 2 Projects	**1827 days**	**Thu 1/1/26**	**Fri 12/31/32**
Del Puerto Canyon Reservoir Project	261 days	Tue 1/1/30	Tue 12/31/30
Little Salado Creek Groundwater Recharge and Flood Control Basin	261 days	Thu 1/1/26	Thu 12/31/26
Patterson Irrigation District Groundwater Bank and/or Flood-MAR-type Project	262 days	Thu 1/1/32	Fri 12/31/32
West Stanislaus Irrigation District Lateral 4-South Recapture and Recirculation Reservoir	1304 days	Thu 1/1/26	Tue 12/31/30
Ortigalita Creek Groundwater Recharge and Recovery Project	1304 days	Thu 1/1/26	Tue 12/31/30
Tier 2 Management Actions	**22 days**	**Thu 1/1/26**	**Sat 1/31/26**
Develop Program to Incentivize Use of Surface Water and Reduce Groundwater Demand	23 days	Thu 1/1/26	Sat 1/31/26
Tier 3 Projects	**5217 days**	**Fri 1/1/21**	**Mon 12/31/40**
Pacheco Reservoir Expansion	2870 days	Tue 1/1/30	Mon 12/31/40
Raising San Luis Reservoir	2870 days	Tue 1/1/30	Mon 12/31/40
Sites Reservoir	2087 days	Sat 1/1/22	Mon 12/31/29
Los Vaqueros Expansion Phase 2	5217 days	Fri 1/1/21	Mon 12/31/40
Tier 3 Management Actions	**3652 days**	**Fri 1/1/27**	**Mon 12/31/40**
Groundwater Extraction Fee with Land Use Modifications	3652 days	Fri 1/1/27	Mon 12/31/40
City of Patterson Reduced Groundwater Use Portfolio	3652 days	Fri 1/1/27	Mon 12/31/40
Rotational Fallowing of Crop Lands	3652 days	Fri 1/1/27	Mon 12/31/40



Project: Implementation Schedule, Northern & Central Delta-Mendota GSP
Date: 2020-2025

Summary | Manual Task

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Figure 8-1. Implementation Schedule (continued)

Table 8-1. Northern & Central Delta-Mendota Region GSP Estimated Implementation Costs

Activity	Estimated Cost	Assumptions
Monitoring Program		
Coordination with Monitoring Entities	$74,000 annually	Coordination with GSAs or member agencies at the GSP-level
Data Field Collection	$136,000 annually	Completed by SLDMWA with consultant support as requested to perform their monitoring activities; Includes two (2) days of field work for water levels per year, one (1) day of field work for water quality per year, and one (1) day of field work for subsidence per year (on average, varies by subsidence management area and remaining Plan area)
Monitoring Data Quality Control and Analysis	$53,000 annually	Data collection and entry from local entities and performing quality control on collected data
Oversight and Coordination of Monitoring	$44,000 annually	Staff oversight and scheduling with local and contract labor
Monitoring Network Maintenance	$22,000 annually	As needed
Data Gap Tracking	$51,000 annually	Tracking of ongoing studies and data collection by other entities and programs
Local Monitoring	$52,000 annually	Data collection and reporting to the GSP-level
Lab Testing	$31,000 annually	Sending water quality samples to the lab and associated chain of custody; Includes annual water quality sampling.
Training	$38,000 annually	Training for new employees or skills
Annual Reporting and Analysis		
Water Levels	$27,000 annually during years with no 5-Year Update	Tracking relative to sustainability indicators and associated thresholds, which include data analysis, tracking trends, and reporting to SLDMWA (Plan Manager)
Change in Storage	$27,000 annually during years with no 5-Year Update	
Water Quality	$27,000 annually during years with no 5-Year Update	
Subsidence	$27,000 annually during years with no 5-Year Update	
Annual Report Documentation	$67,000 annually during years with no 5-Year Update	
5-Year Update		
Threshold Evaluation and Updating	$238,000 every five years (across two years to develop)	
Numerical Model Updates and Coordination	$390,000 every five years (across two years to develop)	Includes model runs and refinement
Evaluation of Initial GSP Effectiveness	$284,000 every five years (across two years to develop)	
Plan to Improve GSP	$284,000 every five years (across two years to develop)	

Activity	Estimated Cost	Assumptions
Coordination		
Advisory Committee Meeting Support	$49,000 annually	Monthly meetings for first two (2) years (2020 and 2021) then, then quarterly thereafter and associated preparation by SLDMWA staff or consultant
GSA Board Meeting Support	$18,000 annually	Monthly meetings for first two (2) years (2020 and 2021) then, then quarterly thereafter and associated preparation by SLDMWA staff or consultant
Public Outreach	$46,000 annually	For modifications and re-adoption of the GSP; Supporting fee development, promote compliance with program, etc.; Includes two (2) public meetings per year
Website Maintenance	$9,000 annually	
Interbasin Coordination	$85,000 annually	Quarterly meetings; Includes consultation with legal support
Intrabasin Coordination	$73,000 annually	Monthly meetings for first two years (2020 and 2021), then quarterly thereafter; Includes consultation with legal support
Regulatory Tracking and Enforcement	$76,000 annually	Oversight by Plan Manager to ensure efforts are staying on Plan
Data Management System (DMS) Maintenance		
Data Quality Control	$45,000 annually	
DMS Cleanup/Maintenance	$24,000 annually	
Budget and Schedule Monitoring	$53,000 annually	
Grant Tracking and Administration		
Grant Tracking and Pursuit	$9,000 annually	Includes tracking grant programs and writing two (2) Requests for Proposals per year; Does not include grant application writing
Grant Administration	$129,000 annually	
General Administration		
Accounting	$15,000 annually	SLDMWA expenses related to GSP implementation, annual reporting, and 5-Year Update
Auditing	$6,000 annually	
Document Management	$7,000 annually	
General Staff Oversight	$47,000 annually	
Contract Management	$3,000 annually	
Legal Support	$88,000 annually	For litigation, Joint Powers Authority (JPA) formation, and coordination with outside counsel
Total - during Annual Report years (2020-2024)	$1,458,000 annually	
Total - during 5-Year Update years (2024-2025)	$2,479,000 annually	

8.2.1 GSP Implementation and Funding

Costs associated with GSP implementation and Northern and Central Delta-Mendota Regions GSAs and Plan Administrator operations include the following:

- GSP-associated administration: Overall program management and coordination activities
- Stakeholder/Board engagement: Monthly Northern and Central Delta-Mendota Activity Agreement Management Committee meetings for first two (2) years, then quarterly thereafter; monthly Delta-Mendota Subbasin Coordination Committee meetings for first two (2) years, then quarterly thereafter; and semi-annual public workshops
- Outreach: Email communications, newsletters, and website management
- GSP implementation program management: Program management and oversight of project and management action implementation, including coordination among GSAs, Plan Administrator staff and stakeholders, coordination of GSA implementation technical activities, oversight and management of consultants, budget tracking, schedule management, and quality assurance/quality control of project implementation activities
- Monitoring: Groundwater level monitoring, groundwater quality monitoring, and land surveying at subsidence benchmarks; collect publicly available subsidence monitoring data and stream gauge data; conduct quality control checks on and manage data; summarize and/or estimate other data sets required for annual reporting
- Data Management: Ongoing management of Data Management System (DMS), including data uploads and system improvements

Implementation of this GSP is projected to run between approximately $1.5 million and $2.5 million per year, with projects and management actions adding an additional $6.6 million to $40 million per year over the 20-year planning horizon. Development of this GSP (and the other five Delta-Mendota Subbasin GSPs) was funded through a Proposition 1 Sustainable Groundwater Planning Grant along with contributions from Subbasin GSA member agencies. Although implementation of this GSP is anticipated to require contributions from the GSAs it represents (and whom are funded through water rates, property taxes, or other public funds), additional funding may be required to implement the GSP. Funding through grants or loans have varying levels of certainty and may be available for some GSP implementation activities (including project implementation). As such, the Northern and Central Delta-Mendota Regions GSAs may choose one or more of the following financing approaches to supplement anticipated GSP implementation costs:

- Assessments: Assessments could be levied using a fee-based assessment on land area or irrigated acreage. Two possible methods for implementing an assessment based on acreage include assessing a fee for all acres in the Plan area (approximately 316,000 acres). Under this scenario, to fund the GSP implementation, assessments would range between approximately $5 and $8 per acre per year and this assessment would not distinguish between land use types. A second option would be to assess a fee only on irrigated acres (approximately 197,000 acres during the current conditions water year [2013]). This type of assessment (based on irrigated acreage) would range between $8 and $13 per acre per year. An assessment solely on irrigated acreage could affect agricultural operations and contribute to land use conversions, which could, in turn, affect the overall assessment amount.
- Pumping Fees: Pumping fees are typically a charge for pumping that would be used to fund GSP implementation activities. In the absence of other sources of funding (i.e., grants, loans, or combined with assessments), fees would range between $11 and $25 per acre-foot (AF) of water pumped per year (based on projected baseline pumping on an average annual basis from 2020 to 2025 and 2020 to 2070, respectively). To meet the funding needs of the GSP, a tiered approach may be used where fees would be lower when groundwater elevations are higher, and be more when groundwater elevations are lower to encourage conservation or a modified fee structure implemented based on the type of pumping (domestic vs agricultural vs municipal).

- **Combination of fees and assessments:** This approach would combine pumping fees and assessments to moderate the effects of either approach on the economy in the Northern & Central Delta-Mendota Region GSP. This approach would likely include an assessment that would apply to all acres within the Plan area, rather than just to irrigated acreage (thereby accounting for a shared regulatory compliance cost), coupled with a pumping fee to account for those properties that extract more groundwater than others.

Ultimately, it will be up to the individual GSAs to determine the means by which they achieve both the Delta-Mendota Subbasin sustainability goal and financial goals for GSP implementation. However, prior to implementing any fee or assessment program, the Northern & Central Delta-Mendota Region GSP Group should agree on the approach, which may include completion of a rate assessment study and other analyses consistent with the requirements of Proposition (Prop) 218, Prop 26, and/or other California regulations, in order to facilitate the public review process across the GSP Plan area.

If grants or loans are secured for project implementation, potential pumping fees and assessments may be adjusted to align with operating costs of ongoing GSP implementation activities. Potential grant or low-interest loan programs that may be used for GSP implementation are summarized in **Table 8-2** along with an assessment of their respective certainty that the funding source could be obtained to help finance GSP implementation.

Table 8-2. Potential Funding Sources for GSP Implementation

Funding Source	Certainty
Ratepayers (within Project Proponent service area or area of project benefit)	**High** – User rates pay for operation and maintenance (O&M) of a utility's system. Depends upon rate structure adopted by the project proponent and the Prop 218 rate approval process, which is dependent upon the structure of the GSA and its authority to collect rates from users. Can be used for project implementation as well as project O&M.
General Funds or Capital Improvement Funds (of Project Proponents)	**High** – General or capital improvement funds are set aside by agencies to fund general operations and construction of facility improvements. Depends upon agency approval.
Special taxes, assessments, and user fees (within Project Proponent service area or area of project benefit)	**High** - Monthly user fees, special taxes, and assessments can be assessed by some agencies should new facilities directly benefit existing customers. Depends upon the rate structure adopted by the project proponent and the Prop 218 rate approval process, which is dependent upon the structure of the GSA and its authority to collect taxes/assessments/fees from users.
Clean Water State Revolving Fund (CWSRF) Loan Program administered by the California State Water Resources Control Board (SWRCB)	**Medium** – Historically, the SWRCB has had $200 to $300 million available annually for low-interest loans (typically ½ of the General Obligation Bond Rate) for water recycling, wastewater treatment, and sewer collection projects. During recent years, available funding has become limited due to high demand. Success in securing a low-interest loan depends on demand of the CWSRF Program and available funding. Applications are accepted on a continuous basis. SWRCB prepares a fundable list for each fiscal year. In order to receive funding, a project must be on the fundable list. Full applications must be submitted by the end of the calendar year to be considered for inclusion on the following year's fundable list.

Funding Source	Certainty
Water Recycling Funding Program (WRFP) – Planning and Construction Grants from SWRCB	**High** (planning) / **Low** (construction) – WRFP grants are funded by Prop 1, as well as the general CWSRF Program. Planning grants (for facilities planning) are available and can fund 50% of eligible costs, up to $75,000. Construction grants have been exhausted. Low-interest loans through the CWSRF program are available and while limited, recycled water projects receive priority over wastewater projects (which are also eligible under CWSRF, the umbrella program for the WRFP).
Drinking Water State Revolving Fund Loan Program administered by the SWRCB Division of Drinking Water	**High** – Approximately $100 to $200 million is available on an annual basis for drinking water projects. Low-interest loans are available for project proponents should they decide to seek financing. Funding has become more limited; however, applicants are encouraged to apply.
Water & Waste Disposal Loan & Grant Program in California administered by the United States Department of Agriculture (USDA), Rural Development	**High** – Long-term, low-interest loans and grants available to fund clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and storm water drainage to household and businesses in eligible rural areas (areas or towns with populations of 10,000 or less). Funds may be used to finance the acquisition, construction, or improvement of drinking water sourcing, treatment, storage, and distribution as well as storm water collection, transmission, and disposal, for example Eligible applicants include most state and local governmental entities, private nonprofits, and federally-recognized tribes. Applications are accepted year-round.
Community Facilities Direct Loan & Grant Program in California administered by USDA, Rural Development	**High** – Low interest direct loans and grants available to provide affordable funding to develop essential community facilities in rural areas. An essential community facility is defined as a facility that provides an essential service to the local community for the orderly development of the community in a primarily rural area and does not include private, commercial, or business undertakings. Funding priorities include small communities with a population of 5,500 or less and low-income communities having a median household income below 80% of the state nonmetropolitan median household income.
Infrastructure State Revolving Fund Loan Program administered by the California Infrastructure and Economic Development Bank (I-Bank)	**High** – Low-interest loans are available from I-Bank for infrastructure projects (such as water distribution). Maximum loan amount is $25 million per applicant. Applications are accepted on a continuous basis.
Title XVI Water Recycling and Reclamation / Water Infrastructure Improvements for the Nation (WIIN) Program – Construction Grants administered by the United States Bureau of Reclamation (USBR)	**Medium** – Grants up to 25% of project costs or $20 million, whichever is less, are available from USBR for water recycling projects. A Title XVI Feasibility Study must be submitted to and approved by USBR to be eligible. USBR solicits grants annually.
WaterSMART Grant Programs administered by USBR	**Medium** – During Fiscal Year 2019, $34 million was appropriated to WaterSMART grant programs. Examples of WaterSMART grant programs include Water and Energy Efficient Grants and Small-Scale

Funding Source	Certainty
	Water Efficiency Projects. Both grant programs can help fund projects such as canal lining/piping, municipal metering, and supervisory control and data acquisition (SCADA) systems.
WaterSMART Title XVI Water Recycling and Reclamation Program – Feasibility Study Grants administered by USBR	Low – Grants up to $150,000 have been available in the past for preparation of Title XVI Feasibility Studies. It is possible future rounds may be administered.
Bonds	Medium – Revenue bonds can be issued to pay for capital costs of projects allowing for repayment of debt service over 20- to 30- year timeframe. Depends on the bond market and the existing debt of project proponents.
Integrated Regional Water Management (IRWM) implementation grants administered by DWR	High (San Joaquin River Funding Area) / Medium (Tulare-Kern Funding Area) – The Westside-San Joaquin IRWM Region, the primary IRWM region overlapping the Delta-Mendota Subbasin, will pursue grant funding through the Prop 1, Round 1 IRWM Implementation Grants. Applications are expected to be due in Fall 2019 through late 2019, depending on the Funding Area. Approximately $28 million will be available in the San Joaquin River Funding Area and approximately $30 million will be available in the Tulare-Kern Funding Area over two rounds of grant awards.
Proposition 68 grant programs administered by various state agencies	Medium – Grant programs funded through Proposition 68, which was passed by California voters in June 2018, administered by various state agencies are expected to be applicable to fund GSP implementation activities. These grant programs are expected to be competitive, where $74 million has been set aside for Groundwater Sustainability statewide.
Disadvantaged Community (DAC) Involvement Program	Medium – The Westside-San Joaquin IRWM Region will receive funding through DWR's DAC Involvement Program for the San Joaquin River Funding Area (which was awarded a total of $3.1 million for the Funding Area as a whole) and the Tulare/Kern Funding Area (which was awarded a total of $3.4 million for the Funding Area). This funding has been secured by the respective Funding Areas. Funding may be used to help develop a project within the Westside-San Joaquin IRWM Region in order to advance it toward implementation. This program is not guaranteed to be funded in the future.

8.2.2 Projects and Management Actions

Costs for projects and management actions are described in Chapter 7 of this GSP. Financing of the projects and management actions vary depending on the activity and timing. Potential financing for projects and management actions are provided in Table 7-3 in Section 7.1 *Projects and Management Actions*, though other financing may be pursued as opportunities arise or as appropriate.

8.3 ANNUAL REPORTS

Annual reports must be submitted by April 1st of each year following GSP adoption, per the GSP Emergency Regulations § 356.2 Annual Reports. Each of the six Delta-Mendota Subbasin GSP Groups will be responsible for compiling information relevant to annual reports for their respective GSP Group consistent with the GSP Emergency Regulations. San Luis & Delta-Mendota Water Authority, as Plan Administrator, will compile the annual report information received from each GSP Group for the submission of a single annual report for the Delta-Mendota Subbasin to DWR. Annual reports must include three key sections as follows:

- General Information
- Basin Conditions
- Plan Implementation Progress

A general outline of what information will be provided in each of these sections of the annual report is included below. Annual reporting would be completed in a manner and format consistent with § 356.2 of the GSP Emergency Regulations, including that the annual report covers the prior water year (October 1 to September 30).

At present, there is no specific format for annual reports as required by DWR. As annual reporting continues, it is anticipated that this outline will change to reflect State requirements, Subbasin conditions, and GSA priorities.

8.3.1 General Information

General information will include an executive summary that highlights the key content of the annual report. As part of the executive summary, this section will include a map of the Subbasin, description of the sustainability goal, and provide a description of GSP projects and their progress, as well as an annual update to the GSP implementation schedule. Key components as required by the GSP Emergency Regulations include:

- Executive Summary
- Map of the Basin

8.3.2 Subbasin Conditions

Subbasin conditions will describe the current groundwater conditions and monitoring results. This section will include an evaluation of how conditions have changed in the Subbasin over the previous year and compare groundwater data for the water year to historical groundwater data. Pumping data, effects of project implementation (e.g., recharge data, conservation, etc., if applicable), surface water flows, total water use, and groundwater storage will be included. Key components as required by the GSP Emergency Regulations include:

- Groundwater elevation data from the monitoring network, including seasonal high and seasonal low contour maps for each principal aquifer
- Hydrographs of elevation data at representative monitoring locations
- Groundwater extraction data
- Surface water supply data by sector and source
- Total water use data
- Change in groundwater storage, including maps for each principal aquifer
- Subsidence rates and survey data

8.3.3 Plan Implementation Progress

Progress toward successful Plan implementation will be included in the annual report. This section of the annual report will describe the progress made toward achieving interim milestones as well as implementation of projects and management actions. Key components as required by GSP Emergency Regulations include:

- Plan implementation progress, including any proposed changes to the Plan
- Progress toward the Subbasin sustainability goal

8.3.4 Data Handling and Coordinated Data Management System

As required in §352.6 Data Management System of the GSP Emergency Regulations, each GSA is required to develop and maintain a DMS that is capable of storing and reporting information relevant to the development or implementation of the GSP(s). Additionally, per §354.4 Reporting Monitoring Data to the Department, all monitoring data is to be stored in a DMS with copies of the monitoring data included in the annual report and submitted electronically on forms provided by DWR. Recognizing that GSP implementation, including annual reporting, will require some efforts at the subbasin level, the 23 GSAs overlying the Delta-Mendota Subbasin have chosen to develop a coordinated DMS that can be utilized by each GSP Group for management of their data, which will allow for the required compendium of data sets for preparation of Subbasin annual reports.

It will be the responsibility of each GSP Group and their respective GSA member agencies to conduct their monitoring programs and associated data collection, including data quality assurance and control, for ensuring that these data are available at the Subbasin-level for analysis in annual reports. Figure 8-2 shows the general flow of data collected from the Delta-Mendota Monitoring programs. Figure 8-3 shows the roles and responsibilities of each GSA and GSP Group in the collecting, processing, and reporting of data for the GSP monitoring networks. Additionally, it is the responsibility of each GSP Group, including their respective GSAs, to maintain the monitoring network and, as appropriate, revise and/or expand the monitoring networks to fill identified data gaps. For more information about monitoring networks in the Northern & Central Delta-Mendota Region GSP, refer to Section 7.2 *Monitoring* of the *Sustainability Implementation* chapter.

8.3.4.1 DMS Development and Functionality

Leading up to the development of the Subbasin-wide DMS, the Delta-Mendota Subbasin GSP Groups used an ad hoc working group of the Delta-Mendota Subbasin Coordination Committee to develop a conceptual design for the DMS software requirements. Following the development of a conceptual design, the software vendor (Houston Engineering, Inc.) created wireframes to communicate the functionality of the DMS.

During the process of DMS development, the ad hoc working group developed data standards for each data type to make data aggregation at the Subbasin-level feasible. The DMS includes permissions and business rules so each Delta-Mendota GSP Group can upload data for only their GSP based upon usernames and roles. The GSP Groups are also not allowed to see data uploaded by other GSP Groups until all annual reporting has been completed, reviewed, and accepted by the Plan Manager.

The DMS developed for the Delta-Mendota Subbasin is a secured web-based application hosted on Amazon Web Services (AWS). The DMS focuses on five (5) core business requirements, which include: centralized data warehouse, security of data, permissioned-based access, data visualization, and reporting. Other goals of the DMS focus on improving data collection/aggregation processes, creating data standards, gaining efficiencies in reporting, and improving data sharing.

The coordinated Subbasin DMS is designed to aggregate data through import processes by GSP Groups to support data visualization and annual report generation. Underlying the web application is a relationship database used to store the information aggregated from GSP Groups across primary data types. These data types include groundwater extractions, surface water deliveries, groundwater storage, groundwater elevations, groundwater quality, interconnected surface water, and land subsidence. The web application functionality includes an embedded Geographic Information System (GIS) viewer, screens to view tables of time series data, and charting capabilities for hydrographs. The embedded GIS viewer contains functionality to store map layers such as reference data, GSA and GSP boundaries, and derived information such as groundwater elevation contours.

In order to facilitate data synthesis, the GSP Groups agreed on the following frequencies for monitoring data collection to be uploaded to the Subbasin-wide DMS:

- For groundwater elevations – Twice per year, with seasonal high groundwater elevation data collected between February and April, and seasonal low groundwater elevation data collected between September and October
- For interconnected surface water – Twice per year in conjunction with groundwater level monitoring
- For groundwater quality – Once per year during irrigation season, typically between May and July
- For land subsidence/elevations – Publicly available subsidence data will be used along with locally-collected data. At a minimum, three data points will be collected within the first five years of GSP implementation, with a baseline value from 2019 or a date prior to that.

Additionally, the GSP Groups will utilize agreed-upon monitoring protocols, which may be the same as, or equal to, data collection protocols (i.e. industry standards and best management practices) to ensure the collection of comparable data using comparable methods. The Northern and Central Delta-Mendota Regions have additionally agreed to use a more detailed monitoring protocol described in the Quality Assurance Program Plan (QAPP) included in Appendix F to ensure that the data were collected in a consistent and coordinated fashion.

In order to be able to track data by location, each monitoring location is assigned a unique identifier in the DMS. The number system is in a format of ##-####, where the first two digits indicates which GSA the monitoring location is associated with and the subsequent four digits indicate which specific monitoring location in that GSA area. As shown in Figure 8-3, the general methodology agreed upon for data import and management is as follows:

- Each GSA collects their respective data per agreed-upon monitoring protocols and transmits it to the GSA Representative.
- Each GSA Representative then compiles the data and conducts a quality control check.
- The GSA Representative then transmits the compiled data set to the GSP Lead or Representative, who then aggregates the data from all GSAs and conducts a second quality control check.
- The GSP Lead or Representative then uploads the data set into the DMS using import wizards designed specifically for this process.
- The Subbasin Plan Manager then uses the data in the DMS to compile information as required for the annual report.

Compiled data sets from the DMS are then augmented with required maps generated externally to produce the required annual report. Mapping prepared outside the DMS are subsequently imported into the DMS as GIS files to ensure all data are kept in one place and to allow for access by GSAs and other Subbasin stakeholders.

The DMS will be maintained by the San Luis & Delta-Mendota Water Authority, while acting as the Plan Manager, with a contract with the software vendor for hosting, maintenance and future maintenance. Each GSP will pay a maintenance fee for the continued hosting and support of the Subbasin coordinated DMS.

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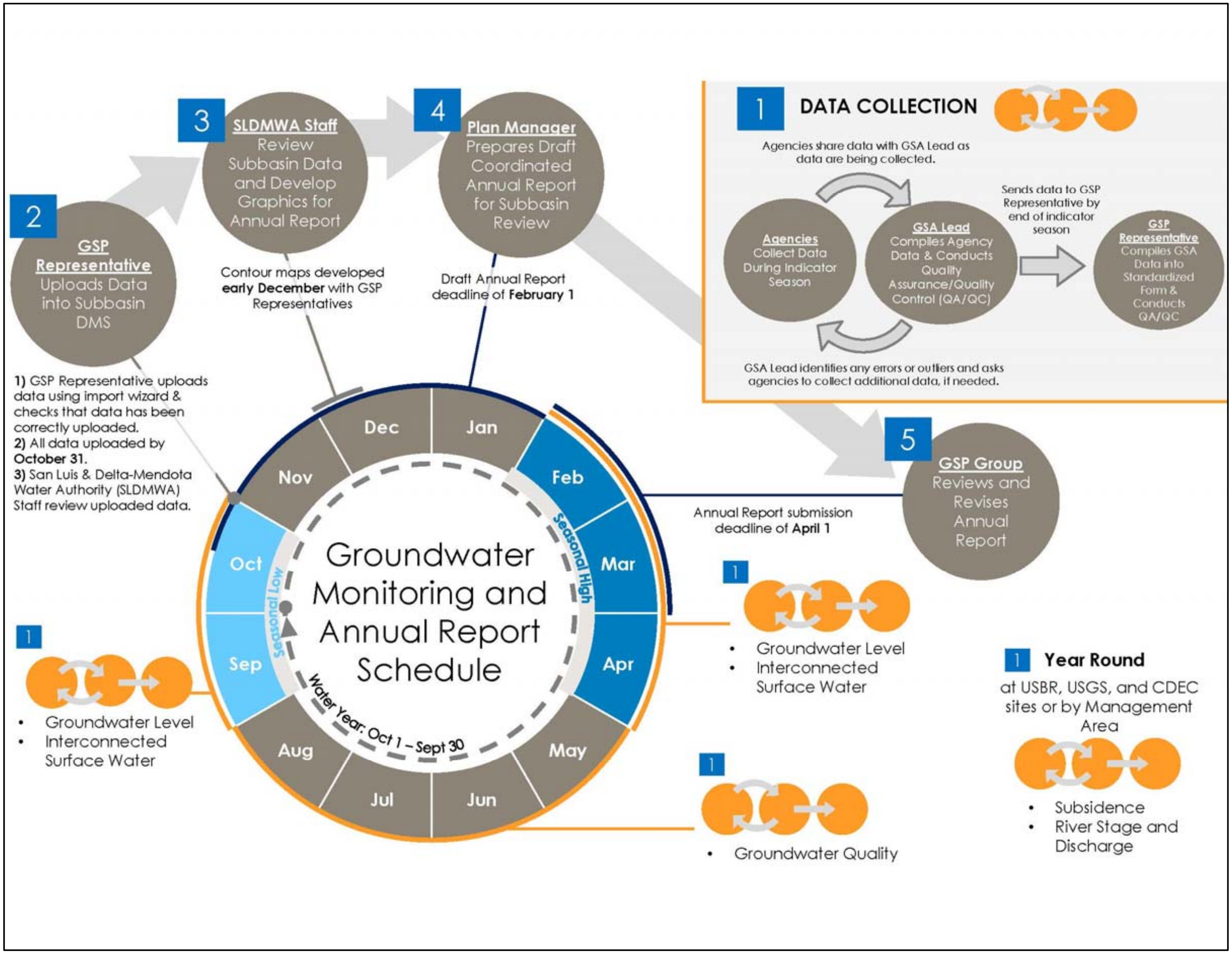

Figure 8-2. Data Flow in Delta-Mendota Subbasin

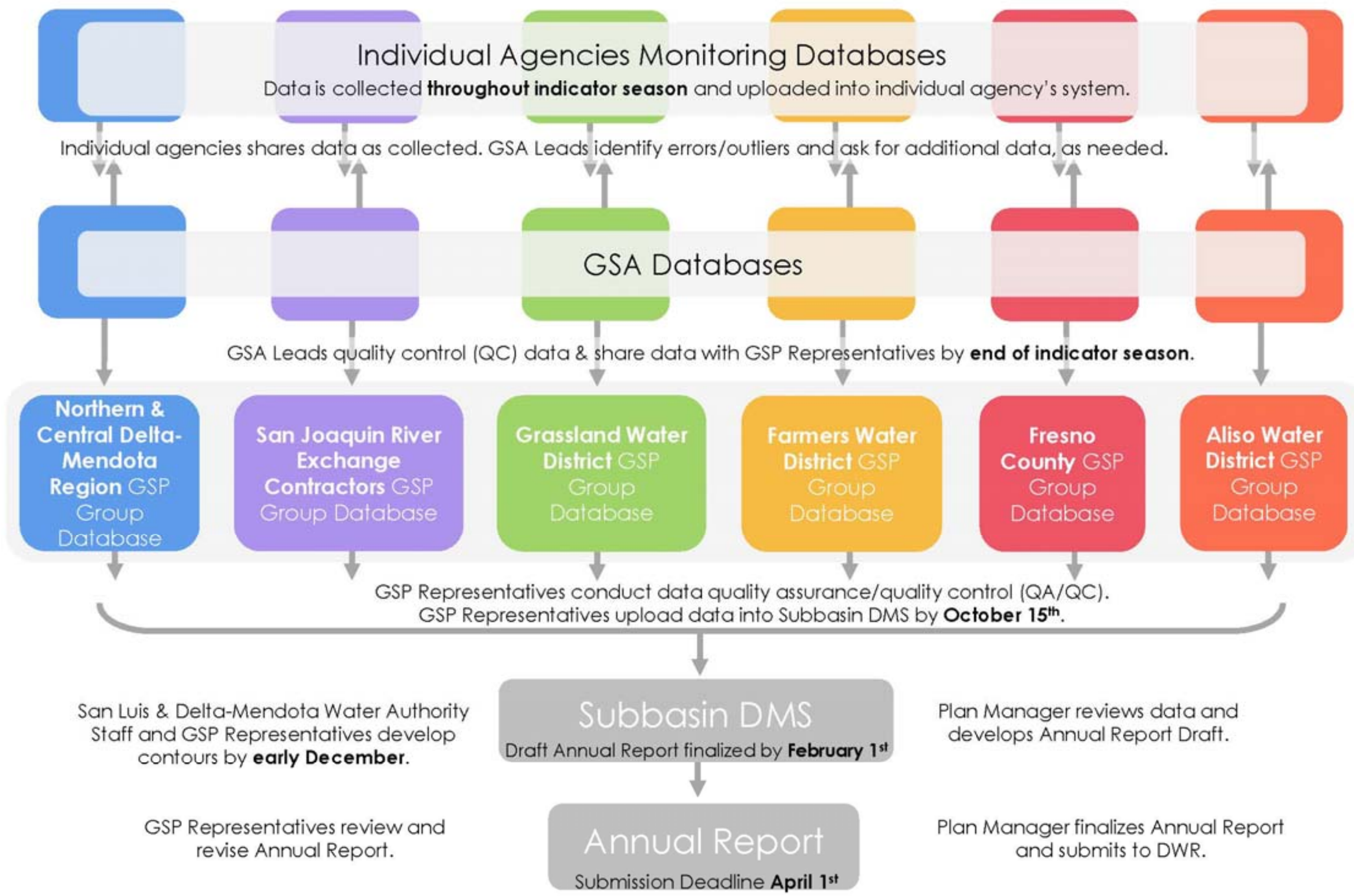

Figure 8-3. Delta-Mendota Subbasin Monitoring and Data Management Roles and Responsibilities

8.4 FIVE-YEAR ASSESSMENT REPORT

SGMA requires an evaluation of GSPs, assessing their progress toward meeting the approved Subbasin sustainability goal, at least every five years or sooner whenever the Plan is amended. SGMA also requires developing a written assessment and submittal of this assessment to DWR. A description of the information that will be included in the five-year assessment report (or periodic evaluation assessment report) and GSP update is provided in the subsequent subsections. All five-year assessment reports (5-Year updates) or periodic evaluation assessment reports will be prepared in a manner consistent with § 356.4 of the GSP Emergency Regulations.

8.4.1 Sustainability Evaluation

This section will contain a description of current groundwater conditions for each applicable sustainability indicator and will include a discussion of overall Subbasin sustainability. Progress toward achieving interim milestones and measurable objectives will be included, along with an evaluation of groundwater elevations (i.e., those being used as direct or proxy measures for the sustainability indicators) in relation to minimum thresholds. If any of the adaptative management triggers are found to be met during this evaluation, a plan for implementing adaptive management described in the GSP would be included.

8.4.2 Plan Implementation Progress

This section will describe the current status of project and management action implementation and report on whether any adaptive management action triggers had been activated since the previous 5-Year Plan update. An updated project implementation schedule will be included, along with any new projects developed to support the sustainability goal of the Subbasin and a description of any projects that are no longer included in the GSP. The effect on groundwater conditions resulting from projects or management actions that have been implemented will be included, and updates on projects and management actions that are underway at the time of the 5-Year Plan update will also be reported.

8.4.3 Reconsideration of GSP Elements

Part of the 5-Year GSP assessment will include a reconsideration of GSP elements. As additional monitoring data are collected during GSP implementation, land uses and community characteristics change over time, and GSP projects and management actions are implemented, it may become necessary to reconsider elements of this GSP and revise the Plan as appropriate. Plan elements to be reassessed may include Subbasin setting, management areas, undesirable results, minimum thresholds, and measurable objectives. If appropriate, the revised GSP completed at the end of the 5-year assessment period will include revisions informed by the outcomes of the monitoring network and changes in the Subbasin, including changes to groundwater uses or supplies and outcomes of project implementation. Additionally, if an evaluation of a GSP shows that the Subbasin is experiencing overdraft conditions or not on the path to achieving an interim goal, an assessment of measures to mitigate the condition will be included.

8.4.4 Monitoring Network Description

A description of the monitoring network will be provided in the 5-Year update to the GSP. Data gaps, or areas of the Subbasin that are not monitored in a manner commensurate with the requirements of Sections 352.4 and 354.34(c) of the GSP Emergency Regulations will be identified. An assessment of the monitoring network's function will also be provided, along with an analysis of data collected to date. If data gaps are identified, the GSP will be revised to include a program for addressing these data gaps, along with an implementation schedule for addressing gaps and how the Delta-Mendota Subbasin GSP Groups will incorporate updated data into their respective GSPs. At this time, the Regions intend to develop a more detailed plan for addressing identified data gaps in 2020, including a scope of services and schedule for addressing those data gaps. This plan will be available upon request following completion.

8.4.5 New Information

New information that becomes available during the 5-year implementation period will be considered and incorporated into the 5-Year Plan assessment. If the new information should warrant a change to the GSP, this would also be included, as described in Section 8.4.3.

8.4.6 Regulations or Ordinances

The 5-Year assessment of GSP implementation will include a summary of the regulations or ordinances related to the GSP that have been implemented by DWR since the previous report and address how these may require updates to the GSP.

8.4.7 Legal or Enforcement Actions

Enforcement or legal actions taken by the Subbasin GSAs or their member agencies in relation to the GSP will be summarized in this section along with how such actions support sustainability in the Subbasin.

8.4.8 Plan Amendments

A description of amendments to the GSP will be provided in the 5-year Plan assessment, including adopted amendments, recommended amendments for future updates, and amendments that are underway during development of the 5-Year Update to the GSP.

8.4.9 Coordination

Ongoing coordination will be required by the GSAs comprising the Northern & Central Delta-Mendota Region GSP Group for plan implementation, in addition to coordination with other GSAs within the remaining five Delta-Mendota Subbasin GSP Groups, neighboring subbasins, and GSAs in neighboring subbasins. This section of the 5-year assessment report will describe coordination activities between these entities, such as meetings, joint projects, or data collection efforts. If additional neighboring GSAs have been formed, existing GSAs have been modified, or changes in neighboring basins have occurred since the previous report that result in a need for new or additional coordination within or outside the Subbasin, such coordination activities would also be included and discussed.

8.4.10 Reporting to Stakeholders and the Public

Any outreach activities associated with the GSP assessment and any resultant updates should be documented in this section of the 5-Year assessment report.

Section 9

References and Technical Studies

Groundwater Sustainability Plan for the Northern and Central Delta-Mendota Regions

Section 9

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9. TECHNICAL STUDIES

The following tables summarize the technical studies used in the development of the Northern & Central Delta-Mendota Region Groundwater Sustainability Plan (GSP). References used in developing the various sections of the GSP are summarized at the end of each GSP chapter.

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Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area	AECOM	2011	https://water.ca.gov/LegacyFiles/lgagrant/docs/applications/City%20of%20Patterson%20(201209870076)/Att03_LGA12_CityofPatterson_GWMP_2of2.pdf		Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Management Plan for the Southern Agencies in the Delta-Mendota Canal Service Area	AECOM	2011; rev 2014	https://water.ca.gov/LegacyFiles/groundwater/docs/GWMP/SJ-14_SanLuisDeltaMendotaWA-South_GWMP_2014.pdf		Chapter 2 - Plan Area
Delta-Mendota Subbasin Coordination Agreement	All Delta-Mendota Subbasin GSAs	2018			Chapter 3 - Governance & Administration
Water quality for agriculture	Ayers, R.S. and D.W. Westcot	1985	http://www.fao.org/docrep/003/T0234E/T0234E00.htm	Table 1 – Guidelines for Interpretations of Water Quality for Irrigation and Table 21 – Recommended Maximum Concentrations of Trace Elements in Irrigation Water. FAO Irrigation and Drainage Paper 29 Rev. 1	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions; Chapter 6 - Sustainable Management Criteria
Numeric simulation of ground-water flow in the central part of the Western San Joaquin Valley, California	Belitz, K, S.P. Phillips, and J.M. Gronberg	1993	https://doi.org/10.3133/wsp2396	U.S. Geological Survey Water-Supply Paper 2396, 69 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Character and Evolution of Ground-Water flow System in the Central Part of the Western San Joaquin Valley, California	Belitz, K. and F.J. Heimes	1990	https://doi.org/10.3133/wsp2348	USGS WaterSupply Paper 2348	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Ground water in the Central Valley, California - A Summary Report	Bertoldi, G.L., R.H. Johnston, and K.D. Evenson	1991	https://doi.org/10.3133/pp1401A	U.S. Geological Survey Professional Paper 1401-A	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model and Section 5.3 Groundwater Conditions
Land Subsidence from Groundwater Use in California	Borchers, J.W. and M. Carpenter	2014	https://water.ca.gov/LegacyFiles/waterplan/docs/cwpu2013/Final/vol4/groundwater/13Land_Subsidence_Groundwater_Use.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Assembly Bill No. 1471 Water Quality, Supply, and Infrastructure Improvement Act of 2014	California Assembly	2014	https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1471	Approved by Governor, filed with Secretary of State in August 2014	Chapter 2 - Plan Area
Faults shapefiles	California Department of Conservation, California Geologic Survey	Various Dates	https://maps.conservation.ca.gov/cgs/#datalist		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
CDFW GIS Clearning House - California Lakes shapefile	California Department of Fish and Wildlife (CDFW)	2013	https://www.wildlife.ca.gov/Data/GIS/Clearinghouse		Maps in all GSP Chapters
CDFW GIS Clearning House - California Streams shapefile	California Department of Fish and Wildlife (CDFW)	2016	https://www.wildlife.ca.gov/Data/GIS/Clearinghouse		Maps in all GSP Chapters
Little Panoche Reservoir Wildlife Area: Description	California Department of Fish and Wildlife (CDFW)	2017	https://www.wildlife.ca.gov/Lands/Places-to-Visit/Little-Panoche-Reservoir-WA		Chapter 2 - Plan Area
Mendota Wildlife Area: Description	California Department of Fish and Wildlife (CDFW)	2017	https://www.wildlife.ca.gov/Lands/Places-to-Visit/Mendota-WA		Chapter 2 - Plan Area
North Grasslands Wildlife Area: Description	California Department of Fish and Wildlife (CDFW)	2017	https://www.wildlife.ca.gov/Lands/Places-to-Visit/North-Grasslands-WA		Chapter 2 - Plan Area
O'Neill Forebay Wildlife Area: Description	California Department of Fish and Wildlife (CDFW)	2017	https://www.wildlife.ca.gov/Lands/Places-to-Visit/ONeill-Forebay-WA		Chapter 2 - Plan Area
West Hilmar Wildlife Area: Description	California Department of Fish and Wildlife (CDFW)	2017	https://www.wildlife.ca.gov/Lands/Places-to-Visit/West-Hilmar-WA		Chapter 2 - Plan Area
CalWater 2.2.1 Watershed Boundaries shapefile	California Department of Forestry and Fire Protection	1999	http://frap.fire.ca.gov/data/frapgisdata-sw-calwater_download		Chapter 2 - Plan Area
The California Water Plan Update, Volumes 1 and 2	California Department of Water Resources	1998	https://water.ca.gov/LegacyFiles/pubs/planning/california_water_plan_1998_update__bulletin_160-98_/b16098_vol1.pdf and https://water.ca.gov/LegacyFiles/pubs/planning/california_water_plan_1998_update__bulletin_160-98_/b16098_vol2.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
San Joaquin Valley Drainage Investigation – San Joaquin Master Drain	California Department of Water Resources (DWR)	1965	http://wdl.water.ca.gov/waterdatalibrary/docs/historic/Bulletins/Bulletin_127/Bulletin_127-P__1965.pdf	Department of Water Resources Bulletin No.127	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Water Well Standards Fresno County, Bulletin No. 74-6	California Department of Water Resources (DWR)	1968	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Wells/Files/Bulletin-74-6-Water-Well-Standards-Fresno-County-1968.pdf?la=en&hash=575EDC3D630BF16689B426E078DC299FB5BC3934		Chapter 2 - Plan Area
Water Well Standards San Joaquin County, Bulletin No. 74-5	California Department of Water Resources (DWR)	1969	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Wells/Files/Bulletin-74-5-Water-Well-Standards.pdf?la=en&hash=0CA6F3E7D243A6DA22E8174C9D92CC465791C90B		Chapter 2 - Plan Area
Water Well Standards: State of California, Bulletin 74-81	California Department of Water Resources (DWR)	1981	https://www.water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Wells/Files/Bulletin-74-81-Water-Well-Standards-State-of-California-December-1981.pdf?la=en&hash=7B64FA212D189E07BE9B1FA909B5C8FECDA20D68		Chapter 2 - Plan Area
California Well Standards, Bulletin 74-90	California Department of Water Resources (DWR)	1991	https://www.water.ca.gov/LegacyFiles/pubs/groundwater/water_well_standards__bulletin_74-90_/ca_well_standards_bulletin74-90_1991.pdf		Chapter 2 - Plan Area
California's Groundwater Bulletin 118 - Update 2003	California Department of Water Resources (DWR)	2003	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/Statewide-Reports/Bulletin_118_Update_2003.pdf		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Contract between the State of California Department of Water Resources and Oak Flat Water District for a Water Supply	California Department of Water Resources (DWR)	2003	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Management/SWP-Water-Contractors/Oak-Flat-Water-District/Files/Original-Contract-with-Amendments-through-No-21-52803.pdf?la=en&hash=8B94326D5750ADEEC0F2A4B7E084AABFF1E76AC1		Chapter 2 - Plan Area
San Joaquin Valley Groundwater Basin Delta-Mendota Subbasin, DWR Bulletin 118	California Department of Water Resources (DWR)	2006	http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.07.pdf		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
California Statewide Groundwater Elevation Monitoring (CASGEM) database	California Department of Water Resources (DWR)	2009	https://www.casgem.water.ca.gov	Accessed on various dates	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
California statewide groundwater elevation monitoring (CASGEM) groundwater elevation monitoring guidelines	California Department of Water Resources (DWR)	2010	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/CASGEM/Files/CASGEM-DWR-GW-Guidelines-Final-121510.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Lines of Equal Elevation of Water in Wells, Unconfined Aquifer, San Joaquin Valley, Spring 2010	California Department of Water Resources (DWR)	2010			Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
IRWM Regions shapefile	California Department of Water Resources (DWR)	2012	https://data.cnra.ca.gov/dataset/irwm-regions		Chapter 2 - Plan Area
2016 Bulletin 118 Basin Boundary Descriptions: 5-022.07 San Joaquin Valley – Delta-Mendota	California Department of Water Resources (DWR)	2016	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/B118-Basin-Boundary-Descriptions-2016/B118-Basin-Boundary-Description-2016---5_022_07.pdf		Chapter 1 - Introduction

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Best Management Practices: Monitoring Networks and Identification of Data Gaps	California Department of Water Resources (DWR)	2016	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Best Management Practices: Monitoring Protocols, Standards, and Sites	California Department of Water Resources (DWR)	2016	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-1-Monitoring-Protocols-Standards-and-Sites.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
California Code of Regulations, Title 23 Waters, Division 2 Department of Water Resources, Chapter 1.5 Groundwater Management, Subchapter 2 Groundwater Sustainability Plans, Article 3 Technical and Reporting Standards	California Department of Water Resources (DWR)	2016	https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Water Districts shapefile	California Department of Water Resources (DWR)	2016	https://data.cnra.ca.gov/dataset/water-districts		Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model; Chapter 5 - Basin Setting, Section 5.5 Management Areas
Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria BMP (DRAFT)	California Department of Water Resources (DWR)	2017	https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT.pdf		Chapter 6 - Sustainable Management Criteria

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
California Aqueduct Subsidence Study	California Department of Water Resources (DWR)	2017	https://water.ca.gov/LegacyFiles/groundwater/docs/Aqueduct_Subsidence_Study-FINAL-2017.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Land Subsidence Monitoring	California Department of Water Resources (DWR)	2017	http://wdl.water.ca.gov/groundwater/landsubsidence/LSmonitoring.cfm		Chapter 2 - Plan Area
What is IRWM?	California Department of Water Resources (DWR)	2017	http://wdl.water.ca.gov/irwm/index.cfm		Chapter 2 - Plan Area
Crop Mapping 2014 shapefile	California Department of Water Resources (DWR)	2018	https://data.cnra.ca.gov/dataset/crop-mapping-2014		Chapter 2 - Plan Area
Disadvantaged Communities Mapping Tool	California Department of Water Resources (DWR)	2018	https://gis.water.ca.gov/app/dacs/		Chapter 2 - Plan Area
Economically Distressed Areas Mapping Tool	California Department of Water Resources (DWR)	2018	https://gis.water.ca.gov/app/edas/		Chapter 2 - Plan Area
Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River	California Department of Water Resources (DWR)	2018		Received via personal communication Alexis R. Phillips-Dowell (DWR)	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Natural Communities Commonly Associate with Groundwater (NCCAG) dataset	California Department of Water Resources (DWR)	2018	https://gis.water.ca.gov/app/NCDatasetViewer/#		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Statewide Gridded Precipitation and ET (Variable Infiltration Capacity [VIC] model) geodatabase	California Department of Water Resources (DWR)	2018	https://data.cnra.ca.gov/dataset/sgma-climate-change-resources/resource/f86f75e8-0de6-4232-968d-83521116496e		Chapter 5 - Basin Setting, Section 5.4 Water Budget
Best Management Practices for the Sustainable Management of Groundwater – Water Budget	California Department of Water Resources (DWR)	December 2016	https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf		Chapter 5 - Basin Setting, Section 5.4 Water Budget
Guidance Document for the Sustainable Management of Groundwater: Groundwater Sustainability Plan (GSP) Annotated Outline	California Department of Water Resources (DWR)	December 2016	https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf		Chapter 1 - Introduction
Groundwater Glossary	California Department of Water Resources (DWR)	n.d.	http://wdl.water.ca.gov/groundwater/groundwater_basics/groundwater_glossary.cfm		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Information Center Interactive Map Application (GICIMA)	California Department of Water Resources (DWR)	n.d.	https://gis.water.ca.gov/app/gicima/		Chapter 2 - Plan Area

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Groundwater Monitoring (CASGEM)	California Department of Water Resources (DWR)	n.d.	https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM		Chapter 2 - Plan Area
Water Data Library	California Department of Water Resources (DWR)	n.d.	http://wdl.water.ca.gov/waterdatalibrary/		Chapter 2 - Plan Area
Well Completion Report Map Application	California Department of Water Resources (DWR)	n.d.	https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37		Chapter 2 - Plan Area
Wells	California Department of Water Resources (DWR)	n.d.	https://www.water.ca.gov/Programs/Groundwater-Management/Wells		Chapter 2 - Plan Area
Depth to the Top of Corcoran Clay. 1:253,440 scale map	California Department of Water Resources (DWR), San Joaquin District	1981	https://water.ca.gov/LegacyFiles/pubs/groundwater/depth_to_top_of_corcoran_clay_map__1981/depth_to_the_top_of_corcoran_clay-1981.pdf		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Central Delta-Mendota GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/206		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
City of Dos Palos GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/360		Chapter 2 - Plan Area
City of Firebaugh GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/269		Chapter 2 - Plan Area
City of Gustine GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/271		Chapter 2 - Plan Area
City of Los Banos GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/71		Chapter 2 - Plan Area
City of Mendota GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/67		Chapter 2 - Plan Area
City of Newman GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/57		Chapter 2 - Plan Area
City of Patterson GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/66		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
County of Madera - 3 GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/70		Chapter 2 - Plan Area
DM-II GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/301		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
Farmers Water District GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/30		Chapter 2 - Plan Area
Fresno County Management Area A GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/298		Chapter 2 - Plan Area
Fresno County Management Area B GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/308		Chapter 2 - Plan Area

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Grasslands Groundwater Sustainability Agency GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/62		Chapter 2 - Plan Area
Merced County - Delta Mendota GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/231		Chapter 2 - Plan Area
Northwestern Delta-Mendota GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/214		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
Oro Loma Water District GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/302		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
Patterson Irrigation District GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/17		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration; Chapter 5 - Basin Setting, Section 5.5 Management Areas
San Joaquin River Exchage Contractors Water Authority GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/10		Chapter 2 - Plan Area
Turner Island Water District - 2 GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/220		Chapter 2 - Plan Area
West Stanislaus Irrigation District GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/13		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration; Chapter 5 - Basin Setting, Section 5.5 Management Areas
Widren Water District GSA shapefile	California Department of Water Resources, SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/237		Chapter 2 - Plan Area; Chapter 3 - Governance & Administration
CA Bulletin 118 Groundwater Basins shapefile	California Natural Resources Agency	March 12, 2019	https://data.cnra.ca.gov/dataset/ca-bulletin-118-groundwater-basins		Maps in all GSP Chapters
California Protected Areas Database	California Protected Areas	2017	https://data.cnra.ca.gov/dataset/california-protected-areas-database-2017a		Chapter 2 - Plan Area
Regulations Related to Recycled Water	California State Water Resources Control Board	October 2018	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf		Chapter 6 - Sustainable Management Criteria
Resolution 68-16 Statement of Policy with Respect to Maintaining High Quality of Waters in California	California State Water Resources Control Board (SWRCB)	1968	https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf		Chapter 6 - Sustainable Management Criteria

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San Joaquin Valley Interagency Drainage Program Environmental Assessment – Phase I	California State Water Resources Control Board (SWRCB)	1977		Prepared for the California State Water Resources Control Board by Environmental Impact Planning Corporation	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
CV-SALTS Lower San Joaquin River Committee, April 28, 2011 Meeting Materials, Agenda Item 4 – Problem Statement	California State Water Resources Control Board (SWRCB)	2011	https://www.waterboards.ca.gov/centralvalley/water_issues/salinity/lower_sanjoaquin_river_committee/administrative_materials/#contracts		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Water quality goals online database	California State Water Resources Control Board (SWRCB)	2013	http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Ambient Monitoring and Assessment Program (GAMA) – Priority Basin Project	California State Water Resources Control Board (SWRCB)	2018	https://www.waterboards.ca.gov/gama/priority_basin_projects.html		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Maximum Contaminant Levels and Regulatory Dates for Drinking Water – U.S. EPA vs California	California State Water Resources Control Board (SWRCB)	2018	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/ccr/MCLsEPAvsDWP-2018-03-21.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions; Chapter 6 - Sustainable Management Criteria
Groundwater Ambient Monitoring and Assessment Program (GAMA) Groundwater Information System database	California State Water Resources Control Board (SWRCB)	2019	https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp	Accessed on various dates	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, Fifth Edition, The Sacramento River Basin and The San Joaquin River Basin	California State Water Resources Control Board (SWRCB)	May 2018	https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr_201805.pdf		Chapter 6 - Sustainable Management Criteria
Electronic Data Transfer (EDT) Library	California State Water Resources Control Board (SWRCB)	n.d.	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html		Chapter 2 - Plan Area
Electronic Water Rights Information Management System (eWRIMS) Public Summary Page: El Solyo Water District (A001476)	California State Water Resources Control Board (SWRCB)	n.d.	http://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWServlet?Page_From=EWWaterRightSearchResults.jsp&Redirect_Page=EWPublicAppSummary.jsp&Purpose=getEwrimsPublicSummary&wrWaterRightID=221&applicationID=30681		Chapter 2 - Plan Area

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Electronic Water Rights Information Management System (eWRIMS) Public Summary Page: Twin Oaks Irrigation Company (A004237)	California State Water Resources Control Board (SWRCB)	n.d.	http://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWServlet?Page_From=EWWaterRightSearchResults.jsp&Redirect_Page=EWPublicAppSummary.jsp&Purpose=getEwrimsPublicSummary&wrWaterRightID=736&applicationID=1321		Chapter 2 - Plan Area
Electronic Water Rights Information Management System (eWRIMS) Public Summary Page: West Stanislaus Irrigation District (A001987)	California State Water Resources Control Board (SWRCB)	n.d.	http://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWServlet?Redirect_Page=EWPublicAppSummary.jsp&Purpose=getEwrimsPublicSummary&wrWaterRightID=299		Chapter 2 - Plan Area
GeoTracker GAMA	California State Water Resources Control Board (SWRCB)	n.d.	http://geotracker.waterboards.ca.gov/gama/		Chapter 2 - Plan Area
State Intervention - The State Back Stop, Sustainable Groundwater Management Act (SGMA)	California State Water Resources Control Board (SWRCB)	n.d.	https://www.waterboards.ca.gov/water_issues/programs/gmp/docs/intervention/intervention_fs.pdf		Chapter 2 - Plan Area
What is a Public Water System?	California State Water Resources Control Board (SWRCB)	n.d.	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/waterpartnerships/what_is_a_public_water_sys.pdf		Chapter 2 - Plan Area
California Cities (2015) shapefile	Caltrans	2015	http://www.dot.ca.gov/hq/tsip/gis/datalibrary/Metadata/cities.html		Chapter 2 - Plan Area
Caltrans Adjusted County Boundaries shapefile	Caltrans	2017	http://www.dot.ca.gov/hq/tsip/gis/datalibrary/Metadata/Counties.html		Maps throughout the GSP Chapters
Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, Fourth Edition	Central Valley Regional Water Quality Control Board (CVRWQCB)	2009	https://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Irrigated Lands Regulatory Program Frequently Asked Questions	Central Valley Regional Water Quality Control Board (RWQCB)	2016	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/ilrp_faq.pdf		Chapter 2 - Plan Area
Irrigated Lands Regulatory Program (ILRP): Overview	Central Valley Regional Water Quality Control Board (RWQCB)	2018	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/		Chapter 2 - Plan Area
CV-SALTS Salt and Nutrient Management Plan, Section 3: Salt & Nitrate in the Central Valley	Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)	2016	https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/conceptual-model-development/3560-snmp-section-3-s-n-conditions-110316-clean/file.html		Chapter 2 - Plan Area

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CV-SALTS Salt and Nutrient Management Plan, Section 4: Central Valley Salt & Nitrate Management Strategy	Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS)	2016	https://www.cvsalinity.org/docs/committee-document/technical-advisory-docs/conceptual-model-development/3559-snmp-section-4-snmp-strategy-110316-clean/file.html		Chapter 2 - Plan Area
CV-SALTS Salt and Nutrient Management Plan	Central Valley Salinity Alternatives Long-term Sustainability (CV-SALTS)	2016	https://www.cvsalinity.org/docs/central-valley-snmp/final-snmp.html		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Ambient groundwater Nitrate as N and TDS concentrations clipped for the Delta-Mendota Subbasin	Central Valley Salinity Alternatives Long-term Sustainability (CV-SALTS)	2018		Received via personal communication with Vicki Kretsinger at Luhdorff & Scalmanini Consulting Engineers (LSCE) on November 29, 2018	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
General Plan	City of Modesto	2008	http://www.modestogov.com/2069/General-Plan		Chapter 2 - Plan Area
General Plan	City of Patterson	2010	http://www.ci.patterson.ca.us/145/General-PlanCity-Maps		Chapter 2 - Plan Area
Los Vaqueros Reservoir Expansion Project – Project Documents	Contra Costa Water District (CCWD)	n.d.	https://www.ccwater.com/993/Project-Documents		Chapter 7 - Sustainability Implementation, Section 7.1 Projects & Management Actions
Groundwater flow net analysis for lower San Joaquin River Basin	Cooley, W.	2001	http://www.sjrdotmdl.org/concept_model/phys-chem_model/documents/300001039.pdf	Draft memo to CRWQCB Aug 8, 2001	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Field-scale monitoring of the long-term impact and sustainability of drainage water reuse on the west side of California's San Joaquin Valley	Corwin, D.L.	2012	https://doi.org/10.1039/c2em10796a	Journal of Environmental Monitoring, Vol. 14, 1576.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Subsurface geology of the Late Tertiary and Quarternary water-bearing deposits of the southern part of the San Joaquin Valley, California	Croft, M.G.	1972	https://pubs.usgs.gov/wsp/1999h/report.pdf	U.S. Geological Survey Water-Supply Paper 1999-H	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Ground-water conditions in the Mendota-Huron Area Fresno and Kings Counties, California	Davis, G.H. and J.F. Poland	1957	https://doi.org/10.3133/wsp1360G	U.S. Geological Survey Water Supply Paper No. 1360-G	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Use of ground-water reservoirs for storage of surface water in the San Joaquin Valley California	Davis, G.H., B.E. Lofgren, and S. Mack	1964	https://doi.org/10.3133/wsp1618	U.S. Geological Survey Water-Supply Paper 1618	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Ground water conditions and storage capacity in the San Joaquin Valley, California	Davis, G.H., J.H. Green, S.H. Olmstead, and D.W. Brown	1959	https://doi.org/10.3133/wsp1469	U.S. Geological Survey Water Supply Paper No. 1469, 287 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model

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Del Puerto Water District Water Management Plan 2014 Criteria	Del Puerto Water District	2017	Received via personal communication		Chapter 2 - Plan Area
Groundwater flow and solute movement to drain laterals, western San Joaquin Valley, California	Deverl S.J. and J.L. Fio	1991	https://doi.org/10.1029/91WR01368	1. Geochemical Assessment. Water Resources Research 27(9), 2233-2246, 2247-2257	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Flood Hazard Area shapefile	Earth Data Analysis Center, University of New Mexico	2014	https://catalog.data.gov/dataset/flood-hazard-area		Chapter 2 - Plan Area
East Stanislaus Region Integrated Regional Water Management Plan Update - Public Draft	East Stanislaus Regional Water Management Group	2017	http://www.eaststanirwm.org/documents/2017-esirwmp-publicdraft.pdf		Chapter 2 - Plan Area
ESRI World Imagery layer	ESRI	2017	https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9	Accessed on various dates	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Progress Report: Subsidence in California, March 2015 – September 2016	Farr, Tom G., Cathleen E. Jones, and Zhen Lieu	2017	https://water.ca.gov/LegacyFiles/waterconditions/docs/2017/JPL%20subsidence%20report%20final%20for%20public%20dec%202016.pdf	Jet Propulsion Laboratory, California Institute of Technology	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Region 4, Central Valley and Pacific Coast Ranges	Farrar, C.D., and G.L. Bertoldi	1988	https://doi.org/10.1130/DNAG-GNA-O2.59	in Back, William, Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology: Boulder, Colorado, Geological Society of America, Geology of North America, v. O-2, p. 59–67	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Groundwater availability of the Central Valley Aquifer, California	Faunt, C., R.T. Hanson, K. Belitz, W. Schmid, S. Predmore, D. L. Rewis, and K. McPherson	2009	http://pubs.usgs.gov/pp/1766/	U.S. Geological Survey Professional Paper 1766	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Development of a three-dimensional model of sedimentary texture in valley-fill deposits of Central Valley, California, USA	Faunt, C.C., K. Belitz., and R.T. Hanson	2010	https://doi.org/10.1007/s10040-009-0539-7	U.S. Geological Survey, Hydrogeology Journal, Vol. 18, 625	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Water availability and land subsidence in the Central Valley, California, USA	Faunt, C.C., M. Sneed, J. Traum, and J.T. Brandt	2015	https://link.springer.com/content/pdf/10.1007%2Fs10040-015-1339-x.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Calculation of a water budget and delineation of contributing sources to drainflows in the Western San Joaquin Valley, California	Fio, J.L.	1994	https://doi.org/10.3133/ofr9445	U.S. Geological Survey, Open-File Report 94-45	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater flow and solute movement to drain laterals, western San Joaquin Valley, California: 2. Quantitative hydrologic assessment	Fio, J.L. and S.J. Deverel	1991	https://doi.org/10.1029/91WR01368	Water Resources Research, Vol. 27, No. 9, 2247.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model

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Stratigraphy of the West Side Southern San Joaquin Valley	Foss, F.D., and R. Blaisdell	1968	http://www.sanjoaquingeologicalsociety.org/wp-content/abstracts/1968_Foss_Blaisdell.pdf		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater quality in the Western San Joaquin Valley study unit, 2010: California GAMA Priority Basin Project	Fram, M.S.	2017	https://pubs.usgs.gov/sir/2017/5032/sir20175032.pdf	U.S. Geological Survey Scientific Investigations Report 2017-5032, 130 p.	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Groundwater	Freeze, R.A., and J.A. Cherry	1979		Englewood Cliffs, NJ, Prentice-Hall, p. 60.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
General Plan	Fresno County	2000	http://www.co.fresno.ca.us/departments/public-works-planning/divisions-of-public-works-and-planning/development-services-division/planning-and-land-use/general-plan-maps		Chapter 2 - Plan Area
Zoning Ordinance of the County of Fresno - Land Use and Planning	Fresno County	2011	http://www.co.fresno.ca.us/departments/public-works-planning/divisions-of-public-works-and-planning/development-services-division/zoning-ordinance		Chapter 2 - Plan Area
Abandoned Well Information	Fresno County	n.d.	http://www.co.fresno.ca.us/departments/public-health/environmental-health/water-surveillance-program/water-well-permitting-program#abandoned		Chapter 2 - Plan Area
Code of Ordinances, Title 14 - Water and Sewage, Chapter 14.08 - Well Construction, Pump Installation and Well Destruction Standards	Fresno County	n.d.	https://library.municode.com/ca/fresno_county/codes/code_of_ordinances?nodeId=TIT14WASE_CH14.08WECOPUINWEDEST		Chapter 2 - Plan Area
Water Well Permitting Program	Fresno County	n.d.	http://www.co.fresno.ca.us/departments/public-health/environmental-health/water-surveillance-program/water-well-permitting-program		Chapter 2 - Plan Area
Requirements for Maintaining an Inactive Water Well	Fresno County Department of Public Health, Environmental Health Division	n.d.	http://www.co.fresno.ca.us/home/showdocument?id=4753		Chapter 2 - Plan Area
Well Destruction Requirements	Fresno County Department of Public Health, Environmental Health Division	n.d.	http://www.co.fresno.ca.us/home/showdocument?id=4763		Chapter 2 - Plan Area
San Joaquin Valley, California—Largest human alteration of the Earth's surface	Galloway, D.L., and F.S. Riley.	1999	https://pubs.usgs.gov/circ/circ1182/pdf/06SanJoaquinValley.pdf	U.S. Geological Survey Circular 1182, p. 23–34	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Land subsidence in the United States	Galloway, D.L., D.R. Jones, and S.E. Ingebritsen	1999	https://doi.org/10.3133/cir1182	U.S. Geological Survey Circular 1182, 175 p	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Generalized subsurface geology of water-bearing deposits, northern San Joaquin Valley, California	Hotchkiss, W.R.	1972	https://doi.org/10.3133/ofr73119		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Geology, hydrology, and water quality of the Tracy-Dos Palo area, San Joaquin Valley, California	Hotchkiss, W.R. and G.O. Balding.	1971	https://doi.org/10.3133/ofr72169	U.S. Geological Survey Open-File Report 72-169. 107 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Land subsidence in the San Joaquin Valley, California, as of 1980	Ireland R.L., J.F. Poland, and F.S. Riley	1984	https://doi.org/10.3133/pp437I	U.S. Geological Survey Professional Paper 437-I, 93 p	Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Land subsidence in the San Joaquin Valley, California, as of 1983	Ireland, R.L.	1986	https://doi.org/10.3133/wri854196	U.S. Geological Survey WaterResources Investigations Report 85–4196, 50 p	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
On the flow of water in an elastic artesian aquifer	Jacob, C.E.	1940	https://doi.org/10.1029/TR021i002p00574	American Geophysical Union Trans., pt. 2, p. 574-586.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Initial Study - Discretionary Well-Permitting and Management Program, Stanislaus County, California	Jacobson James & Associates and Tetra Tech	2016	http://www.stancounty.com/er/pdf/groundwater/InitialStudy.pdf		Chapter 2 - Plan Area
Geological Atlas of California – Santa Cruz Quadrangle.	Jennings, C.W. and R.G. Strand	1958	https://www.conservation.ca.gov/cgs/maps-data/rgm	California Geological Survey, Geologic Atlas of California Map No. 020, 1:250,000 scale	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
State of California Well Completion Report, Well No. E0132267.	Luhdorff & Scalmanini Consulting Engineers (LSCE)	2011		Received via personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Grassland Drainage Area Groundwater Quality Assessment Report	Luhdorff & Scalmanini Consulting Engineers (LSCE)	2016	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/grassland/ground_water/2016_0728_gda_gar.pdf		Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model and Section 5.3 Groundwater Conditions
Grassland Drainage Area Groundwater Quality Trend Monitoring Workplan	Luhdorff & Scalmanini Consulting Engineers (LSCE)	2016	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/grassland/ground_water/2018_0516_gda_gtmp_wp.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Western San Joaquin River Watershed Groundwater Quality Trend Monitoring Workplan, Phase 1 - Monitoring Design Approach	Luhdorff & Scalmanini Consulting Engineers (LSCE)	2016	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/westside_sjr/ground_water/2016_0916_wsjr_gtmp.pdf		Chapter 2 - Plan Area; Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring

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Grassland Drainage Area Groundwater Quality Management Plan	Luhdorff & Scalmanini Consulting Engineers (LSCE)	2017	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/grassland/ground_water/20170831_gda_gqmp_req.pdf		Chapter 2 - Plan Area
Western San Joaquin River Watershed Groundwater Quality Assessment Report	Luhdorff & Scalmanini Consulting Engineers (LSCE), Davids Engineering, and Larry Walker Associates	2015	https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/water_quality/coalitions_submittals/westside_sjr/ground_water/2015_0316_westside_gar.pdf		Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model; Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Madera Integrated Regional Water Management Plan - Final Draft	Madera Regional Water Management Group	2014	https://water.ca.gov/LegacyFiles/irwm/grants/docs/PlanReviewProcess/Madera_IRWMP/Madera%20IRWMP.pdf		Chapter 2 - Plan Area
San Joaquin River Restoration Study Background Report	McBain & Trush, Inc.	2002	https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/sjrf_spprtinfo/mcbainandtrush_2002.pdf	Prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Ground water in the San Joaquin Valley, California	Mendenhall, W.C., R.B. Dole, and H. Stabler.	1916	https://doi.org/10.3133/wsp398	U.S. Geological Survey Water-Supply Paper 398, 310 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
General Plan	Merced County	2011	http://www.co.merced.ca.us/1791/2030-Merced-County-General-Plan-Sections		Chapter 2 - Plan Area
Letter of Intent - Existing or Out of Service Well	Merced County	2012	http://www.co.merced.ca.us/DocumentCenter/View/5107		Chapter 2 - Plan Area
Groundwater Mining and Export Ordinance #1930 - Frequently Asked Questions	Merced County	2015	http://www.co.merced.ca.us/DocumentCenter/View/10906		Chapter 2 - Plan Area
County Code, Title 9 General Health and Safety, Chapter 9.28 Wells	Merced County	n.d.	http://www.qcode.us/codes/mercedcounty/view.php?topic=9-9_28&frames=on		Chapter 2 - Plan Area
Well Construction, Destruction, Mining, and Export Application/Permit	Merced County	n.d.	http://www.co.merced.ca.us/DocumentCenter/View/10907		Chapter 2 - Plan Area
Well Systems - Documents & Resources	Merced County	n.d.	http://www.co.merced.ca.us/2247/Well-Systems		Chapter 2 - Plan Area
Completing the Well Construction, Destruction, Mining, and Export Permit Application	Merced County Department of Public Health, Division of Environmental Health	2015	https://www.co.merced.ca.us/DocumentCenter/View/10905		Chapter 2 - Plan Area

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Quality Assurance Program Plan for groundwater monitoring by the Central Valley Groundwater Monitoring Collaborative	Michael L. Johnson-LLC (MLJ), Luhdorff & Scalmanini, and Provost & Pritchard	2018			Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Personal Communication	Mosley, J. Natural Resources Specialist/GIS Coordinator, Bureau of Indian Affairs Pacific Region	2017			Chapter 2 - Plan Area
Gravity Recovery and Climate Experiment	National Aeronautics and Space Administration (NASA)	2014	https://www.nasa.gov/mission_pages/Grace/index.html		Chapter 2 - Plan Area
Uninhabited Aerial Vehicle Synthetic Aperture Radar	National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory	2018	https://uavsar.jpl.nasa.gov/		Chapter 2 - Plan Area
Part 630 Hydrology National Engineering Handbook, Chapter 7 Hydrologic Soil Groups.	National Resources Conservation Service (NRCS).	2009	http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Soil Survey Manual	Natural Resources Conservation Service (NRCS)	2015	http://www.nrcs.usda.gov/wps/portal/nrcs/detail//?cid=nrcs142p2_054253		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Agricultural Land Use and Wildlife in the San Joaquin Valley, 1769-1930: An Overview. SOLO Heritage Research	Ogden, G. R.	1988		San Joaquin Valley Drainage Program, U.S. Department of Interior. Sacramento, California	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Base of fresh groundwater (approximately 2,000 micromhos) in the San Joaquin Valley, California:	Page, R.W.	1973	https://pubs.usgs.gov/of/1971/0223/plate-1.pdf	U.S. Geological Survey Hydrologic Investigations Atlas HA-489, 1 sheet, scale 1:500,000	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Patterson Irrigation District Water Management Plan/Agricultural Water Management Plan, 2008 Criteria	Patterson Irrigation District	2016	https://www.water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2016/Patterson ID WMP 2016 Update.pdf		Chapter 2 - Plan Area
Land subsidence in the San Joaquin Valley, California, as of 1972	Poland, J.F., B.E Lofgren, R.L. Ireland, and A.G. Pugh	1975	https://doi.org/10.3133/pp437H	U.S. Geological Survey Professional Paper 437-H, 78 p.	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
SJR Diversion Demand	Provost & Pritchard	June 2014		Received via personal communication with Joe Hopkins on May 22, 2019	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
City of Los Banos Urban Water Management Plan 2015 Update	Provost & Pritchard Consulting Group	2016	https://wuedata.water.ca.gov/public/uwmp_attachments/9729664444/2018%200130%20REVISED%20FINAL%202015%20UWMP%20combined.pdf		Chapter 2 - Plan Area

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Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. US EPA, Ground Water Issue EPA/540/S-95/504	Puls, R.W. and M.J. Barcelona	1996	https://www.epa.gov/sites/production/files/2015-06/documents/lwflw2a.pdf		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge	Rantz, S.E. and others	1982	https://pubs.usgs.gov/wsp/wsp2175/pdf/WSP2175_vol1a.pdf	United States Geological Survey (USGS) Water Supply Paper 2175	Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Measurement and Computation of Streamflow: Volume 2. Computation of Discharge	Rantz, S.E. and others	1982	https://pubs.usgs.gov/wsp/wsp2175/pdf/WSP2175_vol2a.pdf	United States Geological Survey (USGS) Water Supply Paper 2175	Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
North Valley Regional Recycled Water Program Final Report	RMC Water & Environment (RMC)	2015	http://www.nvr-recycledwater.org/docs/final_nvrrwp_facilities plan_19may2015_full.pdf		Chapter 2 - Plan Area
City of Patterson 2015 Urban Water Management Plan	RMC Water & Environment (RMC)	2016	https://wuedata.water.ca.gov/public/uwmp_attachments/5439267814/2015 UWMP_Final_w-Appendices.pdf		Chapter 2 - Plan Area
City of Patterson Water Master Plan, Appendix C: Ken Schmidt and Associates Hydrogeological Analysis	RMC Water & Environment/Woodard & Curran (RMC/W&C and Schmidt)	2014	https://www.ci.patterson.ca.us/DocumentCenter/View/4174/Patterson-WMP-Final-12March18_with-Appendices?bidId=		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans	Rohde, M.M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E.J. Remson (The Nature Conservancy)	2018	https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
2035 General Plan	San Benito County	2015	http://cosb.us/wp-content/uploads/Adopted-2035-GPU.pdf		Chapter 2 - Plan Area
San Benito County Code of Ordinances - Title 15 Public Works, Chapter 15.05 Water	San Benito County	n.d.	http://library.amlegal.com/nxt/gateway.dll/California/sanbenitocounty_ca/sanbenitocountycaliforniacodeofordinance?f=templates$fn=default.htm$3.0$vid=amlegal:sanbenitocounty_ca		Chapter 2 - Plan Area
Well Standards (San Joaquin County Ordinance Code Section9-1115.6)	San Joaquin County	2005	https://www.sjgov.org/uploadedFiles/SJC/Departments/EHD/Forms/Well Standards.pdf		Chapter 2 - Plan Area
General Plan	San Joaquin County	2016	https://www.sjgov.org/commdev/cgi-bin/cdyn.exe?grp=planning&htm=gp2035		Chapter 2 - Plan Area

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Division 11: Infrastructure Standards and Requirements	San Joaquin County	n.d.	https://www.sjgov.org/commdev/cgi-bin/cdyn.exe/file/Planning/Title 9/SJC TITLE 9 - Division (11).pdf		Chapter 2 - Plan Area
San Joaquin County Code of Ordinances - Title 5 Health and Sanitation, Division 4 Wells and Well Drilling, Chapter 3 Well Drilling Requirements	San Joaquin County	n.d.	https://library.municode.com/ca/san_joaquin_county/codes/code_of_ordinances?nodeId=TIT5HESA_DIV4WEWEDR_CH3WEDRRE		Chapter 2 - Plan Area
New Well Information form	San Joaquin County, Environmental Health Department	2017	https://www.sjgov.org/uploadedFiles/SJC/Departments/EHD/Forms/New Well Information 1-8-2018.pdf		Chapter 2 - Plan Area
Well/Pump Permit	San Joaquin County, Environmental Health Department	2018	https://www.sjgov.org/uploadedfiles/sjc/departments/ehd/forms/well permit and declaration(1).pdf		Chapter 2 - Plan Area
Water Well Permits	San Joaquin County, Environmental Health Department	n.d.	https://www.sjgov.org/department/envhealth/programs/default?id=26249		Chapter 2 - Plan Area
Well Exemption Statement	San Joaquin County, Environmental Health Department	n.d.	https://www.sjgov.org/uploadedfiles/sjc/departments/ehd/forms/new well information exemption statement.pdf		Chapter 2 - Plan Area
Subsidence Monitoring	San Joaquin River Restoration Program	n.d.	http://www.restoresjr.net/science/subsidence-monitoring/		Chapter 2 - Plan Area; Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Delta-Mendota Subbasin Groundwater Monitoring Program	San Luis & Delta-Mendota Water Authority	2015	https://www.casgem.water.ca.gov/OSS/(S(5jjakkvz0a2rmysuhkssesh2))/Reports/FileDownload.aspx?MNID=314&MEID=5131&File=SLDMWA_Groundwater_Monitoring_Plan_-_Delta_Mendota_Subbasin_08052015124458.pdf	Submitted to the California Department of Water Resources CASGEM Program	Chapter 2 - Plan Area; Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
2019 Westside San Joaquin Integrated Regional Water Management Plan	San Luis & Delta-Mendota Water Authority	January 2019	http://sldmwa.org/OHTDocs/pdf_documents/Groundwater/WSJ_IRWMP_2019_Final_w_appendices.pdf		Chapter 2 - Plan Area
Delta-Mendota Canal	San Luis & Delta-Mendota Water Authority	n.d.	http://www.sldmwa.org/about-sldmwa-facilities/about-the-delta-mendota-canal/		Chapter 2 - Plan Area
Tracy Fish Collection Facility	San Luis & Delta-Mendota Water Authority	n.d.	http://www.sldmwa.org/about-sldmwa-facilities/tracy-fish-collection-facility/		Chapter 2 - Plan Area

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Central Delta-Mendota Region Sustainable Groundwater Management Act Services Activity Agreement	San Luis & Delta-Mendota Water Authority (SLDMWA)	2017			Chapter 3 - Governance & Administration
First Amendment to Central Delta-Mendota Region Sustainable Groundwater Management Act Services Activity Agreement and Consent of SS-MOA Participants	San Luis & Delta-Mendota Water Authority (SLDMWA)	2017			Chapter 3 - Governance & Administration
Memorandum of Agreement for Central Delta-Mendota Region Sustainable Groundwater Management Act Services	San Luis & Delta-Mendota Water Authority (SLDMWA)	2017			Chapter 3 - Governance & Administration
Northern Delta-Mendota Region Sustainable Groundwater Management Act Services Activity Agreement	San Luis & Delta-Mendota Water Authority (SLDMWA)	2017			Chapter 3 - Governance & Administration
Delta-Mendota Canal Check Points coordinates	San Luis & Delta-Mendota Water Authority (SLDMWA)	n.d.		Personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model

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SLDMWA Member Agencies shapefile	San Luis & Delta-Mendota Water Authority (SLDMWA)	n.d.		Personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Data Sharing Agreement	San Luis & Delta-Mendota Water Authority (SLDMWA) on behalf of Northern & Central Delta-Mendota GSP Group; Westlands Water District	2018			Chapter 3 - Governance & Administration
San Luis Water District 2015 SBx7-7 Supplemental Report and Measurement Certification	San Luis Water District	2016	https://www.water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2017/San Luis WD 2015 Supplemental Report.pdf		Chapter 2 - Plan Area
Pacheco Reservoir Expansion Project: A 21st Century Solution Delivering Sustainability Benefits for All of Us	Santa Clara Valley Water District (SCVWD)	n.d.	https://www.valleywater.org/project-updates/dam-reservoir-projects/pacheco-reservoir-expansion-project-proposed		Chapter 7 - Sustainability Implementation, Section 7.1 Projects & Management Actions
Statement from Chair Richard P. Santos on $485 Million Funding Award for the Pacheco Reservoir Expansion Project	Santa Clara Valley Water News	July 2018	https://valleywaternews.org/2018/07/24/statement-from-chair-richard-p-santos-on-485-million-funding-award-for-the-pacheco-reservoir-expansion-project/		Chapter 7 - Sustainability Implementation, Section 7.1 Projects & Management Actions
Topographic map of GSA and Location of Subsurface Geologic Cross Sections, with accompanying cross-sections for the Los Banos Creek area	Schmidt, K.D.	n.d.	\\woodardcurran.net\shared\Projects\RMC\WCR\0617 SLDMWA\0011081 GSP Development\R. Reference Material\Geology-Hydrogeo\Geologic Cross Sections, SJREC.pdf	Received via personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Conditions in and near the Central California Irrigation District	Schmidt, K.D.	1997		Los Banos, California. 89 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Flows in the San Joaquin River Exchange Contractors Service Area	Schmidt, K.D.	1997		Prepared for SJREC, Los Banos, California, 46p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Groundwater Overdraft in the Delta-Mendota Subbasin	Schmidt, K.D.	2015			Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model; Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions

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Aliso Water District GSA shapefile	SGMA Portal	2017	https://sgma.water.ca.gov/portal/gsa/print/23		Chapter 2 - Plan Area
Sites Reservoir Project: Offstream Water Storage North of the Sacramento-San Joaquin Delta (Delta)	Sites Reservoir Authority	August 2018	https://www.sitesproject.org/wp-content/uploads/2018/08/Sites_Overview_Brochure_August2018-1.pdf		Chapter 7 - Sustainability Implementation, Section 7.1 Projects & Management Actions
Land subsidence in the San Joaquin Valley, California, USA, 2007-2014	Sneed, M. and J.T. Brandt	2015	https://www.proc-iahs.net/372/23/2015/piahs-372-23-2015.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Land subsidence along the Delta-Mendota Canal in the northern part of the San Joaquin Valley, California, 2003-10	Sneed, M., J. Brandt, and M. Solt	2013	http://dx.doi.org/10.3133/sir20135142	U.S. Geological Survey Scientific Investigations Report 2013-5142, 87 p.	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Web Soil Survey	Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture.	n.d.	https://websoilsurvey.nrcs.usda.gov/		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Crows Landing Community Plan	Stanislaus County	1987	http://www.stancounty.com/planning/pl/documents/gp/i-a-1-crows-landing-cp.pdf		Chapter 2 - Plan Area
Westley Community Plan	Stanislaus County	1987	http://www.stancounty.com/planning/pl/documents/gp/i-a-9-westley-cp.pdf		Chapter 2 - Plan Area
An Ordinance Amending Chapter 9.37 Relating to Groundwater	Stanislaus County	2014	http://www.stancounty.com/er/pdf/groundwater/chapter-9-37.pdf		Chapter 2 - Plan Area
Discretionary Well Permitting and Management Program, Notice of Preparation Program Environmental Impact Report	Stanislaus County	2016	http://www.stancounty.com/er/pdf/groundwater/notice-of-preparation.pdf		Chapter 2 - Plan Area
Stanislaus County Code, Title 9 Health and Safety, Chapter 9.37 Groundwater, 9.37.060 Implementation	Stanislaus County	n.d.	http://qcode.us/codes/stanislauscounty/?view=desktop&topic=9-9_37-9_37_060		Chapter 2 - Plan Area
Zoning Ordinance	Stanislaus County	n.d.	http://www.stancounty.com/planning/forms/stanislaus-county-code-title-21-zoning-ordinance.pdf		Chapter 2 - Plan Area
Application for Well Construction or Destruction	Stanislaus County, Department of Environmental Resources	2014	http://www.stancounty.com/er/pdf/water-well-construction-and-destruction-application.pdf		Chapter 2 - Plan Area
Groundwater Resources	Stanislaus County, Department of Environmental Resources	2018	http://www.stancounty.com/er/groundwater/		Chapter 2 - Plan Area
County Groundwater Ordinance - Well Application Review Process	Stanislaus County, Department of Environmental Resources	n.d.	http://www.stancounty.com/er/pdf/application-packet.pdf		Chapter 2 - Plan Area

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General Plan	Stanislaus County, Planning Division	2015	http://www.stancounty.com/planning/pl/general-plan.shtm		Chapter 2 - Plan Area
California Code of Regulation Title 22. Division 4. Environmental Health Chapter. 15 Domestic Water Quality and Monitoring Regulations Article 16. Secondary Water Standards	State of California	2006	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/recentlyadoptedregulations/R-21-03-finalregtext.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions; Chapter 6 - Sustainable Management Criteria
Senior Water Rights Curtailed in Delta, San Joaquin & Sacramento Watersheds	State of California	2015	http://www.drought.ca.gov/topstory/top-story-37.html		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
California Regulations Related to Drinking Water	State of California	2017	https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/dwregulations-2017-12-29.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Geologic nitrogen may pose hazard	Strathouse, S. M. and G. Sposito	1980	http://calag.ucanr.edu/archive/?type=pdf&article=ca.v034n08p20	California Agriculture	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Geologic nitrogen and the occurrence of high nitrate soils in western San Joaquin Valley, California	Sullivan, P.J., G. Sposito, S.M. Strathouse, and C.L. Hansen	1979	http://hilgardia.ucanr.edu/fileaccess.cfm?article=152819&p=WXIALI	Hilgardia, Vol. 47, No. 2, 15-49 p.	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Land subsidence in the San Joaquin Valley, updated to 1995	Swanson, A.A.	1998		Borchers, J.W., ed., Land subsidence case studies and current research: Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence, Sacramento, Calif., October 4–5, 1995, Association of Engineering Geologists, Special Publication no. 8, p. 75–79.	Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management	The Nature Conservancy (TNC)	2014	https://www.scienceforconservation.org/assets/downloads/GroundwaterStreamInteraction_2016.pdf		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Identifying Environmental Surface Water Users - Freshwater Species List for Each Groundwater Basin dataset, by GSA	The Nature Conservancy (TNC)	n.d.	https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Santa Nella Community Specific Plan	The Planning Center, CCS Planning and Engineering, and Land Use Economics	2000	http://web2.co.merced.ca.us/pdfs/planning/cplan/completed/santanella/Santa%20Nella%20CSP%2005052000.pdf		Chapter 2 - Plan Area

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State of California Well Completion Report, Well No. 568692.	Tranquillity Irrigation District (Tranquillity ID)	1994		Received via personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
State of California Well Completion Report, Well No. 814966.	Tranquillity Irrigation District (Tranquillity ID)	2000		Received via personal communication	Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
P252 – Overview | PBO Station page	UNAVCO	2019	https://www.unavco.org/instrumentation/networks/status/pbo/overview/P252		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
UNAVCO's Monitoring Network Map database	UNAVCO	2019	https://www.unavco.org/instrumentation/networks/map/map.html#/		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
PBO GPS Stations Network Monitoring	UNAVCO	n.d.	http://www.unavco.org/instrumentation/networks/status/pbo/gps		Chapter 2 - Plan Area
USBR computed full natural flows from 1906-2002	United State Bureau of Reclamation (USBR)	2002			Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Delta-Mendota Canal Non-Project Water Pump-in Program Monitoring Plan	United States Bureau of Reclamation	2018	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=32784		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions; Chapter 6 - Sustainable Management Criteria
Delta-Mendota Canal Groundwater Pump-in Program Water Quality Monitoring Plan	United States Bureau of Reclamation (USBR)	2013	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=11952		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
Central Valley Project (CVP) Water Contractors	United States Bureau of Reclamation (USBR)	2016	https://www.usbr.gov/mp/cvp-water/docs/latest-water-contractors.pdf		Chapter 2 - Plan Area
California Irrigiation District and Del Puerto Water District Orestimba Creek Groundwater Recharge Project, Finding of No Significant Impact	United States Bureau of Reclamation (USBR)	2017	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=29141		Chapter 2 - Plan Area
Central California Irrigation District and Del Puerto Water District Orestimba Creek Groundwater Recharge Project, Draft Environmental Assessment/Initial Study and Mitigated Negative Declaration	United States Bureau of Reclamation (USBR)	2017	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=28394		Chapter 2 - Plan Area
Grassland Bypass Project	United States Bureau of Reclamation (USBR)	2017	https://www.usbr.gov/mp/grassland/		Chapter 2 - Plan Area
Delta-Mendota Canal Groundwater Pump-in Program Revised Design Constraints, Final Environmental Assessment	United States Bureau of Reclamation (USBR)	2018	https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=33261		Chapter 2 - Plan Area

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San Luis Reservoir Expansion Draft Appraisal Report	United States Bureau of Reclamation (USBR)	December 2013	https://www.usbr.gov/mp/sllpp/docs/2013-11-19-draft-san-luis-expansion-appraisal-report.pdf		Chapter 7 - Sustainability Implementation, Section 7.1 Projects & Management Actions
2014 TIGER/Line Shapefiles: Roads, Primary and Secondary Roads, California	United States Census Bureau	2014	https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2014&layergroup=Roads		Maps throughout the GSP Chapters
Population Estimates Program	United States Census Bureau	2015	www.census.gov/quickfacts		Chapter 2 - Plan Area
American FactFinder 2016 California Block Group population data	United States Census Bureau	2016	https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml		Chapter 2 - Plan Area
California Block Group shapefile	United States Census Bureau	2016	https://www.census.gov/cgi-bin/geo/shapefiles/index.php		Chapter 2 - Plan Area
Incorporated Places and Census Designated Places shapefile	United States Census Bureau	2017	https://www.census.gov/geo/maps-data/data/cbf/cbf_place.html		Chapter 2 - Plan Area
Part 650 Engineering Field Handbook, Chapter 1 Surveying	United States Department of Agriculture (USDA), National Resource Conservation Service (NRCS)	October 2009	https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=25276.wba		Chapter 7 - Sustainability Implementation, Section 7.2 Monitoring
BLM National Surface Management Agency Area Polygons shapefiles	United States Department of the Interior, Bureau of Land Management	2013	https://catalog.data.gov/dataset/blm-national-surface-management-agency-area-polygons		Chapter 2 - Plan Area
About the Refuge: San Joaquin River National Wildlife Refuge, California	United States Fish & Wildlife Service	2012	https://www.fws.gov/Refuge/San_Joaquin_River/about.html		Chapter 2 - Plan Area
San Luis National Wildlife Refuge, California	United States Fish & Wildlife Service	2012	https://www.fws.gov/Refuge/San_Luis/about.html		Chapter 2 - Plan Area
Water resources data for California, 1910-2000 for various gaging stations within the San Joaquin Valley	United States Geological Survey (USGS)	2000			Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
Central Valley Spatial Database, Corcoran Clay Depth, Extent, and Thickness shapefiles	United States Geological Survey (USGS)	2012	https://ca.water.usgs.gov/projects/central-valley/central-valley-spatial-database.html		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
California Water Science Center (CAWSC) – Groundwater Ambient Monitoring and Assessment (GAMA) Program, Western San Joaquin Valley Study Unit	United States Geological Survey (USGS)	2018	https://ca.water.usgs.gov/gama/SU/w_sjv.htm		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
National Elevation Dataset, Ground Surface Elevation shapefile	United States Geological Survey (USGS)	2018	https://viewer.nationalmap.gov/advanced-viewer/		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
National Hydrograph Dataset	United States Geological Survey (USGS)	n.d.	https://viewer.nationalmap.gov/basic/?basemap=b1&category=nhd&title=NHD%20View		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model

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National Water Information System: Mapper	United States Geological Survey (USGS)	n.d.	https://maps.waterdata.usgs.gov/mapper/index.html		Chapter 2 - Plan Area
Delta-Mendota Canal: Evaluation of Groundwater Conditions & Land Subsidence	United States Geological Survey (USGS), California Water Science Center (CWSC)	2017	https://ca.water.usgs.gov/projects/central-valley/delta-mendota-canal.html		Chapter 5 - Basin Setting, Section 5.3 Groundwater Conditions
USGS Land Subsidence Resources	United States Geological Survey, California Water Science Center	n.d.	https://ca.water.usgs.gov/land_subsidence/california-subsidence-resources.php		Chapter 2 - Plan Area
Soil Agricultural Groundwater Banking Index (SAGBI)	University of California, Davis (UCD) Department of Agriculture and Natural Resources. n.d. Soil Resource Lab	n.d.	https://casoilresource.lawr.ucdavis.edu/sagbi/		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
Geologic Map of the San Francisco – San Jose Quadrangle. California Geological Survey, Regional Geologic Map No. 5A, 1:250,000 scale.	Wagner, D.L., Bortugno, E.J., and Mc Junkin, R.D.	1991	https://www.conservation.ca.gov/cgs/maps-data/rgm		Chapter 5 - Basin Setting, Section 5.2 Hydrogeologic Conceptual Model
San Luis Reservoir	Water Education Foundation	n.d.	http://www.watereducation.org/aquapedia/san-luis-reservoir		Chapter 2 - Plan Area
West Stanislaus Irrigation District Water Management Plan, 2011 Criteria	West Stanislaus Irrigation District	2014	https://www.water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2016/West Stanislaus ID 2014 WMP.pdf		Chapter 2 - Plan Area
City of Modesto 2015 Urban Water Management Plan	West Yost Associates	2016	https://wuedata.water.ca.gov/public/uwmp_attachments/9017789542/City of Modesto Final 2015 UWMP - June 2016.pdf		Chapter 2 - Plan Area
About Us	Westside San Joaquin River Watershed Coalition	n.d.	http://www.westsidesjr.org/		Chapter 2 - Plan Area
California Canals shapefile	Woodard & Curran	2010			Maps throughout the GSP Chapters
Water in the Bank: One Solution For Drought-Stricken California	Yale School of Foresty & Environmental Studies (YaleEnvironment360)	2015	https://e360.yale.edu/features/water_in_the_bank_one_solution_for_drought-stricken_california		Chapter 2 - Plan Area

Title	Author	Publish Year	Reference URL	Additional Data	GSP Chapter/Section
Central Delta-Mendota Groundwater Sustainability Agency Joint Powers Agreement		2019			Chapter 3 - Governance & Administration

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Prepared by:

WOODARD & CURRAN

In association with:

PROVOST & PRITCHARD CONSULTING GROUP

801 T Street
Sacramento, CA 95811
916.999.8700