Merced Groundwater Subbasin

GROUNDWATER SUSTAINABILITY PLAN

Image courtesy: Veronica Adrover/UC Merced

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MERCED GROUNDWATER SUBBASIN GROUNDWATER SUSTAINABILITY PLAN 2025

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
µg/L	micrograms per liter
AB	Assembly Bill
AF	acre-feet
AFY	acre-feet per year
As	Arsenic
ASO	Airborne Snow Observatory
AWMP	Agricultural Water Management Plan
bgs	below ground surface
BMP	Best Management Practices
CALSIMETAW	California Simulation of Evapotranspiration of Applied Water
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CCR	California Code of Regulations
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDL	Cropland Data Layer
CDP	Census Designated Place
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CGPF	CalSim II Generated Perturbation Factors
CGPS	continuous global positioning system
CGS	California Geological Survey
Cl	chloride
CPT	cone penetration test
Cr^6	Hexavalent Chromium
CSD	Community Services District
CVDRMP	Central Valley Dairy Representative Monitoring Program
CVGM	Central Valley Groundwater Monitoring Collaborative
CVHM	Central Valley Hydrologic Model
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWC	California Water Code
CWD	Chowchilla Water District

CWSRF	Clean Water State Revolving Fund
DAC	disadvantaged community
DBCP	dibromochloropropane
DDW	Division of Drinking Water
DHS	Department of Health Services
DLR	Detection Limit for Purposes of Reporting
DMS	Data Management System
DPR	Department of Pesticide Regulation
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
DWSRF	Drinking Water State Revolving Fund
EC	electrical conductivity
EDB	ethylene dibromide
EPA	Environmental Protection Agency
ESJWQC	East San Joaquin Water Quality Coalition
ET / ETo	evapotranspiration / reference evapotranspiration
EWMP	Efficient Water Management Practices
F	Fahrenheit
Fe	iron
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
Flood-MAR	Flood-Managed Aquifer Recharge
ft	feet
GAMA	Groundwater Ambient Monitoring and Assessment
GAR	Groundwater Quality Assessment Report
GCM	global climate model
GDE	Groundwater Dependent Ecosystem
GICIMA	Groundwater Elevation Monitoring Groundwater Information Center Interactive Mapping Application
GIS	Geographic Information System
GPCD	gallons per capita per day
gpm	gallons per minute
GPS	global positioning system
GQTM	Groundwater Quality Trend Monitoring
GSA	Groundwater Sustainability Agency
GSAs	MIUGSA, MSGSA, and TIWD GSA-1
GSP	Groundwater Sustainability Plan

HCM	Hydrogeologic Conceptual Model
HEC-HMS	Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HUC	Hydrologic Unit Code
HVA	high vulnerability area
IDC	IWFM Demand Calculator
ILRP	Irrigated Lands Regulatory Program
IM	interim milestone
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
IWFM	Integrated Water Flow Model
JPA	Joint Powers Authority
LGAWD	Le Grand Athlone Water District
LIDAR	Light Detection and Ranging
LOCA	local analogs method
LTMWC	Lone Tree Mutual Water Company
LUST	Leaking Underground Storage Tank
MAF	million acre-feet
MAGPI	Merced Area Groundwater Pool Interests
MCL	Maximum Contaminant Level
MCWD	Merquin County Water District
MercedWRM	Merced Water Resources Model
METRIC	Mapping Evapotranspiration at High Resolution and Internalized Calibration
mg/L	milligrams per liter
MID	Merced Irrigation District
MIDH20	Merced Irrigation District Hydrologic and Hydraulic Optimization
MIRWMA	Merced Integrated Regional Water Management Authority
MIUGSA	Merced Irrigation-Urban Groundwater Sustainability
Mn	manganese
MO	measurable objective
MOA	memorandum of agreement
MOI	memorandum of intent
MOU	Memorandum of Understanding
MSGSA	Merced Subbasin Groundwater Sustainability Agency
MSL	Mean Sea Level
MT	minimum threshold

MTBE	Methyl tert-Butyl Ether
N	nitrogen
NCCAG	Natural Communities Commonly Associated with Groundwater
NEPA	National Environmental Policy Act
NO_3	nitrate
NTU	Nephelometric Turbidity Unit
NWIS	National Water Information System
NWR	National Wildlife Refuge
OWTS	onsite wastewater treatment systems
PBO	Plate Boundary Observatory
PCBs	polychlorinated biphenyls
PCE	Tetrachloroethylene or perchloroethylene
pCi/L	picoCuries per liter of air
PFOA	perfluorooctantoic acid
PFOS	perfluorooctanesulfonic acid
PMAs	projects and management actions
PRISM	Precipitation-Elevation Regressions on Independent Slopes Model
PRMS	Precipitation Runoff Model System
PWS	Public Water System
RCP	representative climate pathway
RTS	real time simulation model
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCRO	DWR's South Central Region Office
SDAC	Severely Disadvantaged Community
SED	Substitute Environmental Document
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SMCL	secondary maximum contaminant level
SMMWC	Sandy Mush Mutual Water Company
SNMP	Salt and Nutrient Management Plan
SOI	Sphere of Influence
SSURGO	Soil Survey Geographic Database
Subbasin	Merced Subbasin
SWD	Stevinson Water District
SWRCB	State Water Resources Control Board
TCA	1,1,1-trichloroethane

TCE	trichloroethylene
TCP	1,2,3-trichloropropane
TDS	total dissolved solids
TFP	Tolladay, Fremming & Parson
TIWD	Turner Island Water District
TIWD GSA-1	Turner Island Water District Groundwater Sustainability Agency #1
TM	Technical Memorandum
TNC	The Nature Conservancy
TON	Threshold Odor Number
UCM or UC Merced	University of California Merced
umhos/cm	micromhos per centimeter
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
VIC	Variable Infiltration Capacity
VOC	volatile organic compound
WDL	Water Data Library
WDR	waste discharge requirements
WEAP	Water Evaluation and Planning System
WRIMS	Water Resource Integrated Modeling System (formerly CalSim II)
WY	Water Year

EXECUTIVE SUMMARY

ES-1. INTRODUCTION AND PLAN AREA

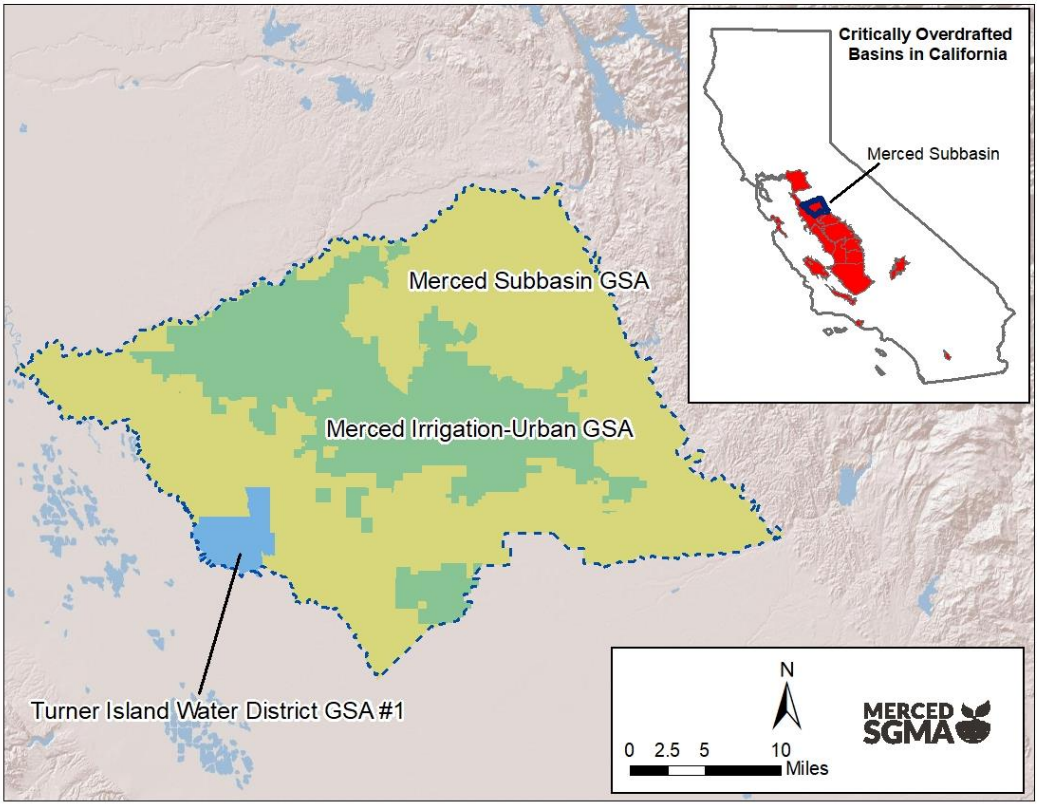
The Sustainable Groundwater Management Act (SGMA), passed in 2014, requires the formation of local Groundwater Sustainability Agencies (GSAs) to oversee the development and implementation of Groundwater Sustainability Plans (GSPs), with the ultimate goal of achieving sustainable management of California's groundwater basins. The purpose of this Groundwater Sustainability Plan is to bring the Merced Groundwater Basin (Merced Subbasin or Subbasin), a critically overdrafted basin located within the San Joaquin Valley (see Figure ES-1), into sustainable groundwater management by 2040. The Subbasin is heavily reliant on groundwater, and users recognize the Subbasin has been in overdraft for a long period of time.

The County of Merced and water purveyors and cities within the Merced Subbasin formed three GSAs in accordance with SGMA: Merced Irrigation-Urban Groundwater Sustainability Agency (MIUGSA), Merced Subbasin Groundwater Sustainability Agency (MSGSA), and Turner Island Water District Groundwater Sustainability Agency #1 (TIWD GSA-1) (see Figure ES-1-1), collectively referred to as "GSAs". The GSAs coordinated efforts to develop this GSP for the Subbasin. The GSAs have adopted the following sustainability goal for the Merced Subbasin:

> **Achieve sustainable groundwater management on a long-term average basis by increasing recharge and/or reducing groundwater pumping, while avoiding undesirable results.**

This goal will be achieved by allocating a portion of the estimated Subbasin sustainable yield to each of the GSAs, implementing demand management and allocation programs within each GSA, and coordinating the implementation of programs and projects to increase both direct and in-lieu groundwater recharge, which will in turn increase the groundwater and / or surface water available in the Subbasin.

Figure ES-1-1: Merced Subbasin Location Map and GSAs



Development and implementation of the GSP are guided by a Coordination Committee composed of members appointed by the GSA Boards to provide recommendations on technical and substantive basin-wide issues. The Coordination Committee and GSA Boards are also informed by a Stakeholder Advisory Committee, which consists of a broad group of groundwater beneficial users (also appointed by the GSA Boards) to review groundwater conditions, management issues and needs, and projects and management actions to improve sustainability in the basin. Extensive outreach has also been conducted to seek input from additional beneficial users of groundwater through multiple venues including public workshops held in locations specifically selected to provide access to disadvantaged communities. Figure ES-1-2 illustrates the relationship among the groups described above.

Figure ES-1-2: Diagram of Levels of Engagement and

This 2025 GSP Update includes revisions to the July 2022 GSP in response to changes in Subbasin conditions, Subbasin management, and to the Statement of Findings issued by the California

Department of Water Resources (DWR) on August 4, 2023 (DWR, 2023). A redlined version of the GSP that highlights the edits can be found on MercedSGMA.org.

ES-2. BASIN SETTING

Hydrogeologic Conceptual Model

The Merced Subbasin contains three principal aquifers that are defined by their relationship to the Corcoran Clay aquitard, a laterally-extensive silt and clay layer that underlies approximately the western half of the Subbasin and acts as a significant confining layer.

The **Above Corcoran Principal Aquifer** includes all aquifer units that exist above the Corcoran Clay Aquitard and generally contains moderate to large hydraulic conductivities and yields for domestic and irrigation uses.

The **Below Corcoran Principal Aquifer** includes all aquifer units that exist below the Corcoran Clay Aquitard and contains hydraulic conductivities and yields ranging from small to large for irrigation as well as some domestic and municipal uses.

The **Outside Corcoran Principal Aquifer** includes all aquifers that exist outside of the eastern lateral extent of the Corcoran Clay. The Outside Corcoran Principal Aquifer is connected laterally with the Above Corcoran Principal Aquifer at shallower depths and the Below Corcoran Principal Aquifer at deeper depths. Major uses of water in the Outside Corcoran Principal Aquifer include irrigation, domestic, and municipal uses.

The Principal Aquifers are underlain by a deep aquifer with higher salinity relative to the principal aquifers. See Figure ES-1-3 for a 3D illustration demonstrating the relationship between the principal aquifers, deeper higher-salinity water body, and the Corcoran Clay aquitard.

Figure ES-1-3: 3D Illustration of Merced Subbasin Principal Aquifers and Aquitard

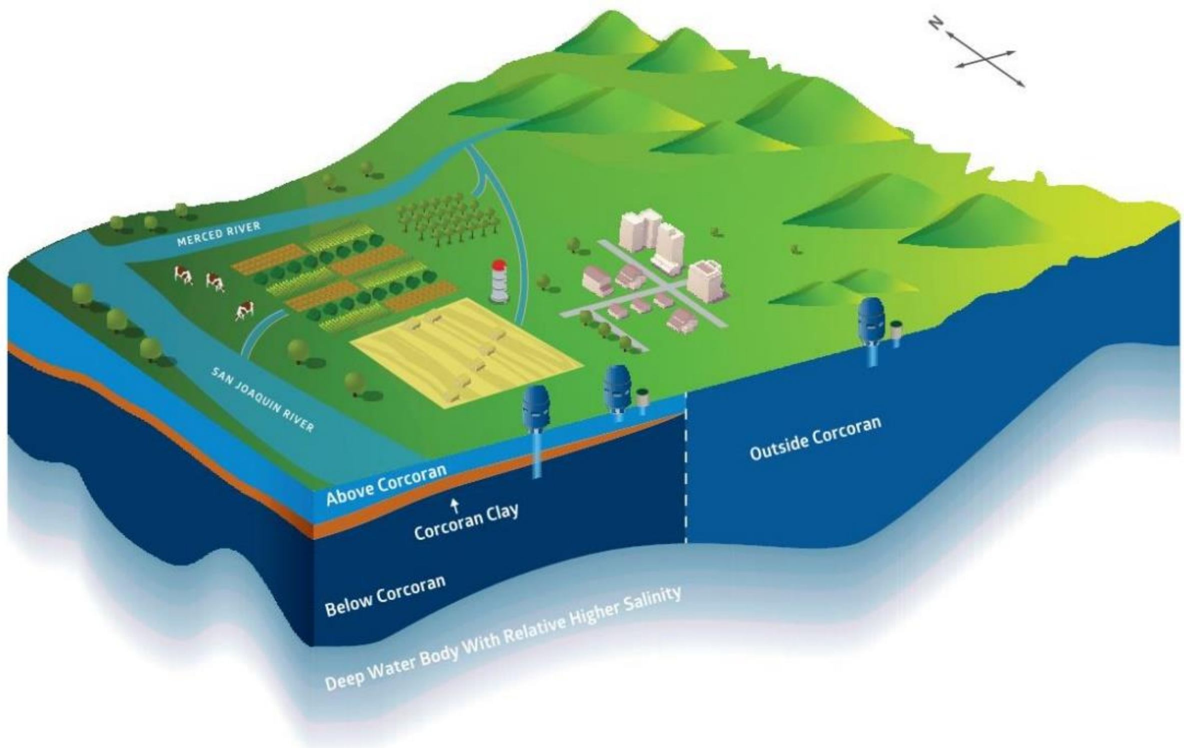
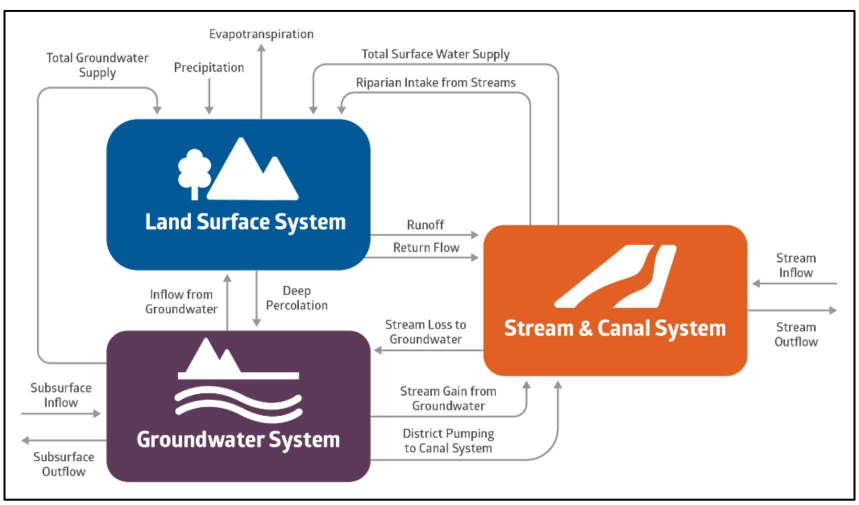


Figure ES-1-4: Generalized Water Budget Diagram

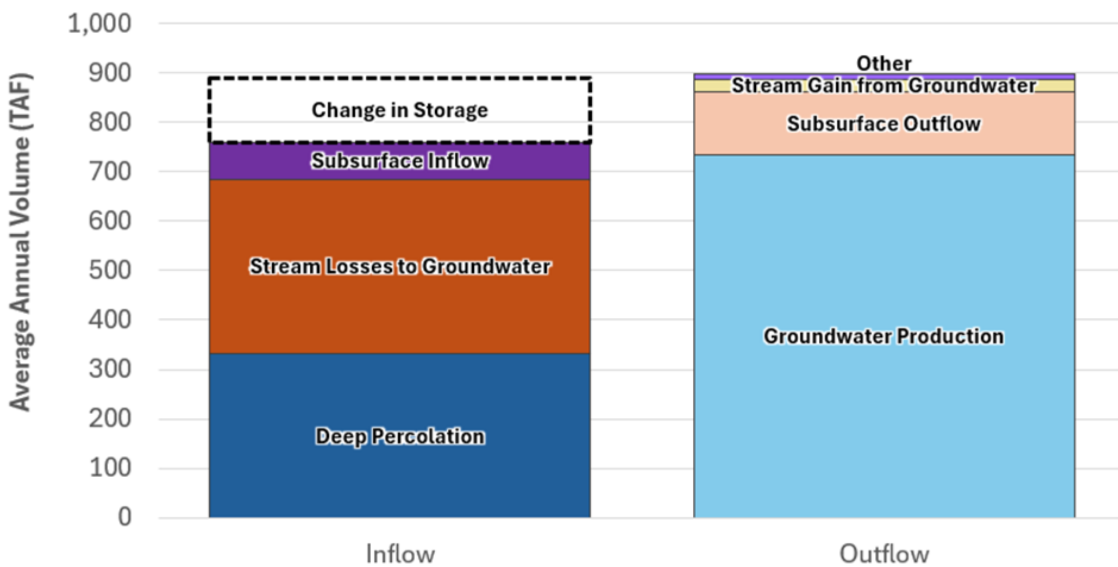


Water Budget Information

Water budgets provide quantitative accounting of water entering and leaving the Merced Subbasin and can be used to help estimate the extent of overdraft occurring now and in the future. Consistent with SGMA requirements, water budgets for historical, current, projected, and sustainable conditions were developed for the Merced Subbasin. An additional projected conditions scenario that includes existing and planned projects and management actions was also developed. Within each of these conditions, water budgets were developed for the groundwater system, the land surface system, and the stream and canal system. These water budgets were developed using the Merced Water Resources Model

(MercedWRM), a fully integrated surface and groundwater flow model developed and calibrated specifically for the Subbasin. See Figure ES-1-4 for a conceptual diagram of the inputs and outputs quantified by the model. The historical conditions water budget (see Figure ES-1-5) shows an annual average rate of overdraft ("Change in Storage") of 129,000 acre-feet per year (AFY) over water years 2006 through 2022. In this Figure, the "Change in Storage" represents the average annual decline in storage resulting from the Subbasin outflows, principally groundwater pumping.

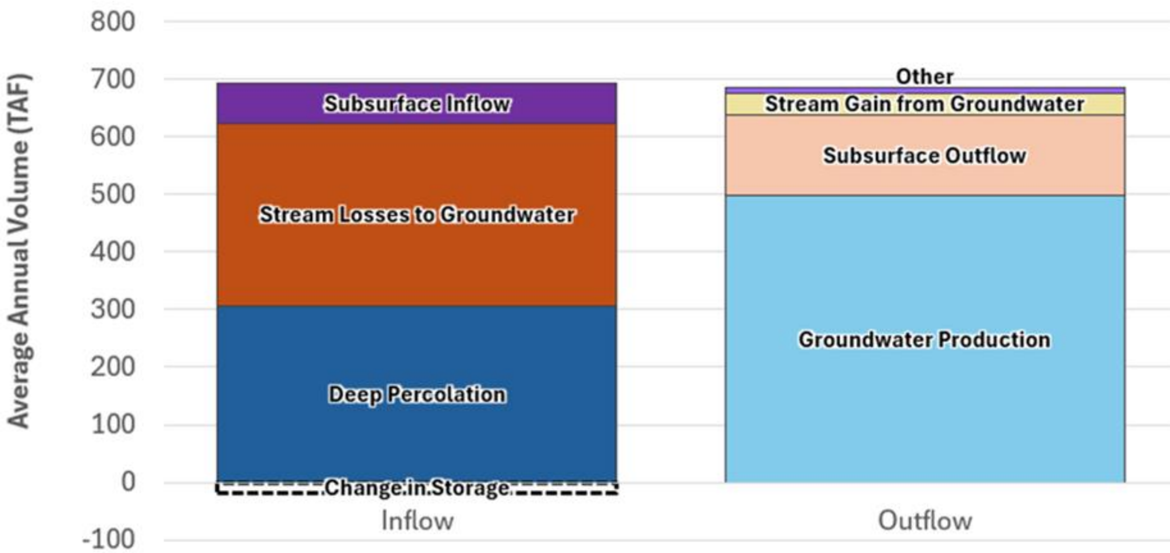
Figure ES-1-5: Historical Conditions Water Budget (2006-2022)



SGMA defines sustainable yield 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 §10721(w)).

For the Merced Subbasin, sustainable yield was estimated by modifying conditions in the groundwater model to balance out the change in stored water over time and avoid undesirable results. In order to achieve a net-zero change in groundwater storage over a long--term average condition and avoid undesirable results, current agricultural and urban groundwater demand in the Merced Subbasin would need to be reduced by approximately 8 percent beyond the modeled implementation of completed and proposed supply-side or recharge projects and demand reduction programs. Figure ES-1-6 illustrates the Subbasin water budget under long term sustainable conditions. It is noted that the sustainable yield estimate is heavily dependent on the management of neighboring subbasins and on the nature of future hydrology. The difference in pumping between modeled projects/management actions and the sustainable yield scenario is considered within the margin of error of the model estimate and the GSAs intend to adaptively implement projects and management actions during GSP implementation to ultimately achieve sustainability through avoidance of undesirable results.

Figure ES-1-6: Groundwater Water Budget under Sustainable Groundwater Management Conditions Long-Term (50-Year) Average Annual



ES-3. SUSTAINABLE MANAGEMENT CRITERIA

SGMA requires consideration of six sustainability indicators. For each indicator, the GSP must define undesirable results for the basin ("significant and unreasonable" negative impacts) and determine if they could occur. For the indicators with the potential for undesirable results, the GSP must establish sustainable management criteria that are intended to prevent undesirable results from occurring and establish a monitoring network.

Sustainable management criteria were developed to be protective of beneficial uses in the Merced Subbasin and to support the Subbasin's sustainability goal. Demonstration by 2040 of meeting the sustainability management criteria and an absence of undesirable results will support a determination that the basin is operating within its sustainable yield, and thus that the sustainability goal has been achieved.

A summary of the sustainable management criteria for the Merced Subbasin is shown in Table ES-1-1.

Table ES-1-1: Summary of Sustainable Management Criteria

Sustainability Indicator	Minimum Threshold (MT)	Interim Milestone (IM)	Measurable Objective (MO)	Undesirable Result
Groundwater Levels	Fall 2015 groundwater elevation	Based on range of projected values that account for hydrologic uncertainty, more details in Section 3.3.3.	November or October 2011 groundwater elevation (measured, or estimation if historical record not available)	Greater than 25% of representative wells fall below MT in 2 consecutive years
Groundwater Storage	Groundwater levels used as a proxy for this sustainability indicator			
Seawater Intrusion	Not applicable - not present and not likely to occur due to the distance between the Subbasin and the Pacific Ocean (and Sacramento-San Joaquin Delta)			
Degraded Water Quality	1,000 mg/L TDS	1,000 mg/L TDS	500 mg/L TDS	At least 25% representative wells exceed MT for 2 consecutive years
Land Subsidence	0 ft/year, subject to uncertainty of +/-0.16 ft/year	2025: -0.75 ft/year 2030: -0.5 ft/year 2035: -0.25 ft/year	0 ft/year	Exceedance of MT at 3 or more representative sites for 2 consecutive years
Depletions of Interconnected Surface Waters	Groundwater levels used as a proxy for this sustainability indicator			

Sustainable management criteria were established to be protective of Subbasin beneficial uses as described below.

Minimum thresholds for **chronic declining groundwater levels** were developed based on the fall 2015 elevation recorded at each representative monitoring well. This threshold keeps groundwater levels generally above levels that have been experienced in the past. In this way, impacts to shallow well users and other beneficial users of groundwater will generally not exceed what has historically been experienced in the Subbasin. Sustainable management criteria for declining groundwater levels were evaluated against the depths of the shallowest domestic and public water supply wells in Merced County's well permitting database. Groundwater levels are also being used as a proxy indicator for reduction of groundwater storage and depletions of interconnected surface waters.

Significant and unreasonable **reduction of groundwater storage** are not likely to occur in the Subbasin, since historical reductions have been insignificant relative to the total volume of freshwater water storage in the Subbasin. However, based on a recommendation from DWR, the Subbasin has decided to manage this sustainability indicator using groundwater levels as a proxy.

Degraded water quality is unique among the six sustainability indicators because it is already the subject of extensive federal, state, and local regulations carried out by numerous entities, and SGMA does not directly address the role of GSAs relative to these other entities (Moran & Belin, 2019). SGMA does not specify water quality constituents that must have minimum thresholds. Groundwater management (e.g., via controls on pumping and/or recharge) is the mechanism available to GSAs to implement SGMA. Establishing minimum thresholds for constituents that cannot be managed by increasing or decreasing pumping was deemed inappropriate by the GSAs and basin stakeholders. The major water quality issue being addressed by sustainable groundwater management is the migration of relatively higher salinity water into the freshwater principal aquifers. The nexus between water quality and water supply management exists for the pumping-induced movement of low-quality water from the west and northwest to the east. Other water quality concerns are being addressed through various water quality programs and agencies that have the authority and responsibility to address them.

While **land subsidence** has been recognized by the GSAs as an area of concern within the Merced Subbasin, it is not considered to have caused a significant and unreasonable reduction in the viability of the use of infrastructure. However, it is noted that subsidence has caused a reduction in freeboard of the Middle Eastside Bypass over the last 50 years and has caused problems in neighboring subbasins, highlighting the need for ongoing monitoring and management in the Merced Subbasin and surrounding subbasins. Sustainable management criteria were established based on the long-term avoidance of land subsidence, set with the recognition that the interconnectedness of the Merced Subbasin with surrounding subbasins makes meeting the sustainability management criteria dependent on the successful management of all nearby subbasins. The criteria are also set to be consistent with the sustainable management criteria for groundwater levels which seek to keep levels above 2015 conditions. A management action has also been developed to avoid declines in storage below historical levels, further reducing the risk of subsidence.

Depletions of interconnected surface waters will be managed using groundwater levels as a proxy due to the challenges inability to directly measure streamflow depletions and because of the significant correlation between groundwater levels and depletions.

ES-4. MONITORING NETWORKS

Consistent with SGMA requirements, the GSAs have established monitoring networks for each sustainability indicator to monitor trends in the Subbasin and evaluate GSP implementation against sustainable management criteria. The groundwater level monitoring network consists of wells originally evaluated for the California Statewide Groundwater Elevation Monitoring (CASGEM) Program that were selected to provide representative conditions for groundwater levels across the Subbasin. The groundwater quality monitoring network includes a combination of wells in the Subbasin that are part of the East San Joaquin Water Quality Coalition Groundwater Quality Trend Monitoring Program as well as public water system wells that report data to the Division of Drinking Water. The subsidence monitoring network relies on control points monitored by the United States Bureau of Reclamation as part of the San Joaquin River Restoration Program. While the monitoring networks reflect a robust history of monitoring Subbasin conditions and numerous data gaps have been filled in the initial GSP was developed, additional data gaps still exist and plans to continue filling these data gaps for each sustainability indicator are described in this GSP.

ES-5. DATA MANAGEMENT SYSTEM

The Merced Subbasin Data Management System (DMS) was developed to serve as a data sharing portal to enable utilization of the same data and tools for visualization and analysis to support sustainable groundwater management and transparent reporting of data and results. Monitoring data can be manually input by users or batch uploaded via template and includes groundwater level, groundwater quality, streamflow, and subsidence data. All monitoring locations can be viewed spatially (map or list format) and data records per site can be viewed temporally (chart or list format). Ad-hoc queries and standard reports greatly assist in answering questions about basin characterization, providing input for decision-making, and developing reports to meet annual report submittal requirements.

ES-6. PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY GOAL

SGMA requires that GSPs describe the projects and management actions to be implemented as part of bringing the Subbasin into sustainability. The primary means for achieving sustainability in the Subbasin will be reduction in groundwater pumping achieved through implementation of management actions within each GSA’s jurisdiction to allocate or otherwise manage the sustainable yield of the basin.

Since the initial GSP development, several projects have been fully implemented and numerous new projects have been identified and fully or partially funded. Projects and management actions typically either increase surface water supplies to augment the sustainable groundwater yield or increase groundwater recharge, which will in turn increase the amount of groundwater that may be sustainably used; or reduce groundwater demands.

ES-7. PLAN IMPLEMENTATION

Implementation of the GSP will be a substantial undertaking that will include implementation of the projects and management actions as well as GSAs administration, public outreach, implementation of the monitoring programs and filling data gaps, development of annual reports, and development of a 5-year periodic evaluation report. The GSAs have developed an implementation schedule (see Table ES-1-2) and estimated costs for all activities, as well as potential funding mechanism options. Implementation of the GSP is projected to be $1.6M per year. Costs for projects and management actions are estimated to be an additional $72.0M in total, with costs for individual projects or management actions ranging between $26,000 to $31M in total.

Table ES-1-2: GSP Implementation Schedule (2025-2040)

2025 – 2030	2030 – 2035	2035 – 2040
Preparation for Allocations and Low Capital Outlay Projects	**Prepare for Sustainability**	**Implement Sustainable Operations**
• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue, filling additional data gaps as necessary	• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue	• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue
• Continued coordination on allocation program • As-needed demand reduction to reach Sustainable Yield allocation • Implement Metering program	• As-needed demand reduction to reach Sustainable Yield allocation	• Full implementation demand reduction as needed to reach Sustainable Yield allocation by 2040
• Planning/ Design/ Construction for small to medium sized projects	• Planning/ Design/ Construction for larger projects begins	• Project implementation completed
• Outreach regarding GSP and allocations continues	• Outreach continues	• Outreach continues

1 INTRODUCTION AND PLAN AREA

1.1 INTRODUCTION AND AUTHORITY

This 2025 Update includes revisions to the July 2022 Groundwater Sustainability Plan (GSP) in response to the Statement of Findings issued by the California Department of Water Resources (DWR) on August 4, 2023 (DWR, 2023) and to update the plan to reflect the most recent data and information available. A redlined version of the GSP that highlights the edits can be found on MercedSGMA.org.

1.1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this GSP is to bring the Merced Subbasin, a DWR-designated critically overdrafted basin located within the San Joaquin Valley, into sustainable groundwater management by 2040 by meeting the regulatory requirements set forth in the three-bill legislative package Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley) collectively known as the Sustainable Groundwater Management Act (SGMA), §10720 - 10737.8 of the California Water Code (CWC). Under SGMA, critically overdrafted, high- and medium-priority basins must be managed by a GSP by January 31, 2020. GSPs are prepared and implemented by Groundwater Sustainability Agencies (GSAs) that are newly formed from local and regional authorities.

SGMA defines sustainable groundwater management as "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results," which are any of the following effects caused by groundwater conditions occurring throughout the Subbasin:

- 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 planning and implementation horizon is defined by SGMA as a "50-year time period over which a groundwater sustainability agency determines that plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield."

1.1.2 Sustainability Goal

The sustainability goal succinctly states the GSAs' objectives and desired conditions of the Merced Subbasin. The Merced Subbasin is heavily reliant on groundwater, and users recognize the Subbasin has been in overdraft for a long period of time. The GSAs have adopted the following sustainability goal for the Merced Subbasin:

> **Achieve sustainable groundwater management on a long-term average basis by increasing recharge and/or reducing groundwater pumping, while avoiding undesirable results.**

This goal will be achieved by allocating a portion of the estimated Subbasin sustainable yield to each GSA and coordinating the implementation of programs and projects to increase both direct and in-lieu groundwater recharge, which will, in turn, increase the groundwater and / or surface water available to each GSA.

More information on the sustainability goal and sustainable management criteria is detailed in Section 3 - Sustainable Management Criteria.

1.1.3 Agency Information

This GSP for the Merced Groundwater Subbasin was developed jointly by the Merced Irrigation-Urban Groundwater Sustainability Agency (MIUGSA), the Merced Subbasin Groundwater Sustainability Agency (MSGSA), and Turner Island Water District Groundwater Sustainability Agency #1 (TIWD GSA-1). Collectively, these three GSAs will be referred to as "GSAs".

The GSAs developed a Memorandum of Understanding (MOU) that provides the basis for the agreement of the GSAs to work together to develop and implement a GSP for the Merced Subbasin (Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2017). The GSAs submitted an Initial Notification to jointly develop a GSP for the Merced Subbasin on January 4, 2018 (Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2018). The MOU is provided as Appendix A to this document.

1.1.3.1 Organization and Management Structure of the GSAs

The GSAs were guided by a Coordination Committee that is composed of up to four representatives from each GSA and appointed by each respective GSA Board (Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2017). The Coordination Committee is responsible for developing recommendations on technical and substantive Subbasin-wide issues, and then submitting the recommendations to each GSA governing board for final approval. To become fully effective, each GSA governing board must approve the Coordination Committee's recommendations. The Coordination Committee is tasked with developing actions including, but not limited to, the following:

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

(Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2017)

A process for dispute resolution, including internal resolution and mediation prior to judicial or administrative remedies, is laid out in the GSAs' MOU.

The Coordination Committee and GSA Boards were also informed by a Stakeholder Advisory Committee which consists of community representatives who review groundwater conditions, management issues and needs, and projects and management actions to improve sustainability in the basin. The committee met monthly during the development of the GSP and will meet quarterly during GSP implementation. These sessions are open to the public, providing a forum for testing ideas as well as providing information and feedback from members' respective constituencies. The committee consists of 24 members, including representatives from local cities, public and private utilities, agriculture, local nonprofits, business owners, researchers or university employees, and residents. An application to join the committee was disseminated in early 2018. More than 35 applications were received. The 23 Stakeholder Advisory Committee members were selected by the Coordination Committee and approved by the GSAs to represent the broad interests and geography of the region (see Appendix N for a list of Stakeholder Advisory Committee members).

1.1.3.1.1 Merced Irrigation-Urban Groundwater Sustainability Agency (MIUGSA)

MIUGSA was formed by an MOU between the Merced Irrigation District, City of Merced, City of Atwater, City of Livingston, Le Grand Community Services District, Planada Community Services District, and Winton Water and Sanitary District. Decision-making is intended to be by unanimous consent of all Parties, but otherwise allows for a majority vote where MID and each of the cities is entitled to one vote and the community service districts are collectively entitled to one vote. MID is designated as the primary agent for purposes of developing technical information as well as being the point of contact and designated representative for MIUGSA for coordination with the other two GSAs in the Merced Subbasin as well as adjacent basins.

The mailing address for MIUGSA is:

Merced Irrigation-Urban Groundwater Sustainability Agency
PO Box 818
Merced, CA 95341

1.1.3.1.2 Merced Subbasin Groundwater Sustainability Agency (MSGSA)

MSGSA was formed as a Joint Powers Authority (JPA), including Plainsburg Irrigation District, Le Grand-Athlone Water District, Stevinson Water District, Merquin County Water District, County of Mariposa, and County of Merced. Two mutual water companies, Lone Tree Mutual Water Company and Sandy Mush Mutual Water Company, participate in the JPA as Contracting Entities. The JPA formed a Governing Board consisting of six members:

1. An elected member of the Board of Supervisors for the County of Merced
2. One representative from the Western White Area[1] (actively and primarily engaged in agriculture, appointed by County of Merced Board of Supervisors)
3. One Representative from the Eastern White Area[2] (actively and primarily engaged in agriculture, appointed by County of Merced Board of Supervisors)
4. One member from the Board of Directors of a Contracting Entity
5. One member from the Board of Directors for either the Stevinson Water District or Merquin County Water District
6. One member from the Board of Directors for either the Le Grand-Athlone Water District or Plainsburg Irrigation District

Each Board Member has one vote, and decisions are made by affirmative vote of four Board Members, except in the following cases, which require five affirmative votes: decisions about initiating litigation, adoption of the GSP, incurring bond debt, and expenditures over $100,000.

[1] "Western White Area" refers to all lands southwest of the Merced Irrigation District service area within the Merced Subbasin but outside of established water or irrigation districts, municipalities, community service districts, Contracting Entities, or other eligible local agencies as defined by the Act. (MSGSA, 2016)

[2] "Eastern White Area" refers to all lands northeast of the Merced Irrigation District service area within the Merced Subbasin but outside of established water or irrigation districts, municipalities, community service districts, Contracting Entities, or other eligible local agencies as defined by the Act. (MSGSA, 2016)

Since the GSA was formed, Amsterdam Water District was formed and added as a member agency.

The mailing address for MSGSA is:

Merced Subbasin Groundwater Sustainability Agency
Merced County
2222 M Street
Merced, CA 95340

1.1.3.1.3 Turner Island Water District Groundwater Sustainability Agency #1 (TIWD GSA-1)

TIWD GSA-1 is governed exclusively by the Turner Island Water District (TIWD), a local water agency. TIWD is comprised of several agriculture landowners that rely on groundwater for irrigation. The GSA is differentiated as #1 because TIWD also has a role as a GSA (TIWD GSA #2) in the adjacent Delta-Mendota Subbasin. The mailing address for TIWD GSA-1 is:

Turner Island Water District GSA #1
1269 W. I Street
Los Banos, CA 93535

1.1.3.1.4 Merced GSP Plan Manager

SGMA regulations require the GSP designate a plan manager to serve as a point of contact with DWR. The contact information for the Merced GSP Plan Manager is:

Hicham ElTal,
Merced Irrigation-Urban Groundwater Sustainability Agency
744 W. 20th Street
Merced, CA 95340
Phone: 209.722.5761
Email: heltal@mercedid.org

1.1.3.2 Legal Authority of the GSAs

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

MIUGSA's MOU describes the following powers in addition to authorities granted to GSAs by SGMA (MIUGSA, 2017):

- Adopt standards for measuring and reporting water use

- Adopt rules, regulations, policies and procedures to govern the adoption and implementation of the GSP, as authorized by SGMA including funding of the GSA, and the collection of fees or charges as may be applicable
- Develop and implement conservation best management practices
- Develop and implement metering, monitoring, and reporting related to groundwater pumping
- Hire consultants as determined necessary or appropriate by the GSAs
- Prepare a budget

MSGSA's JPA describes the following powers in addition to authorities granted to GSAs by SGMA (MSGSA, 2016):

- Employ agents, consultants, advisors, independent contractors, employees, and other staff members
- Enter contracts
- Acquire, hold, and convey real and personal property
- Incur debts, borrow money, accept contributions/grants/loans
- Invest money not needed for immediate necessities
- Reimburse Agency Members for expenses
- Sue and be sued

TIWD is the only local agency governing TIWD GSA-1 and has powers granted to GSAs by SGMA.

The MOU between the GSAs describes the following collective authorities (Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2017):

- To coordinate the implementation of SGMA among the GSAs
- To recommend the adoption of actions, rules, regulations, policies, and procedures related to the coordination of the GSAs for purposes of implementation of SGMA
- To perform all acts necessary or proper to carry out fully the purposes of the Agreement; and to exercise all other powers necessary and incidental to the implementation of the powers set forth herein.

1.1.3.3 Estimated Cost of Implementing the GSP and the GSAs' Approach to Meet Costs

Implementation of the GSP is estimated to be $1.6M per year. Costs for projects and management actions are estimated to be an additional $72M in total plus $1.3M per year, with costs for individual projects or management actions ranging between $26K to $31M in total. While the development of the 2020 GSP was substantially funded through a Proposition 1 Sustainable Groundwater Planning Grant, the implementation of the GSP and future SGMA compliance continues to be a substantial and costly undertaking that has required the GSAs to collect additional fees as well as seek additional outside funding. Costs for GSP project implementation will be shared based on project beneficiaries. Costs of overall GSP administration have been (and are expected to continue to be) shared by the GSAs consistent with the cost share in the MOU (Appendix A). Financing options under consideration include pumping fees, assessments, loans, and grants. Prior to implementing any fee or assessment program, the GSAs would complete a rate assessment study or other analysis consistent with the regulatory requirements.

More detailed information can be found in Chapter 7 - Plan Implementation.

1.1.4 GSP Organization

This GSP is organized according to DWR's "GSP Annotated Outline" for standardized reporting (DWR, 2016d). The Preparation Checklist for GSP Submittal in DWR formatting can be found below in Table 1-1 (DWR, 2016e).

Table 1-1: DWR Preparation Checklist

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
Article 3. Technical and Reporting Standards				
352.2		Monitoring Protocols	• Monitoring protocols adopted by the GSA for data collection and management • Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin	GW levels: 4.5.5 GW quality: 4.8.5 Subsidence: 4.9.5 Depletions of interconnected surface waters: 4.10.5
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4		General Information	• Executive Summary • List of references and technical studies	Executive Summary: Section ES References & technical studies: Chapter 8
354.6		Agency Information	• GSA mailing address • Organization and management structure • Contact information of Plan Manager • Legal authority of GSA • Estimate of implementation costs	1.1.3
354.8(a)	10727.2(a)(4)	Map(s)	• Area covered by GSP • Adjudicated areas, other agencies within the basin, and areas covered by an Alternative • Jurisdictional boundaries of federal or State land • Existing land use designations • Density of wells per square mile	1.2
354.8(b)		Description of the Plan Area	• Summary of jurisdictional areas and other features	1.2.1

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
354.8(c) 354.8(d) 354.8(e)	10727.2(g)	Water Resource Monitoring and Management Programs	• Description of water resources monitoring and management programs • Description of how the monitoring networks of those plans will be incorporated into the GSP • Description of how those plans may limit operational flexibility in the basin • Description of conjunctive use programs	1.2.2
354.8(f)	10727.2(g)	Land Use Elements or Topic Categories of Applicable General Plans	• Summary of general plans and other land use plans • Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects • Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans • Summary of the process for permitting new or replacement wells in the basin • Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	1.2.3
354.8(g)	10727.4	Additional GSP Contents	**Description of Actions related to:** • Control of saline water intrusion • Wellhead protection • Migration of contaminated groundwater • Well abandonment and well destruction program • Replenishment of groundwater extractions • Conjunctive use and underground storage • Well construction policies • Addressing groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects • Efficient water management practices • Relationships with State and federal regulatory agencies	1.2.4

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
			• Review of land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity • Impacts on groundwater dependent ecosystems	
354.10		Notice and Communication	• Description of beneficial uses and users • List of public meetings • GSP comments and responses • Decision-making process • Public engagement • Encouraging active involvement • Informing the public on GSP implementation progress	1.2.5
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14		Hydrogeologic Conceptual Model	• Description of the Hydrogeologic Conceptual Model • Two scaled cross-sections • Map(s) of physical characteristics: topographic information, surficial geology, soil characteristics, surface water bodies, source and point of delivery for imported water supplies	2.1
354.14(c)(4)	10727.2(a)(5)	Map of Recharge Areas	• Map delineating existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas	2.1.3.5
	10727.2(d)(4)	Recharge Areas	• Description of how recharge areas identified in the plan substantially contribute to the replenishment of the basin	2.1.3.5
354.16	10727.2(a)(1) 10727.2(a)(2)	Current and Historical Groundwater Conditions	• Groundwater elevation data • Estimate of groundwater storage • Seawater intrusion conditions • Groundwater quality issues • Land subsidence conditions • Identification of interconnected surface water systems • Identification of groundwater-dependent ecosystems	2.2

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
354.18	10727.2(a)(3)	Water Budget Information	• Description of inflows, outflows, and change in storage • Quantification of overdraft • Estimate of sustainable yield • Quantification of current, historical, and projected water budgets	2.3
	10727.2(d)(5)	Surface Water Supply	• Description of surface water supply used or available for use for groundwater recharge or in-lieu use	2.1.3.3 (Surface Water) 2.1.3.5 (Groundwater Recharge and Discharge Areas)
354.20		Management Areas	• Reason for creation of each management area • Minimum thresholds and measurable objectives for each management area • Level of monitoring and analysis • Explanation of how management of management areas will not cause undesirable results outside the management area • Description of management areas	3.2
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24		Sustainability Goal	• Description of the sustainability goal	3.1
354.26		Undesirable Results	• Description of undesirable results • Cause of groundwater conditions that would lead to undesirable results • Criteria used to define undesirable results for each sustainability indicator • Potential effects of undesirable results on beneficial uses and users of groundwater	GW levels: 3.3.1 GW storage: 3.4 Seawater intrusion: 3.4.1 GW quality: 3.6.1 Subsidence: 3.7.1 Depletions of interconnected surface water: 3.8.1
354.28	10727.2(d)(1) 10727.2(d)(2)	Minimum Thresholds	• Description of each minimum threshold and how they were established for each sustainability indicator • Relationship for each sustainability indicator • Description of how selection of the minimum threshold may affect beneficial uses and users of groundwater • Standards related to sustainability indicators • How each minimum threshold will be quantitatively measured	GW levels: 3.3.2 GW storage: 3.4 Seawater intrusion: 3.4.1 GW quality: 3.6.2 Subsidence: 3.7.2 Depletions of interconnected surface water: 3.8.2

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
354.30	10727.2(b)(1) 10727.2(b)(2) 10727.2(d)(1) 10727.2(d)(2)	Measurable Objectives	• Description of establishment of the measurable objectives for each sustainability indicator • Description of how a reasonable margin of safety was established for each measurable objective • Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones	GW levels: 3.3.3 GW storage: 3.4 Seawater intrusion: 3.4.1 GW quality: 3.6.3 Subsidence: 3.7.3 Depletions of interconnected surface water: 3.8.2
Article 5. Plan Contents, Subarticle 4. Monitoring Networks				
354.34	10727.2(d)(1) 10727.2(d)(2) 10727.2(e) 10727.2(f)	Monitoring Networks	• Description of monitoring network • Description of monitoring network objectives • Description of how the monitoring network is designed to: demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features; estimate the change in annual groundwater in storage; monitor seawater intrusion; determine groundwater quality trends; identify the rate and extent of land subsidence; and calculate depletions of surface water caused by groundwater extractions • Description of how the monitoring network provides adequate coverage of Sustainability Indicators • Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends • Scientific rational (or reason) for site selection • Consistency with data and reporting standards • Corresponding sustainability indicator, minimum threshold, measurable objective, and interim milestone	Overall objectives: 4.1 GW levels: 4.5 GW storage: 4.6 Seawater intrusion: 4.7 GW quality: 4.8 Subsidence: 4.9 Depletions of interconnected surface water: 4.10
			• Location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used • Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	GW levels: 4.5 GW storage: 4.6 Seawater intrusion: 4.7 GW quality: 4.8 Subsidence: 4.9 Depletions of interconnected surface water: 4.10

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
354.36		Representative Monitoring	• Description of representative sites • Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators • Adequate evidence demonstrating site reflects general conditions in the area	GW levels: 4.5.4 GW quality: 4.8.4 Subsidence: 4.9.4 Depletions of interconnected surface water: 4.10.4
354.38		Assessment and Improvement of Monitoring Network	• Review and evaluation of the monitoring network • Identification and description of data gaps • Description of steps to fill data gaps • Description of monitoring frequency and density of sites	GW levels: 4.5.6, 4.5.7 GW quality: 4.8.7, 4.8.9 Subsidence: 4.9.6, 4.9.8 Depletions of interconnected surface water: 4.10.6, 4.10.8
Article 5. Plan Contents, Subarticle 5. Projects and Management Actions				
354.44		Projects and Management Actions	• Description of projects and management actions that will help achieve the basin's sustainability goal • Measurable objective that is expected to benefit from each project and management action • Circumstances for implementation • Public noticing • Permitting and regulatory process • Time-table for initiation and completion, and the accrual of expected benefits • Expected benefits and how they will be evaluated • How the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included. • Legal authority required • Estimated costs and plans to meet those costs • Management of groundwater extractions and recharge	Chapter 6
354.44(b)(2)	10727.2(d)(3)		• Overdraft mitigation projects and management actions	Chapter 6

GSP Regulations Section	Water Code Section	Requirement	Description	Section(s) in the GSP
Article 8. Interagency Agreements				
357.4	10727.6	Coordination Agreements - Shall be submitted to the Department together with the GSPs for the basin and, if approved, shall become part of the GSP for each participating Agency.	**Coordination Agreements shall describe the following:** • A point of contact • Responsibilities of each Agency • Procedures for the timely exchange of information between Agencies • Procedures for resolving conflicts between Agencies • How the Agencies have used the same data and methodologies to coordinate GSPs • How the GSPs implemented together satisfy the requirements of SGMA • Process for submitting all Plans, Plan amendments, supporting information, all monitoring data and other pertinent information, along with annual reports and periodic evaluations • A coordinated data management system for the basin • Coordination agreements shall identify adjudicated areas within the basin, and any local agencies that have adopted an Alternative that has been accepted by the Department	3.9

1.2 PLAN AREA

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

1.2.1 Summary of Jurisdictional Areas and Other Features

The Merced Subbasin falls within the larger San Joaquin Valley Groundwater Basin (see Figure 1-1). Basin and Subbasin designations by DWR were first published in 1952, and subsequently updated in 1975, 1980, and 2003. The San Joaquin River Hydrologic Region contains 11 distinct subbasins, where the Merced Subbasin (Bulletin 118 Basin Number 5-022.04) is bordered to the north by the Turlock Subbasin (Bulletin 118 Basin Number 5-022.03), to the south by the Chowchilla Subbasin (Bulletin 118 Basin Number 5-022.05), and to the west by the Delta-Mendota Subbasin (Bulletin 118 Basin Number 5-022.07) (see Figure 1-2).

The Merced Subbasin includes lands south of the Merced River between the San Joaquin River on the west and the crystalline basement rock of the Sierra Nevada foothills on the east. The Subbasin boundary on the south stretches westerly along the Chowchilla River (Merced-Madera County boundary) and then along the northern edge of the sphere of influence boundary of Chowchilla Water District. Geologic units in the Merced Subbasin consist of consolidated rocks and unconsolidated deposits.

Figure 1-1: San Joaquin Valley Groundwater Basin

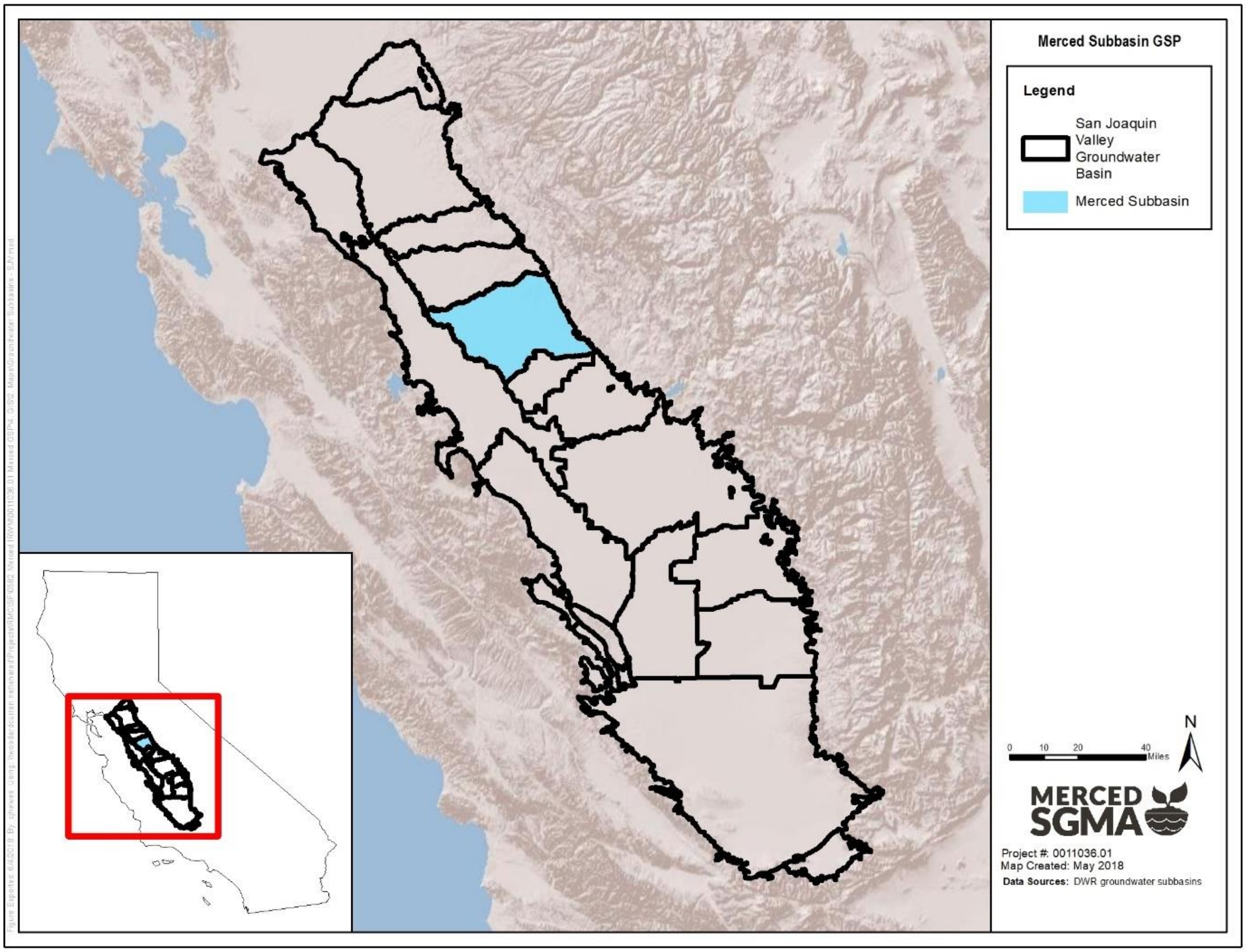


Figure 1-2: Neighboring Groundwater Subbasins

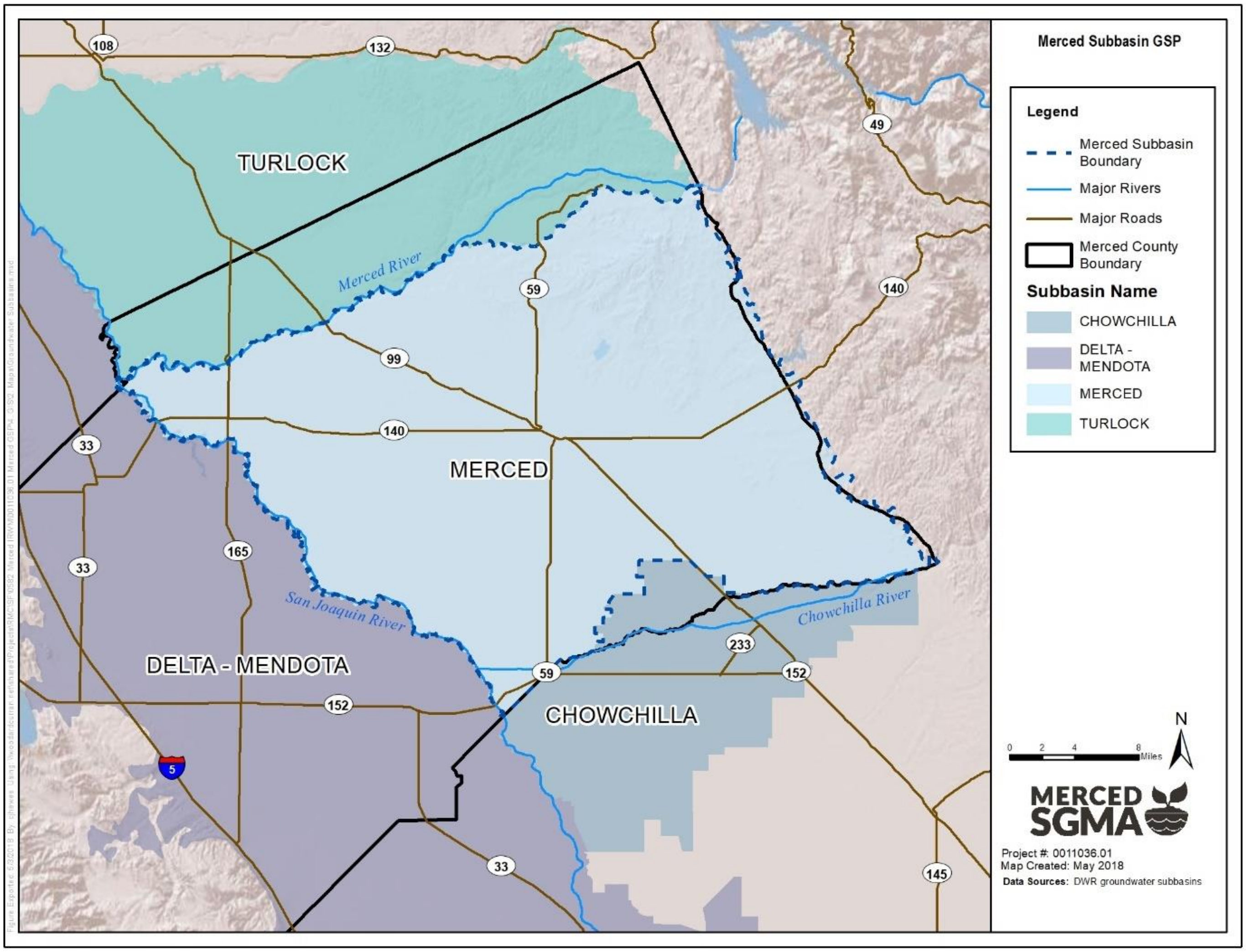


Figure 1-3 shows the location of Merced County within the State of California as well as the seven counties bordering Merced County: Tuolumne, Mariposa, Madera, Fresno, San Benito, Santa Clara, and Stanislaus. While nearly all of the Merced Subbasin is within Merced County, a very small portion is within Mariposa County.

Figure 1-3: Surrounding Counties

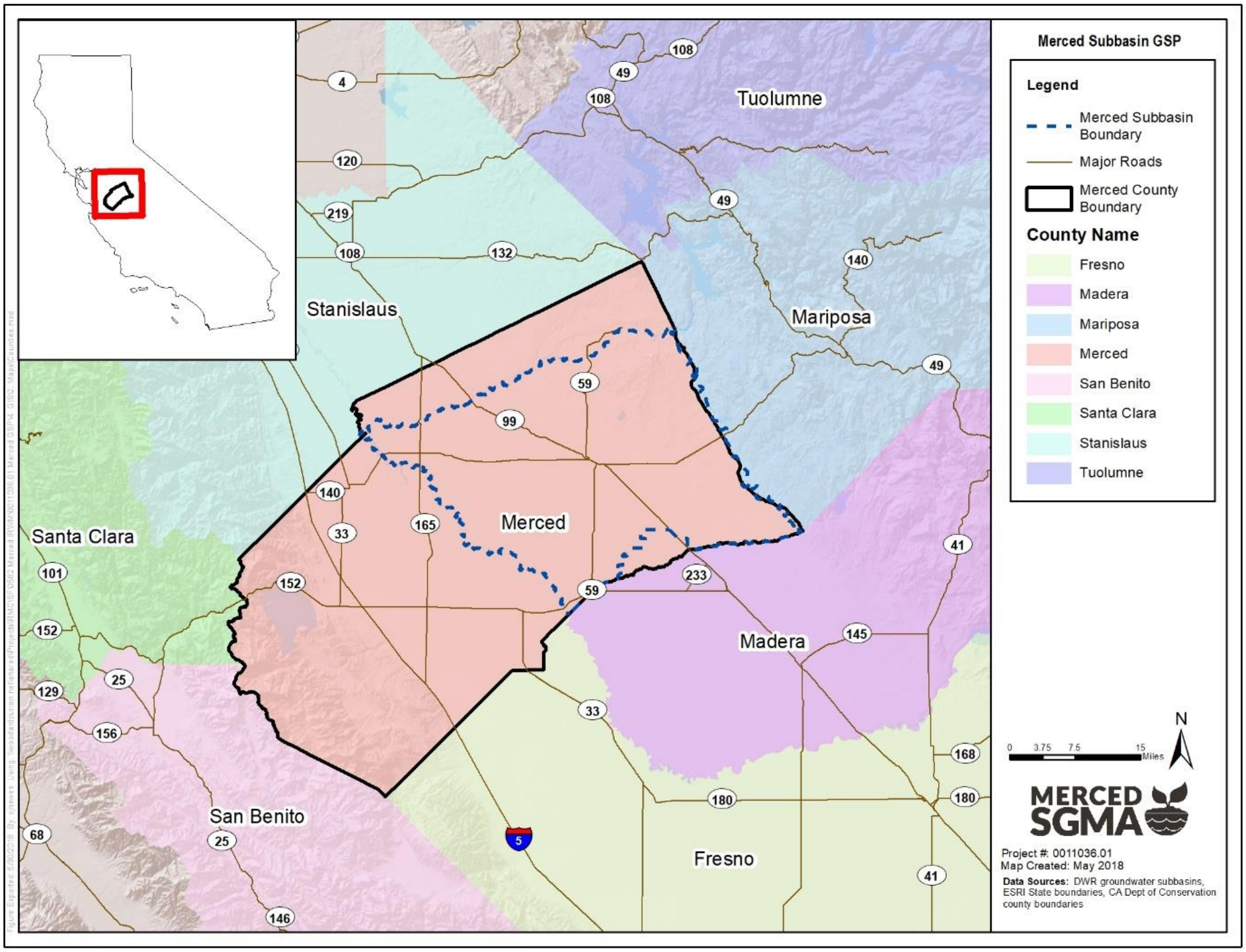


Figure 1-4 shows the Merced Subbasin and the Subbasin's key cities, communities, and major rivers. The Subbasin encompasses an area of about 801 square miles. There are five entities within the region with land use jurisdiction: the County of Merced, the City of Merced, the City of Livingston, the City of Atwater, and the University of California, Merced (UC Merced). A small portion of the Subbasin falls within the western edge of Mariposa County. The cities of Merced, Atwater, and Livingston and UC Merced are contained entirely within the Subbasin, while only part of the eastern portion of Merced County lies within the Subbasin. The Merced Subbasin encompasses the following unincorporated communities within eastern Merced County: Bear Creek (Celeste), Cressey, El Nido, Franklin/Beachwood, Le Grand, McSwain, Planada, Stevinson, Tuttle, and Winton.

Figure 1-4: City Boundaries

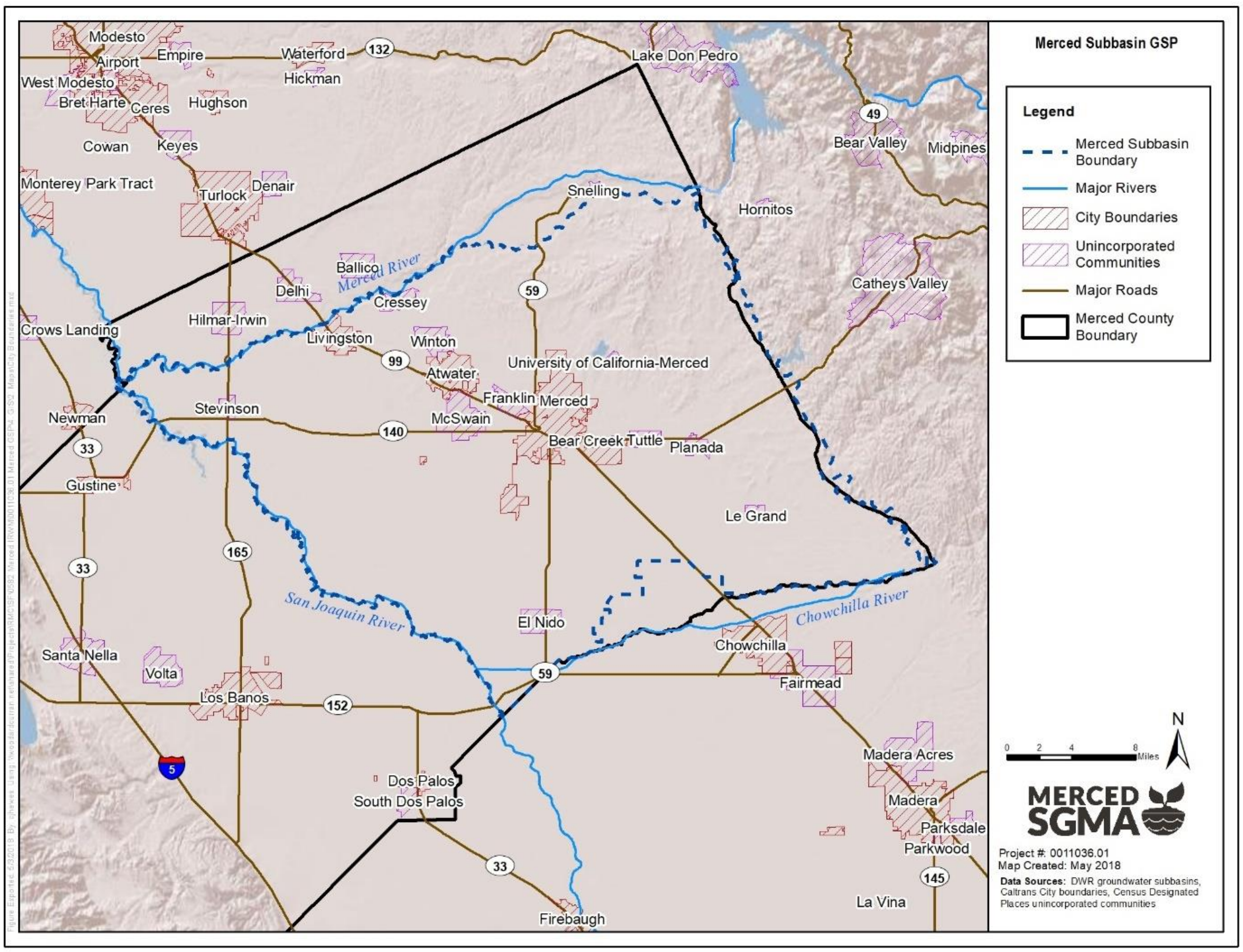


Figure 1-5 shows the extent of the GSAs which together encompass the entire Merced Subbasin. See Section 1.1.3.1 for a description of the agencies making up each GSA.

Figure 1-5: GSA Boundaries

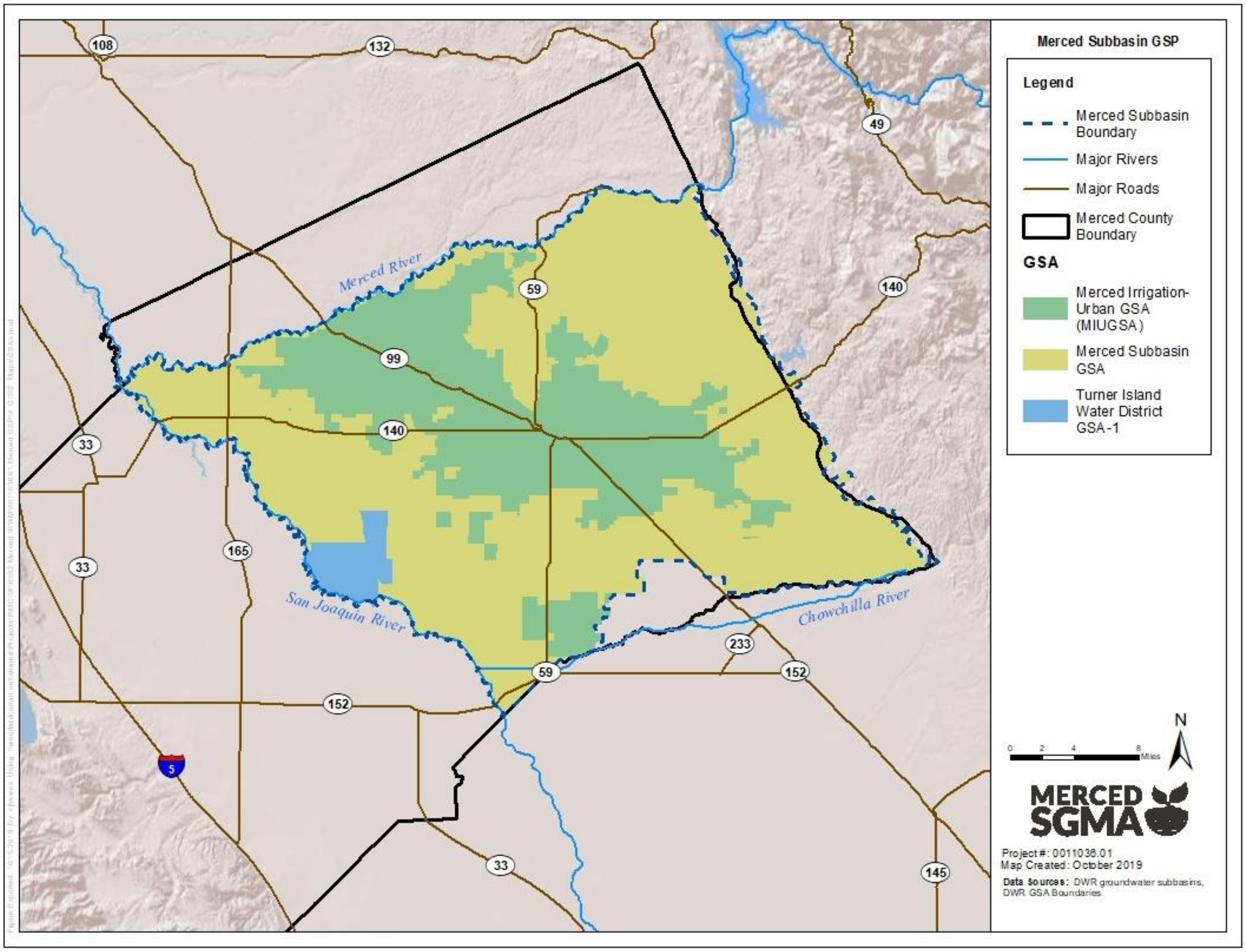


Figure 1-6 shows a map of land use in Merced County across four general categories: cropland, rangeland, undeveloped, and urban. These categories were aggregated based on categories provided by 2016 land use from the California Farmland Mapping and Monitoring Program. It is noted that these categorizations were focused on distinguishing cropland from other land uses, with less focus on specific subcategories for managed wetlands or other habitats. Areas of federal lands or state parks with managed habitats are shown in Figure 1-7. More information about groundwater dependent ecosystems can be found in Section 2.2.8.

Land use patterns in the Merced Subbasin are dominated by agricultural uses, including animal confinement (dairy and poultry), grazing, forage, row crops, vineyards, and nut and fruit trees. These uses rely heavily on purveyors/districts, private groundwater wells, and surface water sources in some areas. Urban land use relies on groundwater except for limited landscape applications. Land use is primarily controlled by local agencies. Land use patterns in the mountainous areas to the east are dominated by national forest and timber, recreation, tourism, and rangeland grazing of forested areas in the lower foothills.

Woodard & Curran

Figure 1-6: Land Use

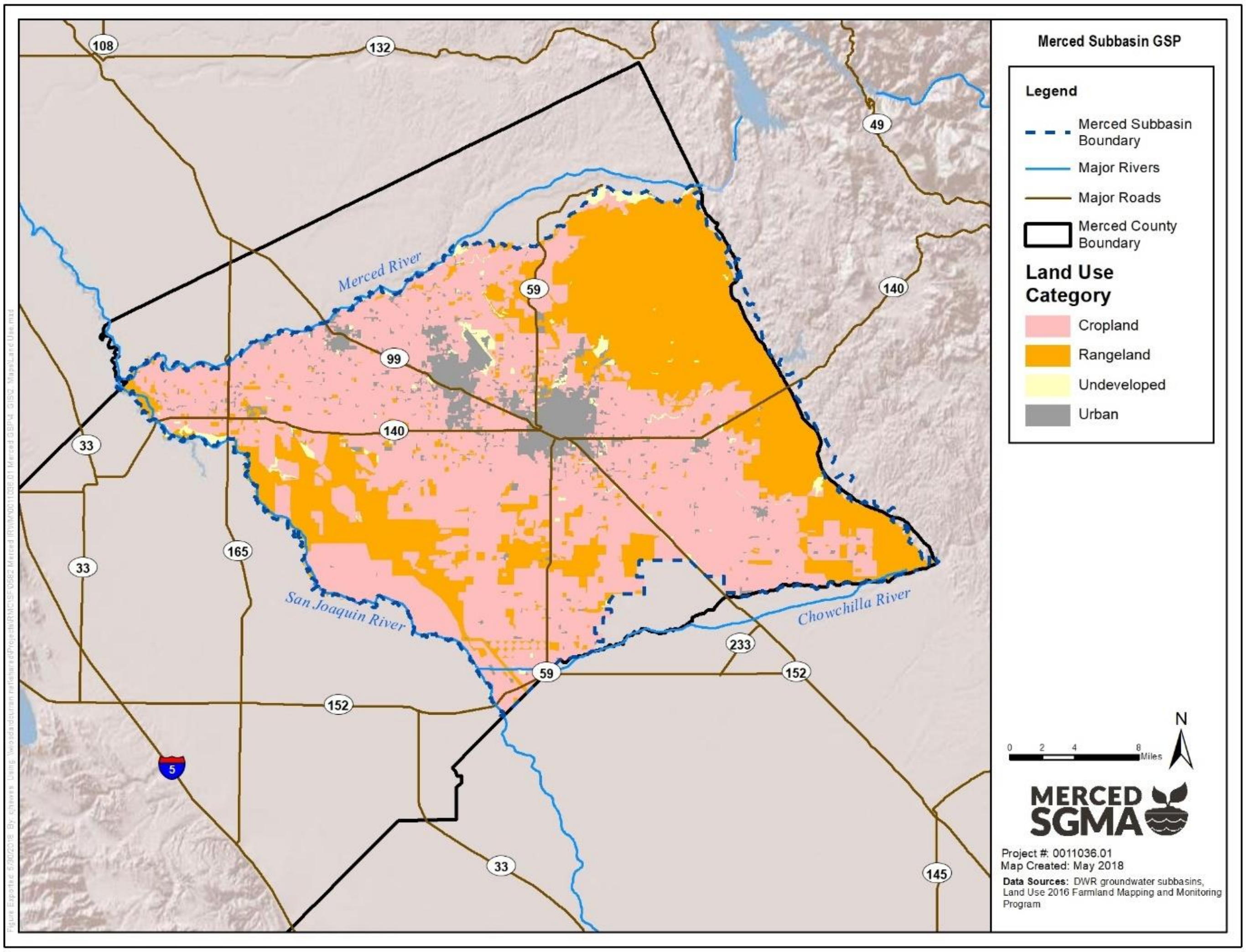


Figure 1-7 shows a map with boundaries of federal and state lands within the Merced Subbasin.

The US Fish & Wildlife Service (USFWS) has three properties at least partially within the Subbasin: San Luis National Wildlife Refuge (NWR), Merced NWR, and the Grasslands Wildlife Management Area (which is composed of several fee title and easement subgroups). All properties are part of the San Luis NWR Complex.

The San Luis NWR Complex uses both delivered surface water and pumped groundwater to manage wetlands throughout certain parts of each property. Across 2009-2016, the San Luis NWR used primarily surface water for management purposes, averaging 33,400 AFY of surface water and 728 AF of groundwater. Note that only a portion of the San Luis NWR is located within the Merced Subbasin. Across the same 2009-2016 period, at the Merced NWR, surface water diversions averaged 7,988 AFY while groundwater pumping averaged 8,689 AFY (noting that 2,500 AFY are used by a grazing cooperator). Note that the Merced NWR directly reports surface water and groundwater use to the GSAs as part of the GSP's ongoing Annual Report process.

California State Parks maintains two properties that have small portions of their total area within the Subbasin: Great Valley Grasslands State Park and McConnell State Recreation Area.

Figure 1-7: Boundaries of Federal and State Lands

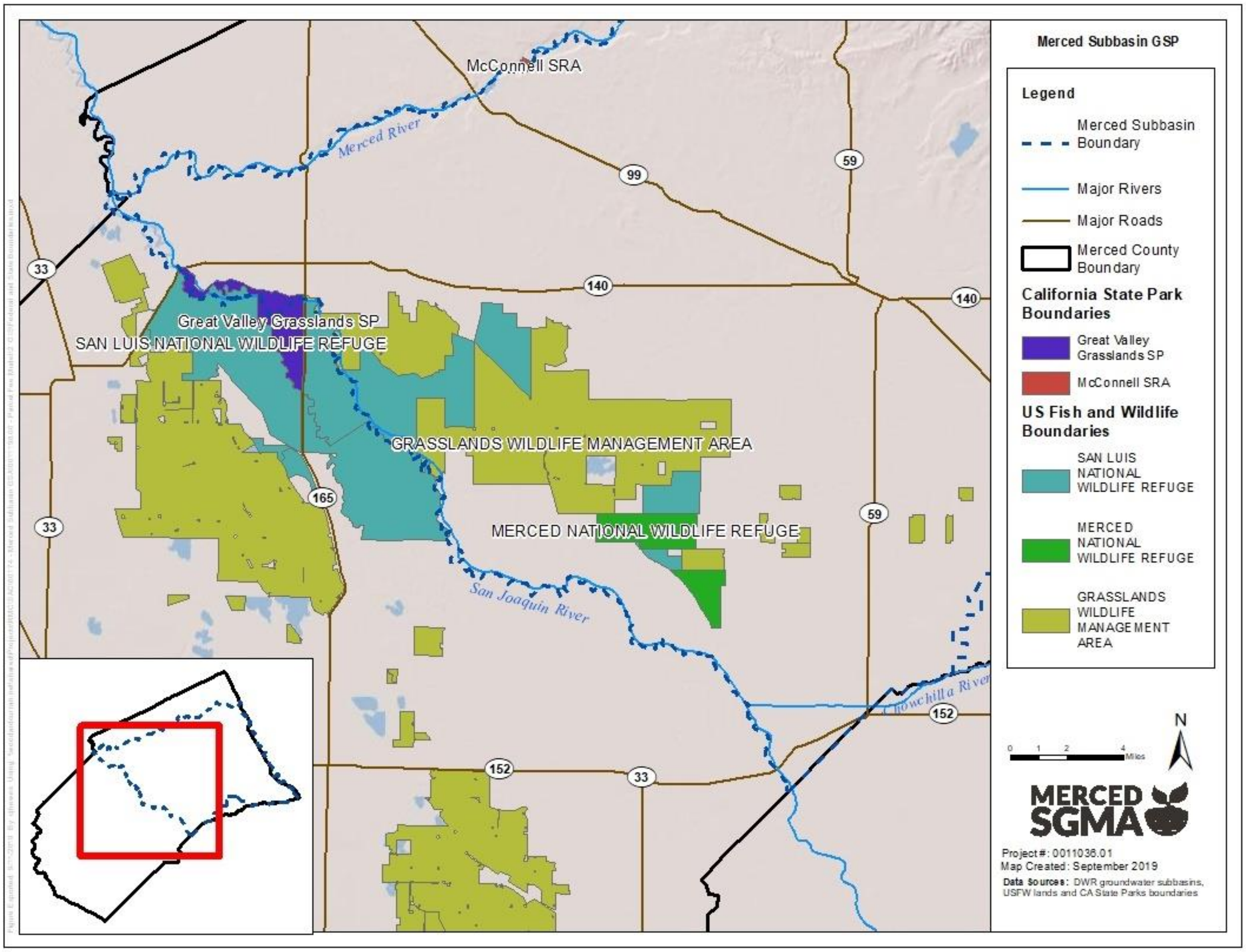


Figure 1-8 shows the density of non-domestic wells (primarily for irrigation and public water supply) per square mile in the Merced Subbasin. This includes 1,241 unique wells collected from Merced County's well permitting database that records wells permitted in the 1990s or later (last updated May 2024 for GSP analyses).

Figure 1-9 shows the density of domestic wells per square mile in the Merced Subbasin. This includes 3,298 active domestic wells from Merced County's electronic well database that records wells permitted in the 1990s or later (last updated May 2024 for GSP analyses).

In both figures below, city and unincorporated boundaries (from Figure 1-4) have been added for reference.

Figure 1-8: Density of Non-Domestic Wells per Square Mile

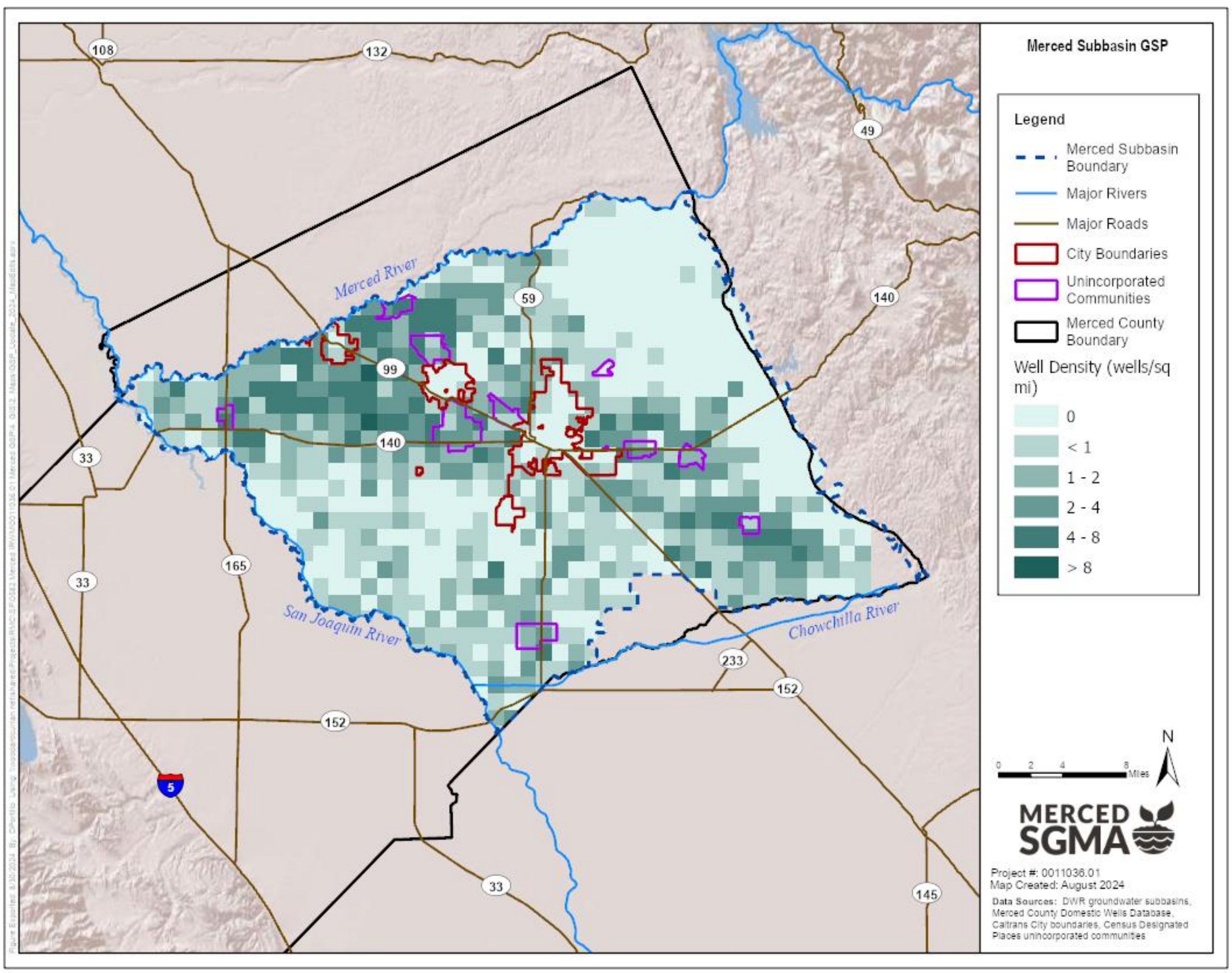
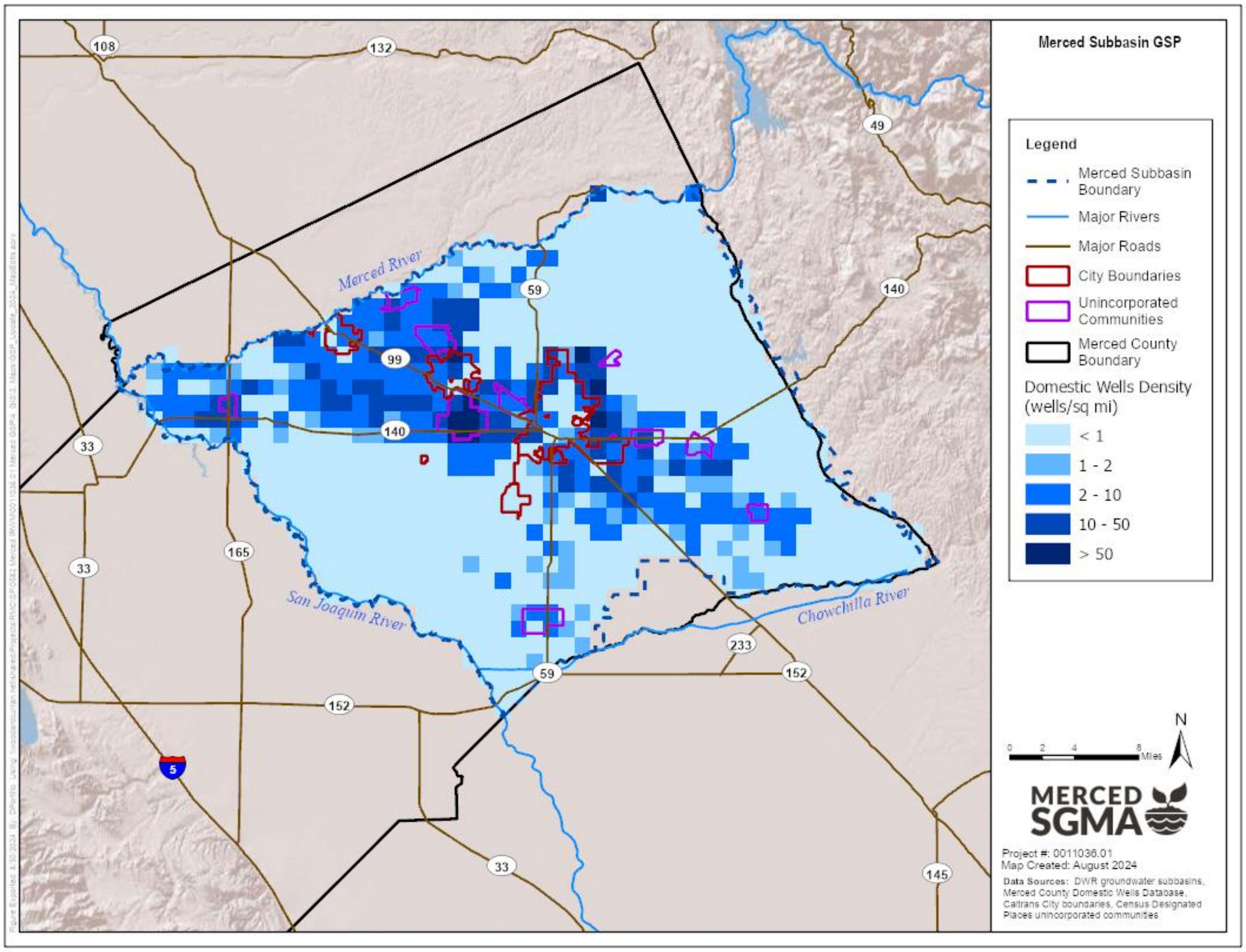


Figure 1-9: Density of Domestic Wells per Square Mile



1.2.2 Water Resources Monitoring and Management Programs

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

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

Statewide Monitoring Programs (Agencies and Databases):

- California Data Exchange Center (CDEC)
- California Department of Pesticide Regulation (CDPR)
- California Environmental Data Exchange Network (CEDEN)
- State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW)
- Department of Water Resources (DWR)
- SGMA Data Viewer
- Groundwater Ambient Monitoring and Assessment Program (GAMA)
- UNAVCO
- United States Bureau of Reclamation (USBR)
- United States Geological Survey (USGS)

Regional Monitoring Programs:

- Groundwater Quality Trend Monitoring Program (GQTMP) through SWRCB Irrigated Lands Regulatory Program (ILRP)
- San Joaquin River Restoration Program (SJRRP)

Local Monitoring Agencies

- City of Atwater
- City of Livingston
- Le Grand Community Service District (CSD)
- Meadowbrook Water Company
- McConnell Recreation Area
- Merced County Department of Public Health, Division of Environmental Health
- Merced Irrigation District (MID)
- San Luis National Wildlife Refuge (NWR) Complex
- Stevinson Water District (SWD)

1.2.2.1 Groundwater Level Monitoring

The subsections below describe various sources of groundwater level monitoring data. The count of wells and ranges of observation time periods have not been updated since the original 2020 GSP.

1.2.2.1.1 City of Livingston, Department of Public Works

The City of Livingston, Department of Public Works records depth to groundwater measurements for nine wells in their service area. Depth to groundwater readings were taken biannually from 1993 to 1994 and in 2002, and monthly from 2014 to 2017. There is a total of seven years of data for the nine wells.

1.2.2.1.2 SGMA Data Viewer

DWR's previous Groundwater Information Center Interactive Mapping Application was replaced by the SGMA Data Viewer. The SGMA Data Viewer is an interface that displays information about each SGMA sustainability indicator, as well as numerous other datasets relevant to groundwater budgeting and hydrogeologic conceptual models. Groundwater elevations are measured biannually, in the spring and fall, by local monitoring agencies as part of SGMA or the California Statewide Groundwater Elevation Monitoring Program (CASGEM) program.

1.2.2.1.3 Merced Area Groundwater Pool Interests

The Merced Area Groundwater Pool Interests (MAGPI) was formed in 1997 and is a consortium of 15 municipal and agricultural water purveyors, one Member at Large, and two interest groups within Merced County. On September 18, 2023, the consortium agreed to terminate the MOU that established MAGPI since the organization has effectively been replaced by the GSP (for monitoring network coordination and structure) and the GSAs (as coordinating monitoring entities).

While it was active, MAGPI selected wells from member agencies and developed a well network to form a representative groundwater profile of the Merced Subbasin. The cooperating agencies reported groundwater levels to MAGPI. As of approximately 2015, in total, the MAGPI monitoring network consists of 44 CASGEM wells and eight voluntary wells. Through the data request, monthly groundwater level data were received for 36 MAGPI wells for 1993 through 2014. The following specific wells from individual member agencies are reported to MAGPI:

- Black Rascal Water Company (2 wells, monthly groundwater levels from 2003-2015)
- City of Atwater – Department of Public Works (10 wells, monthly static groundwater levels)
- Le Grand CSD (3 wells, monthly static groundwater levels for 2013-2014)
- MID (310 wells, monthly static groundwater levels from 1993-2013)
- Planada CSD (5 wells, monthly static groundwater levels 2005-2015)
- Stevinson Water District (5 wells, monthly groundwater levels 1962-2008)
- Winton Water & Sanitary District (5 wells, monthly static groundwater levels 2005-2015)

1.2.2.1.4 San Luis National Wildlife Refuge Complex

The San Luis NWR Complex records groundwater elevation data for 25 wells in the Merced National Wildlife Refuge, typically only when well tests are performed by a contractor, which occurs less than once per decade on each well.

1.2.2.1.5 Merced County Department of Public Health, Division of Environmental Health

The Merced County Department of Public Health, Division of Environmental Health maintains data on 530 irrigation, domestic, and public water system wells in the Subbasin, each of which have at least one groundwater elevation measurement, but no available date.

1.2.2.2 Groundwater Quality Monitoring

Numerous agencies within Merced County collect or maintain groundwater quality data and are described in the sections below. The count of wells and ranges of observation time periods have not been updated since the original 2020 GSP.

1.2.2.2.1 State Agencies

1.2.2.2.1.1 DWR Water Data Library (WDL)

The WDL contains water quality data recorded at 211 unique monitoring wells within the Merced Subbasin, with sampling dates from 1946 through 1988. The majority of monitoring activity took place in the 1950s and 1960s, and most wells have one to two days of sampling results, as wells are not regularly sampled. The most frequently sampled parameters (more than 1,000 sample results) are dissolved chloride, sodium, calcium, boron, magnesium, and sulfate as well as conductance, pH, and total alkalinity and hardness. Nutrients, metals, and total dissolved solids (TDS) were also sampled but have fewer sample results available.

1.2.2.2.1.2 California Department of Pesticide Regulations

The CDPR maintains a well inventory database containing data from wells sampled for pesticides by a variety of agencies, including the California Department of Public Health (prior to reporting being taken over by the SWRCB), CDPR, DWR, USGS, and SWRCB DDW. These agencies monitor a variety of wells, including monitoring, domestic, large and small water systems, irrigation, and community wells for 35 different pesticides and report measurements to the CDPR. Exact locations are not known, but based on estimation of coordinates via county, township, range, and section, there are 951 wells monitored within the Merced Subbasin with groundwater quality measurements on pesticides, such as DBCP and xylene, sampled between 1979 and 2015.

1.2.2.2.1.3 Groundwater Ambient Monitoring and Assessment Program (GAMA)

Established in 2000, the GAMA Program monitors groundwater quality throughout California. GAMA is intended to create a comprehensive groundwater monitoring program throughout the state and increase public availability and access to groundwater quality and contamination information. Agencies submit data from monitoring wells for 244 constituents including TDS, nitrates and nitrites, arsenic, and manganese. GAMA data for the Merced Subbasin contains wells monitored by the DDW, CDPR, environmental monitoring wells monitored by regulated facilities, and USGS, with sampling performed from 1930 through 2016. Most wells have one or two days with sampling results because wells are not regularly sampled. Agencies submitting data to GAMA are summarized below.

Division of Drinking Water

The SWRCB DDW monitors public water system wells for Title 22 requirements (such as organic and inorganic compounds, metals, microbial, and radiological analytes). Data are available for active and inactive drinking water sources for water systems that serve the public –defined as serving 15 or more connections or more than 25 people per day. Data are electronically transferred from certified laboratories to the DDW daily. Wells are monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate. In the Merced Subbasin, DDW reported groundwater quality data for 177 wells from 1984 through 2016.

California Department of Pesticide Regulations

CDPR is described above. CDPR reports data to GAMA. Unlike data reported directly from CDPR, GAMA provides latitude and longitude coordinates for CDPR wells**.** In the Merced Subbasin, CDPR reported groundwater quality measurements for 170 wells with water quality data from 1981 through 2012. CDPR only monitors for pesticides and therefore does not have results on water quality constituents such as nitrates and TDS.

DWR

DWR's groundwater quality data are incorporated from the WDL, described earlier in this section.

Environmental Monitoring Wells

Environmental monitoring wells are monitored by facilities that in many cases have identified contamination but may not necessarily require an investigation and cleanup (i.e., monitoring through GeoTracker described below). Environmental monitoring wells that fall under the GAMA program typically include municipal water purveyors or small water supply systems. 355 wells were identified in the GAMA data download with water quality measurements taken from 2000 through 2016. Contaminated sites often have concentrations of constituents that are not indicative of regional groundwater quality, so environmental monitoring wells may often be excluded from water quality analysis. However, these wells and associated data may have utility in SGMA analysis related to the presence and impact of point-source contamination.

United States Geological Survey

USGS data within the GAMA database reports groundwater quality data for 173 wells within the Merced Subbasin, monitored from 1950 through 2012.

1.2.2.2.1.4 GeoTracker

GeoTracker, operated by the SWRCB, is a subset program of the GAMA program. GeoTracker GAMA does not regularly monitor for general groundwater quality constituents. GeoTracker contains records for sites that require cleanup, such as leaking underground storage tank sites, Department of Defense sites, and cleanup program sites. GeoTracker also contains records for various unregulated projects as well as permitted facilities including: Irrigated Lands Regulatory Program, oil and gas production, operating permitted underground storage tanks, and land disposal sites. GeoTracker receives records and data from SWRCB programs and other monitoring agencies. 669 are sites within Merced County, with increased density near cities such as Merced, Atwater, Livingston, Gustine, Los Banos, and Dos Palos. Of the 669 sites identified in Merced County, 80 are listed as active or open.

1.2.2.2.2 Regional Monitoring

1.2.2.2.2.1 Merced County Department of Public Health, Division of Environmental Health

Merced County Department of Public Health, Division of Environmental Health monitors 60 domestic wells in Merced County for chloride. Additionally, it has monitored nine domestic wells within the Merced Subbasin for general minerals, inorganics, dibromochloropropane (DBCP), and ethylene dibromide (EDB) since 1988 (AMEC, 2008).

1.2.2.2.2.2 Irrigated Lands Regulatory Program

The RWQCB initiated the Irrigated Lands Program in 2003, later renamed to the Irrigated Lands Regulatory Program, to regulate discharge from irrigated agriculture to surface waters and groundwater. The program monitors for a variety of pollutants found in runoff from irrigated lands, including pesticides, fertilizers, pathogens, salts, and sediment. Groundwater is required to be sampled biannually.

The Eastern San Joaquin Water Quality Coalition (ESJWQC) represents the region with waste discharge orders. ESJWQC monitors the Turlock, Merced, and Chowchilla groundwater subbasins. The ESJWQC submitted a Groundwater Quality Assessment Report (GAR) in 2015. The GAR characterizes past and present groundwater quality (nitrates, salinity, TDS, and pesticides) and the impact of irrigated agricultural practices on groundwater quality.

1.2.2.3 Land Subsidence Monitoring

In the Merced Subbasin, subsidence monitoring is performed using continuous global positioning system (GPS) stations monitored by UNAVCO's Plate Boundary Observatory (PBO) program as well as static GPS points from the USBR's SJRRP. There are no known extensometers in the Merced Subbasin. The count of monitoring sites and ranges of observation time periods have not been updated since the original 2020 GSP.

1.2.2.3.1 UNAVCO's Plate Boundary Observatory Program

The UNAVCO PBO network consists of a network of about 1,100 continuous global positioning system (CGPS) and meteorology stations in the western United States to measure deformation resulting from the constant motion of the Pacific and North American tectonic plates in the western United States. Information from this monitoring can support monitoring of land subsidence resulting from extraction of groundwater. There are two CGPS stations within Merced County but not within the Merced Subbasin: P303, near the City of Los Banos, and P252, near the City of Gustine. Both station P303 and P252 have subsidence data from 2005 to present (2017).

1.2.2.3.2 United States Bureau of Reclamation

The most comprehensive subsidence monitoring within Merced County comes from USBR's SJRRP. USBR has been surveying 85 static GPS points across the San Joaquin Valley biannually, in July and December of each year, to monitor ongoing subsidence since 2011. The Merced Subbasin contains 11 of the total 85 static GPS points, with an additional 9 points within Merced County and 31 additional GPS points located within 20 miles of the county boundary, primarily to the south.

1.2.2.3.3 United States Geological Survey

There are no known extensometers monitored by the USGS within Merced County. However, there are three USGS cable extensometers directly south of the county, with the closest extensometer approximately 3 miles southwest of the city of Dos Palos (the other two extensometers are 13 and 15 miles south of Dos Palos). The three extensometers have recorded data since 1958, 1961, and 1964, with periodic gaps in the data (i.e., most monitoring occurred in the 1960s through 1990s with a lapse in data until the early 2000s). Only the two farthest extensometers are currently monitoring subsidence, the third extensometer that is closer to the county boundary has been offline since a cable broke in 2012 (USGS, 2017).

1.2.2.3.4 InSAR

Additional land subsidence monitoring derived from Interferometric Synthetic Aperture Radar (InSAR) satellite data was collected by DWR and provided to GSAs for GSP development and implementation. InSAR measures vertical ground surface displacement changes at high degrees of measurement resolution and spatial detail (DWR, 2024). InSAR data coverage began in late

2014. The InSAR dataset includes point data that represent average vertical displacement values for 100 meter by 100 meter areas, as well as total vertical displacement relative to June 13, 2015 and annual vertical displacement rates in monthly time steps. InSAR data has been compared to available ground based continuous global position systems and found to be within 18 mm vertical accuracy at 95% confidence level.

1.2.2.4 Surface Water

The subsections below describe various sources of surface water monitoring data. The count of monitoring sites and ranges of observation time periods have not been updated since the original 2020 GSP.

1.2.2.4.1 Streamflow Monitoring Data

Streamflow monitoring data in the Merced Subbasin is available on the following waterbodies:

- Merced River
- San Joaquin River
- Bear Creek

Figure 4-8 in Chapter 4 (Monitoring Networks) shows a map of the streamflow gauging stations described in the sections below.

1.2.2.4.1.1 Department of Water Resources

DWR has a total of seven river discharge monitoring stations located in or along the border of the Merced Subbasin; four are co-operated with DWR's South Central Region Office (SCRO) and one station is co-operated with DWR's Flood Management Agency. Of the seven sites operated by DWR, SCRO, and Flood Management, two are located along the Merced River, one is located along Bear Creek, and four are located along the San Joaquin River. DWR monitors river stage (feet) and river discharge (cubic feet per second [cfs]) hourly. The oldest available data record is from 1984, but most stations went online in 1997 and have been monitoring since.

1.2.2.4.1.2 Merced Irrigation District

MID has three stream gages on the Merced River (one jointly operated with the USGS). Available data from MID monitoring of Merced River water diversions and flow extends back to 1998. Two monitoring stations monitor surface water diversions from dams to canals; one at the Merced Falls Dam into the Northside Canal and the second at the Crocker-Huffman Diversion Dam into the Main Canal. The third Merced River monitoring station monitors streamflow at the Shaffer Bridge.

1.2.2.4.1.3 United States Army Corps of Engineers

The United States Army Corps of Engineers (USACE) has two streamflow gages on Bear Creek, one at the Bear Creek Dam and Reservoir and the other on Bear Creek at McKee Road. The USACE has hourly data records on the inflow and outflow (cfs) to the Bear Creek Reservoir and streamflow (cfs) for Bear Creek at McKee Road, in addition to Bear Creek Reservoir storage (acre-feet [AF]), for water years 1995 through 2017.

1.2.2.4.1.4 United States Geological Survey

Within the Subbasin, the USGS operates three streamflow gages on the San Joaquin River and two on the Merced River. Rivers are monitored at 15- to 60-minute intervals for streamflow (cfs), gage height (feet), and change in gage height (feet). The oldest stream gage (#11270900) has 115 years of data (from 1901 through 2016) of daily streamflow and gage height changes. The other four gages in the Subbasin have a range from 105 years of data (#1127400, installed in 1912) to two years of data (#11260815, installed in 2014).

1.2.2.4.2 Surface Water Diversion

The following agencies divert surface water and record their diversions:

- Merquin County Water District
- Stevinson Water District
- Merced Irrigation District
- San Luis National Wildlife Refuge Complex (which includes the Merced National Wildlife Refuge)
- Turner Island Water District

1.2.2.5 Canal Diversions and Seepage

MID performed a study from 2010 through 2015 to monitor seepage and established that canal seepage is one of the main components of groundwater recharge in the Subbasin. Seepage and deep percolation from applied water on grower's fields varied between 133,000 AF and 313,000 AF between 2010 and 2015 (MID, 2016). Canal seepage alone contributed between 21,454 AF and 181,107 AF from 2010 through 2015 (MID, 2016). Results from this study helped characterize the seasonality and location of seepage, finding that seepage rates increase during low precipitation years and that about half of all seepage occurs in the utilized portions of creeks, sloughs and drains, as well as regulating reservoirs and off-channel inundated areas (MID, 2016).

Currently, MID does not monitor for water quality in the canals. In 2016, MID designated certain canals for water supply conveyance to future surface water treatment plants in Merced, Atwater, and Livingston, once the groundwater basin reaches a certain threshold for water quality and groundwater levels (MID, 2016).

1.2.2.6 Existing Water Management Programs

The subsections below contain descriptions of the Integrated Regional Water Management Plan, Agricultural Water Management Plan, and Urban Water Management Plans that apply to the Merced Subbasin.

1.2.2.6.1 Integrated Regional Water Management Plan

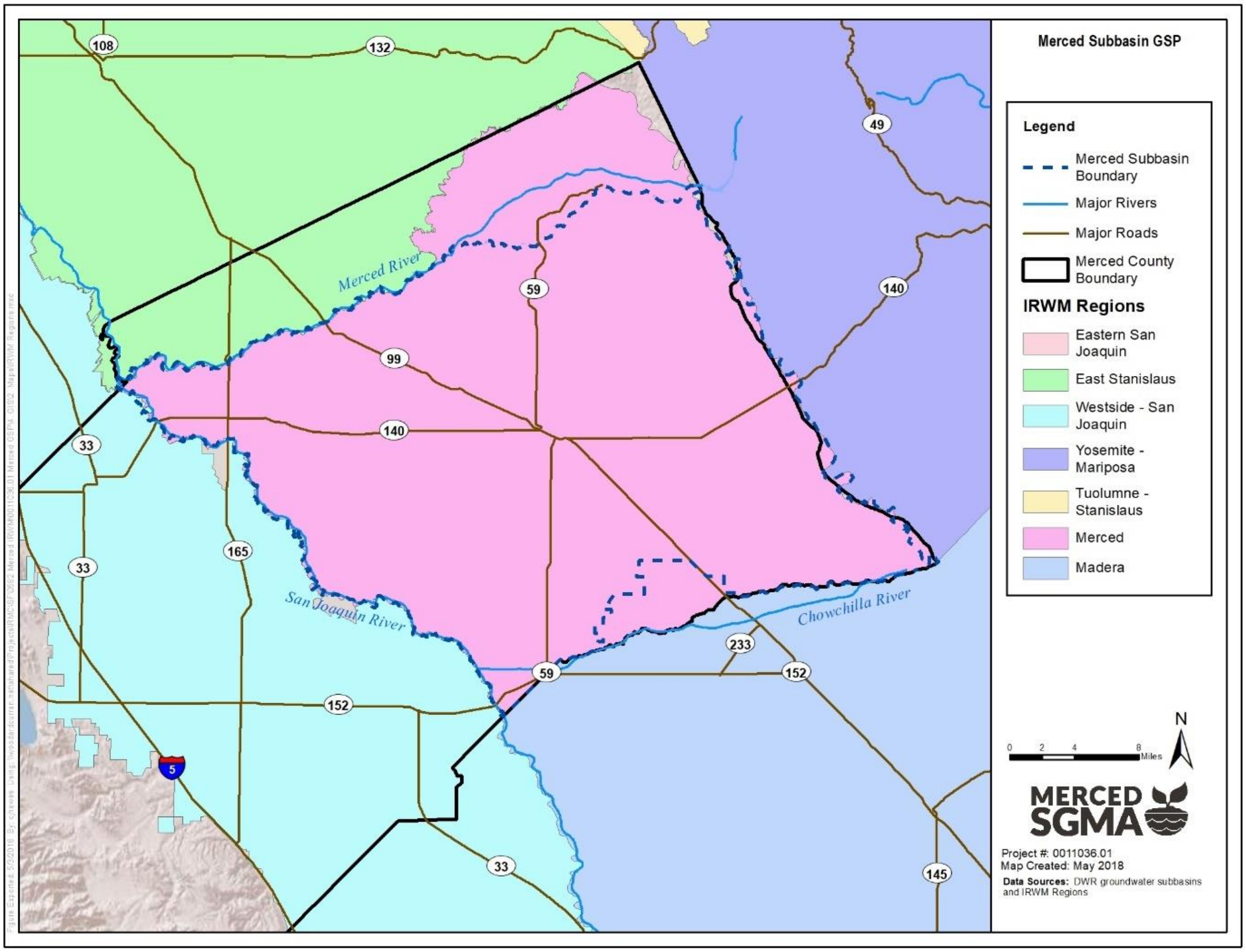
The Merced Integrated Regional Water Management Plan (Merced IRWMP) is a collaborative regional planning document that was published in August 2013 and later updated in 2018. The IRWMP covers a geographic region that includes the entirety of the Merced Subbasin, and also portions of the Turlock Subbasin to the north and Chowchilla Subbasin to the south. The IRWMP boundaries are generally defined by the eastern boundary of the Merced and Turlock Groundwater Subbasins to the east, the San Joaquin River to the west, the northern boundary of the Dry Creek watershed to the north, and the Chowchilla River to the south. Low-lying areas north of the Merced River between the river's confluences with Dry Creek and the San Joaquin River are also included (Woodard & Curran, 2019) .

The following 2018 IRWMP objectives related to groundwater use would potentially influence implementation of the GSP:

- Correct groundwater overdraft conditions
- Manage flood flows and stormwater runoff (including those caused by climate change) for public safety, water supply, recharge, and natural resource management
- Meet demands for all uses, including agriculture, urban, and environmental resource needs
- Protect and improve water quality for all beneficial uses, consistent with the Basin Plan
- Address water-related needs of disadvantaged communities (DACs)

The 2018 IRWMP provides valuable resources related to potential concepts, projects, and monitoring strategies that are leveraged in this Merced GSP. See Figure 1-10 for a map of the Merced IRWM Region.

Figure 1-10: Merced IRWM Region Setting



1.2.2.6.2 Agricultural Water Management Plan

The Agricultural Water Management Plan (AWMP) was last developed and adopted by MID in 2021 in compliance with SB X7-7 of 2009 which required certain agricultural water suppliers to prepare an AWMP and implement Efficient Water Management Practices (EWMPs) (MID, 2021). The Critical EWMPs include:

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

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

- Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage
- Facilitate use of available recycled water
- Facilitate financing of capital improvements for on-farm irrigation systems
- Implement an incentive pricing structure that promotes one or more of the goals identified in the CWC
- Expand line or pipe distribution systems, and construct regulating reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage
- Increase flexibility in water ordering by, and delivery to, water customers within operational limits
- Construct and operate supplier spill and tailwater recovery systems
- Increase planned conjunctive use of surface water and groundwater within the supplier service area
- Automate canal control structures
- Facilitate or promote customer pump testing and evaluation
- Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report
- Provide for the availability of water management services to water users
- Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage
- Evaluate and improve the efficiencies of the supplier's pumps

The 2021 AWMP provides a framework of management practices to help meet water management goals that align with the goals of the Merced GSP.

1.2.2.6.3 City of Merced Urban Water Management Plan

The City of Merced 2020 Urban Water Management Plan (UWMP) was developed according to requirements of the CWC (City of Merced, 2021). The city's water supply used within the service area is entirely from groundwater in the Merced Subbasin (20,076 AF in 2020. Year 2040 projections of water supplies include exchanges and transfers with MID, but groundwater remains the top source of water supply. Total water demands are expected to increase from 20,076 AF per year (AFY) in 2020 to 31,825 AFY in 2040. Long-term demand projections made in 2020 are 6,000 – 7,000 AFY lower than projected in the prior 2015 UWMP.

The City of Merced uses the following actions to encourage conservation and efficient use of water:

- Water Waste Prohibition Ordinance
- Fully metered distribution system
- Tiered water rates
- Public education and outreach efforts
- Programs to assess and manage distribution system real loss
- Free residential plumbing retrofit devices
- Washing Machine Rebate program
- Turf replacement initiative (offered previously)

1.2.2.6.4 City of Livingston Urban Water Management Plan

The City of Livingston 2020 UWMP was developed according to requirements of the CWC (City of Livingston, 2022). The city's water supply comes entirely from the Merced Subbasin and is expected to remain the sole source of water through 2040. Total water demands are expected to increase from 8,530 AFY in 2015 to 13,660 AFY in 2040.

The City of Livingston uses the following actions to encourage conservation and efficient use of water:

- Water shortage contingency plan
- Majority of distribution system is metered
- Excess water use is billed at a variable rate
- Public education and outreach efforts

1.2.3 Land Use Elements or Topic Categories of Applicable General Plans

1.2.3.1 Existing General Plans

The Merced Subbasin is located almost entirely within Merced County, which has jurisdiction over land use planning for the majority of the surface area of the Subbasin. The incorporated cities of

Merced, Atwater, and Livingston make up the remaining area. Implementation of the Merced GSP will be affected by the policies and regulations outlined in the Merced County General Plan, as well as the General Plans for the other three cities, given that the long-term land use planning decisions that would affect the Subbasin are under the jurisdiction of the county and respective cities.

This section describes how implementation of the various General Plans may change water demands in the basin, how the General Plans may influence the GSP's ability to achieve sustainable groundwater use, and how the GSP may affect implementation of General Plan land use policies.

1.2.3.1.1 Merced County General Plan

The Merced County General Plan describes the official County "blueprint" on the location of future land use, development preservation, and resource conservation decisions. It's five guiding principles encompass the core issues facing the community: support and protection of agriculture, expansion and diversification of economic development, protection of environmental quality, support of all essential public facilities and services, and coordination of transportation networks (Merced County, 2013).

1.2.3.1.1.1 Relevant Merced County General Plan Goals and Policies

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

- Goal LU-2: Preserve, promote, and expand the agricultural industry in Merced County.
- Policy LU-2.5: Agricultural Support Facilities (RDR/JP): Allow consideration of locating characteristically-specific commercial and industrial uses in rural areas in limited cases based on the unique nature of the use and for health and safety reasons, which require location on large parcels or in sparsely populated areas. In addition, consider the following criteria during the Conditional Use Permit review process:
    - h) The use shall not have a detrimental effect on surface or groundwater resources
- Policy LU-4.4: Efficient Development (RDR): 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.F.1: New Urban Community Size and Location Requirements (RDR): 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:
    - b) Contain few wetlands or significant natural resources;

  - g) 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 (RDR): Prohibit new Urban Communities, or the expansion of existing urban communities, if they will negatively impact the water supply of existing users.

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

- Goal AG-2: Ensure the long-term preservation and conservation of land used for productive agriculture, potentially-productive agricultural land, and agricultural-support facilities.
  - Note that the term "productive agriculture" is defined as: "farmland that has received water supplies in three of the prior 10 years and is classified as Prime Farmland, Farmland of Statewide Importance, or Unique Farmland on the Statewide Important Farmland map." (Merced County, 2013)

The following Merced County General Plan Water Element goals and policies related to groundwater use would potentially influence implementation of the GSP:

- 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 (MPSP/IGC): 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-1.3: Agricultural Water Study (MPSP/IGC): 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 (RDR): 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 (RDR/IGC): Coordinate with the cities and special districts in developing County-wide guidelines regarding the location and construction of new water wells.

- Policy W-1.7: Water Sufficiency Requirement (RDR): Require new developments to prepare a detailed source water sufficiency study and water supply assessment per Title 22 and SB 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 (IGC): Encourage consolidation of single user wells into local water districts (with management plans) where feasible.
- Policy W-1.10: Groundwater Overdraft Protection (RDR/MPSP): 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.
- Goal W-2: Protect the quality of surface and groundwater resources to meet the needs of all users.
- Policy W-2.1: Water Resource Protection (RDR): 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 (RDR): 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 (RDR/MPSP): 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 (JP): 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 (RDR): 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 (MPSP): 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-2.8: Water Contamination Protection (RDR/MPSP): Coordinate with the State Water Resources Control Board, Regional Water Quality Control Board, and other

responsible agencies to ensure that sources of water contamination (including boron, salt, selenium and other trace element concentrations) do not enter agricultural or domestic water supplies and will be reduced where water quality is already affected.

- Policy W-3.1: Water Availability and Conservation (SO/PI): Support efforts of water agencies and districts to prevent the depletion of groundwater resources and promote the conservation and reuse of water.
- Policy W-3.2: Landscape Water Efficiency (SO/PI): Ensure the conservation of water in urban areas through the implementation of the State Model Water Efficient Landscape Ordinance as implemented in Section 18.38 (Landscaping Standards) of the County Zoning Ordinance.
- Policy W-3.4: High Water Use Processing Activities (RDR): 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-3.13: Agricultural Water Reuse (RDR): Promote and facilitate using reclaimed wastewater for agricultural irrigation, in accordance with Title 22 and guidelines published by the State Department of Public Health.
- Policy W-3.14: Agricultural Water Conservation (JP): Encourage farmers to use irrigation methods which conserve water in areas where flood irrigation is used for groundwater recharge.
- Policy W-3.15: Agricultural Water Efficiency (IGC): Coordinate with the Farm Bureau and agricultural irrigation districts to promote protection of water resources in agricultural areas by encouraging programs that assist producers to use water efficiently in agricultural operations and by promoting technology for efficient water use in agriculture.
- Goal W-4: Enhance and protect County watersheds through responsible water and land use management practices that address water bodies, open spaces, soils, recreation, habitat, vegetation, groundwater recharge, and development.
- Policy W-4.1: Water Resource Protection and Replenishment (RDR/MPSP/IGC): Protect watersheds, aquifer recharge areas, and areas susceptible to ground and surface water contamination by identifying such areas, and implementing requirements for their protection such as:
    - a) Implement zoning and development regulations to protect water resources, including aquifer recharge areas and areas susceptible to ground and surface water contamination;

- b) For new development, and when adopting new Community Plans, require community drainage systems that incorporate on-site infiltration and contaminant control measures that are compatible with the County SWMP and NPDES regulations for post-construction runoff conditions; and
- c) Cooperate with other agencies and entities with responsibilities for water quality and watershed protection.

- Goal W-5: Promote interagency communication and cooperation between local governments, irrigation districts, and water districts in order to optimize use of resources and provide the highest level of dependable and affordable service, while respecting individual entities water rights and interests.
- Policy W-5.1: Countywide Water Supply Study (RDR/MPSP/PSR): 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.
- Policy W-5.2: Master Plan Development (IGC): Coordinate with all agricultural and urban water districts to develop water supply master plans to guide future groundwater basin water supplies through regional solutions.
- Policy W-5.3: Water Forum (IGC/FB): Support a county-wide water forum to coordinate long-term water demand and supply programs that emphasize sustainability in the County consistent with approved IRWMPs.

1.2.3.1.1.2 Merced County General Plan's Influence on Water Demand and Groundwater Sustainability Plan

The General Plan explicitly encourages preservation of the county's groundwater resources, and states that future urban and agricultural growth should be accommodated only while ensuring that this growth occurs within the sustainable capacity of these resources. Due to the complementary nature of the General Plan and the GSP, implementation of the GSP is anticipated to be consistent with the General Plan's goals and policies.

1.2.3.1.1.3 Groundwater Sustainability Plan's Influence on Merced County General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Merced Subbasin's groundwater supply is managed in a sustainable manner. Given the amount of population growth projected in the county in the coming years, it is possible that changes in groundwater management by the GSP will impact the location and type of development that will occur in the Subbasin in the future.

It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the county.

1.2.3.1.2 City of Merced General Plan

The City of Merced General Plan describes the City's 2030 vision and provides guidance for the growth needed to achieve it (City of Merced Development Services Department, 2011). The General Plan for 2030 vision was built upon the Merced Vision 2015 General Plan (adopted 1997) and was developed through a series of public forums, stakeholder and property owner meetings, and joint City Council/Planning Commission study sessions to solicit input from citizens, property owners, and decision makers.

1.2.3.1.2.1 Relevant City of Merced General Plan Goals and Policies

The following City of Merced General Plan goals and policies related to groundwater use would potentially influence implementation of the GSP:

- Policy P-3.1: Ensure that adequate water supply can be provided within the City's service area, concurrent with service expansion and population growth.
- Policy P-3.2: In cooperation with the County and the Merced Irrigation District, work to stabilize the region's aquifer.

1.2.3.1.2.2 City of Merced General Plan's Influence on Water Demand and Groundwater Sustainability Plan

The General Plan supports the efforts of the MAGPI (now dissolved, see Section 1.2.2.1.3) in preservation of groundwater resources and recognizes that groundwater recharge is critical to supporting the city's future growth (City of Merced Development Services Department, 2011). Due to the complementary nature of the General Plan and the GSP, implementation of the GSP is anticipated to be consistent with the General Plan's goals and policies.

1.2.3.1.2.3 Groundwater Sustainability Plan's Influence on City of Merced General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Merced Subbasin's groundwater supply is managed in a sustainable manner. Given the amount of population growth projected in the city in the coming years, it is possible that changes in groundwater management by the GSP will impact the location and type of development that will occur in the city in the future. It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the city.

1.2.3.1.3 City of Atwater General Plan

The City of Atwater General Plan was published in 2000 and is a guide for community growth and development (Pacific Municipal Consultants, 2000). This update of the General Plan was assisted by an 18-member Technical Work Group composed of representatives from various city departments, and other local public agencies. Core group input was augmented by representatives from local school districts, businesses, and community organizations. As of 2024, the City of Atwater is developing a General Plan Update.

1.2.3.1.3.1 Relevant City of Atwater General Plan Goals and Policies

The following City of Atwater General Plan goals and policies related to groundwater use would potentially influence implementation of the GSP:

- Goal CO-1: Support efforts to monitor and remediate existing groundwater contamination within the planning area.
- Goal CO-2: Prevent the creation of new groundwater contamination or the spread of existing contamination.

1.2.3.1.3.2 City of Atwater General Plan's Influence on Water Demand and Groundwater Sustainability Plan

The General Plan focuses on groundwater contamination in the form of nitrates, pesticides (mainly dibromochloropropane), and other contaminants as a result of past operations at the former Castle Air Force Base (Pacific Municipal Consultants, 2000). Groundwater overdraft is not mentioned as an issue within this General Plan, likely due to being published in 2000, prior to more recent drought and overdraft issues. Implementation of the GSP is anticipated to be consistent with the General Plan's goals and policies related to groundwater quality monitoring.

1.2.3.1.3.3 Groundwater Sustainability Plan's Influence on City of Atwater General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Merced Subbasin's groundwater supply is managed in a sustainable manner. While population estimates are nearly two decades old, expected ongoing growth in the city means that it is possible that changes in groundwater management by the GSP will impact the location and type of development that will occur in the Subbasin in the future. It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the county. It is also likely that the GSP will influence groundwater quality monitoring and remediation described in the 2000 General Plan.

1.2.3.1.4 City of Livingston General Plan

The City of Livingston General Plan was updated and published in 1999 and is a long-term, comprehensive framework to guide physical, social, and economic development within the community (Quad Knopf, Inc., 1999). The 1999 General Plan update was developed by a General Plan consultant who worked with city staff and a General Plan Review Committee, with input from meetings with local service clubs, a workshop, and four town hall meetings. Key Issues of importance that guided policies for the General Plan were identified in these sessions and include agricultural preservation, contiguous planning, payment for expansion of public facilities by new development, and neighborhood development. As of 2024, the City of Livingston is working on developing a 2040 General Plan.

1.2.3.1.5 Relevant City of Livingston General Plan Goals and Policies

The following City of Livingston General Plan goals and policies related to groundwater use would potentially influence implementation of the GSP:

- Objective 5.2 (A): Protect natural resources including groundwater, soils, and air quality, to meet the needs of present and future generations.
- Policy 5.2 (1): Protect areas of natural groundwater recharge from land uses and disposal method[s] which would degrade groundwater quality. Promote activities, which combine stormwater control, and water recharges.
- Policy 5.2 (2): Expand programs that enhance groundwater recharge in order to maintain the groundwater supply, including the installation of detention ponds in new growth areas.
- Policy 9.1 (16): To encourage groundwater recharge, ponding basins shall be designed as detention basins. However, pumping facilities shall be included in such facilities to handle peak flows and to provide for disposal of storm water into irrigation ditches when necessary. Stormwater inflow into irrigation district canals and pipelines shall be subject to existing or future agreements by and between the City and the irrigation districts specifying maximum inflow, maximum service area boundary, and any other limitation thereto.
- Policy 9.1 (22): The City of Livingston shall cooperate with local water agencies to identify and resolve long-term water supply issues.

1.2.3.1.6 City of Livingston General Plan's Influence on Water Demand and Groundwater Sustainability Plan

The General Plan supports the efforts of preservation of groundwater supply and quality (Quad Knopf, Inc., 1999). Due to the complementary nature of the General Plan and the GSP, implementation of the GSP is anticipated to be consistent with the General Plan's goals and policies.

1.2.3.1.7 Groundwater Sustainability Plan's Influence on City of Livingston General Plan's Goals and Policies

Successful implementation of the GSP will help to ensure that the Merced Subbasin's groundwater supply is managed in a sustainable manner. While population estimates are nearly two decades old, expected ongoing growth in the city means that it is possible that changes in groundwater management by the GSP will impact the location and type of development that will occur in the Subbasin in the future. It is anticipated that GSP implementation will reinforce the General Plan's goals related to sustainable land use development in the county.

1.2.3.2 Land Use Plans Outside the Subbasin

Land use planning in the portions of the Turlock and Delta-Mendota Subbasins that are adjacent to the Merced Subbasin are located within Merced County and are thus covered by the Merced County General Plan described in Section 1.2.3.1.

A small portion of the Chowchilla Subbasin is located within Merced County, but most of the adjacent portions are located within Madera County. The Madera County General Plan is a major guiding document for land use development adjacent to the southern portion of the Merced Subbasin. It was last updated in 1995, with 17 amendments through 2015. A notable amendment in 2004 included the resolution that "The County shall implement policies and procedures stated in the County adopted "AB3030 Groundwater Management Plan" for the Chowchilla, Delta-Mendota, and Madera Basins" (Madera County, 1995).

Land use decisions in neighboring areas experiencing subsidence and overdraft are likely to effect groundwater conditions in the Merced Subbasin.

Surface water users (Merquin County Water District, Stevinson Water District, Merced Irrigation District, and San Luis National Wildlife Refuge Complex) are more likely to be impacted by land use change outside of the Subbasin, which might affect San Joaquin River or Merced River flows.

1.2.3.3 Well Permitting

In 2015, Merced County implemented a new well permitting program for any new, replacement, back-up, and De Minimis well construction. The permit program is enforced by County Municipal Code Chapter 9.27 (Groundwater Mining and Export) and 9.28 (Wells). Applicants must provide information about groundwater elevation estimates, land elevation estimates, land subsidence rate estimates, depth to Corcoran Clay, and other basic well characteristics (Merced County, 2015). In 2022, Merced County amended Municipal Code Chapter 9.27 to include a permit requirement for Groundwater Sustainability Agencies to provide a determination that the impacts of a proposed new or replacement well are consistent with the respective Groundwater Sustainability Plan. Under County Municipal Code Chapter 9.27 groundwater cannot be "exported", meaning used outside of the same basin from which it is extracted, without an exemption claim.

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

The City of Merced also enforces water well standards through Chapter 8.12 (Water Wells) in the City Code of Ordinances, under legal authority granted under CWC, Section 13801, for "Special Ground Water Protection" to minimize impacts and prevent the migration of harmful chemicals into aquifers used by the city (City of Merced, n.d.). The standards apply to all new and existing water wells, monitoring wells, cathodic protection wells, test wells and those exploratory holes deeper than twenty feet within the jurisdictional boundaries of the city. The city requires a permit for construction, rehabilitation, sealing, modification, or destruction of wells, which includes requirements for well site inspection by the city. Permittees are directed to DWR's State Water Well Standards for all standards related to location, construction, maintenance, rehabilitation, modification, abandonment, or destruction of wells.

New monitoring wells are subject to the same permitting requirements described above.

1.2.4 Additional GSP Elements

SGMA requires that the following topics are addressed in the GSP (CWC §10727.4). See below for references to where each topic is addressed.

- Control of saline water intrusion
  - See Section 3.4.1 for an explanation of why the saline water intrusion sustainability indicator does not apply to the Merced Subbasin.
- Wellhead protection
  - Details on wellhead protection are discussed in Section 1.2.3.3 (Well Permitting).
- Migration of contaminated groundwater
  - Details on migration of contaminated groundwater are discussed in Section 2.2.4.4 (Point-Source Contamination).

- Well abandonment and well destruction program
  - Details on well abandonment and well destruction are discussed in Section 1.2.3.3 (Well Permitting).
- Replenishment of groundwater extractions
  - Details on projects are discussed in Chapter 6 (Projects and Management Actions to Achieve Sustainability Goal).
- Activities implementing, opportunities for, and removing impediments to, conjunctive use and underground storage
  - Details on this topic are discussed in Chapter 6 (Projects and Management Actions to Achieve Sustainability Goal).
- Well construction policies
  - Details on well construction policies are discussed in Section 1.2.3.3 (Well Permitting).
- Measures addressing groundwater contamination cleanup, recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects.
  - Details on projects are discussed in Chapter 6 (Projects and Management Actions to Achieve Sustainability Goal).
- Efficient water management practices for the delivery of water and water conservation methods to improve the efficiency of water use
  - Details on efficient water management practices are discussed in Section 1.2.2.6 (Existing Water Management Programs) and Section 1.2.3 (Land Use Elements or Topic Categories of Applicable General Plans).
- Efforts to develop relationships with State and federal regulatory agencies
  - Details on this topic can be found in Section 7 (Plan Implementation).
- Land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity
  - Details on this topic can be found in Section 1.2.3 (Land Use Elements or Topic Categories of Applicable General Plans).
- Impacts on groundwater dependent ecosystems

- Details on groundwater dependent ecosystems are discussed in Section 2.2.8 (Groundwater-Dependent Ecosystems).

1.2.5 Notice and Communication

1.2.5.1 Beneficial Uses and Users in the Basin

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

Groundwater users in the region include municipalities, utilities, or other public water districts that provide groundwater as a drinking water supply, agricultural purveyors, individual private supply wells, and the environment. For the environment, the US Fish & Wildlife Service operates several wildlife refuges/management areas that are supported by groundwater. There are additional wetlands and other groundwater-dependent ecosystems throughout the Subbasin but are primarily concentrated in the western portion.

Merced National Wildlife Refuge is able to receive up to 15,000 AFY of water for environmental surface water flows from the beginning of April through the end of September from MID (according to 1993 settlement between MID and USFWS, recognized by the Federal Energy Regulatory Commission [FERC]). This GSP does not relieve any entity within the Subbasin of their commitments. Since 2000, Merced River releases by MID for the Vernalis Adaptive Management Plan to facilitate the migration of juvenile Chinook salmon have been approximately 60,000 AFY. During 2002 and again in 2007, MID released approximately 25,000 AF of surface water from the Merced River to the Environmental Water Account for protection and restoration of at-risk fish species listed under the Federal and California Endangered Species Acts. MID pumped an equal amount of groundwater to replace the surface water supply to growers within the District (AMEC, 2008).

Additional interests (as listed in CWC §10723.2) include, but are not limited to:

- Public water systems/municipal well operators:
    - Le Grand-Athlone Water District
    - Merquin County Water District
    - Plainsburg Irrigation District
    - Stevinson Water District
    - Lone Tree Mutual Water Company
    - Sandy Mush Mutual Water Company

- California American Water, Meadowbrook District
- Le Grand Community Services District
- Planada Community Services District

- Local land use planning agencies: described in Section 1.2.3 - Land Use Elements or Topic Categories of Applicable General Plans
- State Agencies
    - California Department of Fish and Wildlife
    - Great Valley Grasslands State Park
- Federal government:
    - U.S. Fish and Wildlife: San Luis National Wildlife Refuge, Merced National Wildlife Refuge, and the Grasslands Wildlife Management Area (all are part of the San Luis National Wildlife Refuge Complex)
    - USDA Natural Resource Conservation Service, Fresno
    - USDA, Farm Service Agency
    - U.S. Geological Survey, California Water Science Center, Sacramento
- Disadvantaged communities (DAC), combined list based on DWR's DAC Mapping Tool[3] and Merced County's SB244 Analysis[4]:
    - Disadvantaged: Atwater City, Le Grand Census Designated Place (CDP), Merced City, Stevinson CDP, The Grove, Tuttle CDP, Winton CDP
    - Severely Disadvantaged: Bear Creek CDP (Celeste), El Nido CDP, Franklin CDP, Planada CDP
- Environmental interests
    - Audubon California
    - East Merced Resource Conservation District / Sustainable Conservation

[3] DWR DAC Mapping tool: https://gis.water.ca.gov/app/dacs/. Data is based on US Census ACS 2010-2014.

[4] Merced County SB244 report: http://www.co.merced.ca.us/DocumentCenter/View/12199. Report is dated May 2016, based on 2000 Census data.

- U.S. Fish and Wildlife Service
- California Department of Fish and Wildlife
- River Partners

Potential interests (listed in CWC §10723.2) that are not present in the Merced Subbasin include:

- California Native American tribes

1.2.5.2 Public Engagement and Active Involvement

During the development of the original 2020 GSP, a Merced Subbasin Stakeholder Engagement Strategy was developed (see Appendix N) to achieve the following goals:

- Conduct an inclusive outreach and education process that best supports the success of well-prepared GSP and that meets SGMA requirements.
- Offer a comprehensive, transparent outreach and education process that builds understanding and trust among the various stakeholders.
- Using a Planning Roadmap, that aligns the public engagement opportunities with the development of technical information at key points throughout the project, create an atmosphere of clear, concise, transparent, reliable information flow and opportunities for input.
- Engagement methods used will be evaluated throughout the GSP process and modified as needed. (Woodard & Curran, 2018a)

Active public participation was encouraged through the following opportunities for public engagement:

- Accepting public comment at GSA Board Meetings of all three GSAs.
- Accepting public comments at Coordination Committee Meetings and Stakeholder Advisory Committee Meetings.
- Forming the Stakeholder Advisory Committee that includes community representatives of the diverse interests in the Subbasin to review and provide input on the elements of the GSP through monthly meetings open to the public.
- Conducting briefings and Public Workshops to provide opportunities for community members and interests groups to learn about, discuss, and comment on the GSP planning process before major decision milestones.
- Coordinating with Leadership Counsel and Self-Help Enterprises in their DAC outreach efforts.

- Developing a robust website with timely, pertinent information, opportunity to make comments, and sign-up for email notifications. The website houses information about SGMA, the GSP process, the Merced Subbasin GSA Boards, Coordination Committee, Stakeholder Advisory Committee, Public Workshops, and draft GSP sections.
- Issuing news releases announcing public participation opportunities at Public Workshops.
- Providing translation services at Public Workshops.

The public comments received at GSA Board Meetings, Coordination Committee Meetings, Stakeholder Advisory Committee Meeting and Public Workshops were used to inform the GSP team and allow the team to make adjustments to the GSP during its development. Meeting notes from the Stakeholder Advisory Committee, Coordination Committee, and Public Workshops are included in Appendix B of the original 2020 GSP and capture the issues discussed during development of the GSP. Additional meetings of all three types have continued after the GSP was originally developed and have informed the 2022 and 2025 Updates as well. Meeting minutes from 1/1/2020 onward are provided in Appendix B.

Noticing methods included:

- Website: (www.mercedsgma.org) Agendas for all committee meetings and public workshops were posted at least 48 hours ahead of meetings.
- A public email listserv was used to provide notice of GSA, Coordination Committee, and Stakeholder Advisory Committee meetings and Public Workshops.
- Informational e-newsletter articles**:** Articles that informed stakeholders about GSP planning, technical issues, and opportunities for participation and review were periodically provided to the Merced Farm Bureau, East Merced Conservation District, and the Greater Merced Area Chamber of Commerce for distribution to their constituents.
- Engagement with local and regional organizations and partners: Organizations and partners assisted in noticing Community Workshops and sharing project information. Organizations and partners included the GSAs, Merced County, City of Merced, City of Livingston, City of Atwater, participating water and irrigation districts, Merced Farm Bureau, Greater Merced Chamber of Commerce, Hispanic Chamber of Commerce (Merced), Self-Help Enterprises, Leadership Counsel for Justice and Accountability, East Merced Resource Conservation District, and several area Municipal Advisory Councils.
- Social media channels: The County of Merced, Merced Irrigation District and McSwain Municipal Advisory Council posted information about GSP development and Community Workshops on their social media platforms.
- Press Releases: To announce opportunities for participation and input, press releases were issued to media lists maintained by the County of Merced and Merced Irrigation District.

- Display Advertisements: To announce Community Workshops, display ads were placed in the news section of the Merced Sun-Star.
- Noticing in Disadvantaged and Severely Disadvantaged Communities: Community Workshop notices and other related GSP information were distributed by Self-Help Enterprises and the Leadership Council on behalf of the Merced Subbasin GSP team.

Later during GSP implementation, the GSAs solicited and selected a new set of Stakeholder Advisory Committee members through a public application process. Stakeholder Advisory Committee members advised on the revised July 2022 GSP development, implementation of ongoing projects and programs, and supported the development of this update.

1.2.5.3 List of Public Meetings Where the Original 2020 GSP was Discussed

The following lists the public meetings held from January 2018 through June 2019.

GSA Board Meetings

The Boards of the 3 GSAs met regularly during plan development and not all meetings are listed below. The following GSA Board meetings included GSP-specific presentations:

Joint GSP Planning Workshop of the 3 GSAs (MSGSA, MIUGSA, TIWD GSA-1)

2018: January 11

MSGSA Board Meeting – Presentation on Water Budgets

2018: November 1

2019: April 11

Joint Board meeting of MIUGSA, MID, and TIWD GSA-1 – Presentation on Water Budgets

2018: December 4

Joint Board meeting of MIUGSA, MID, and TIWD GSA-1 – Draft GSP Public Comments 2019: September 18

Coordination Committee Meetings (monthly on 4th Monday March 2018 – October 2019)

2018: March 26, April 23, May 29, June 25, July 23, August 27, September 24, October 22, November 26, December 17

2019: January 28, February 25, March 25, April 22, May 29, June 24, July 22, August 26, October 28

Stakeholder Advisory Committee Meetings (monthly on 4th Monday May 2018 – October 2019)

2018: May 29, June 25, July 23, August 27, September 24, October 22, November 26, December 17

2019: January 28, February 25, March 25, April 22, May 29, June 24, July 22, October 28

Public Workshops (with Spanish translation available)

2018: August 2, December 4, December 13

2019: February 25, May 29

1.2.5.4 List of Additional Public Meetings Where the July 2022 GSP Update was Discussed

The following lists the public meetings held from January 2022 through June 2022 where the July 2022 GSP Update was discussed.

GSA Board Meetings

The Boards of the GSAs continued to meet regularly after GSP adoption, including meetings to discuss the July 2022 GSP Update in the first half of 2022.

Coordination Committee Meetings

2022: February 7, March 21, April 25, June 1, June 27

Note that additional meetings of the Coordination Committee were held in 2020 (November 2 and December 1) and 2021 (February 22, April 26, July 26, October 25, and December 22) after the adoption of the GSP in 2019 to discuss ongoing implementation activities.

Stakeholder Advisory Committee Meetings

2022: January 31, March 21, April 25, June 1, June 27

Note that additional meetings of the Stakeholder Advisory Committee were held in 2021 (April 12, July 12, and November 8) after the adoption of the GSP in 2019 to discuss ongoing implementation activities.

1.2.5.5 List of Additional Public Meetings Where this GSP Update was Discussed

The following lists the public meetings held from January 2023 through October 2024 where this GSP Update was discussed.

GSA Board Meetings

The Boards of the GSAs continued to meet regularly.

Coordination Committee Meetings

2023: February 27, May 24, September 18, November 29

2024: January 25, March 20, May 22, July 17, October 16

Stakeholder Advisory Committee Meetings

2023: February 27, May 24, September 18

2024: January 24, March 20, May 22, July 17, October 16

Public Workshops (with Spanish translation available)

2024: May 22, August 26

1.2.5.6 Comments Regarding the Plan

Meeting notes from the Stakeholder Advisory Committee, Coordination Committee, and Public Workshops are included in Appendix B (for 1/1/2020 onward; older meeting minutes are provided in the previous iteration of Appendix B in the original 2020 GSP) and capture the issues discussed for implementation of the GSP, the July 2022 update in response to DWR comments, and the 2025 GSP update.

Original 2020 GSP

The Merced GSP Public Draft was published July 19, 2019, and written comments were collected for a 30-day period ending August 19, 2019. Additional comments were also received at a joint meeting of the three GSA Boards held on September 18, 2019. Individual comments from all letters and the public were reviewed, categorized, and addressed in the original version of Appendix O published in the 2020 GSP.

July 2022 GSP

The Merced GSP July 2022 update was discussed at numerous public meetings (see Section 1.2.5.4) in the first half of 2022. The document was revised by the GSAs before review and adoption by the three GSA Boards in July 2022.

2025 GSP

This GSP Update was discussed at numerous public meetings (see Section 1.2.5.5) in 2023-2024. The document was revised by the GSAs before review and adoption by the three GSA Boards in

January 2025. Prior to adoption, a 30-day public comment period was held, ending November 22, 2024. No comments were received.

1.2.5.7 Communications

1.2.5.7.1 Decision-Making Processes

This GSP was developed jointly by MIUGSA, MSGSA, and TIWD GSA-1 (GSAs). The GSAs were guided by a Coordination Committee that is composed of up to four representatives from each GSA and is responsible for coming to unanimous agreement on recommendations for the technical and substantive Basin-wide issues, and then submitting the recommendations to the governing board of each GSA for final approval. To become fully effective, each GSA governing board must approve the Coordination Committee's recommendations (Merced Subbasin GSA, MIUGSA, Turner Island Water District GSA-#1, 2017). The Coordination Committee met monthly during GSP development starting in March 2018 and transitioned to meeting every 2-3 months once the GSP was initially published in early 2020. Meetings were open to the public with agendas posted at least 48 hours in advance. Coordination Committee meeting agendas, presentations, and notes are posted on the Merced GSP website (www.mercedsgma.org).

The GSAs were also informed by a Stakeholder Advisory Committee which consisted of community representatives who reviewed groundwater conditions, management issues and needs, and projects and management actions to improve sustainability in the basin. The committee met monthly starting in May 2018 (and transitioned to meeting every 2-3 months once the GSP was initially published in early 2020) in sessions open to the public, providing a forum for testing ideas as well as providing information and feedback from members' respective constituencies. Agendas were posted at least 48 hours prior to meetings. The meeting agendas, presentations, and notes are posted to the website.

A more detailed description of the governing bodies of each individual GSA can be found in Section 1.1.3.1 - Organization and Management Structure of the GSAs.

1.2.5.7.2 GSP Implementation and Updates to GSP

The GSAs intend to continue public outreach and provide opportunities for engagement during GSP implementation. This will include providing opportunities for public participation, especially from beneficial users, at public meetings, providing access to GSP information online, and continued coordination with entities conducting outreach to DAC communities in the Basin. Announcements will continue to be distributed via email prior to public meetings (e.g., Stakeholder Advisory Committee meetings, Coordination Committee meetings, public workshops, and GSA Board meetings). Emails will also be distributed as specific deliverables are finalized, when opportunities are available for stakeholder input and when this input is requested, or when items of interest to the stakeholder group arise, such as relevant funding opportunities. The

Merced SGMA website, managed as part of GSP Administration, will be updated a minimum of monthly, and will house meeting agendas and materials, reports, and other program information. The website may be updated to add new pages as the program continues and additional activities are implemented. Additionally, public workshops will be held semi-annually to provide an opportunity for stakeholders and members of the public to learn about, discuss, and provide input on GSP activities, progress towards meeting the Sustainability Goals of this GSP, and the SGMA program.

2 BASIN SETTING

2.1 HYDROGEOLOGIC CONCEPTUAL MODEL

This section describes the Hydrogeologic Conceptual Model (HCM) for the Merced Subbasin. The HCM is developed to understand and convey the physical conditions by which water moves through in the basin and is used elsewhere in the Groundwater Sustainability Plan (GSP) to support the development of sustainable management criteria, monitoring networks, water budgets, projects, and programs and management actions.

Consistent with the Sustainable Groundwater Management Act (SGMA) requirements, the HCM:

- Provides an understanding of the general physical characteristics related to regional hydrology, land use, geology geologic structure, water quality, principal aquifers, and principal aquitards of the basin setting*;*
- Provides the context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks; and
- Provides a tool for stakeholder outreach and communication.

The HCM is based on several existing geologic and hydrogeologic studies as briefly described below:

- R.W. Page & Gary O. Balding, 1973. *Geology and Quality of Water in the Modesto-Merced Area, San Joaquin Valley, California, with a Brief Section on Hydrology*. United States Geological Survey (USGS) Water-Resources Investigations Report 73-6, prepared in cooperation with the California Department of Water Resources (DWR).
    - Provides the basis for the understanding of the underlying geology of the Merced Subbasin.
- Page, R.W., 1977. *Appraisal of Ground-Water Conditions in Merced, California, and Vicinity*. USGS Open-File Report 77-454, prepared in cooperation with DWR.
    - Provides the basis for the understanding of the five aquifer systems and the base of fresh water in the Merced Subbasin.
- Page, R.W., 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California, with Texture Maps and Sections*. USGS professional paper 1401-C.
    - Provides the basis for the understanding of surficial geology in the Merced Subbasin as well as underlying geologic structure.
- AMEC Geomatrix, Inc., 2008. *Merced Groundwater Basin Groundwater Management Plan Update*, submitted to Merced Area Groundwater Pool Interests, Merced, CA.
    - Provides a summary of previous geologic studies with more recent information on groundwater subbasin and water resources conditions.

2.1.1 Regional Geologic and Structural Setting

The Merced Subbasin is located in the San Joaquin Valley, a broad structural trough approximately 200 miles long and up to 70 miles wide. This trough is 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 mountains. Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins near the eastern boundary of the Subbasin toward the axis of the structural trough near the western boundary of the Subbasin. This depositional axis is below and slightly west of the series of rivers, lakes, sloughs, and marshes that mark the current and historical axis of the surface drainage of the San Joaquin Valley (DWR, 2004).

The Merced Subbasin is generally bounded by the foothills of the Sierra Nevada Mountain range in the east and other groundwater subbasins of the Central Valley to the north, south, and west (see more detail in Section 2.1.6). The southwest portion of the basin is underlain by the Corcoran Clay, a bed of laterally extensive reduced (blue/grey) silt and clay. The Corcoran Clay is a significant confining layer up to 60 feet thick.

This geologic setting is reflected throughout the HCM. The very deep sediments create a large volume of groundwater within the Merced Subbasin. At greater depths, this groundwater is saline, reflective of deposition of the deeper aquifer materials in a marine environment. Shallower depths have fresh groundwater, reflective of deposition in a non-marine environment or flushing with fresh water from higher in the system. The nature of the aquifer materials holding this groundwater is driven by the depositional environment. In higher-energy environments, such as fast-moving streams, larger materials are deposited, such as gravels and sands. In lower-energy environments, such as lakes, smaller materials are deposited, such as clays and silts. Thus, the aquifer system typically has coarser, more conductive materials along current or ancestral river courses and closer to the foothills. Finer, less-conductive materials are present farther from current or ancestral river courses and towards the axis of the valley near the San Joaquin River. In addition to spatial influences on aquifer materials, there is a time component as well. The deposition of continental deposits in alluvial fans emanating from the foothills was interrupted when the valley was inundated by Lake Corcoran, creating a low-energy depositional environment which resulted in the regional clay unit known as the Corcoran Clay. The Corcoran Clay is an important aquitard in that portion of the basin, separating the subsurface into two distinct aquifer systems, one above the clay and one below.

2.1.2 Geologic History

The geologic history of the Merced Subbasin is one of deposition of sediments in an environment with changing climate, changing sea levels, and tectonic movement, all of which resulted in the sediments that form today's aquifer system. A summary of the geologic history is provided below. This summary refers to the geologic time scale, which is included in Appendix C as a reference.

As with other areas on the east side of the San Joaquin Valley, the deposition of sediments occurred on a westward-tilted block of crystalline basement composed of Sierra Nevada plutonic and metamorphic rocks under the eastern part of the valley and mafic and ultramafic rocks of a presumed ophiolite of Jurassic age under the central and western parts of the valley (Bartow J. A., 1991). Thus, the bottom of the basin is a westward extension of the materials associated with the Sierra Nevada or is ophiolitic material associated with subducting oceanic crust from the west. In addition to forming the bottom of the basin, the continued tilting of the Sierran block contributed to the ability to accumulate sediments in the basin and resulted in the dipping units and angular unconformities between units.

Pre-Tertiary marine rocks are deposited at the greatest depths and in great thickness. Cretaceous Period marine rocks are as much as 20,000 feet thick in areas of the San Joaquin Valley (Page R. W., 1986).

Most of the materials relevant to groundwater management were deposited in the more recent Cenozoic Era. Near the close of the Mesozoic Era, the San Joaquin Valley area was the southern part of an extensive forearc basin (Bartow J. A., 1991). Tectonic movements elevated many Coast Range areas, including those adjacent to the Sacramento Valley and the northern San Joaquin Valley; these movements created the ancestral Tertiary San Joaquin and Sacramento basins as restricted troughs of deposition lying between the emerging Coast Ranges and the eastern Sierra Nevada (Page R. W., 1986). With significant restriction between what is now the valley and the ocean, the depositional environment varied based on sea level, tectonics, and deposition.

The Ione Formation was deposited in the middle Eocene Epoch discontinuously on pre-Tertiary rocks, dipping gently to the southwest (Bartow J. A., 1991). Overall, the formation is considered deltaic in origin, with fluvial, lacustrine, and lagoonal deposits (Page R. W., 1986). The beginning of the middle Eocene was characterized with lower eustatic sea levels resulting in a non-marine depositional environment for earlier Ione Formation materials. As eustatic sea levels rose through the middle Eocene, the depositional environment became more shoreline or shallow marine. The Merced Subbasin was generally a coastal environment with open ocean to the west. The more southwesterly portions of the Subbasin would be more likely to be shallow marine and the more northeasterly portions of the basin more likely to be non-marine. Towards the end of the middle Eocene, lower eustatic sea levels again moved the Ione to more non-marine deposition (Bartow J. A., 1991).

Deformation, driven by tectonic forces, generally resulted in west or southwest tilting. This causes the subtle angular unconformities in the Cenozoic units with discordances of generally less than 1 degree. Discordances appear to be less between Eocene and younger units compared to Eocene and older units, but there is evidence of continued tilting in the Oligocene based on differences in the gradient of depositional surfaces in the Eocene Ione and Miocene Valley Springs Formations. Currently, tilting continues to be present, likely at an accelerated rate (Bartow J. A., 1991).

The Oligocene marks a change in sedimentary history in the Merced area and the San Joaquin Valley, with a change from few, long-lasting, San Joaquin Valley-wide depositional sequences, to shorter sequences of more local extent. This is associated with a regional transition from a convergent continental margin to a transform margin (Bartow J. A., 1991).

During the Oligocene, at the time of maximum regression, the entire Subbasin was above sea level, sloping towards the south. A hiatus representing most of the Oligocene is evidence that there was negligible subsidence in the western part of the block during that interval (Bartow J. A., 1991).

The Subbasin remained above sea level during the Miocene, although uplift to the south resulted in a change in slope towards the southwest. The Valley Springs Formation was deposited in the Upper Oligocene and Lower Miocene unconformably over the Ione, dipping gently to the southwest. The Valley Springs was deposited following a period of low eustatic sea levels. While eustatic sea levels became higher during this period, the depositional environment remained non-marine, with fluvial sequences and ash deposits.

The Mehrten Formation was deposited in the Middle to Upper Miocene unconformably over the Valley Springs, dipping gently to the southwest. The Mehrten Formation is considered to have been laid down by streams carrying andesitic debris associated with the beginning of andesitic volcanism in the Sierra Nevada (Page R. W., 1986). There is no apparent angular discordance between the Mehrten and the Valley Springs, although there is an unconformity with as much as 120 meters of erosional relief in the eastern part of the outcrop area (Bartow J. A., 1991).

By the end of the Pliocene (approximately 2 million years ago), seaway connections were completely closed due to rapid filling of the San Joaquin Valley with sediment (Elam, 2012), marking the end of marine deposition and the beginning of continental deposition.

Interrupting the alluvial deposition of continental deposits, in the Pleistocene Epoch a large lake known as Lake Corcoran was impounded, filling nearly the entire valley (Bartow J. A., 1991). The period coincided with low eustatic sea levels associated with glaciation. The large lake is evidenced by the widespread deposition of the lacustrine clays today known as the Corcoran Clay. Outwash from alpine glaciers was deposited into the lake by Sierra Nevada rivers. The lake drained approximately 600,000 years ago when the present-day drainage outlet of the Carquinez Strait was carved out. However, several other smaller lakes also occupied portions of the valley later during the Quaternary Period (Bartow J. A., 1991).

More recent deposits are alluvial, aeolian, and floodplain deposits derived primarily from the Sierra Nevada (Page R. W., 1986) (Page & Balding, 1973). The presence of today’s Corcoran Clay at depths of approximately 40 feet to 240 feet is indicative of rates of tectonic subsidence (not related to groundwater withdrawal) that have occurred over the past 600,000 years.

2.1.3 Surface and Near-Surface Conditions

This section describes the topography, soils, surface water, imported water supplies, and recharge areas in the basin.

2.1.3.1 Topography and Physiography

The Merced Subbasin is largely flat, with a minimum elevation of approximately 50 feet, near the confluence of the Merced and San Joaquin Rivers and a maximum elevation of 836 feet, in the foothills near the northern corner of the Subbasin. Figure 2-1 shows a map of elevation within the Subbasin.

The topography is driven by the physiography of the area. The following description of the physiography and geomorphology of the Merced Subbasin is provided to add context to the topography and is based on geomorphic descriptions and maps by the USGS (Davis, Green, Olmsted, & Brown, 1959) as referenced in the Merced Groundwater Management Plan (AMEC, 2008).

The physiographic units in the Merced Subbasin area include the Sierra Nevada, dissected uplands, low alluvial plains and fans, river floodplains and channels, and overflow lands (Page & Balding, 1973). These physiographic units are presented on Figure 2-2. The Sierra Nevada unit, which can be found along the eastern border of the Merced Subbasin, consists of metamorphic and granitic mountains that have deep river-cut canyons and highly dissected foothills.

The dissected uplands unit has a width ranging between 5 and 18 miles and covers a significant portion of the Merced Subbasin. Local relief may be up to 200 feet. Within the uplands, the Merced River has developed two terraces and a broad floodplain while the Chowchilla River is only slightly entrenched into the upland surface.

The low alluvial plains and fans unit, which consists primarily of coalescing alluvial fans, has a width ranging between 14 and 20 miles and also covers a significant portion of the Merced Subbasin. Local relief may be up to 10 feet. Between Atwater and Turlock, northwest trending sand dunes underlie the surface of the plains and fans.

The river floodplains and channels unit flank the channels of the major rivers including the Merced and Chowchilla Rivers. In the dissected uplands unit, the floodplain of the Merced River ranges in width between 0.25 and 1 mile. In the Cressey area, natural levees are present. Near the valley trough, the Merced River floodplain becomes indistinguishable from the surrounding alluvial plains. The Chowchilla River, which is entrenched about 40 feet near where it leaves the Sierra Nevada, has developed a thin floodplain through the dissected uplands. The river has deposited natural levees throughout the low alluvial plains and fans unit.

Figure 2-1: Topography

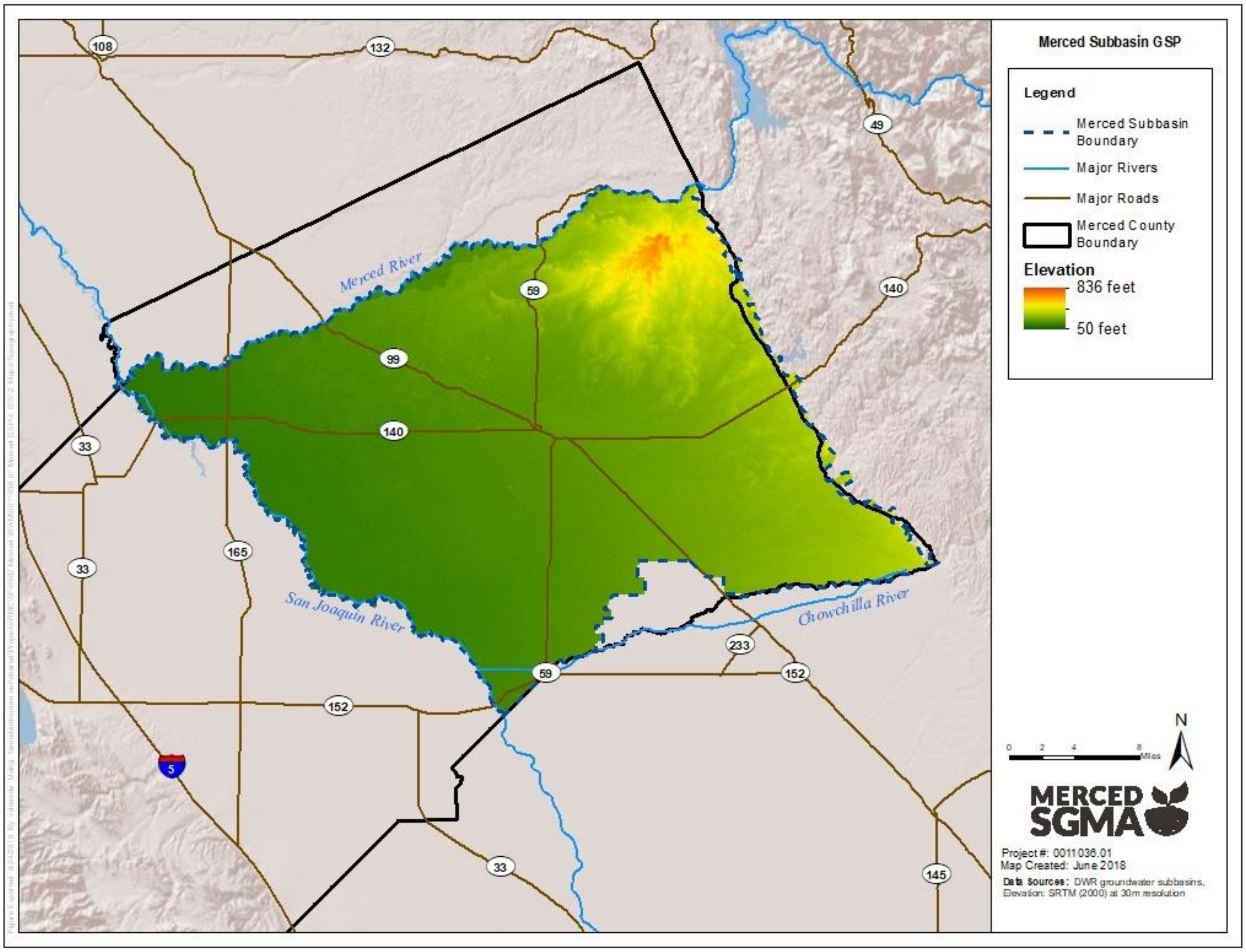
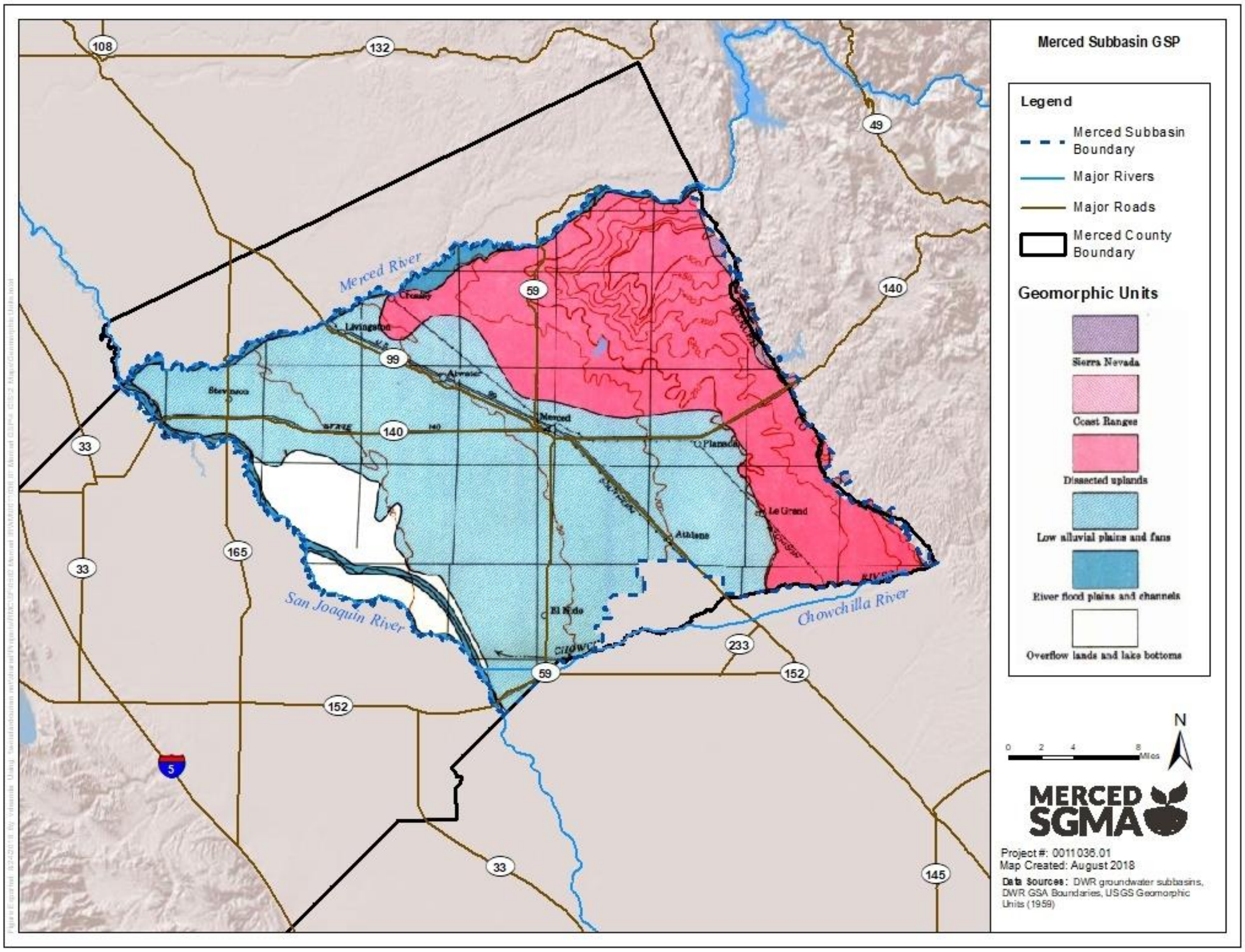


Figure 2-2: Geomorphic Units



Source: (Davis, Green, Olmsted, & Brown, 1959)

2.1.3.2 Surface Soils

The United States Department of Agriculture (USDA) Soil Conservation Service (now the USDA Natural Resource Conservation Service) conducted a soil survey in Merced County and identified more than 200 unique soil types within the Merced Subbasin. Data on soils can assist in the understanding of how water may infiltrate or run off the surface as well as how chemical constituents may interact with soils. The soil types can be grouped into 25 associations based on general soil type (Figure 2-3 and Table 2-1) and permeability (Figure 2-4), along with other characteristics identified by the USDA. Soil types and permeability were mapped using the Soil Survey Geographic (SSURGO) database last updated 2017.

Figure 2-3: Soil Types

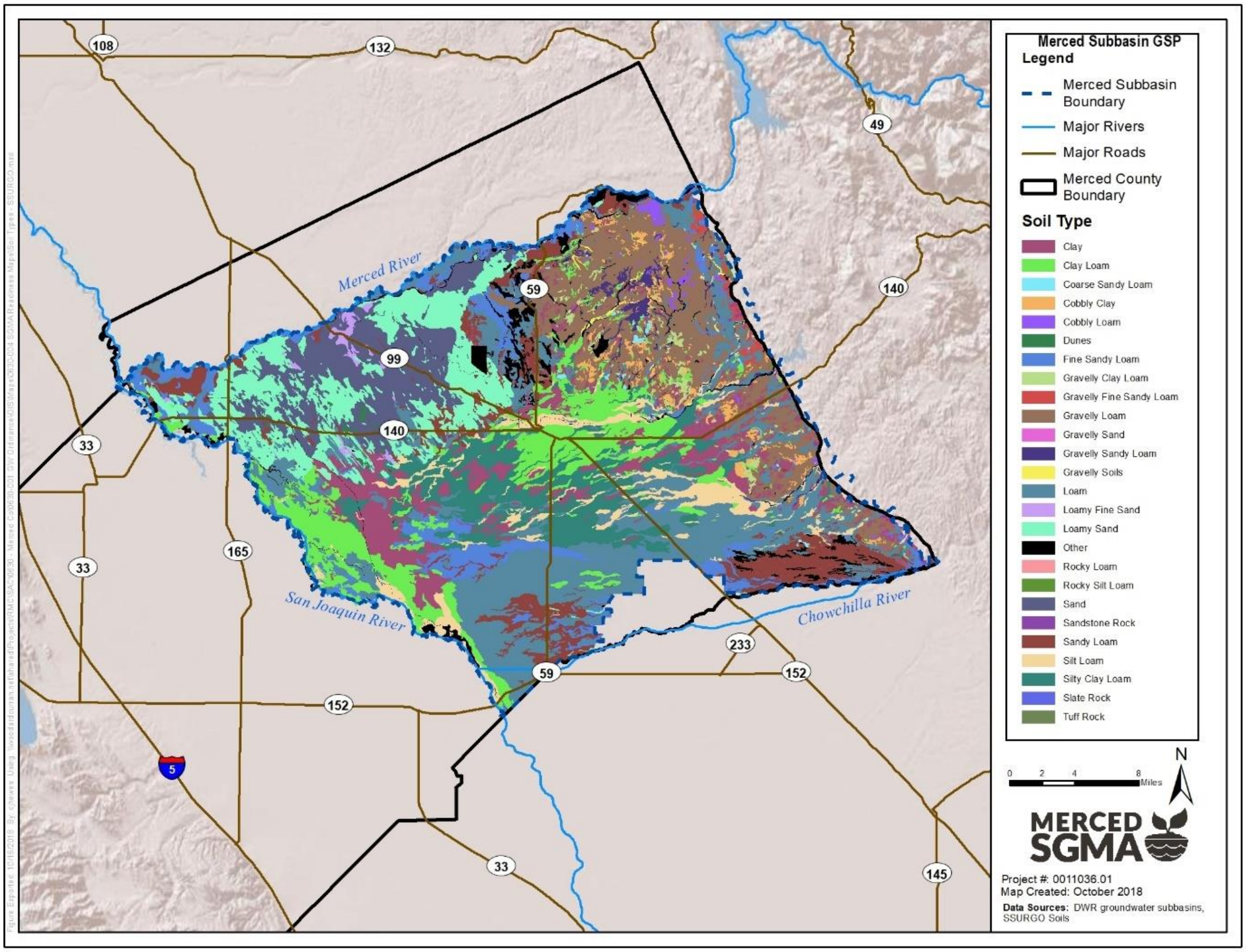
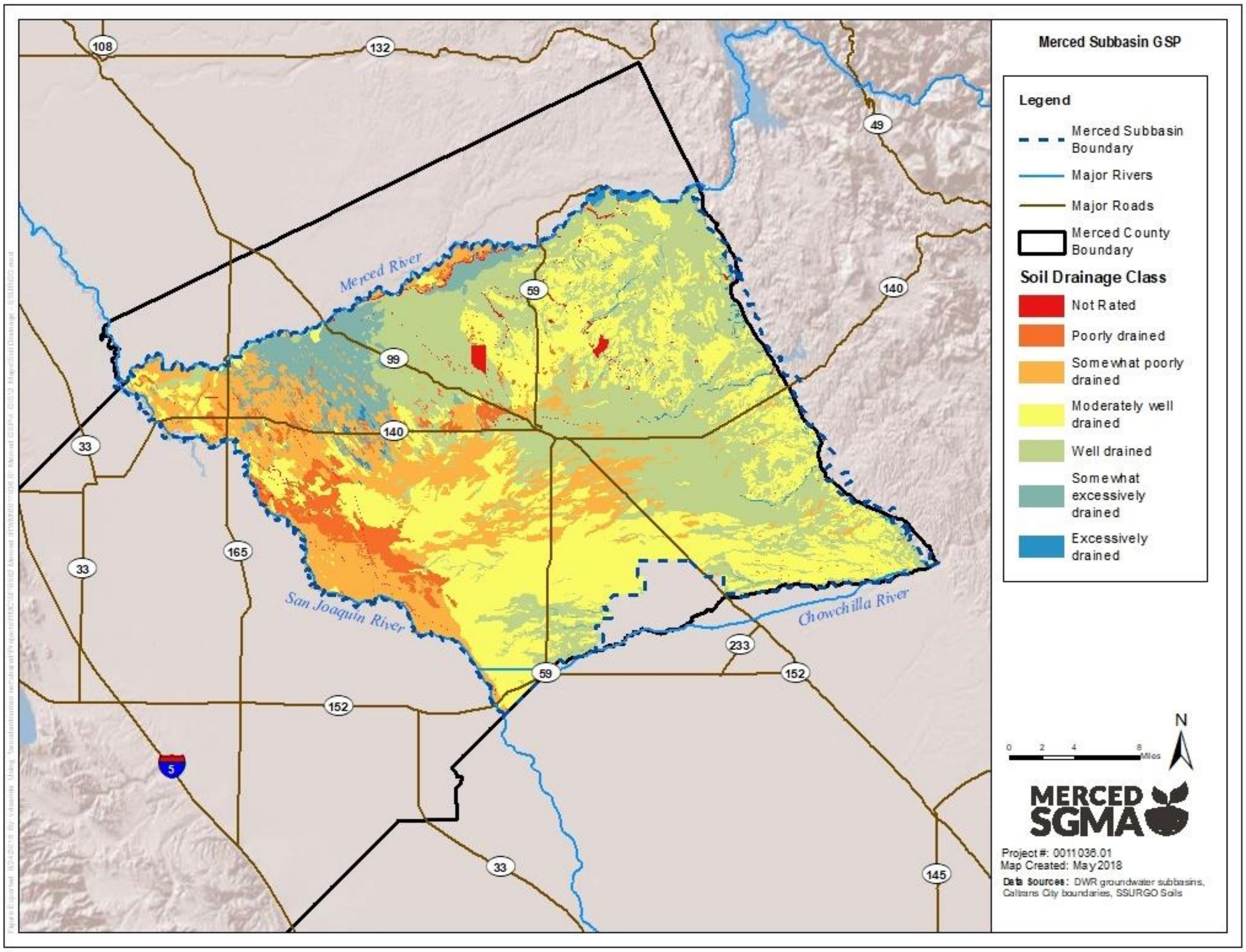


Table 2-1: Soil Type Summary

Soil Type	Area (sq miles)	% of total
Loam	145.8	18%
Gravelly Loam	96.3	12%
Clay Loam	77.8	10%
Loamy Sand	74.5	9%
Sand	66.9	8%
Silty Clay Loam	63.9	8%
Clay	62.2	8%
Sandy Loam	54.5	7%
Fine Sandy Loam	48.0	6%
Silt Loam	32.6	4%
Other (Includes Water, Fill, No Data Available)	28.2	4%
Cobbly Clay	10.9	1%
Gravelly Sandy Loam	6.7	1%
Gravelly Clay Loam	4.7	1%
Gravelly Fine Sandy Loam	4.0	1%
Loamy Fine Sand	3.8	<1%
Cobbly Loam	3.7	<1%
Coarse Sandy Loam	1.6	<1%
Gravelly Soils	1.4	<1%
Dunes	1.2	<1%
Sandstone Rock	1.1	<1%
Rocky Silt Loam	1.0	<1%
Rocky Loam	0.2	<1%
Slate Rock	0.0	<1%
Tuff Rock	0.0	<1%
Gravelly Sand	0.0	<1%
Total	**791.3**	**100%**

Figure 2-4: Soil Drainage Class

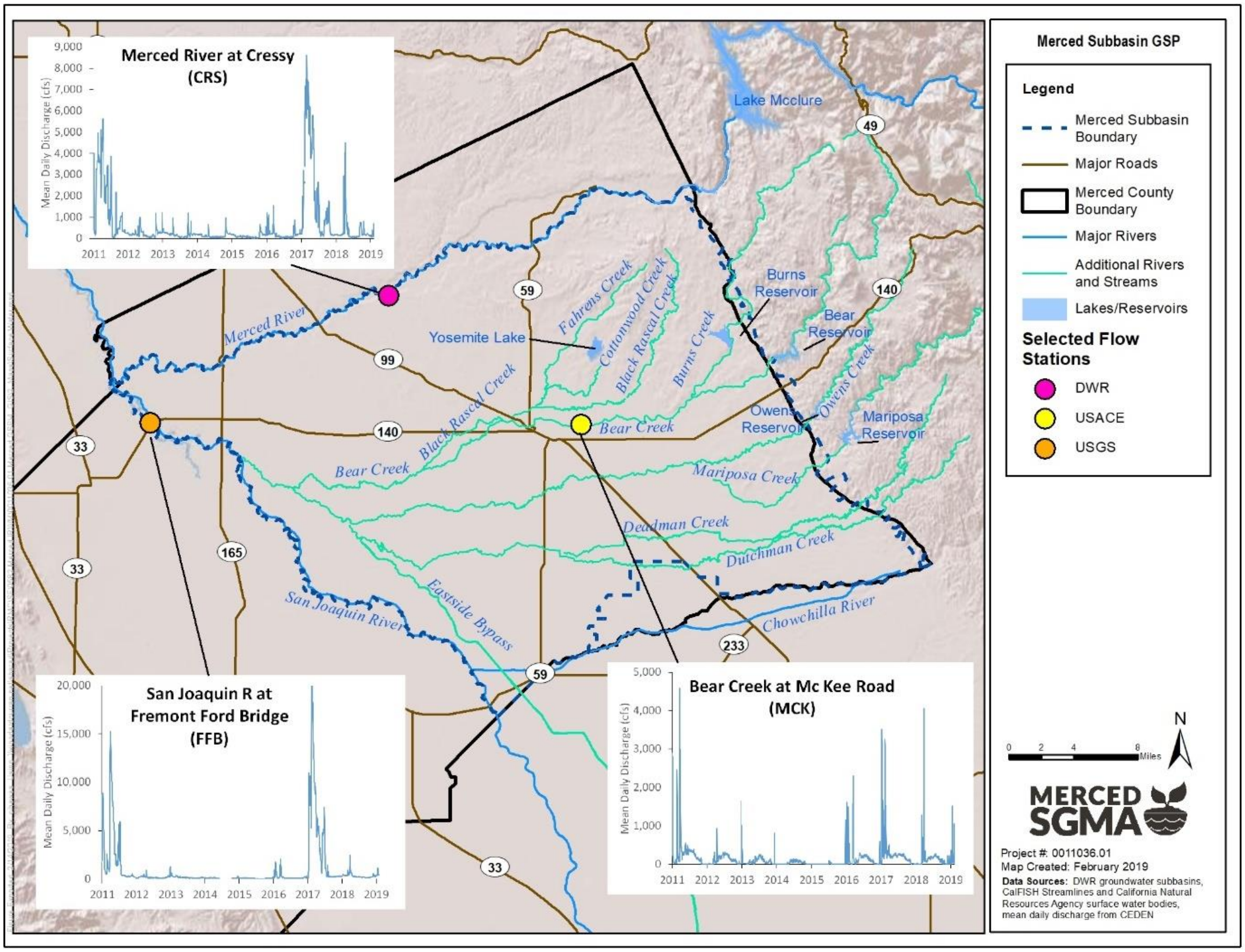


2.1.3.3 Surface Water

Many surface water courses cross the Merced Subbasin, generally flowing from the uplands in the northeast towards the San Joaquin River in the southwest. The San Joaquin River is an exception, flowing northwest towards the Sacramento-San Joaquin Delta. The San Joaquin and Merced Rivers are the largest rivers in the Subbasin. The Chowchilla River is also a significant water course.

Other surface water bodies within the Merced Subbasin include the following streams, nearly all of which are utilized for conveyance of irrigation water: Bear Creek, Black Rascal Creek, Burns Creek, Canal Creek, Cottonwood Creek, Deadman Creek, Dutchman Creek, Fahrens Creek, Little Dutchman Creek, Mariposa Creek, and Owens Creek (Figure 2-5). Figure 2-5 shows hydrographs for mean daily discharge (in cubic feet per second) at three selected gauging stations on the Merced River, San Joaquin River, and Bear Creek. The water in these surface water features is a mixture of snowpack and rainfall. No DWR, USGS, or United States Army Corps of Engineers (USACE) stream gauges are operational on the Chowchilla River with available discharge information.

Figure 2-5: Surface Waters



Source: (DWR California Data Exchange Center), *Hydrographs show mean daily discharge in cubic feet per second (cfs) from 2011-2018.*

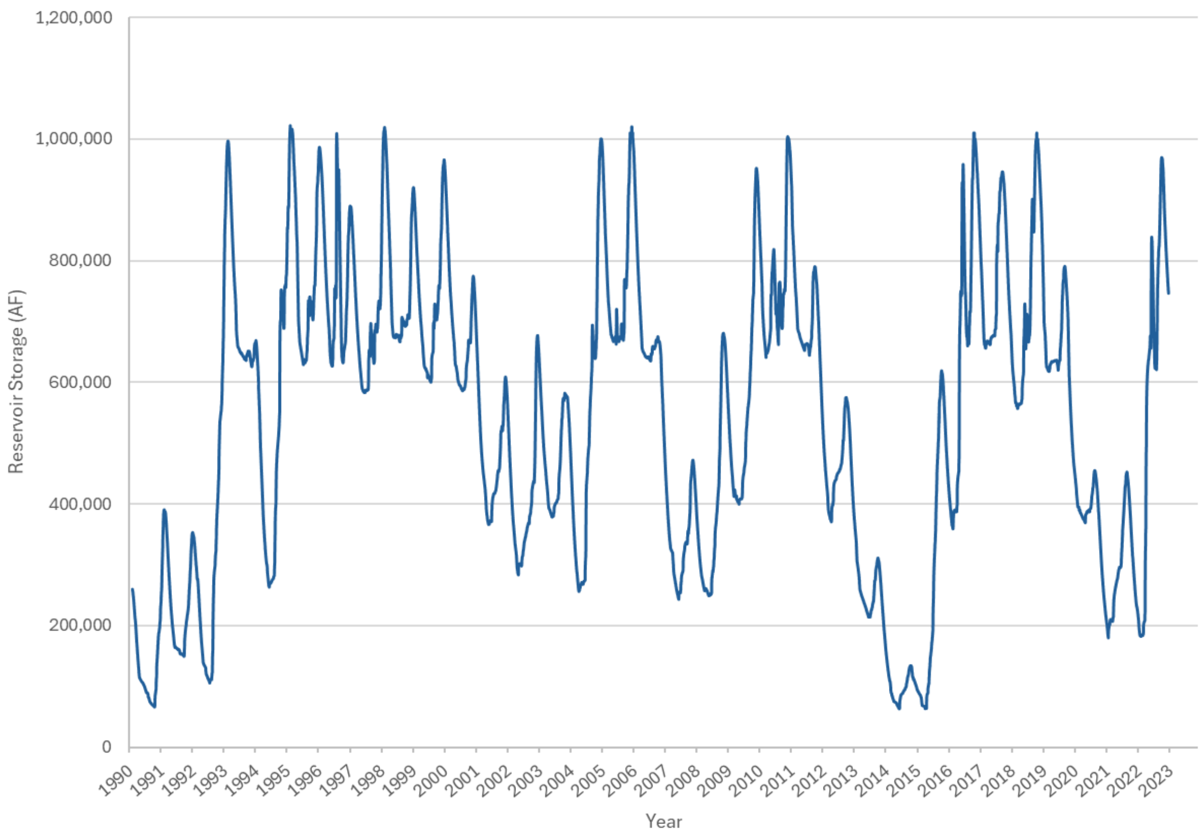
The Merced River is the principal renewable surface water supply in the Merced Subbasin (see Figure 2-5). The Merced River is impounded by New Exchequer Dam, forming Lake McClure. Lake McClure has a storage capacity of over 1 million acre-feet (MAF) and is used for flood control and storage of irrigation water. Under agreement with the USACE, each spring the storage pool in Lake McClure is reduced to a maximum of 675,000 acre-feet (AF) for flood control purposes (AMEC, 2008).

From 1990-2017, storage in Lake McClure has ranged from about 63,300 AF (February 2015) to 1,022,000 AF (July 1995) and averaged about 524,000 AF (Figure 2-6).

Diversions from the Merced River include:

- Merced Irrigation District (MID) – 430,000 acre-feet per year (AFY) (2003 - 2015 average)
- Stevinson Water District (SWD) – 18,000 AFY (2003 – 2013 average)
- Merquin County Water District (MCWD) – 16,000 AFY (2003 – 2013 average)

Figure 2-6: 1990-2023 Lake McClure Reservoir Storage



Source: USGS Data for Site 11269500 LK MCCLURE A EXCHEQUER CA

Minimum flow requirements for the Merced River downstream of Crocker-Huffman diversion dam (which is downstream of New Exchequer Dam), as measured at Shaffer Bridge, as required by MID's existing FERC license, are shown in Table 2-2. The values do not represent actual flows.

Table 2-2: Merced River Minimum Flow Requirements

Period	Normal Years (cfs)	Dry Years (cfs)
June 1 through October 15	25	15
October 16 through October 31	75	60
November 1 through December 31	100	75
January 1 through May 31	75	60

Source: (FERC, 2015)

The MID distribution system includes portions of natural streams (or drains), about 121 miles, that convey irrigation water, as well as 422 miles of unlined canals, and 97 miles of lined canals (MID, 2013). See Table 2-3 for details. The canals are conveyance structures that do not fall under the jurisdiction of SGMA legislation but are presented here for context of understanding the entire surface water system in the Subbasin.

Table 2-3: MID Water Conveyance and Delivery System

System Used	Number of Miles
Natural Channels (creeks and sloughs)	142
Unlined canal	406
Lined canal	105
Pipelines	178
Drains	31
Total Mileage of System	**862**

Source: (MID, 2013)

The Chowchilla River drains a 254 square-mile watershed on the western slope of the Sierra Nevada and is regulated by Buchanan Dam. Some flows downstream of the dam are diverted at Chowchilla Water District canals. Average annual natural flows from 1912 to 2008 at Buchanan Dam were approximately 70,000 AF. Chowchilla Water District has been able to take delivery of approximately 43,000 AF annually from the reservoir. The remaining 27,000 AF have been released as flood flows from the dam (RMC Water and Environment, 2015).

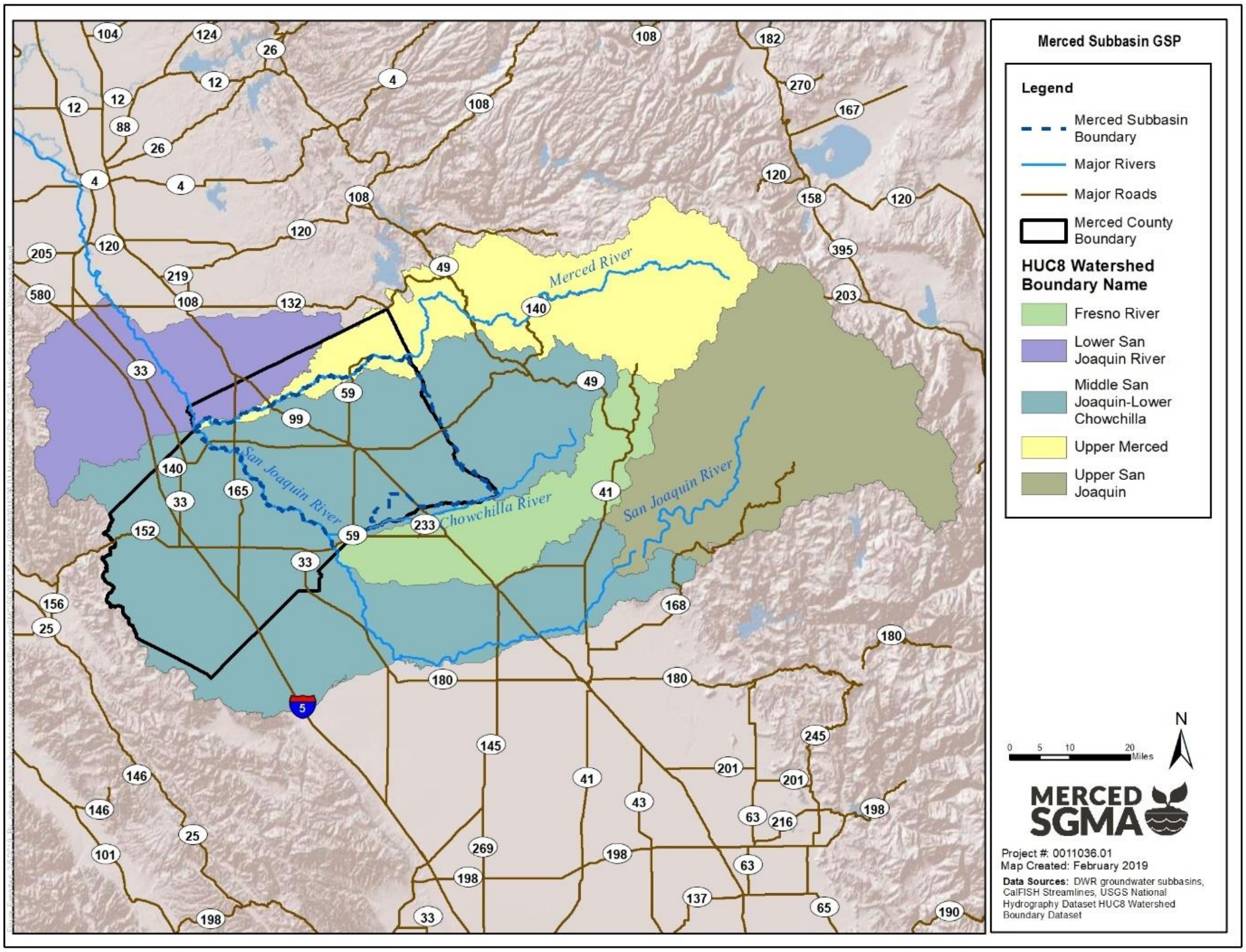
The San Joaquin River is regulated by Millerton Reservoir and other reservoirs on upstream tributaries. In the Merced Subbasin, the river is a source of water supplies for Turner Island Water District which diverts approximately 20,000 AFY (2003 to 2013 average) using the San Luis Canal Company conveyance. Turner Island Water District also receives periodic flood flows from the Eastside Bypass of 5,000 AFY, when available.

Based on outreach to stakeholders, there are no known active springs or seeps within the Merced Subbasin. Wetlands within the Subbasin are generally supplied supplemental water and are not dependent on shallow groundwater. Additional information on groundwater dependent ecosystems can be found in Section 2.2.8.

Figure 2-7 shows the Merced River, San Joaquin River, and Chowchilla River within their respective Hydrologic Unit Code (HUC) 8 watershed boundary, where HUC8 is a designation within the USGS

Watershed Boundary Dataset. HUC's range in size from 2 (large regional systems) to 12 (small subwatersheds), with 8 being an appropriate size designation to provide some context of the size and location of the regional watersheds compared to the Merced Subbasin.

Figure 2-7: HUC8 Watershed Boundaries



2.1.3.4 Imported Water

No agencies in the Merced Subbasin benefit from imported water supplies from outside the Subbasin, such as from the Central Valley Project or State Water Project. The Turner Island Water District is split into two GSAs. Turner Island Water District GSA #1 (TIWD GSA-1) is the portion of the water district that falls within the Merced Subbasin while #2 falls within the Delta-Mendota Subbasin. There is some transfer of groundwater between the two GSAs, though the exact volume is unknown.

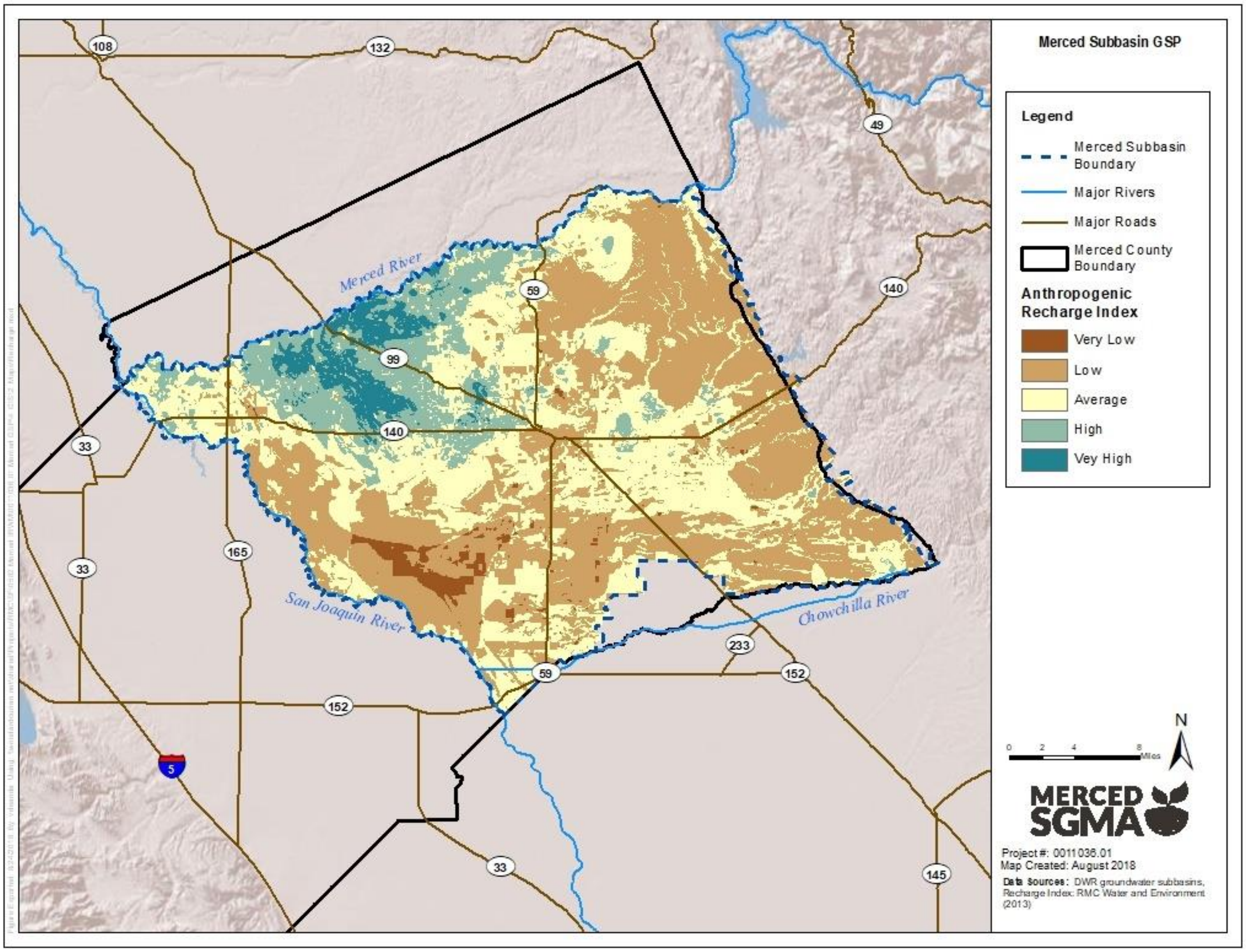
2.1.3.5 Groundwater Recharge and Discharge Areas

Groundwater recharge and discharge is driven by both natural and anthropogenic (human-influenced) factors. Areas of recharge and discharge within the Merced Subbasin are discussed below. Quantitative information about natural and anthropogenic recharge and discharge is provided in the water budget section.

2.1.3.5.1 Anthropogenic Groundwater Recharge

Anthropogenic recharge, particularly deep percolation from agricultural irrigation and earthen-lined canals, is a key source of recharge in the Merced Subbasin. A Groundwater Recharge Study was conducted as part of the Merced Integrated Regional Water Management (IRWM) Plan Development in 2013 to identify where recharge is occurring. The study used a Geographic Information System (GIS) overlay method to analyze spatial data and integrate information to interpret recharge areas (RMC Water and Environment, 2013b). The Subbasin was divided into five different categories, relating the relative amount of recharge occurring in the area (see Figure 2-8). The map shows recharge is occurring in areas with coarser materials in the upper subsurface and in areas with extensive applied water to support irrigated agriculture. The map does not show the recharge occurring from surface water courses, including rivers and canals. Estimates of the quantities of these recharge components are provided in the water budget discussion in Section 2.3. Since the study was conducted, new recharge projects have been developed (see Section 6.3).

Figure 2-8: Areas of Recharge



2.1.3.5.2 Natural Groundwater Recharge and Discharge

Groundwater discharge is primarily through groundwater production wells. However, groundwater also discharges to rivers and streams where groundwater elevations are higher than river stage. This occurs in limited areas in the lower portions of the Subbasin. Figure 2-9 shows gaining streams in red where groundwater discharges to rivers, while losing streams are shown in blue where streams recharge groundwater.

This analysis was based on modeling results from the Merced Water Resources Model (MercedWRM) for approximately 1,500 stream nodes in the Merced Subbasin. The stream nodes within the MercedWRM contain information on the quantity of stream gains and losses on a monthly basis. Using the historical simulation (see 2.3.4.1 - Historical Water Budget), the median value of monthly stream gains and losses was calculated over the 2005 to 2015 time period. Figure

2-9 indicates where these stream nodes indicate gaining conditions (groundwater contributing to streamflow, where median monthly gains were larger than losses) and where they indicate losing conditions (surface water recharging groundwater, where median monthly gains were less than losses). Any stream nodes that are disconnected from the principal aquifer (see Figure 2-10) are noted as losing. Disconnection from the principal aquifer was determined where the invert elevation of the streambed is higher than the elevation of the groundwater levels within the MercedWRM aquifer hydrogeologic structure. In areas of the Shallow Unconfined Aquifer (described later in Section 2.1.7.1 - Aquifer Systems in the Basin), conditions can result in regions of perched water tables (AMEC, 2008) which are often associated with or affected by instream flow levels and may not always be considered a full interconnection with the deeper groundwater system typically accessed by production wells.

The groundwater elevation data indicate that there is groundwater discharge along the San Joaquin River (gaining stream). There is a trough in the water table elevations that follows the San Joaquin River. Groundwater inflow to the river and surrounding areas occurs from both sides of the San Joaquin Valley. Apart from groundwater pumping, this river and the surrounding areas are the primary groundwater discharge area for the valley (AMEC, 2013).

On the north side of the Merced Subbasin west of State Highway 99, the lower reaches of the Merced River appear to be a groundwater discharge area (where the Merced River is a gaining stream). East of the highway, the river may be acting as a constant head source and supplying water to the pumping depression centered approximately 17 miles northwest of Merced. East of Oakdale Road (Township 5 South, Range 12 East, Section 36), the river is higher than the groundwater and probably provides some recharge to the groundwater (AMEC, 2013).

Comparison of Chowchilla River elevations with groundwater levels indicates that the river is higher than the groundwater. Consequently, the river probably contributes some recharge to groundwater along the reach south of the study area. The pumping depressions near the Chowchilla River do not appear to be affected by the presence of the river (AMEC, 2013).

Figure 2-9: Losing and Gaining Streams

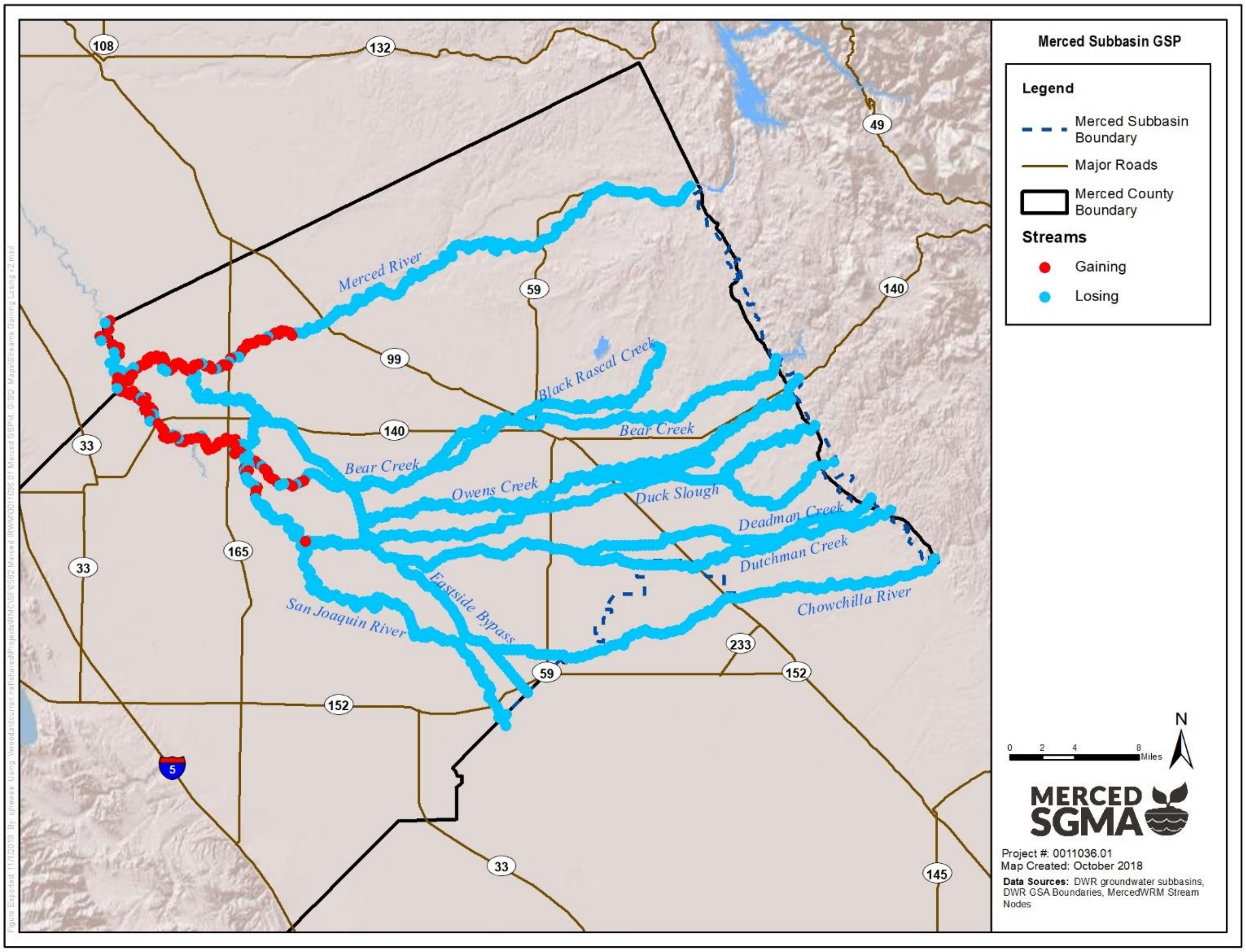
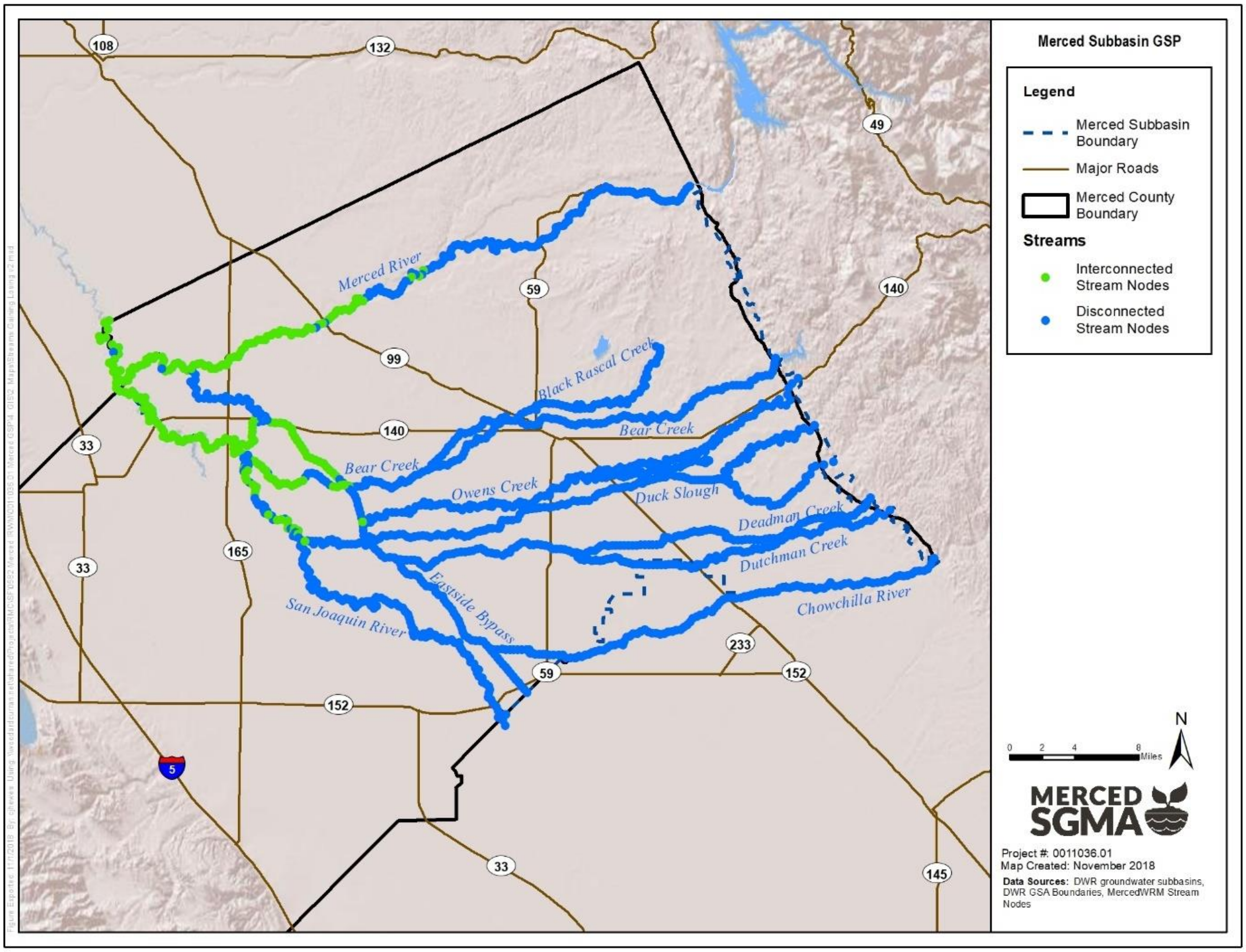


Figure 2-10: Interconnected and Disconnected Streams



2.1.4 Geologic Formations and Stratigraphy

DWR's best management practices (BMP) for the HCM suggests using California Geological Survey (CGS) or USGS data for surficial geologic mapping. For this GSP, surficial geology as well as cross-sections were developed based on detailed USGS work performed by Page & Balding (1973), Page (1977), and Page (1986).

The Merced Subbasin is underlain by consolidated rocks and unconsolidated deposits. The consolidated rocks, from bottom to top, include the Sierra Nevada basement complex, Ione Formation and other sedimentary rocks, the Valley Springs Formation, and the Mehrten Formation (Page & Balding, 1973). The unconsolidated deposits include continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood-basin deposits.

A description of the consolidated rocks and unconsolidated deposits is provided below, with a map of surficial geology shown as Figure 2-11 and a summary table of the units and their water-bearing characteristics provided as Table 2-4.

Note that the text, table, and maps are taken from different sources and use slightly different terminology. Therefore, Table 2-5 is provided to map terminology between items.

The Merced Groundwater Management Plan (AMEC, 2008) provides the following description of the Subbasin geology in the following subsections. The discussions are supported by a geologic map (Figure 2-12) and cross sections (Figure 2-13 through Figure 2-22) from several sources.

2.1.4.1 Consolidated Rocks

The consolidated rocks include the Sierra Nevada basement complex, Ione Formation and other sedimentary rocks, the Valley Springs Formation, and the Mehrten Formation.

The Sierra Nevada bedrock complex consists largely of metasedimentary and metavolcanic rock of pre-Tertiary age (Page & Balding, 1973). These rocks occur as foothill ridges along the eastern edge of the Merced Subbasin (Figure 2-11). Where the basement complex occurs near the surface, fracture sets and joints within the bedrock complex may contain sufficient groundwater for domestic or stock supplies.

The Eocene Ione Formation unconformably overlies the Sierra Nevada bedrock complex and is composed of marine to non-marine clay, sand, sandstone, and conglomerate. These rocks occur as foothill ridges along the eastern edge of the Merced Subbasin (Figure 2-11). The Ione is characterized by a white sandy clay (kaolinite) at its base and beds of conglomerate and yellow, red, and gray sandstone in its upper parts. In localized areas near the Sierra Nevada foothills, the formation contains fresh water; however, well yields are highly variable.

The Miocene Valley Springs Formation overlies the Ione Formation and is composed of a fluvial sequence of rhyolitic ash, sandy clay, and siliceous gravel in a clay matrix. These rocks occur as foothill ridges along the eastern edge of the Merced Subbasin (Figure 2-11). Because of the abundant ash and clay matrix, the Valley Springs has a relatively low groundwater yield, sufficient for domestic or stock supplies, but generally insufficient for irrigation.

The Miocene/Pliocene Mehrten Formation overlies the Valley Springs Formation and is composed of fluvial deposits of sandstone, breccia, conglomerate, luff, siltstone, and claystone. It contains a large amount of andesitic material, making it easy to distinguish. The Mehrten outcrops over a large area in eastern Merced Subbasin (Figure 2-11). It forms an important aquifer in the Merced Subbasin with relatively high yields.

2.1.4.2 Unconsolidated Deposits

The unconsolidated deposits, from bottom to top, include continental deposits, lacustrine and marsh deposits, older alluvium, younger alluvium, and flood-basin deposits.

The Pliocene/Pleistocene continental deposits consist of a heterogeneous mixture of poorly sorted gravel, sand, silt, and clay derived primarily from the Sierra Nevada. The sediments, which are found throughout the Merced Subbasin, dip gently to the southwest and have variable thickness up to 700 feet. The continental deposits have relatively large yields to wells and are an important part of the aquifer system.

The lacustrine and marsh deposits consist of two beds: the Corcoran Clay Member of the Pleistocene Tulare Formation and a shallow clay bed of Holocene age (Page R. W., 1977). The Corcoran Clay is a bed of laterally extensive reduced (blue/grey) silt and clay that underlies about 437 square miles in the southwest portion of the Merced Subbasin (Figure 2-39). The Corcoran Clay is a significant confining layer up to 60 feet thick. The shallow clay bed of Holocene age is composed of oxidized (brown/red) sandy clay and clay with silica cemented intervals (hardpan). It is found throughout most of the Merced Subbasin at a shallow depth (-35 feet). For more information on the Corcoran Clay, see Section 2.1.7.2: Principal Aquifers and Aquitards.

The older alluvium consists of a heterogeneous mixture of poorly sorted gravel, sand, silt, and clay up to 400 feet thick derived primarily from the Sierra Nevada. The sediments, which are found throughout the Merced Subbasin, were deposited as a series of interbedded coarse-grained and fine-grained layers and form a leaky-aquifer system.

The flood-plain deposits consist of intercalated lenses of reduced to oxidized fine sand, silt, and clay. These deposits are found in the southwestern portion of the Merced Subbasin (Figure 2-11) and generally are less than 30 feet thick.

The younger alluvium consists of well-sorted gravel and sand derived primarily from the Sierra Nevada. The younger alluvium is found in a narrow band along the stream channels throughout the Merced Subbasin (Figure 2-11) (Page & Balding, 1973).

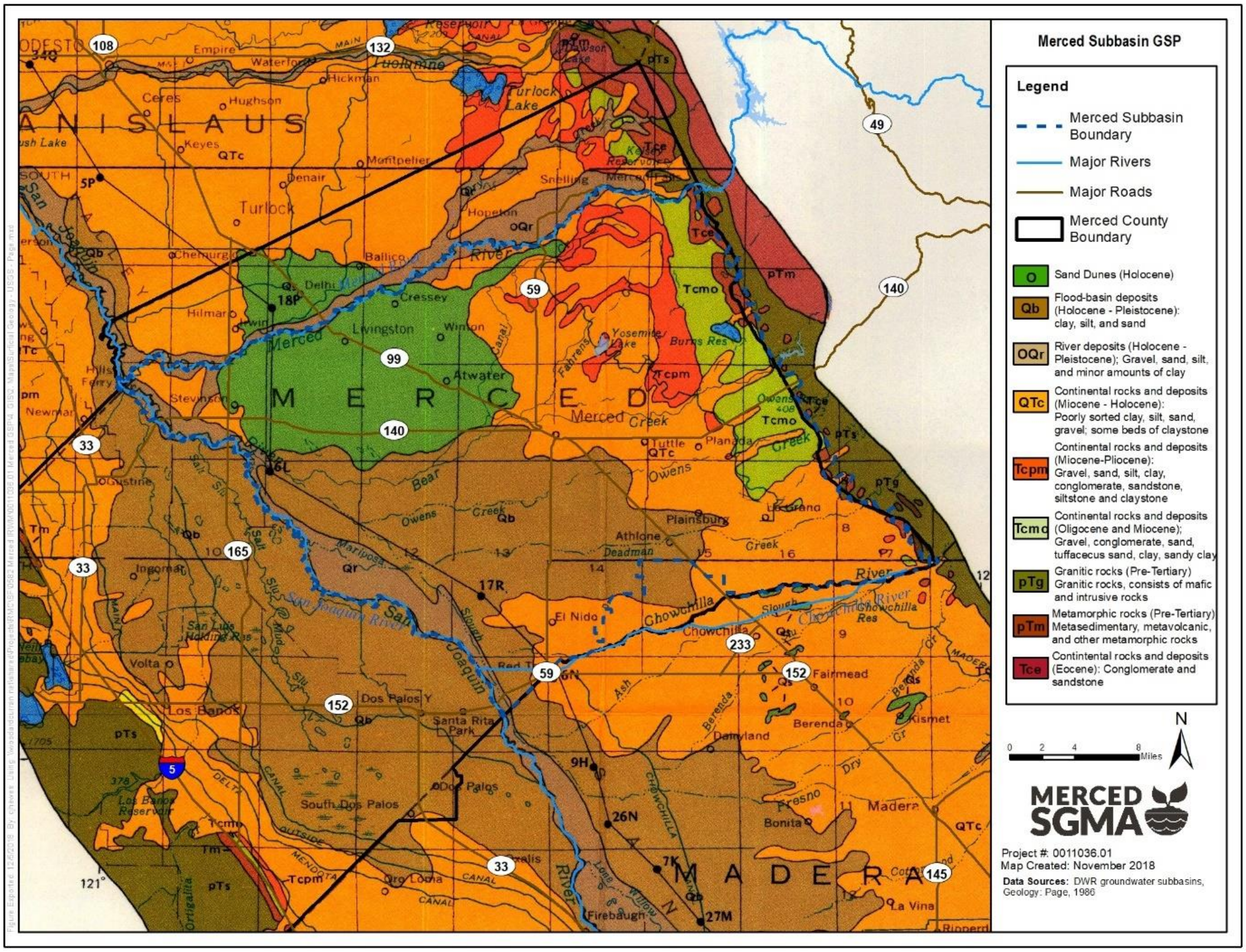
Table 2-4: Generalized Section of Geologic Units and Their Water-Bearing Characteristics

Period and Epoch		Geologic Unit	Lithologic Character	Maximum thickness (feet)	Water-Bearing Character	For Reference - Figure 2-11 Formation Name
Unconsolidated Deposits						
Quaternary	Holocene	Flood-basin deposits	Silt, clay, and fine sand, bluish-gray, brown, and reddish-brown.	100	Small hydraulic conductivities and small yields to wells.	Qb (Flood-basin deposits [Holocene-Pleistocene])
	Holocene	Younger alluvium	Gravel, sand, and find sand, some silt and clay, little or no hardpan; yellow, yellowish-brown, brown.	100	Moderate to large hydraulic conductivities, where saturated yields moderate quantities to wells. Unconfined.	Qr (River deposits [Holocene-Pleistocene])
	Pleistocene and Holocene?	Older alluvium	Gravel, sand, silt, and clay, some hardpan; brown, reddish-brown, gray, brownish-gray, white, blue, and black.	400 (in northern part of area) 700 (in southern part of area)	Moderate to large hydraulic conductivities; yields to wells reported as large as 4,451 gpm (gallons per minute); average yield to large wells (1900 gpm). North of study area transmissivities of about 11,700 ft^2/day (cubic feet per day per foot). Unconfined and confined.	QTc (Continental rocks and deposits [Miocene-Holocene])
	Pleistocene	Lacustrine and marsh deposits	Silt, silty clay, and clay, gray and blue.	100	Confining bed, very small hydraulic conductivities. (includes the Corcoran Clay)	(not pictured)
Tertiary and Quaternary?	Pliocene and Pleistocene	Continental deposits	Gravel, sand, silt, and clay; brown, yellow, gray, blue, and black.	>450 (In northern part of area) >700 (in southern part of area)	Moderate to large hydraulic conductivities; yield to wells as large as 2,102 gpm. North of study area transmissivities of about 8,000 ft^2/day. Confined beneath lacustrine and marsh deposits. In extreme western part of area, water contains in excess of 2,000 mg/l (milligrams per liter) dissolved solids.	QTc (Continental rocks and deposits [Miocene-Holocene])

Period and Epoch		Geologic Unit	Lithologic Character	Maximum thickness (feet)	Water-Bearing Character	For Reference - Figure 2-11 Formation Name
Consolidated Rocks						
Tertiary	Miocene and Pliocene	Mehrten Formation	Sandstone, breccia, conglomerate, tuff, siltstone, and claystone; brown, yellowish-brown, grayish-brown, pinkish-brown, pink, blue, yellow, green, gray, and black. Large amounts of andesitic material occur in beds.	200 (In northern part of area) >700 (In southern part of area)	Small to moderate hydraulic conductivities. North of study area ranges in hydraulic conductivity from 0.01 to 67 ft/day. Yield to wells as large as 2,102 gpm. In western part of area, water contains in excess of 2,000 mg/l dissolved solids content. Locally in eastern part of area water probably contains in excess of 2,000 mg/l dissolved solids.	Tcpm (Continental rocks and deposits [Miocene-Pliocene])
	Miocene and Pliocene	Valley Springs Formation	Ash, sandy clay, and siliceous sand and gravel generally in clay matrix, tuff, siltstone, and claystone; yellow, yellowish-brown, brown, reddish-brown, gray, greenish-gray, white, pink, green, and blue. Rhyolitic material occurs in beds.	900 (In northern part of area) Unknown in southern part of area	Probable small hydraulic conductivities. Quality of water ranges from fair to poor.	Tcmo (Continental rocks and deposits [Oligocene and Miocene])
	Eocene	Ione Formation and other sedimentary rocks	Conglomerate, sandstone, clay, and shale; partly marine; yellow, red, gray, and white.	800 (In northern part of area) Unknown in southern part of area	Probable small to moderate hydraulic conductivities. In places reported to yield saline water.	Tce (Continental rocks and deposits [Eocene])
Cretaceous		Marine sandstone and shale	Sandstone and shale.	>9,500 (In northern part of area) Unknown in southern part of area	Unknown. Reported to yield saline water.	(not pictured)
Pre-Tertiary		Basement complex	Metamorphic and igneous rocks.		Fractures and joints locally yield small quantities of water; otherwise virtually impermeable.	pTm (Metamorphic rocks [Pre-Tertiary])

Source: (Page & Balding, 1973)

Figure 2-11: Surficial Geology



The units generally dip to the west; that is, the elevation of the units is higher in the east than in the west. Some units are not present across the entire basin. Notably, this is true of the Corcoran Clay which extends east to near Highway 99, where it is generally shallow and thin, and becomes deeper and thicker to the west where it extends beyond the western boundary of the Subbasin. Details on materials in the subsurface are provided through cross sections and a three-dimensional rendering of the basin.

Five cross sections were developed by Page & Balding (1973) across the Merced Subbasin and neighboring Turlock Subbasin. The locations of the cross-section are shown on Figure 2-12, with the cross-sections themselves shown on Figure 2-13 through Figure 2-17. The cross sections show the units dipping towards the west, highlighting the depth, thickness and extent of the Corcoran Clay as well as the depth of the base of fresh water (short dashed line). Note that these cross sections include vertical exaggeration in order to highlight the small difference in the vertical axis.

Distances shown vertically are 52.8 times the horizontal distances, allowing visualization of finer detail with depth, but also resulting in dip angles appearing much steeper and the overall aquifer appearing much deeper than in reality.

Four additional cross sections were developed by Page (1977) more specifically for the City of Merced-City of Atwater area. The locations of these cross-sections are shown on Figure 2-18, with the cross sections shown on Figure 2-19 through Figure 2-22.

Figure 2-12: Location of Geologic Cross Sections (Page & Balding 1973)

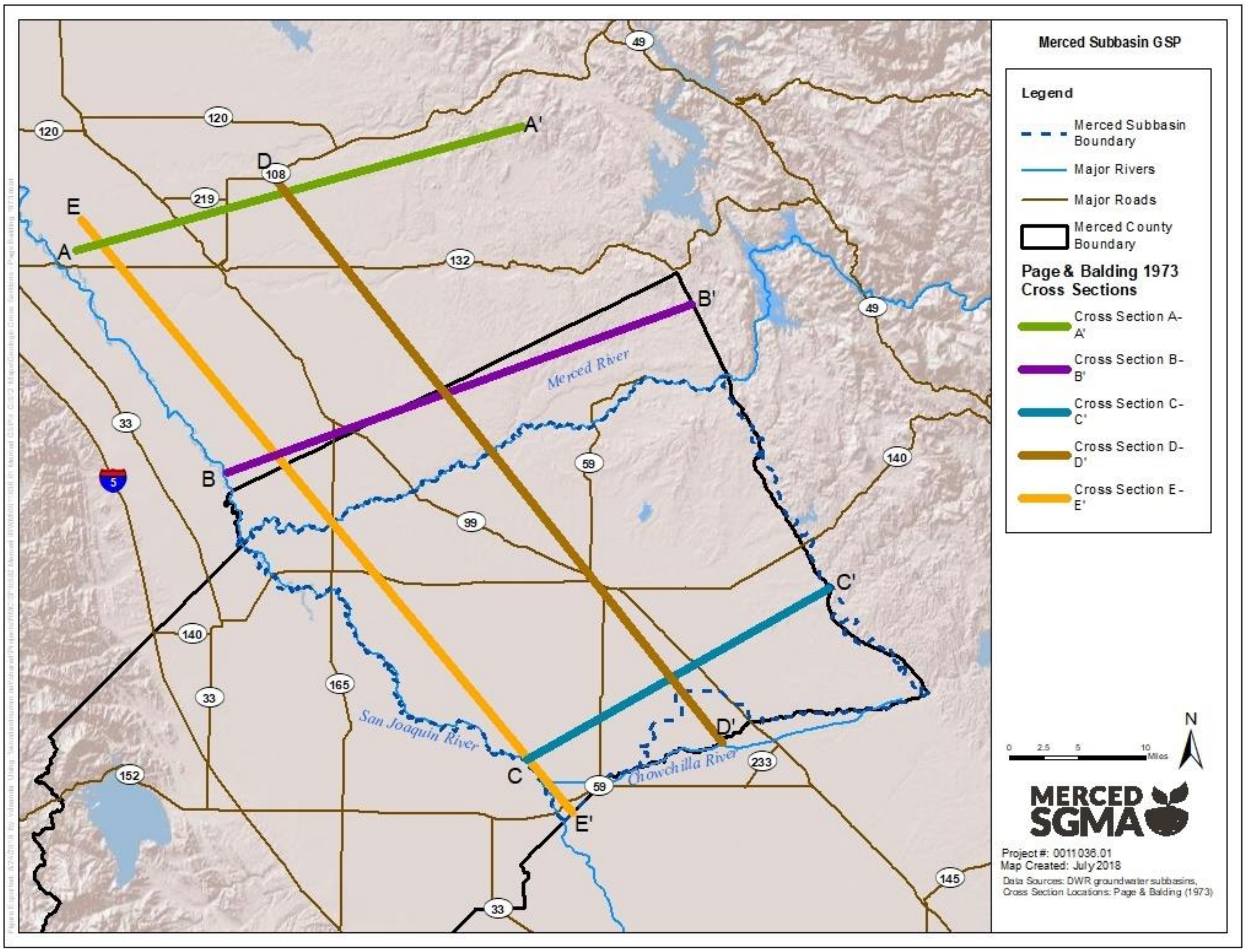
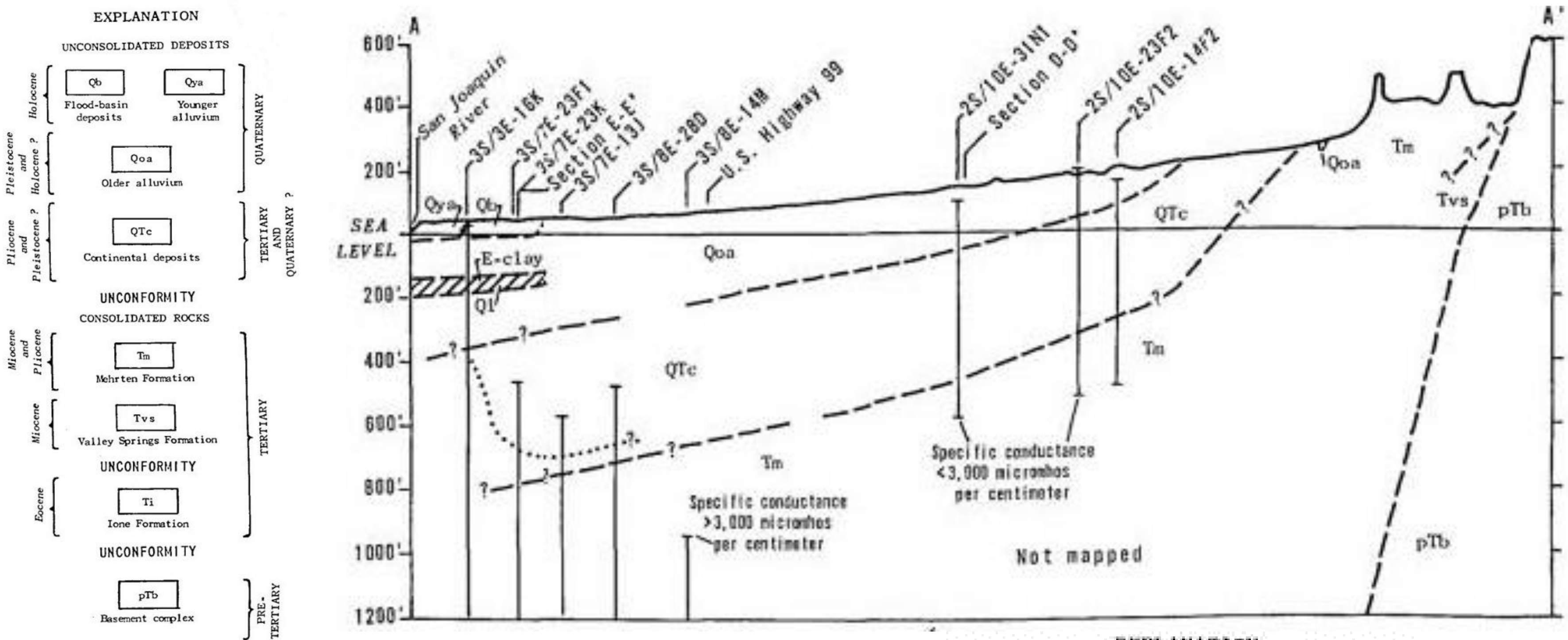
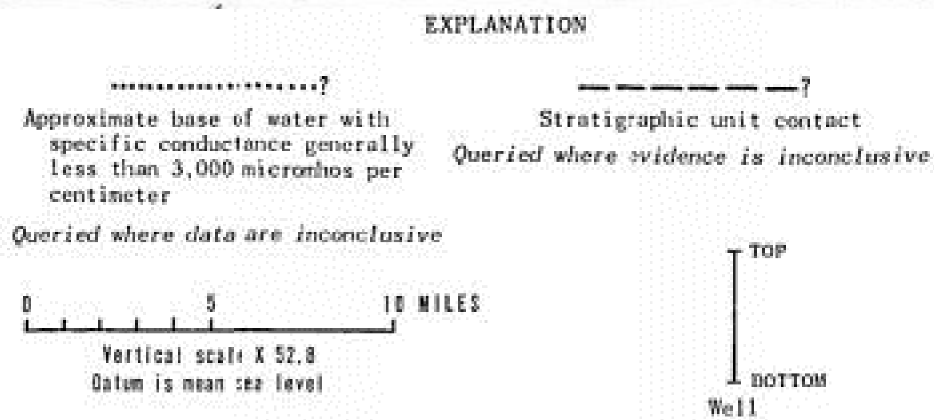


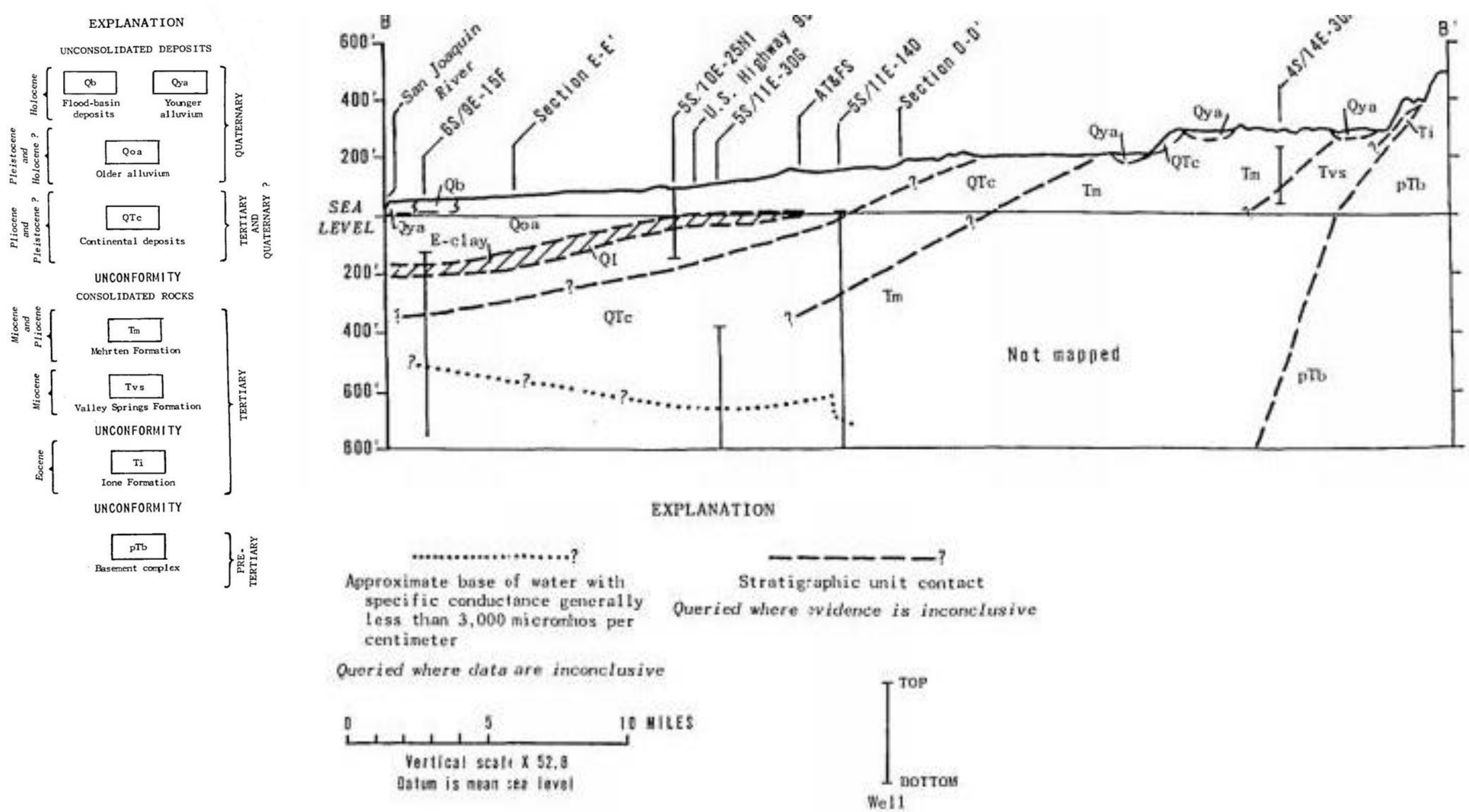
Figure 2-13: Geologic Cross-Section A (Page & Balding 1973)





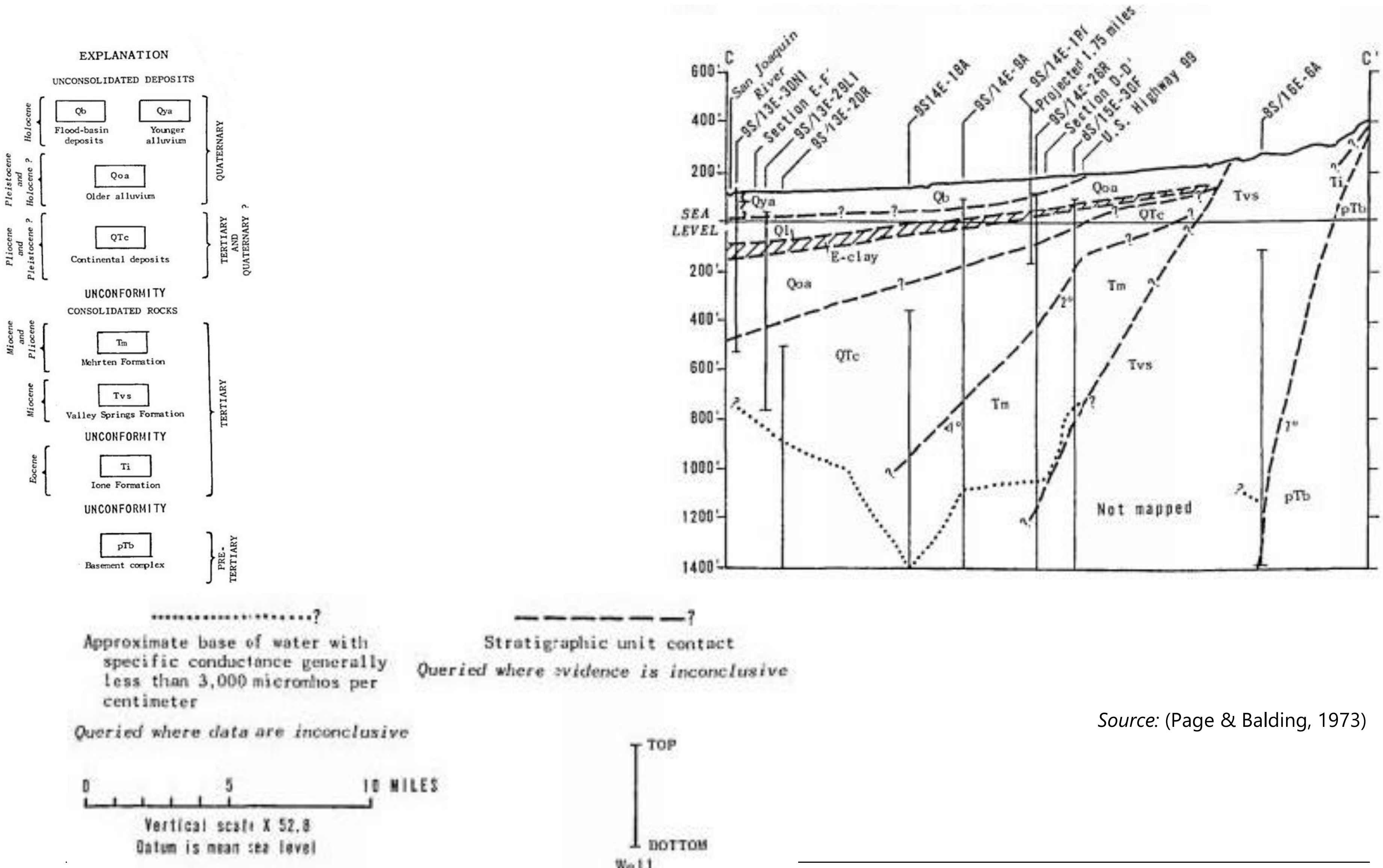
Source: (Page & Balding, 1973)

Figure 2-14: Geologic Cross-Section B (Page & Balding 1973)



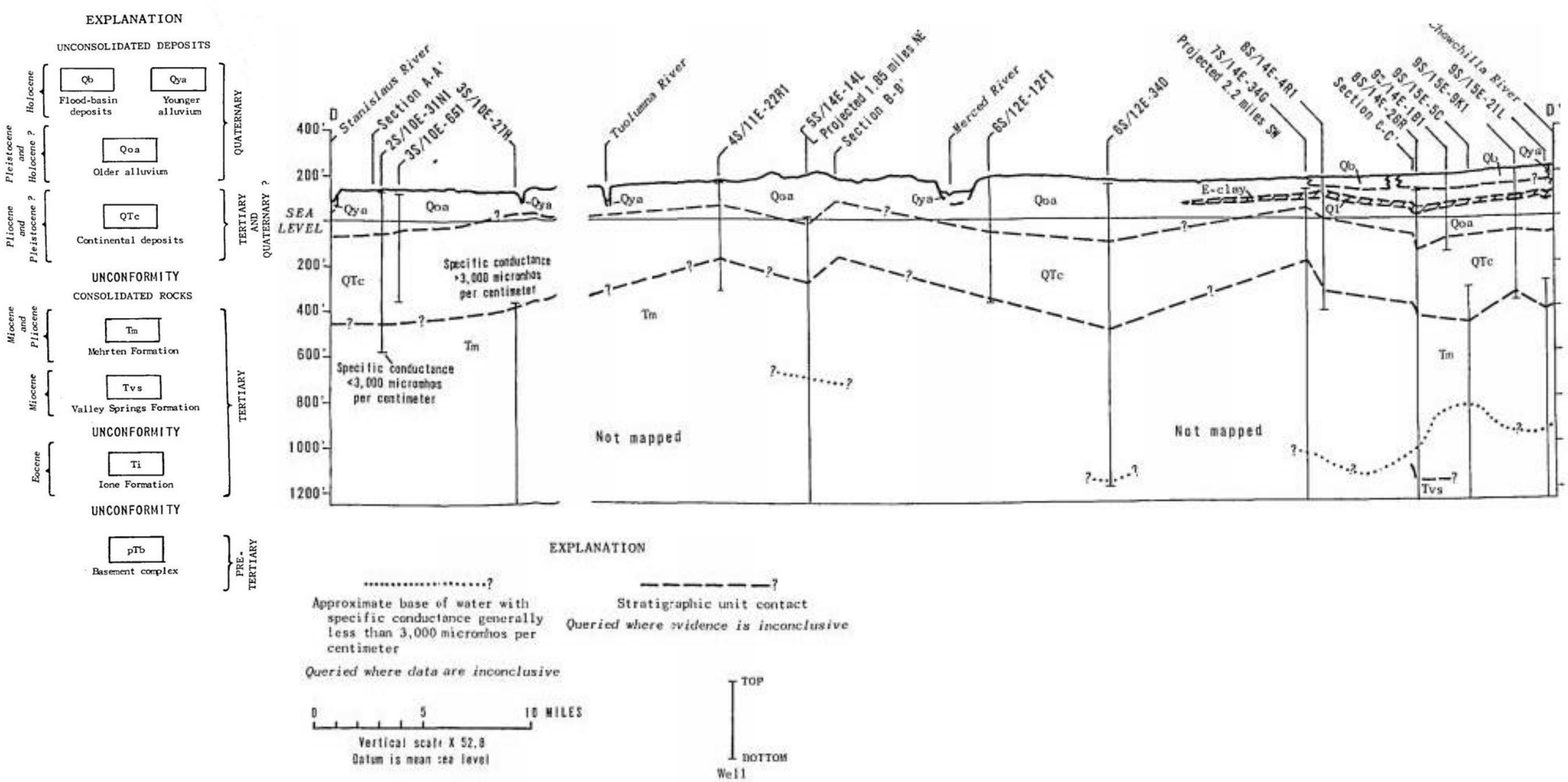
Source: (Page & Balding, 1973)

Figure 2-15: Geologic Cross-Section C (Page & Balding 1973)



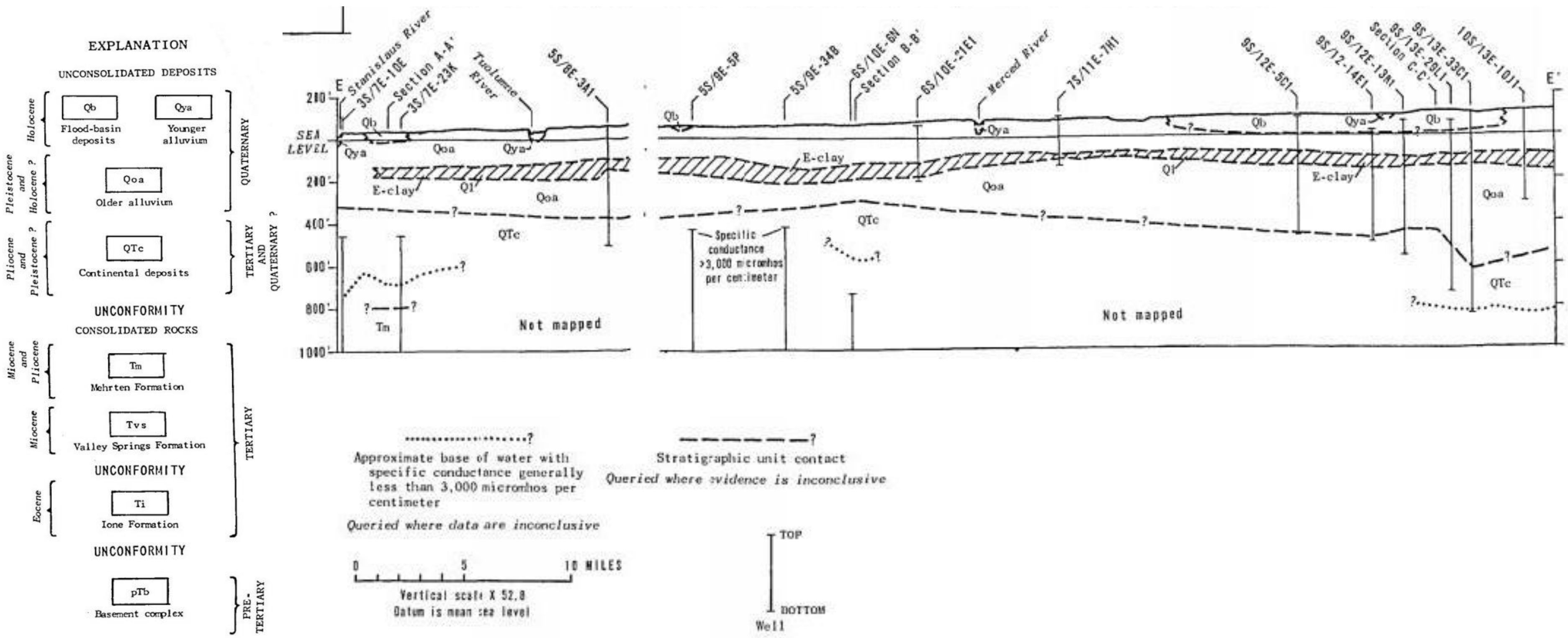
Source: (Page & Balding, 1973)

Figure 2-16: Geologic Cross-Section D (Page & Balding 1973)



Source: (Page & Balding, 1973)

Figure 2-17: Geologic Cross-Section E (Page & Balding 1973)



Source: (Page & Balding, 1973)

Figure 2-18: Location of Geologic Cross Sections (Page 1977)

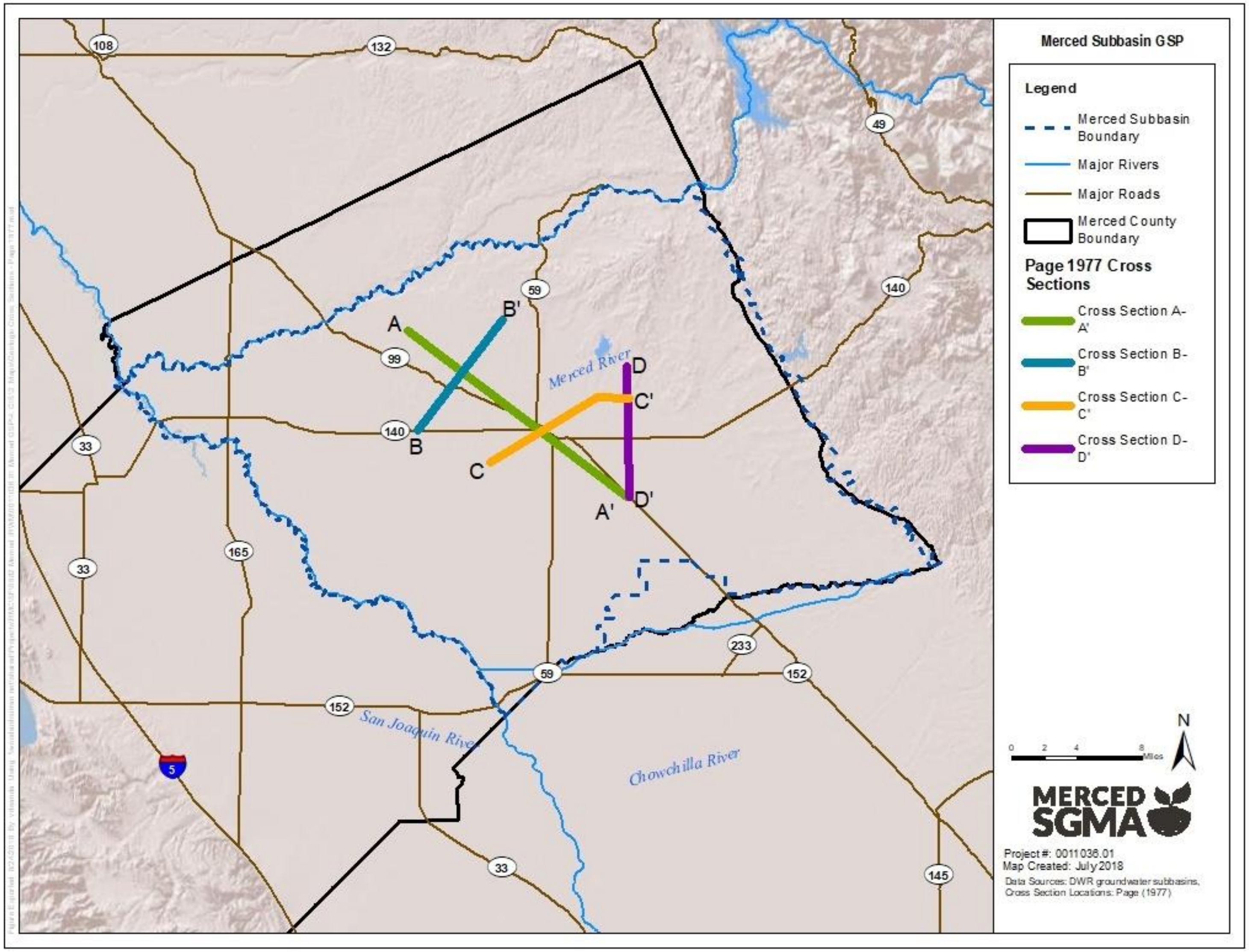
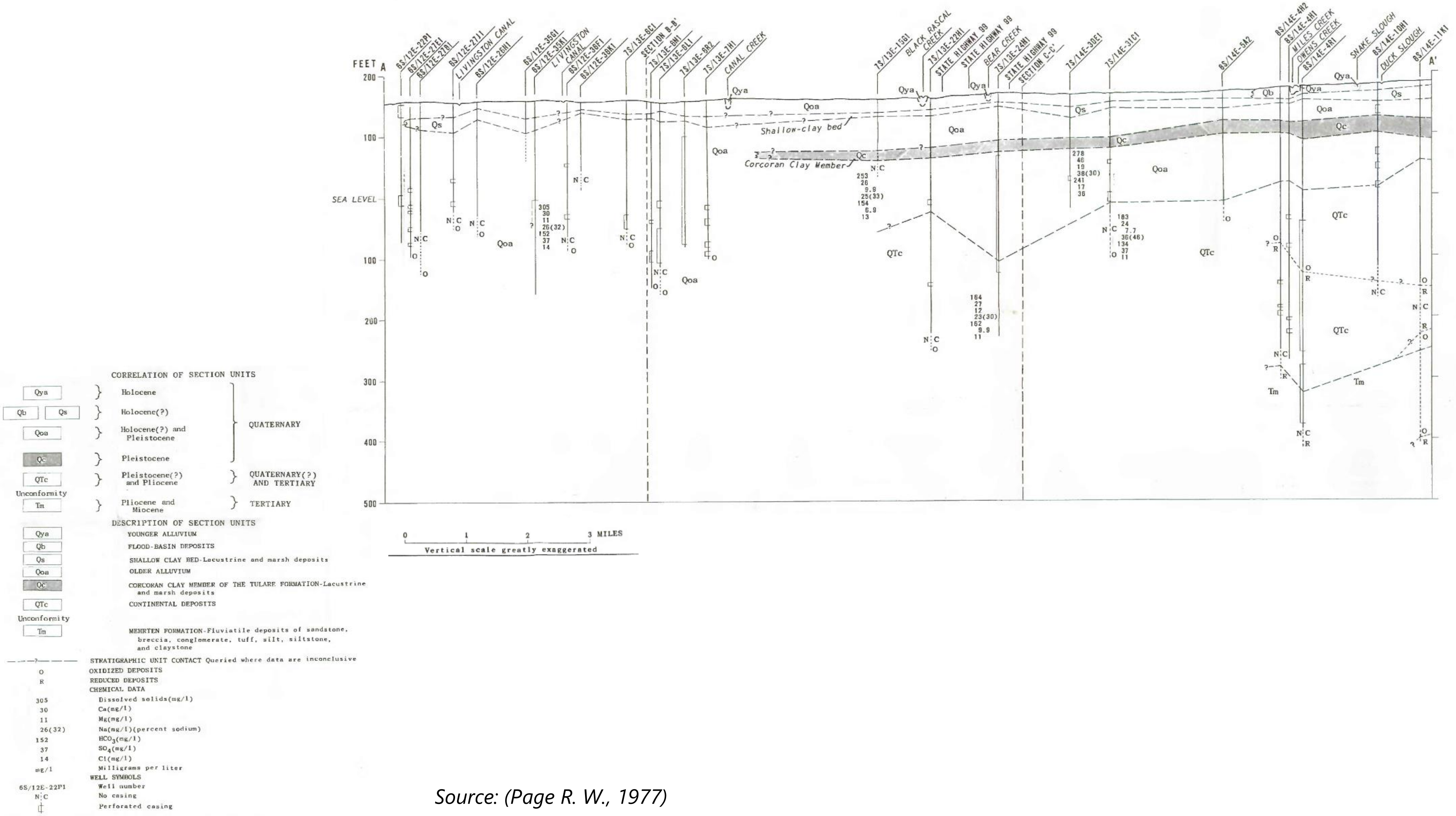
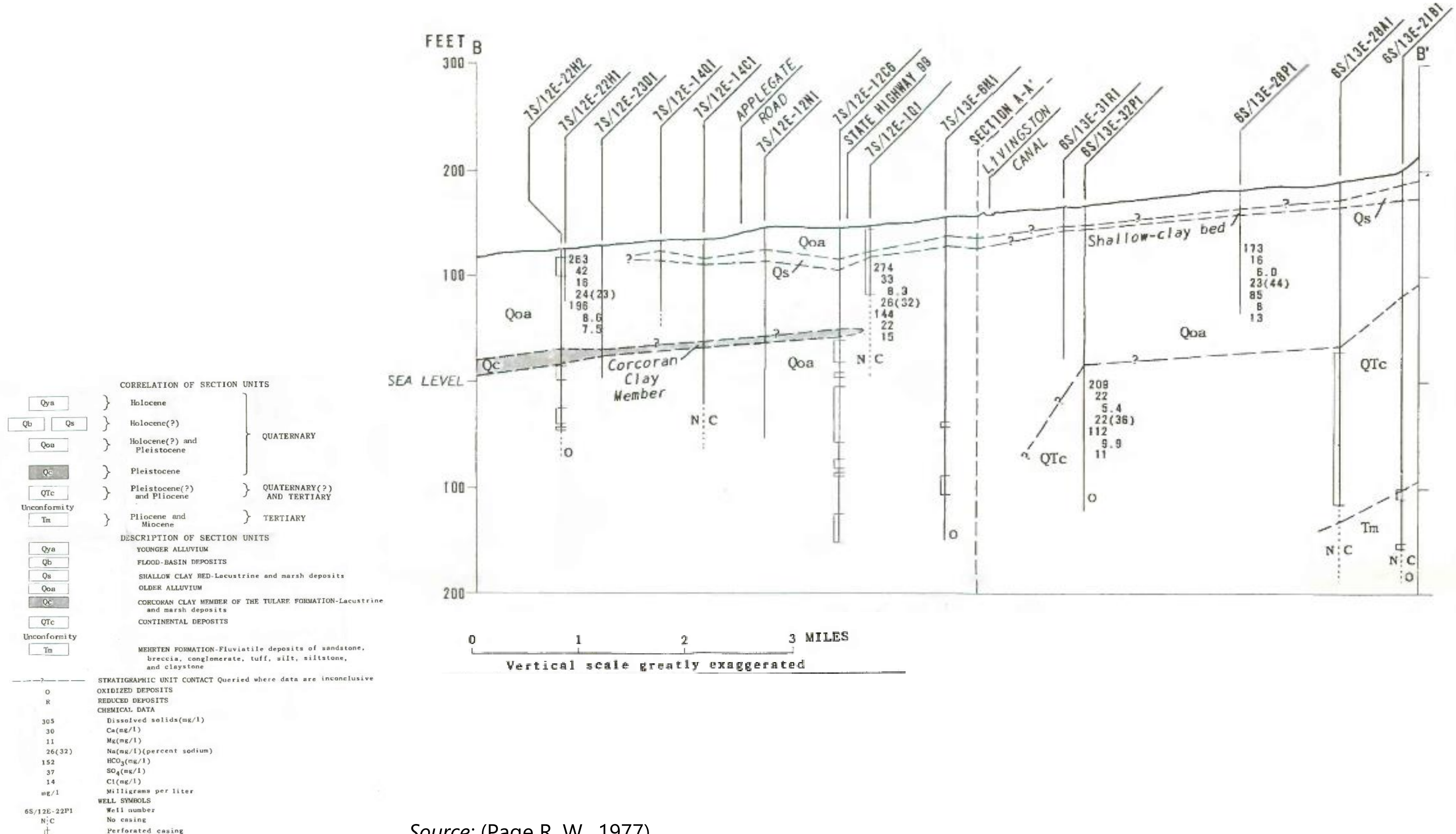


Figure 2-19: Geologic Cross-Section A (Page 1977)



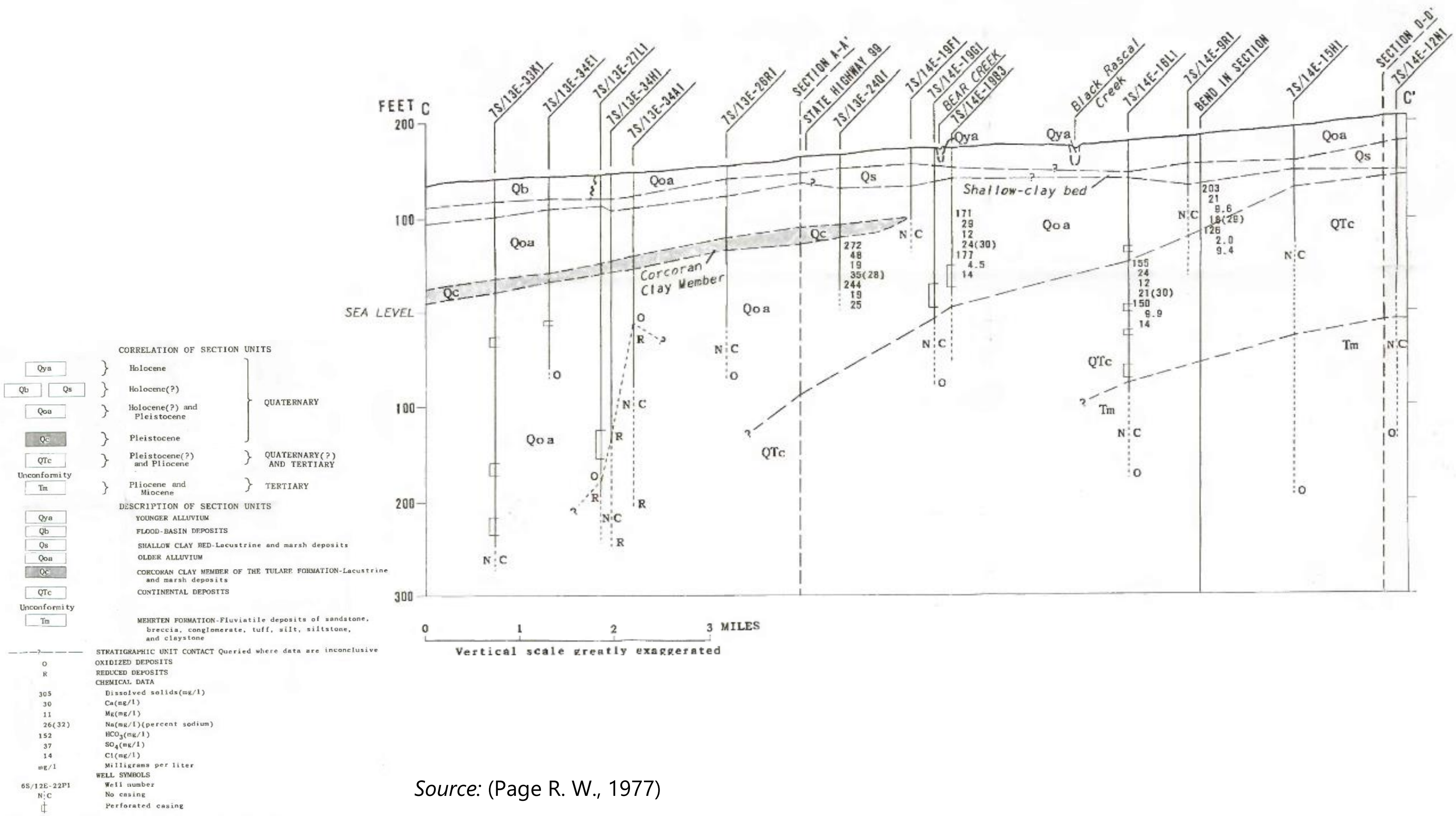
Source: (Page R. W., 1977)

Figure 2-20: Geologic Cross-Section B (Page 1977)



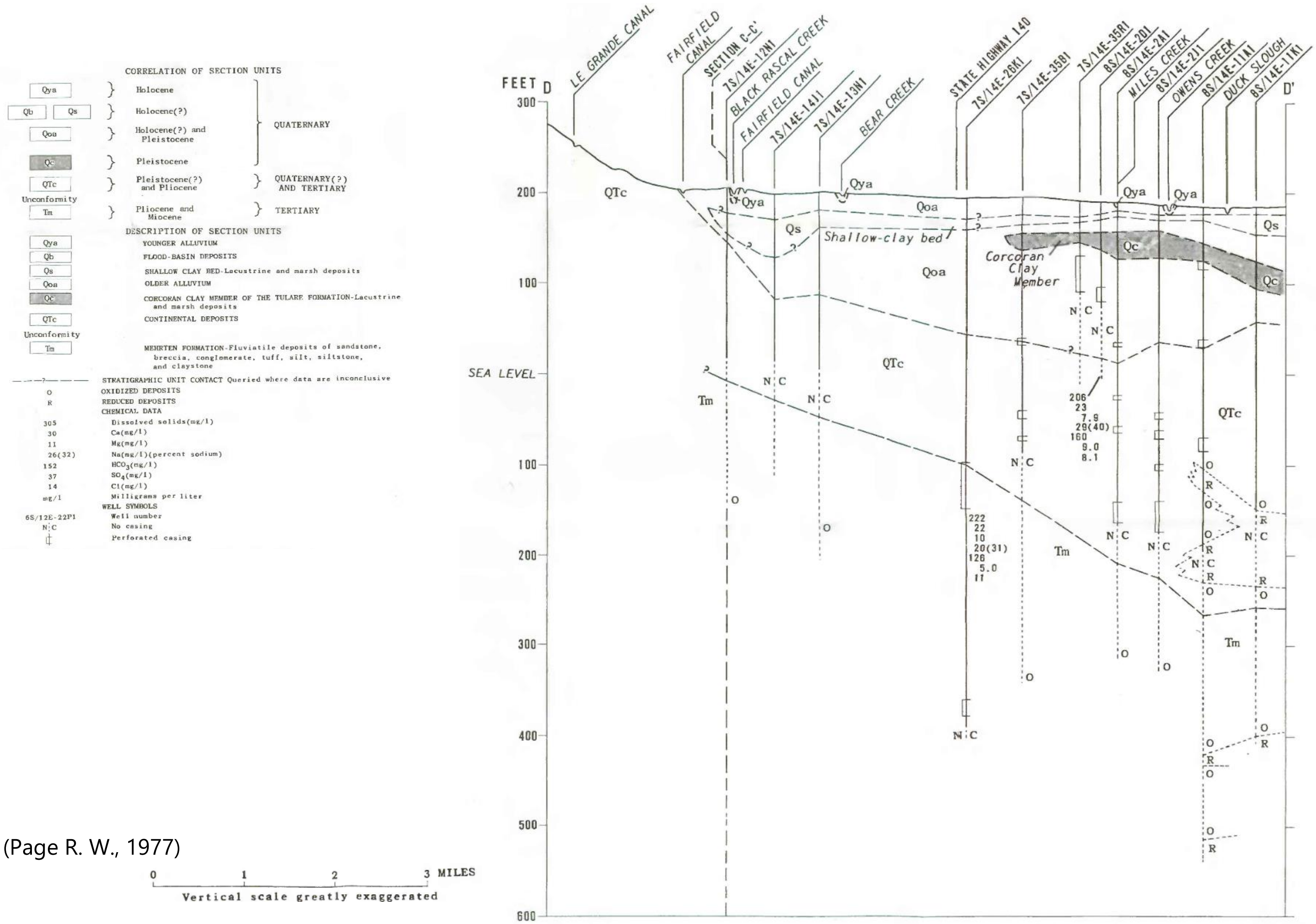
Source: (Page R. W., 1977)

Figure 2-21: Geologic Cross-Section C (Page 1977)



Source: (Page R. W., 1977)

Figure 2-22: Geologic Cross-Section D (Page 1977)



Source: (Page R. W., 1977)

Table 2-5 provides a lookup table that links the various names used for the formations described in the earlier text of Section 2.1.3 with the cross sections shown below (Figure 2-13 through Figure 2-22).

The cross sections from Page & Balding (1973) and Page (1977) were used together with the USGS Central Valley Hydrologic Model (CVHM) texture model to develop the basis of the physical structure and hydrogeologic characteristics of the MercedWRM. The texture model was used to augment the cross sections with more recent boring log data through 2004 at a finer spatial resolution. The USGS applied data from several thousand boreholes to a geostatistical analysis to estimate the percentage of fine- and coarse-grained materials, which relates to aquifer parameters. These parameters were then adjusted and calibrated within the MercedWRM to reflect long-term trends in water levels. Additional information about incorporation of USGS CVHM Texture Model data can be found in Appendix D (MercedWRM Documentation).

Table 2-5: Formation Name Lookup for Geologic Text, Tables, and Figures

<table>
<tr><th colspan="2">Formation Name in Report Text</th><th>Formation Name in Surficial Geology Map (Page 1986)</th><th>Formation Name in Page & Balding 1973 Cross Sections</th><th>Formation Name in Page 1977 Cross Sections</th></tr>
<tr><td colspan="2">Sierra Nevada bedrock complex</td><td>pTm (Metamorphic rocks [Pre-Tertiary]) + pTg (Granitic rocks (Pre-Tertiary)]</td><td>pTb (Basement complex)</td><td>-</td></tr>
<tr><td colspan="2">Eocene Ione Formation</td><td>Tce (Continental rocks and deposits [Eocene])</td><td>Ti (Ione Formation)</td><td>-</td></tr>
<tr><td colspan="2">Miocene Valley Springs Formation</td><td>Tcmo (Continental rocks and deposits [Oligocene and Miocene])</td><td>Tvs (Valley Springs Formation)</td><td>-</td></tr>
<tr><td colspan="2">Micoene/Pliocene Mehrten Formation</td><td>Tcpm (Continental rocks and deposits [Miocene-Pliocene])</td><td>Tm (Mehrten Formation)</td><td>Tm (Mehrten Formation - Fluviatile deposits of sandstone, breccia, conglomerate, tuff, silt, siltstone, and claystone)</td></tr>
<tr><td rowspan="2">Lacustrine and marsh deposits</td><td>Corcoran Clay Member</td><td>N/A – not surficial</td><td>E-clay or Ql</td><td>Qc (Corcoran Clay Member of the Tulare Formation - Lacustrine and marsh deposits)</td></tr>
<tr><td>Shallow clay bed (Holocene age)</td><td>N/A – not surficial</td><td>-</td><td>Qs (Shallow Clay Bed - Lacustrine and marsh deposits)</td></tr>
<tr><td colspan="2">Pliocene/Pleistocene continental deposits</td><td rowspan="2">QTc (Continental rocks and deposits [Miocene-Holocene])</td><td>QTc (Continental deposits)</td><td>QTc (Continental deposits)</td></tr>
<tr><td colspan="2">Older alluvium</td><td>Qoa (Older alluvium)</td><td>Qoa (Older alluvium)</td></tr>
<tr><td colspan="2">Flood-plain deposits</td><td>Qb (Flood-basin deposits [Holocene-Pleistocene])</td><td>Qb (Flood basin deposits)</td><td>Qb (Flood basin deposits)</td></tr>
<tr><td colspan="2">Younger alluvium</td><td>Qr (River deposits [Holocene-Pleistocene])</td><td>Qya (Younger alluvium)</td><td>Qya (Younger alluvium)</td></tr>
</table>

A three-dimensional representation of the Subbasin (Figure 2-23) provides the capability to understand geologic conditions at different depths and locations throughout the Subbasin.

The three-dimensional representation allows for the development of cross sections at any location, with examples shown in Figure 2-24 and Figure 2-25. Originally developed for the MercedWRM, the three-dimensional representation incorporates information from the Page & Balding (1973) cross sections and the surficial geologic map, in addition to subsurface texture data from the USGS. Model layers were aligned with the formations and are described in detail in Section 2.1.7 - Principal Aquifers and Aquitards. More information on the MercedWRM can be found in Appendix D.

Figure 2-23: 3D Rendering Cross Section Overview

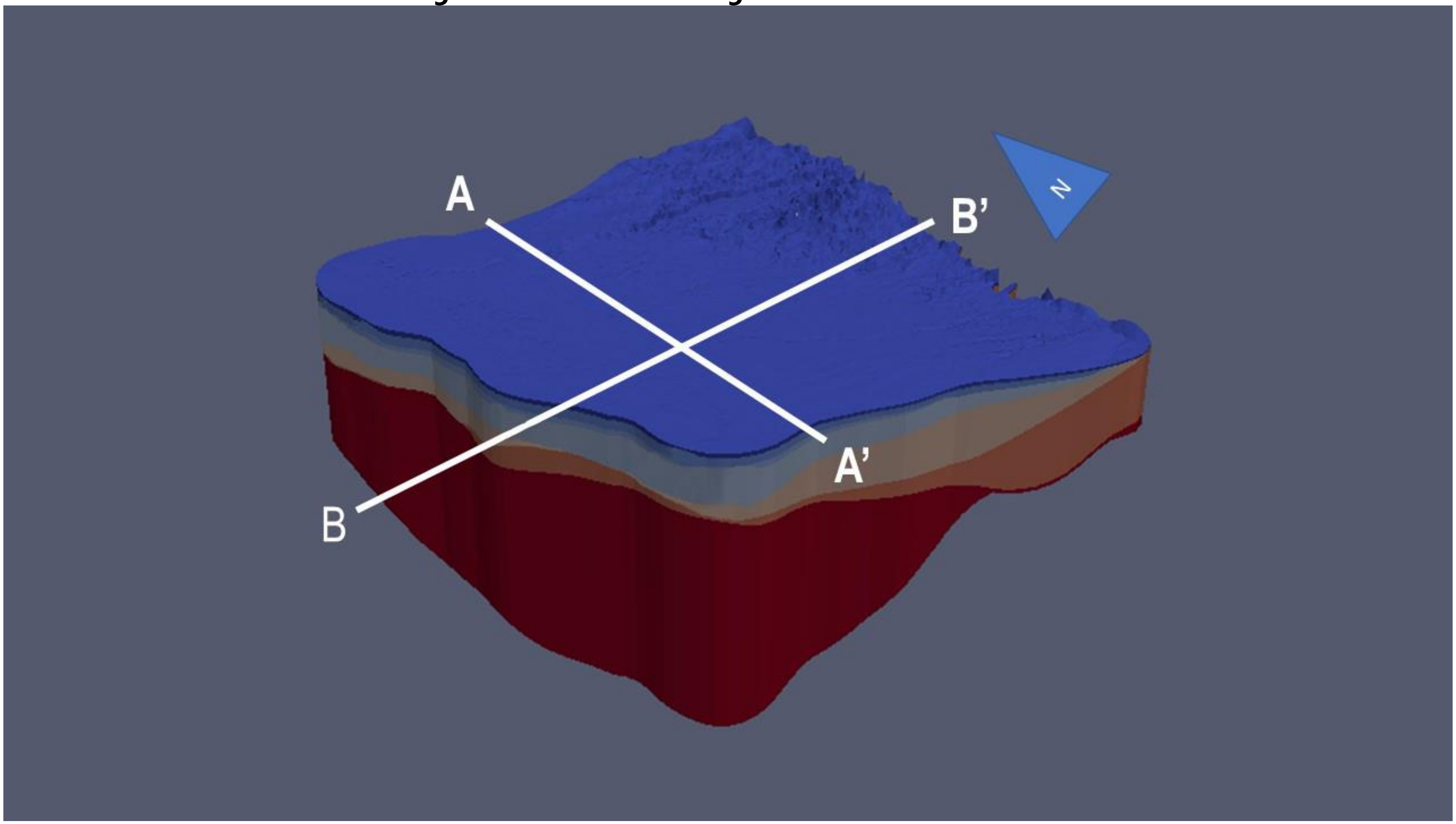


Figure 2-24: 3D Rendering A-A′

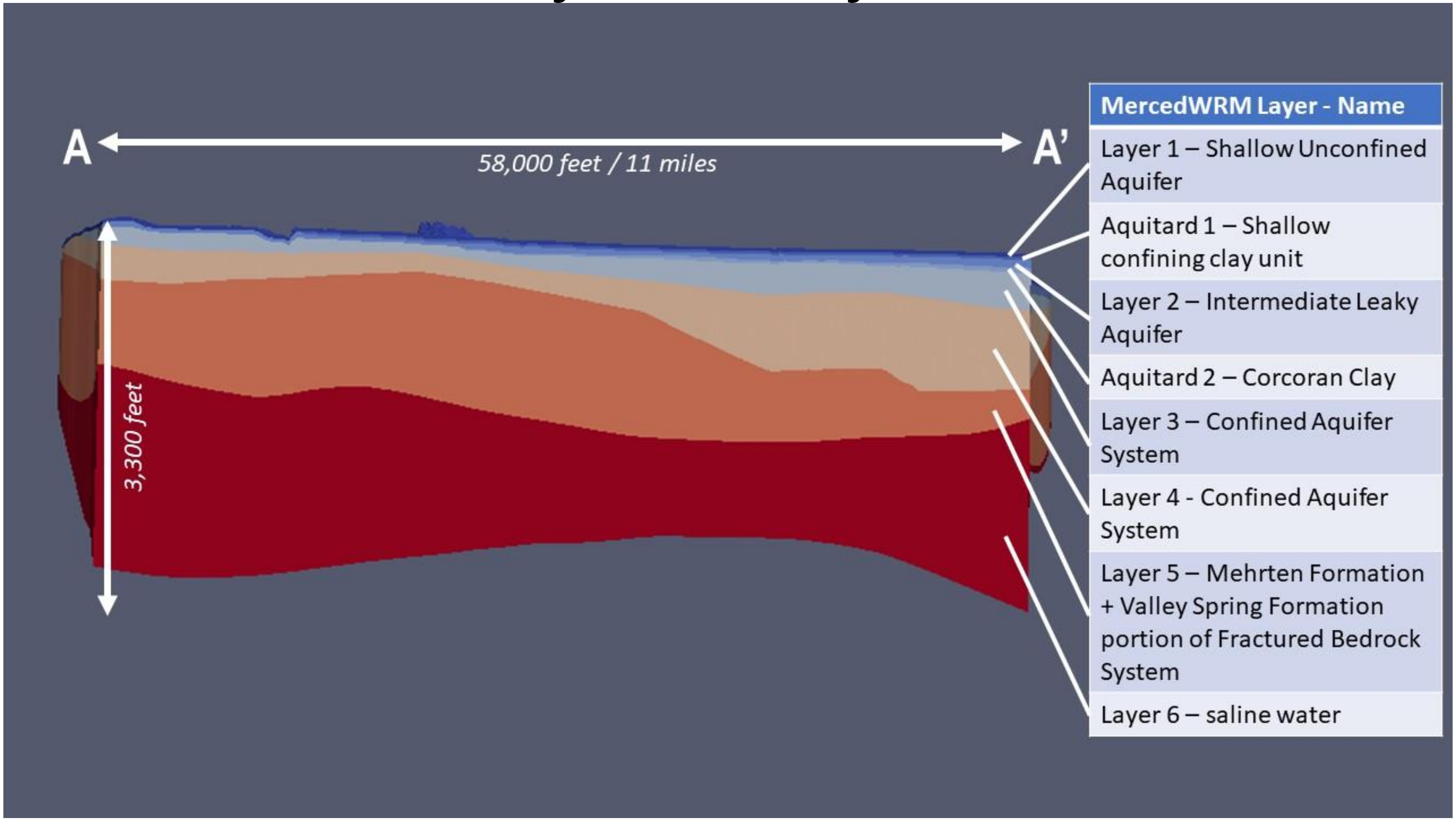
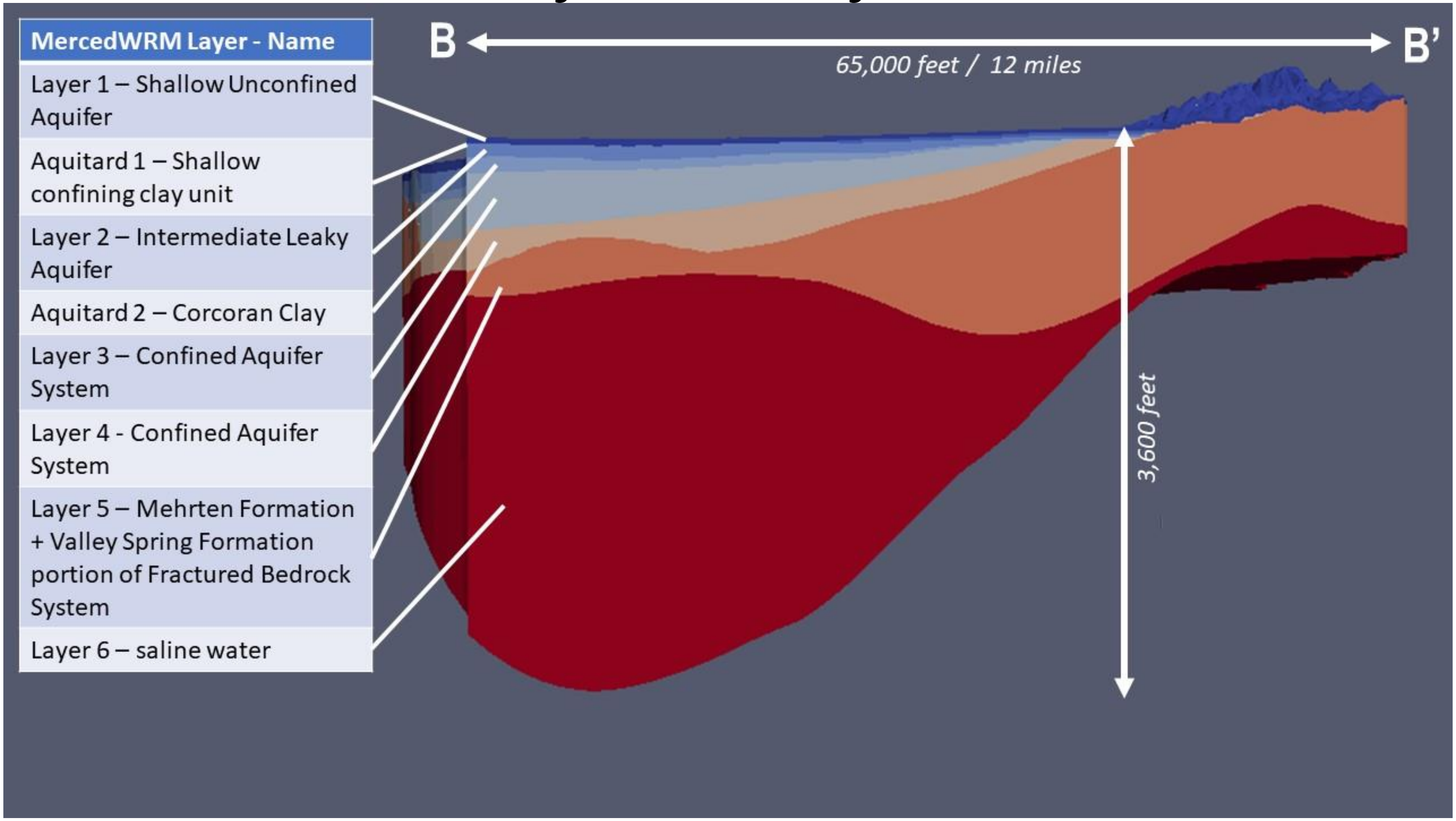


Figure 2-25: 3D Rendering B-B′



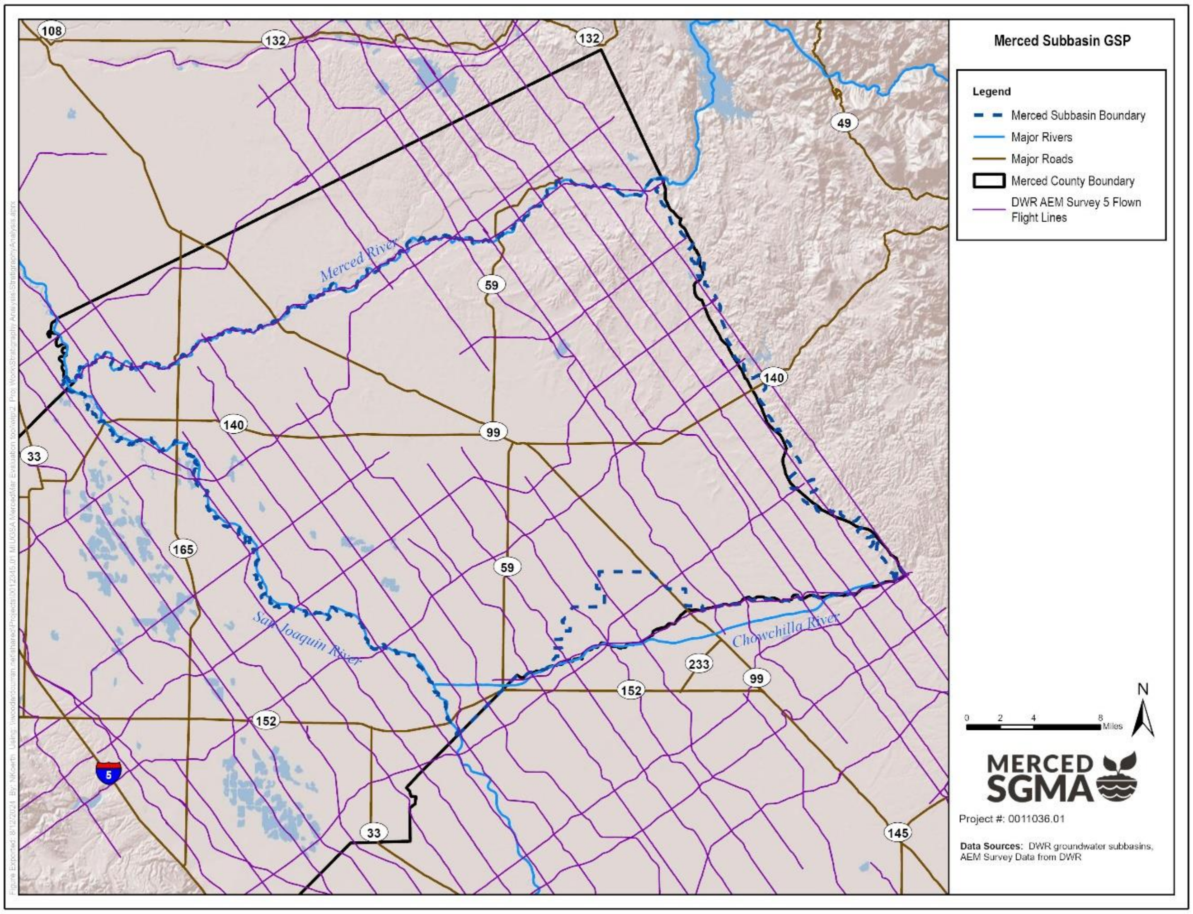
2.1.4.3 2023 Airborne Electromagnetic Surveys

On April 15, 2023, DWR published the Data Report for Survey Area 5, Merced, Turlock, and Modesto Groundwater Subbasins which discussed the acquisition, processing, inversion and lithology transform for the airborne electromagnetic (AEM) survey conducted in the Merced, Turlock and Modesto Subbasins. The survey included flight line planning, local coordination and public outreach, data collection and processing, and lithology modeling.

Electromagnetic (EM) surveying is a geophysical technique performed either from the air or land surface to measure the electrical properties of earth's materials. AEM is the airborne version of an EM survey and involves suspending geophysical equipment beneath an aircraft across multiple flight paths or survey areas. By collecting electromagnetic data of the Subbasin's surface materials, AEM provides the GSAs with additional information to compliments the Subbasin's Hydrogeologic Conceptual Model and better manage groundwater resources.

Flight lines were developed in a five-step process. First, a 2-mile by 8-mile grid was positioned over the survey area to capture large-scale hydrogeologic features such as aquifers, geologic bedding and fault orientation, and the presence of brackish to saline groundwater. Flight line development took into consideration certain survey areas in order to prevent safety hazards and minimize noise impacts to urban and agricultural areas, oil and gas well fields, major highways and roads, railroads, utility lines, pipelines, and vineyards. Next, flight lines were modified to incorporate areas identified by the GSAs as important or in need of data. Flight lines were further refined to be co-located with existing lithology or geophysical data, either provided from public databases or provided by the GSAs. Finally, flight lines were provided to DWR's consultants for potential infrastructure interference and safety consideration adjustments. Flight lines for the Merced Subbasin are shown in Figure 2-26.

Figure 2-26: Merced Subbasin AEM Survey Flight Lines



AEM survey data was paired with lithology, water quality, and geophysical data to better process and transform the survey data into the lithology and hydrostratigraphic models. The AEM survey required a minimum of two lithology logs per square mile area which the flight line crossed. Lithology logs were compiled from over 1,600 wells within the Subbasin of low and high quality. Borehole geophysical data logs were also compiled from wells where data extend through the depth interval of the AEM survey. The locations of the lithology and geophysical logs are shown in Figure 2-27 and a summary of these logs is provided in Table 2-6.

Figure 2-27: Merced AEM Survey Flight Lines and Boring Logs

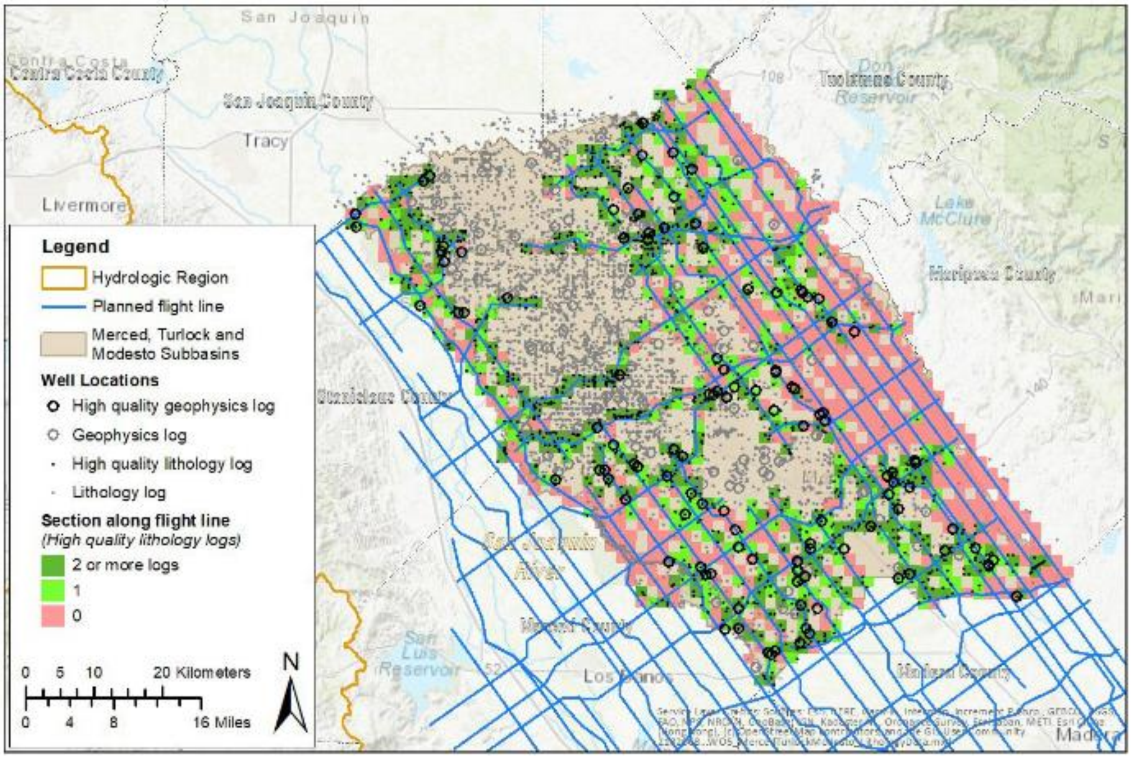
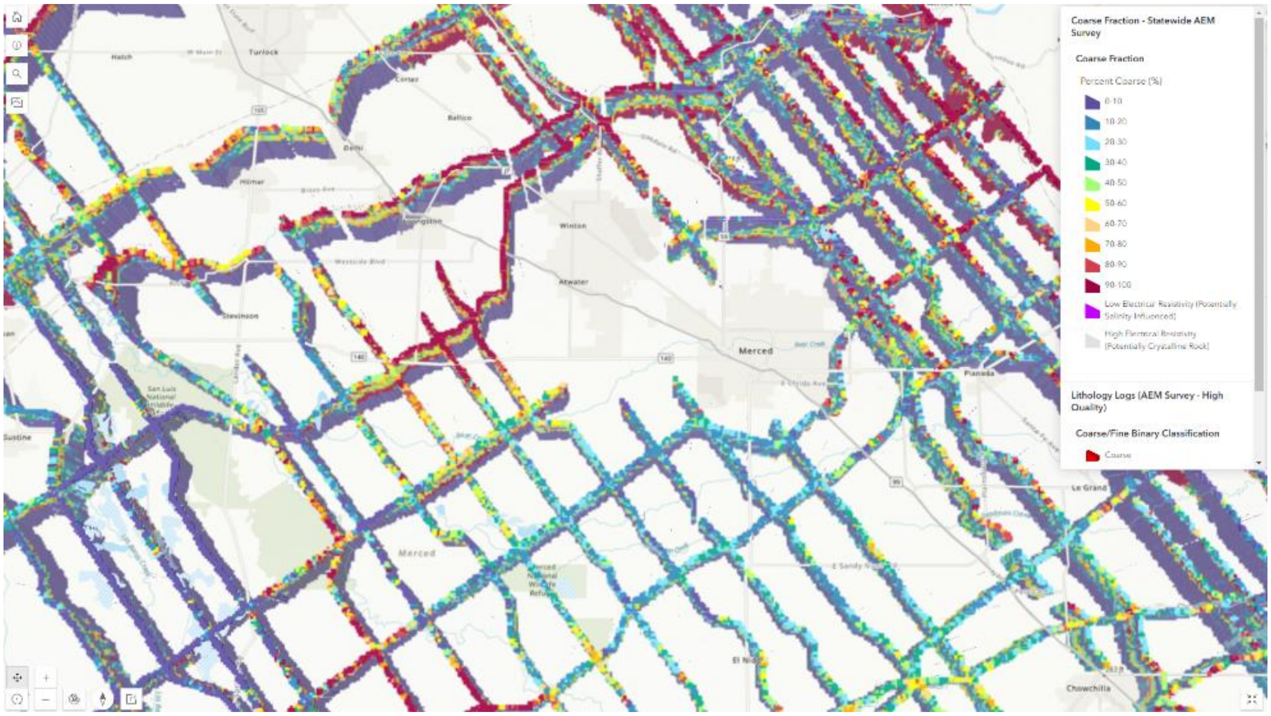


Table 2-6: Merced AEM Survey Lithology and Geophysical Logs

Lithology Logs		Geophysical Logs		Total
High Quality	Low Quality	Within Flight Line PLSS	Outside of Flight Line PLSS	
480	1,042	79	34	1,634

Results from the AEM survey data provided the GSAs with additional information to better refine the Hydrogeologic Conceptual Model. AEM survey data collected shows a high percentage of coarse material at shallows depths throughout the Subbasin, specifically in the north, northwestern, and eastern areas, which aligns with the proximity of these areas to major surface water bodies and known alluvial deposits. Coarse percentages decrease with depth and a distinct layer with low percentages (0-10%) is observed across the Subbasin below the shallow coarse layers, which is consistent with the inferred extent of the Corcoran Clay. Beneath the Corcoran Clay, coarser material reappears also aligning with the Below Corcoran Clay Aquifer evaluated in the Subbasin's Hydrogeologic Conceptual Model. Figure 2-42 presents the AEM survey coarse fraction data collected by DWR within the Subbasin.

Figure 2-42: AEM Survey Coarse Fraction Visualization



Initially, the MercedWRM estimated shallow clays extended along the northern border of the Subbasin (Figure 2-43). Analysis of the AEM data showed that this shallow clay layer may not be present and the lithology in that area is likely coarser grained material (Figure 2-44). The GSAs will evaluate changes to the Hydrogeologic Conceptual Model and consider its potential implications to groundwater conditions, water budgets, and/or projects favorable to this type of lithology.

Figure 2-42: Initial MercedWRM Lithology Cross-Section, Northern Border

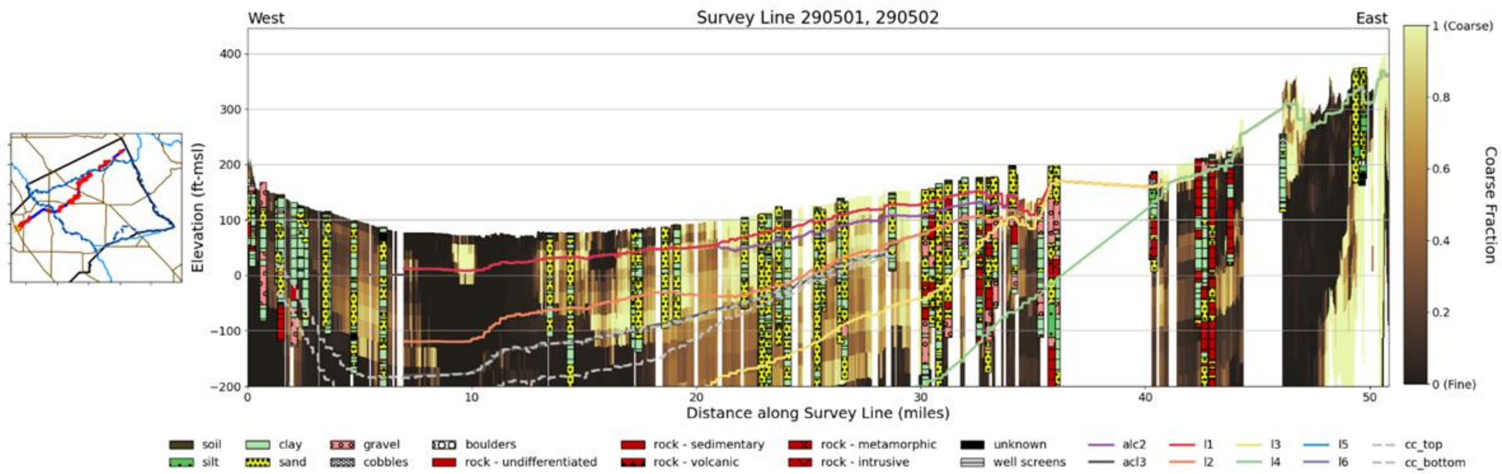
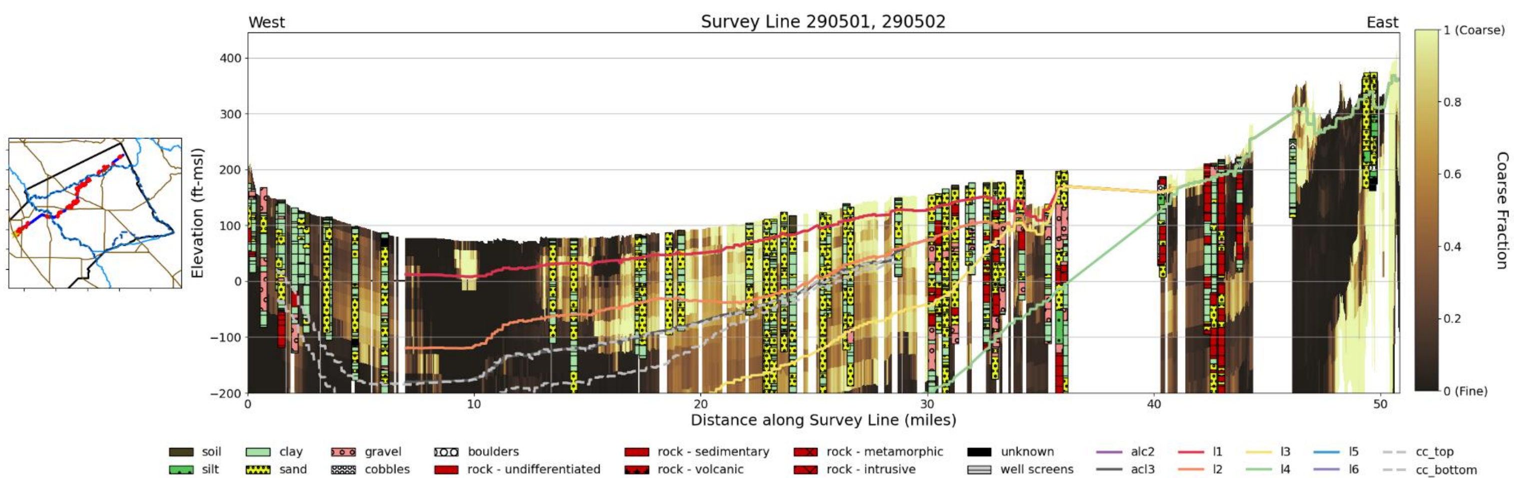


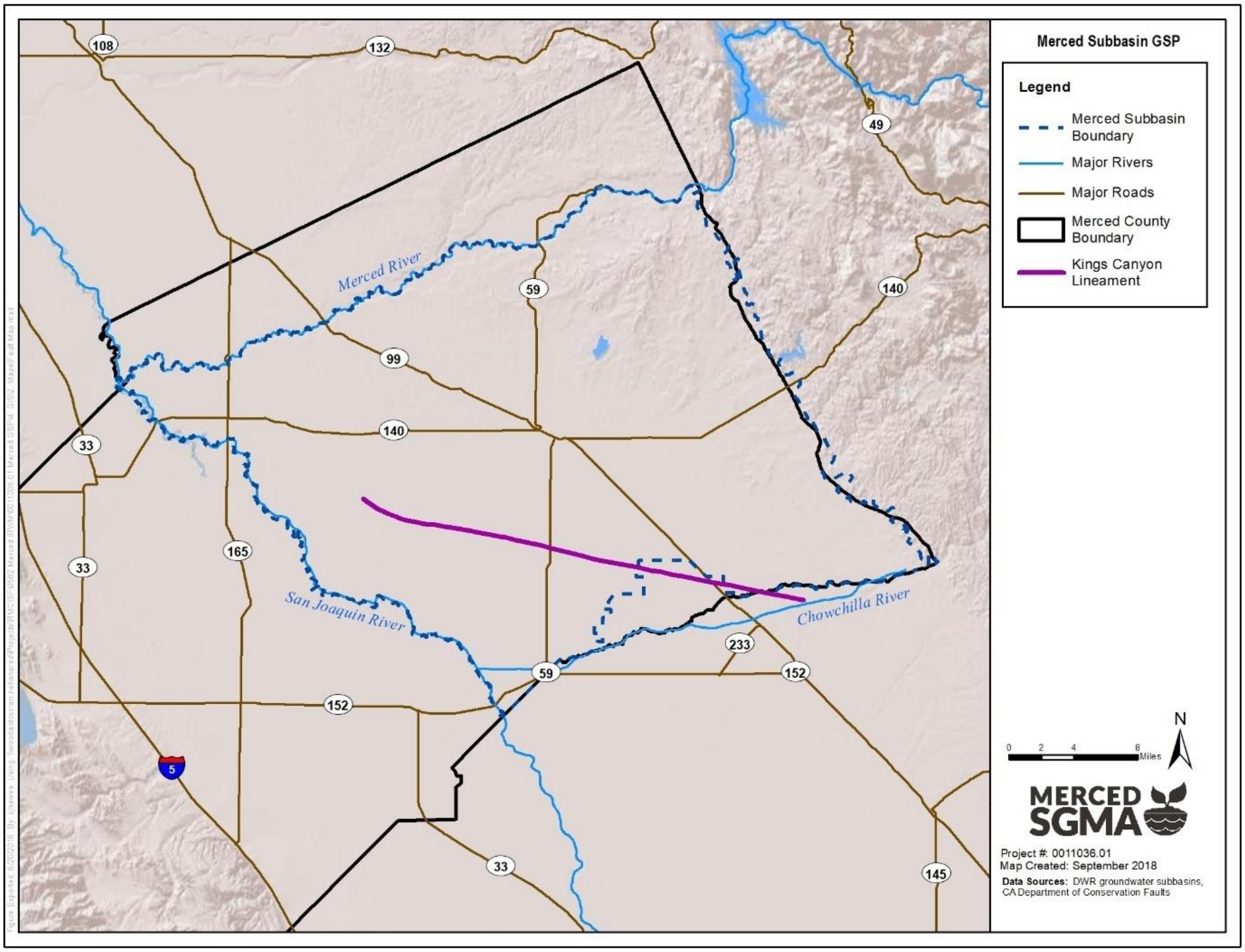
Figure 2-43: Updated MercedWRM Lithology Cross-Section, Northern Border



2.1.5 Faults and Structural Features

There are no major faults, anticlines, or synclines in the Merced Subbasin. The only minor feature present in the Subbasin is the Kings Canyon Lineament, shown in Figure 2-28 (California Geological Survey, 2010). This feature coincides with an unnamed inferred fault based on apparent offset of subsurface materials (Bartow J. A., 1985) and is not known to affect groundwater flow in the basin (DWR, 2004) nor is it known to affect subsidence or groundwater quality. The key geologic feature that affects groundwater flows is the Corcoran Clay, which is described previously.

Figure 2-28: Fault Map



2.1.6 Subbasin Boundaries

The horizontal and vertical boundaries of the Merced Subbasin are described below.

2.1.6.1 Lateral Boundaries and Boundaries with Neighboring Subbasins

The Merced Subbasin includes lands south of the Merced River between the San Joaquin River on the west and the crystalline basement rock of the Sierra Nevada foothills on the east. The Subbasin boundary on the south stretches westerly along the Chowchilla River (Merced-Madera County boundary) and then along the northern edge of the sphere-of-influence boundary of Chowchilla Water District.

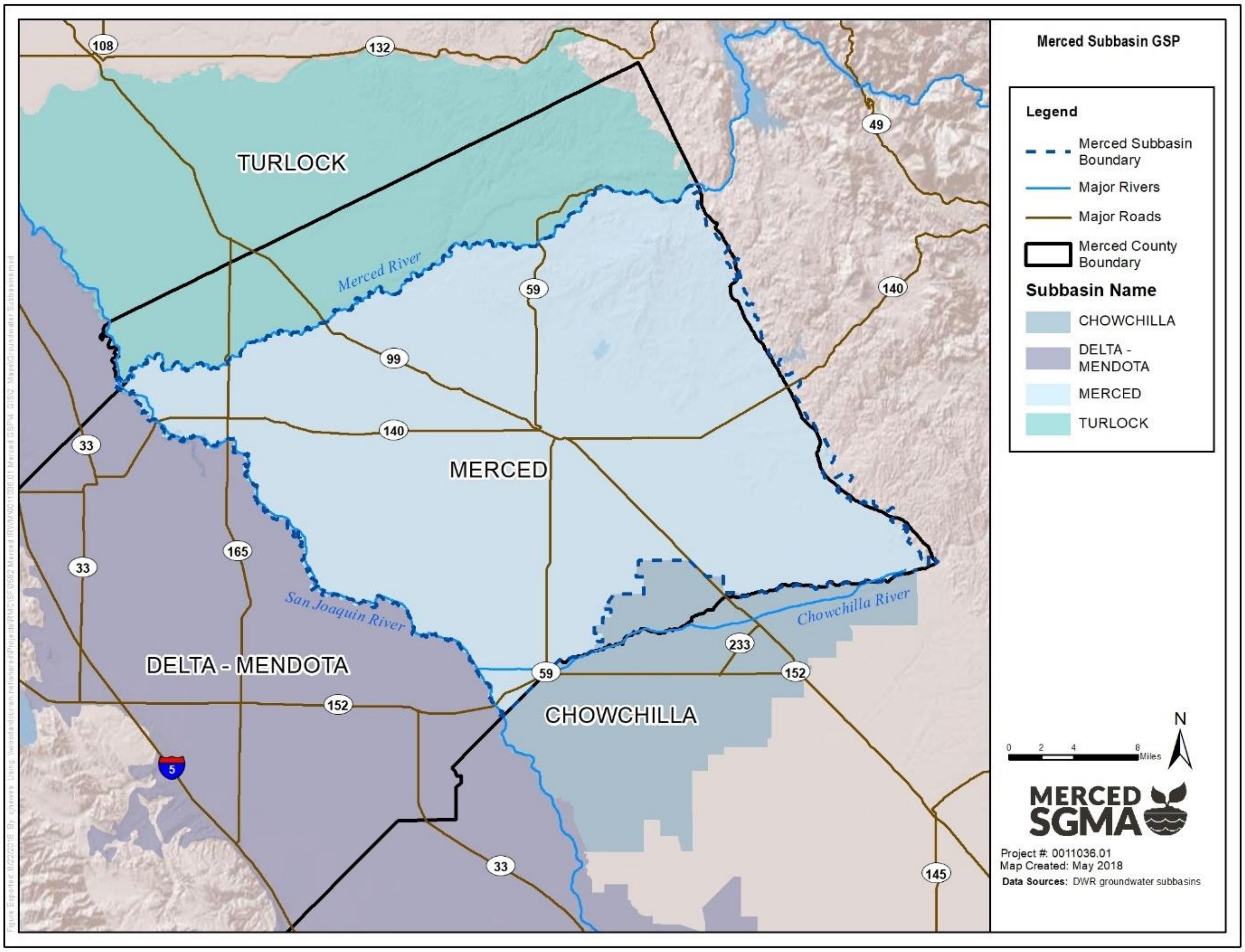
DWR defines boundaries based on the following restrictions on groundwater flow: impermeable bedrock, constructions in permeable materials, faults, low permeability zones, groundwater divides, and adjudicated basin boundaries (DWR, 2003). While boundaries divide the Merced Subbasin from surrounding subbasins of the San Joaquin Valley Groundwater Basin, groundwater within the Merced Subbasin is hydraulically connected with groundwater in the surrounding subbasins. The boundaries of the Merced Subbasin are described below in Table 2-7 based on these boundary types. Figure 2-29 shows a map of the surrounding subbasins.

Table 2-7: Basin Boundary Description and Type

Boundary	Boundary Type	DWR Definition	Boundary Description
Eastern	Impermeable Bedrock	"Impermeable bedrock with lower water yielding capacity. These include consolidated rocks of continental and marine origin and crystalline/or metamorphic rock." (DWR, 2003)	Bounded by the crystalline bedrock of the Sierra Nevada mountain range.
Northern	Groundwater Divide	"A groundwater divide is generally considered a barrier to groundwater movement from one basin to another for practical purposes. Groundwater divides have noticeably divergent groundwater flow directions on either side of the divide with the water table sloping away from the divide. The location of the divide may change as water levels in either one of the basins change, making such a "divide" less useful. Such a boundary is often used for subbasins." (DWR, 2003).	The Merced River forms northern boundary of Merced Subbasin (Bulletin 118 Basin Number 5-022.04) and divides the Subbasin from the Turlock Subbasin (Bulletin 118 Basin Number 5-022.03).
Southern (eastern side)	Groundwater Divide	(defined above)	The Chowchilla River divides the Merced Subbasin from the Chowchilla Subbasin (Bulletin 118 Basin Number 5-022.05) along the eastern edge of the southern boundary. The Chowchilla River also generally forms the boundary between Merced and Madera Counties in this area.

Boundary	Boundary Type	DWR Definition	Boundary Description
Southern (western side)	Jurisdictional Boundary	Not defined.	The boundary generally follows the sphere-of-influence boundary of Chowchilla Water District. Starting from the intersection of the Chowchilla River at the northwest corner of Section 13, Township 9 South, Range 15 East, it runs north and west along the east and north boundary of Section 11, Township 9 South, Range 15 East until it reaches the Southern Pacific Railroad tracks. Then northwesterly along the Southern Pacific Railroad tracks until it reaches the northeast corner of Section 4, Township 9 South Range 15 East. Then west along the north boundary of Sections 4, 5, and 6, Township 9 South, Range 15 East. Then southwesterly along the boundary of the Chowchilla Water District until it reaches the northern boundary of Madera County (County of Madera, 2016).
Western	Groundwater Divide	(defined above)	Based on the San Joaquin River, which divides the Merced Subbasin from the Delta-Mendota Subbasin (Bulletin 118 Basin Number 5-022.07).

Figure 2-29: Neighboring Subbasins

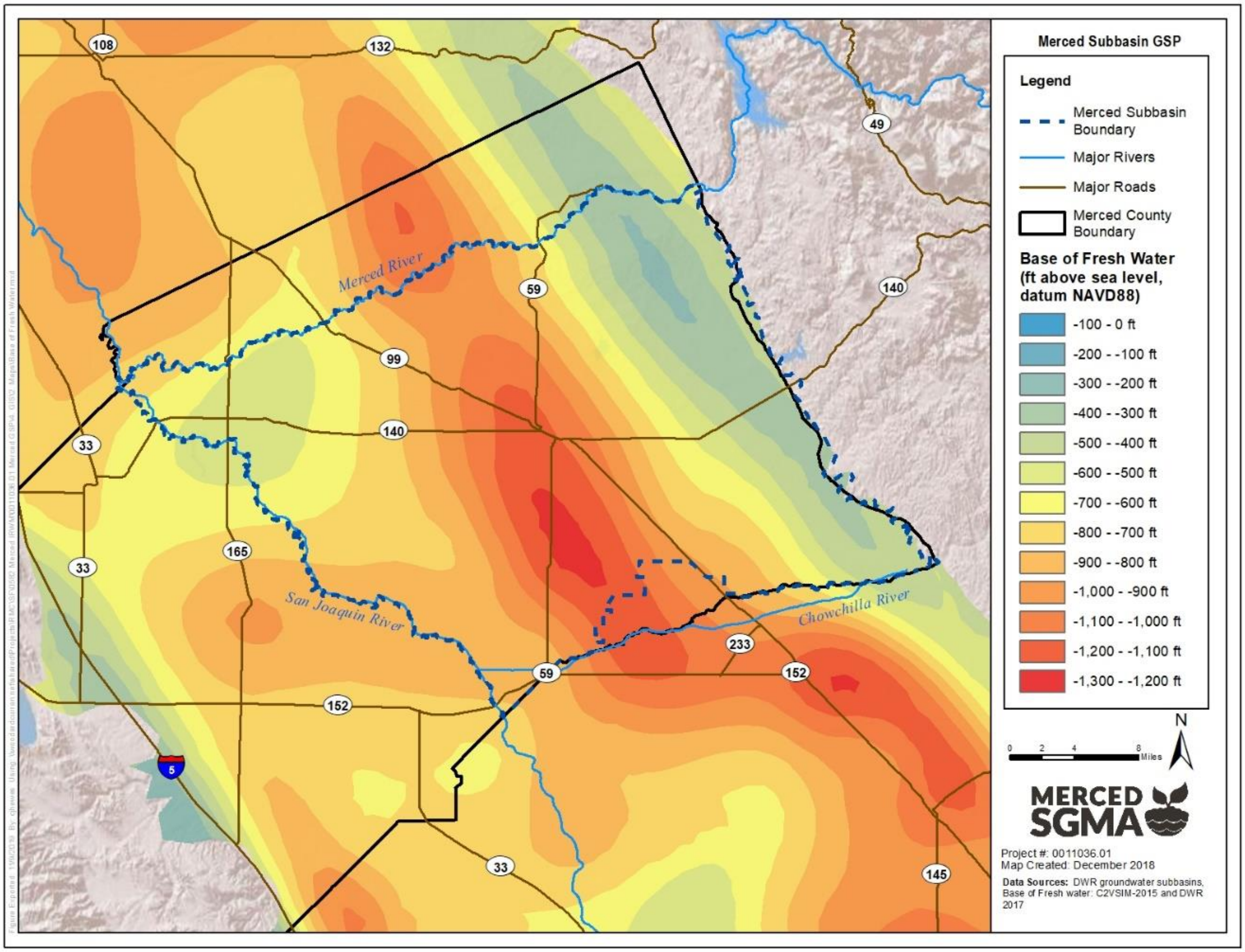


2.1.6.2 Bottom of the Merced Basin

As discussed above, the San Joaquin Valley is filled with up to 32,000 feet of marine and continental sediments. However, only the uppermost portion of these sediments are saturated with fresh groundwater. Deeper sediments contain saline groundwater. The bottom of the Merced Basin is defined as the lowest elevation of fresh water. This elevation is called the "base of fresh water" and is defined here as specific conductance of less than 3,000 micromhos per centimeter. The depth of the base of fresh water is defined by Page (1973), who mapped the base of fresh water based on measurements at wells of specific conductance of less than 3,000 micromhos per centimeter. Page's interpretation of the base of fresh water is incorporated into the California Central Valley Groundwater-Surface Water Simulation Model, which includes this information in the definition of model layers and was last updated by DWR in 2017 (see Figure 2-30 which shows elevation of the base of fresh water in feet above sea level). In most parts of the Subbasin, the base of fresh water is very deep (greater than 500 feet) which is reflected in the relatively large total storage volume described elsewhere in this GSP. The variations in the elevation of the base of fresh water are driven by underlying geology as well as locations of deeper saline groundwater.

While the vast majority of known groundwater production wells are screened at depths above the defined bottom of the Merced Subbasin, a small number of wells have been identified with screens that extend below the bottom of the aquifer. The Merced County well permitting database (for wells permitted 1990s through mid-2024) identified 16 wells with screens or total depths extending below the GSP-defined bottom of the Subbasin. These wells are all located in the eastern corner of the Subbasin, southeast of Planada along South Santa Fe Avenue, near Buchanan Hollow Rd just east of South Santa Fe Avenue, and northwest of Planada between Highway 140 and Flying M Airport, near Bear Creek. While these wells extend below the bottom of the aquifer, all extraction is incorporated into the analyses included in the GSP. The wells are all agricultural wells, and modeling analysis does not include details of individual private wells. The deeper wells do suggest the potential for a thicker aquifer in this area, with a potentially higher volume of groundwater in storage. They also may indicate a need to refine the HCM in this area and the model layering in the MercedWRM. Prior to making those adjustments, additional study would be required to assess the salinity of groundwater at that depth and to assess the materials at depth to verify that the wells are accessing the alluvial aquifer system and not groundwater contained in fractured rock below the bottom of the basin. The presence of the small number of deeper wells is not anticipated to impact basin management, but additional study may be warranted to better understand localized conditions in the Planada/Le Grand area.

Figure 2-30: Base of Fresh Water



2.1.7 Principal Aquifers and Aquitards

There are five different aquifer systems identified in the Subbasin based on their differing geologic history and hydrogeologic characteristics. These systems have been modeled in the MercedWRM. The systems interact with each other throughout the Subbasin but are separated in some areas by the presence of the confining Corcoran Clay layer. Based on these interactions and for the practical purpose of developing and implementing this GSP, the five aquifer systems have been combined into three pertinent Principal Aquifers and are described further in the sections below.

2.1.7.1 Aquifer Systems in the Basin

Five aquifer systems have been identified in the Merced Subbasin by the Merced Groundwater Management Plan (AMEC, 2008), including, in order of decreasing depth: a fractured bedrock aquifer, the Mehrten Formation, a confined aquifer, an intermediate "leaky" aquifer, and a shallow unconfined aquifer. These aquifer systems interact with each other throughout the basin, except where the Corcoran Clay exists.

In addition to the descriptive information from the Merced Groundwater Management Plan, the MercedWRM (see Appendix D) provides information on aquifer characteristics by aggregating available data and calibrating selected characteristics to closely match observed and simulated groundwater elevation and streamflows. The model uses five distinct fresh-water aquifer layers, one saline aquifer, and two confining units. The fresh water aquifer layers correspond closely with the aquifer formations described below from the Merced Groundwater Management Plan.

Hydraulic conductivity, specific storage, and specific yield are three aquifer parameters that describe physical characteristics of aquifers that are important for groundwater modeling.

Hydraulic conductivity is defined and mapped separately for each aquifer layer (Figure 2-31 through Figure 2-35). Hydraulic conductivity is a numeric characteristic of an aquifer that describes the ease with which groundwater moves through pore spaces or fractures in soil or rock.

During a sensitivity analysis in which changes in aquifer parameters were compared against modeled groundwater level outputs, specific storage (Figure 2-36) and specific yield (Figure 2-37) were determined to not vary significantly between aquifer layers and thus are defined across the entire Subbasin for all aquifer layers (Woodard & Curran, 2019). Specific storage describes the unit volume of water released or taken into storage per unit change in hydraulic head. It is a unitless quantity. Specific storage is a more important characteristic for unconfined aquifers (i.e., above the Corcoran Clay) and has less importance for confined aquifers (i.e., below the Corcoran Clay). Specific yield describes the unit volume released from the aquifer per unit change in head under the force of gravity.

These five aquifer systems are described from deepest to shallowest, and the following Section 2.1.7.2 describes the three principal aquifers to be used in this GSP based on the interactions of the five systems described below. Table 2-8 shows the relationship between MercedWRM layer, formation name, and principal aquifer name.

Fractured Bedrock - Along the eastern edge of the Merced Subbasin, wells have been completed within the Valley Springs and lone Formations (Page & Balding, 1973), (Page R. W., 1977). The Ione Formation unconformably overlies the Sierra Nevada bedrock complex and is composed of marine to non-marine clay, sand, sandstone, and conglomerate. The Valley Springs Formation is composed of a fluvial sequence of rhyolitic ash, sandy clay, and siliceous gravel in a clay matrix. Wells in this system appear to be completed in fractured bedrock with limited and variable yields.

Because of the limited extent (and poor yields) of the fractured bedrock aquifer, the fractured aquifer is not a significant source of water in the Merced Subbasin (AMEC, 2008).

Hydraulic conductivity is shown in Figure 2-31 as part of the MercedWRM Layer 5 which contains both the Valley Springs Formation portion of the Fractured Bedrock system where it underlies the Mehrten Formation as well as the Mehrten Formation itself (described below).

The Mehrten Formation - The Mehrten Formation outcrops over a large area in the Merced Subbasin. It is composed of fluvial deposits of sandstone, breccia, conglomerate, luff, siltstone, and claystone. It contains a large amount of andesitic material, making it easy to distinguish. Many water supply wells in the eastern portion of the Merced Subbasin penetrate the formation, and it is a significant source of groundwater. Where the Mehrten occurs beneath the Corcoran Clay, it is considered a confined aquifer. Where the Mehrten does not underlie the Corcoran Clay, there is insufficient data to determine the degree of confinement of the formation (AMEC, 2008).

Laboratory and field tests made by USACE and DWR in other areas indicate a range in hydraulic conductivity in the Mehrten Formation range from 0.01 to about 67 ft/day. Yields from the Mehrten, therefore, can be expected to differ greatly from place to place and at different depths. Based on another DWR regional study, the Mehrten formation has a yield of about 1,000 gallons per minute (gpm) and a horizontal transmissivity of about 9,100 ft^2/day (Page & Balding, 1973).

Hydraulic conductivity is shown in Figure 2-31 as part of the MercedWRM Layer 5 which contains both the Mehrten Formation and the Valley Springs Formation portion of the Fractured Bedrock system (described above).

Confined Aquifer - The confined aquifer occurs in older alluvium (and Mehrten Formation) deposits that underlie the Corcoran Clay (Figure 2-39). The older alluvium consists of a heterogeneous mixture of poorly sorted gravel, sand, silt, and clay up to 400 feet thick derived primarily from the Sierra Nevada. Many water supply wells in the western portion of the Merced Subbasin penetrate the Corcoran Clay into the confined aquifer, and it is a significant source of groundwater (AMEC, 2008).

In the older alluvium, yields to wells were as large as 4,450 gpm with an average 1,900 gpm. The specific capacity of 101 sampled wells ranged from 8.2 gpm/ft to 134.6 gpm/ft with a mean of 41.9 gpm/ft and a median of 36.7 gpm/ft. Specific capacities in the eastern part of the area, where wells penetrate older rocks and deposits, were generally smaller than those in the west. Because specific capacity is a rough indicator of transmissivity, the pattern indicates smaller transmissivities in the eastern part of the area near where the consolidated rocks crop out (Page & Balding, 1973).

The Confined Aquifer's hydraulic conductivity is shown in both Figure 2-32 and Figure 2-33 as part of the MercedWRM Layers 3 and 4 which together describe the Confined Aquifer. Layer 3 consists of older alluvium while layer 4 consists of continental deposits.

Intermediate Leaky-Aquifer - The intermediate leaky aquifer occurs in older alluvium deposits that overlie the Corcoran Clay or are east of the Corcoran Clay. Where the Corcoran Clay is absent, the intermediate leaky aquifer extends to the Mehrten Formation. In the eastern portion of the Merced Subbasin the intermediate aquifer consists of a series of interbedded coarse-grained (gravel and sand) layers separated by fine-grained (silt and clay) layers. The fine-grained layers inhibit, but do not prevent vertical groundwater flow between layers and thus form a leaky-aquifer system. Many water supply wells in the Merced Subbasin are completed in the intermediate leaky-aquifer, and it is a significant source of groundwater (AMEC, 2008).

The intermediate leaky-aquifer is the most extensively developed aquifer in the Merced Subbasin. Measured well yields within the Merced Subbasin range from 670 to 4,000 gpm (Page & Balding, 1973). Estimates of specific capacity of supply wells throughout the Merced Subbasin range from about 20 to 40 gpm/ft of drawdown and indicate that the specific capacity increases from east to west.

Hydraulic conductivity is shown in Figure 2-34 as part of the MercedWRM Layer 2.

Shallow Unconfined Aquifer - The shallow unconfined aquifer occurs in older and younger alluvium deposited above the shallow clay bed. Because of its shallow depth, few water supply wells are completed in the shallow unconfined aquifer. Where water levels in the intermediate leaky aquifer fall below the base of the shallow clay bed, groundwater in the intermediate aquifer becomes unconfined and water in the overlying shallow aquifer becomes perched (AMEC, 2008).

Hydraulic conductivity is shown in Figure 2-35 as part of the MercedWRM Layer 1.

The sixth layer of the model (not mapped) consists of saline water below the base of fresh water (described in 2.1.6.2) and was implemented as a refinement to the water quality model and for the potential use of scenario development for the simulation of deep well production (Woodard & Curran, 2019).

Table 2-8: Formation, Aquifer Name, and MercedWRM Layer Number Lookup

Formation/Aquifer Name	Principal Aquifer for GSP	MercedWRM Layer Number
Ione Formation	N/A	6
Valley Springs Formation	Outside Corcoran Clay	5
Mehrten Formation (outside of Corcoran Clay extent)	Outside Corcoran Clay	5
Mehrten Formation (within Corcoran Clay extent)	Below Corcoran Clay	5
Confined Aquifer	Below Corcoran Clay	4 (continental deposits)
	Below Corcoran Clay	3 (older alluvium)
Intermediate Leaky-Aquifer (within Corcoran Clay extent)	Above Corcoran Clay	2
Intermediate Leaky-Aquifer (outside of Corcoran Clay extent)	Outside Corcoran Clay	2

Shallow Unconfined Aquifer (outside of Corcoran Clay extent)	Outside Corcoran Clay	1
Shallow Unconfined Aquifer (within Corcoran Clay extent)	Above Corcoran Clay	1

Figure 2-31: Hydraulic Conductivity – Mehrten Formation and Valley Springs Portion of Fractured Bedrock System (MercedWRM Layer 5)

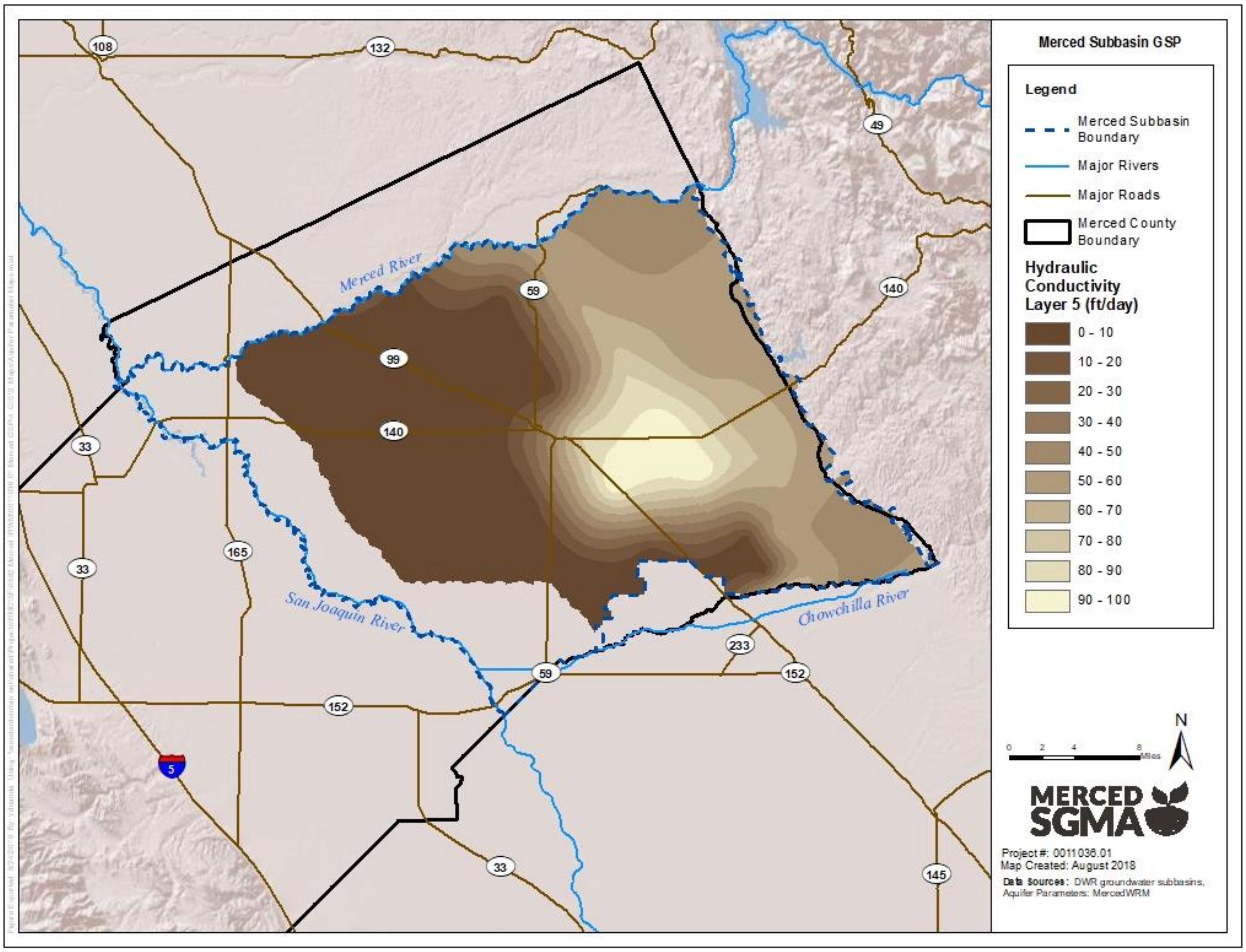


Figure 2-32: Hydraulic Conductivity – Confined Aquifer (MercedWRM Layer 4)

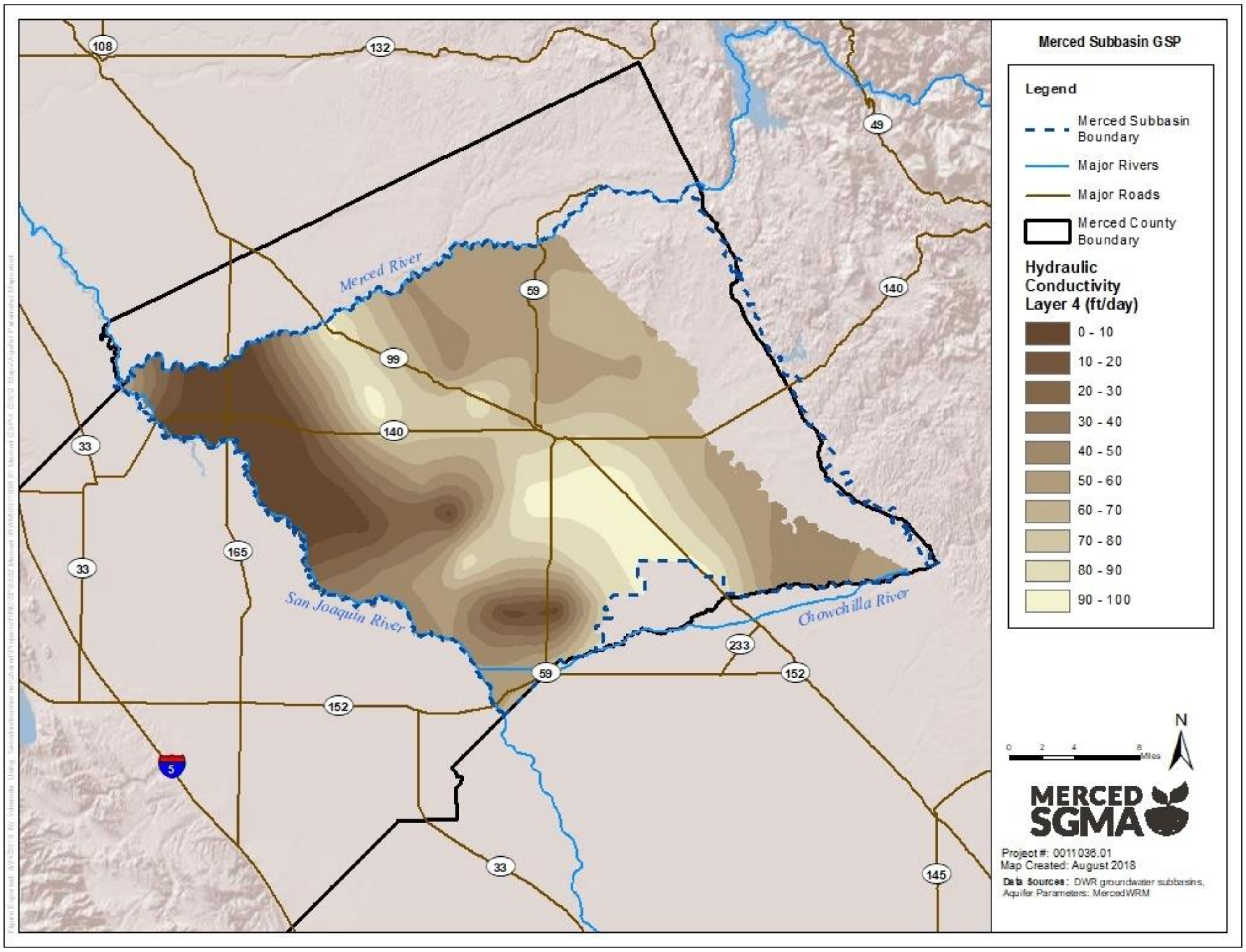


Figure 2-33: Hydraulic Conductivity – Confined Aquifer (MercedWRM Layer 3)

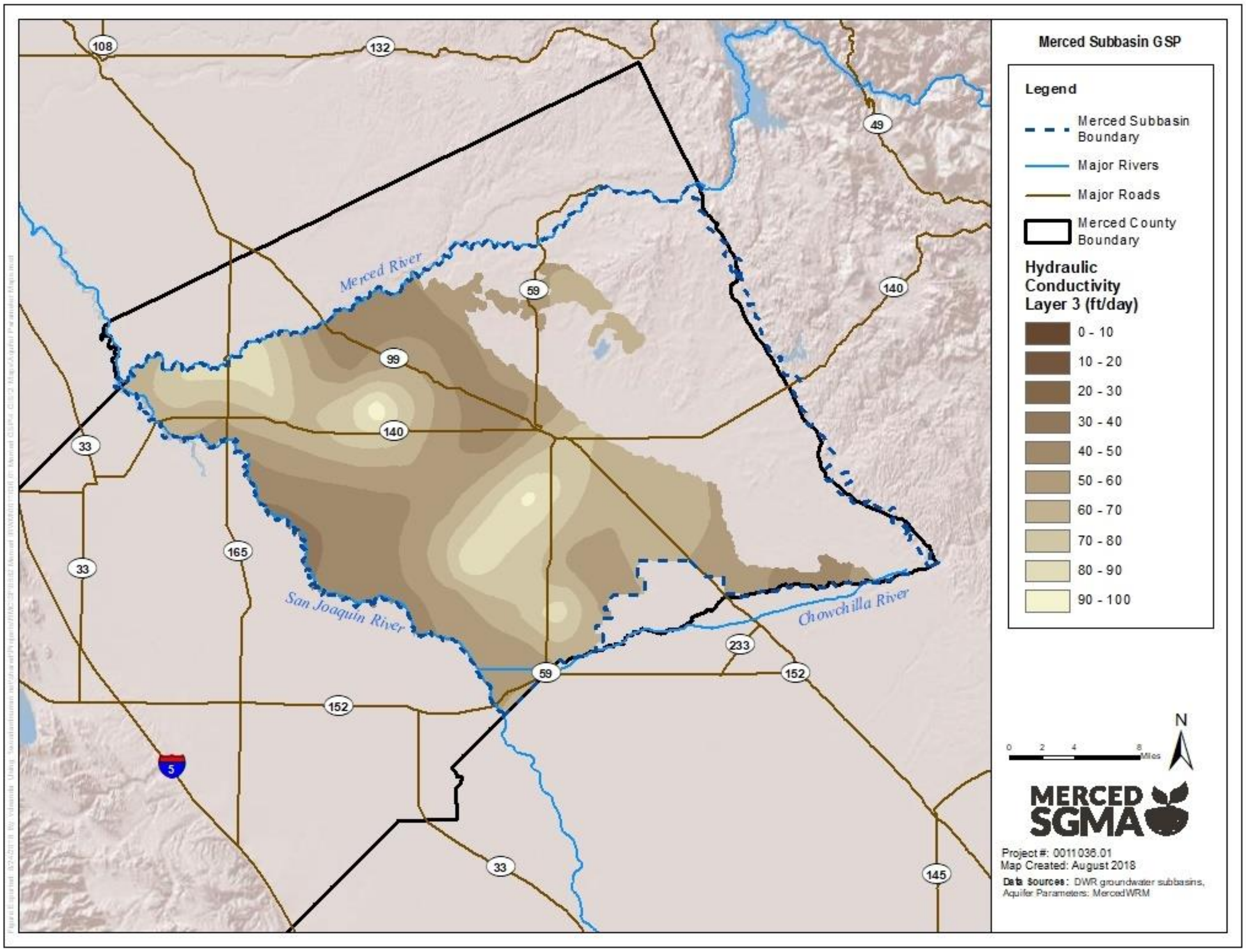


Figure 2-34: Hydraulic Conductivity – Intermediate Leaky-Aquifer (MercedWRM Layer 2)

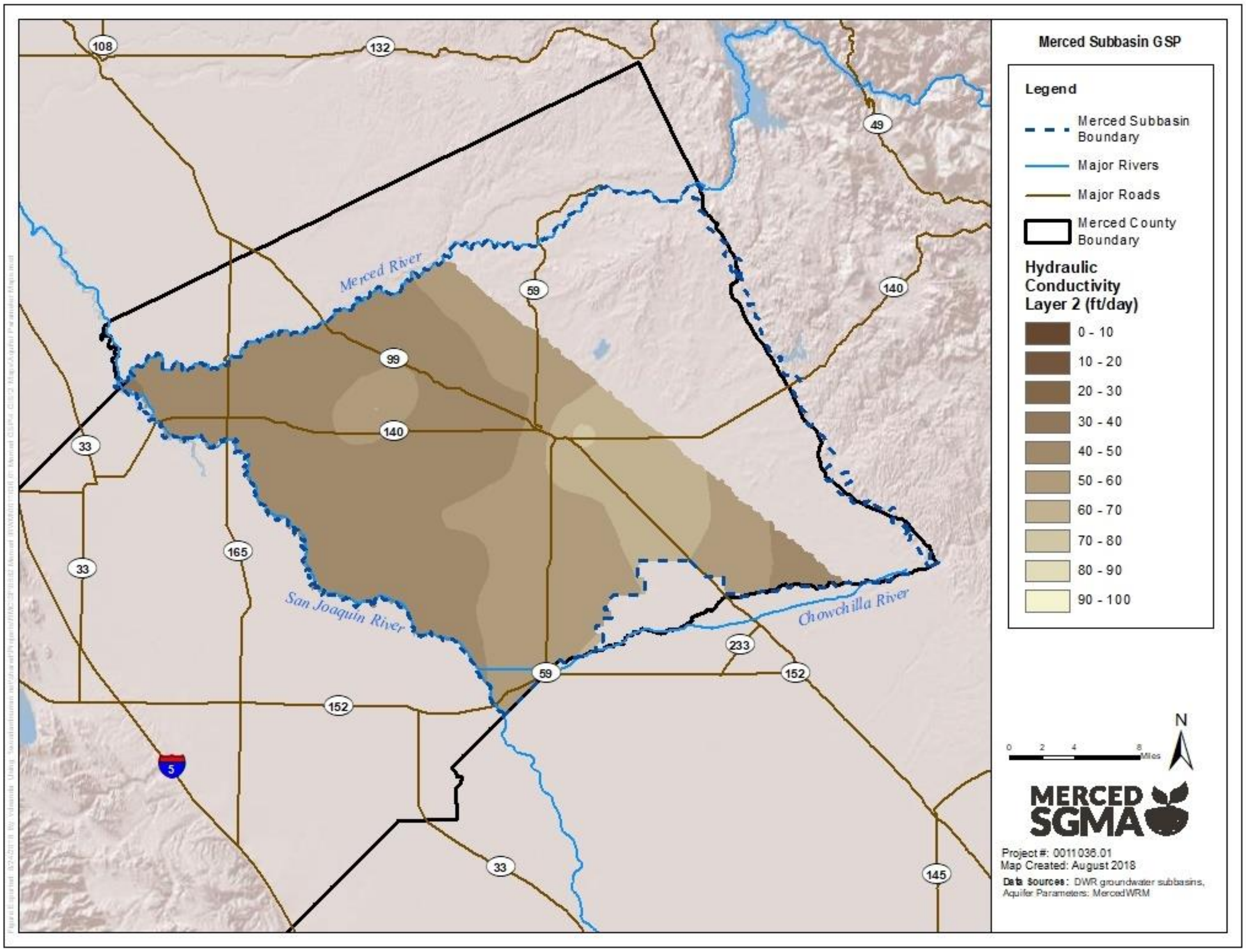


Figure 2-35: Hydraulic Conductivity – Shallow Unconfined Aquifer (MercedWRM Layer 1)

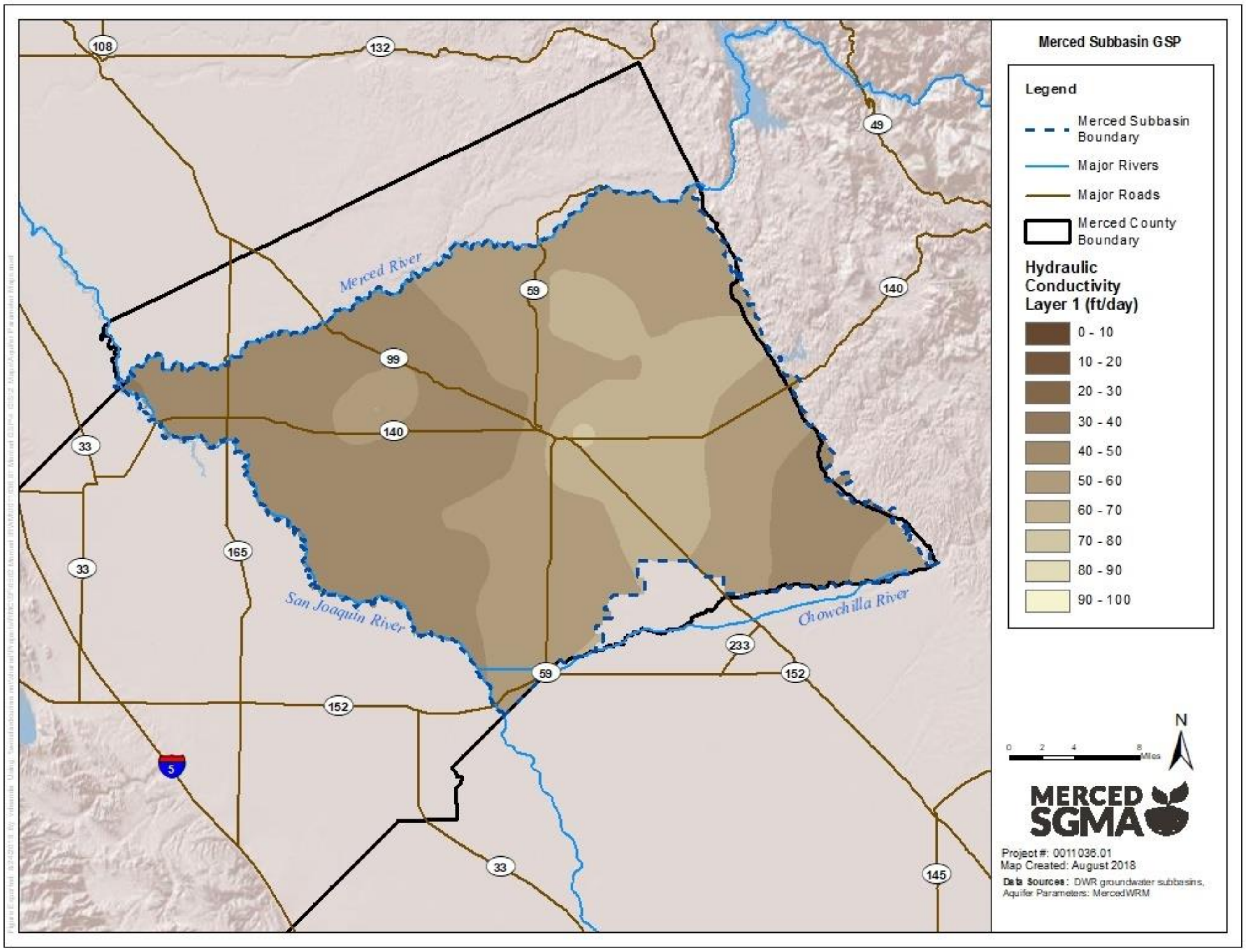
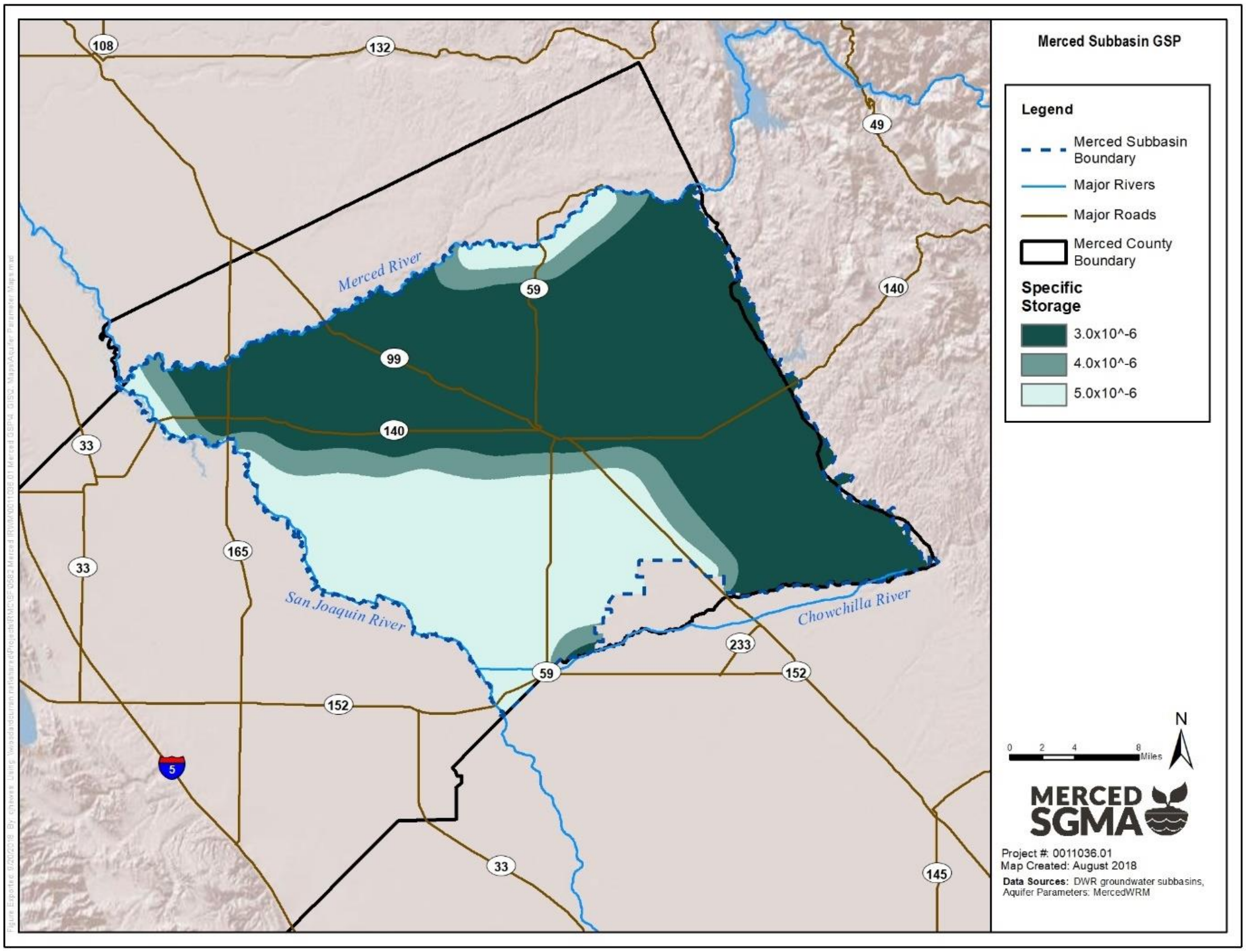
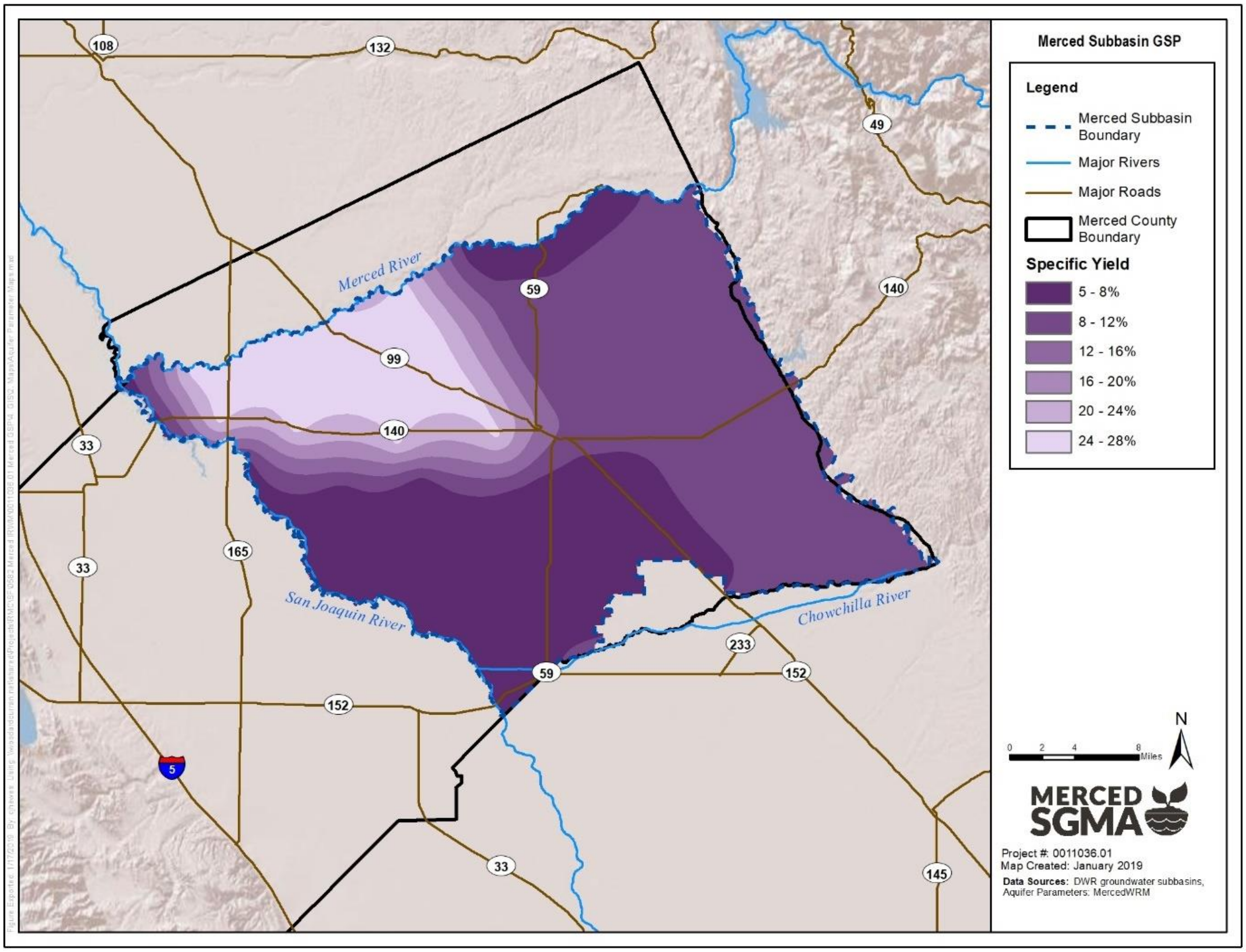


Figure 2-36: Specific Storage (All Aquifer Layers)



(Note that Specific Storage is a dimensionless (unitless) quantity)

Figure 2-37: Specific Yield (All Aquifer Layers)



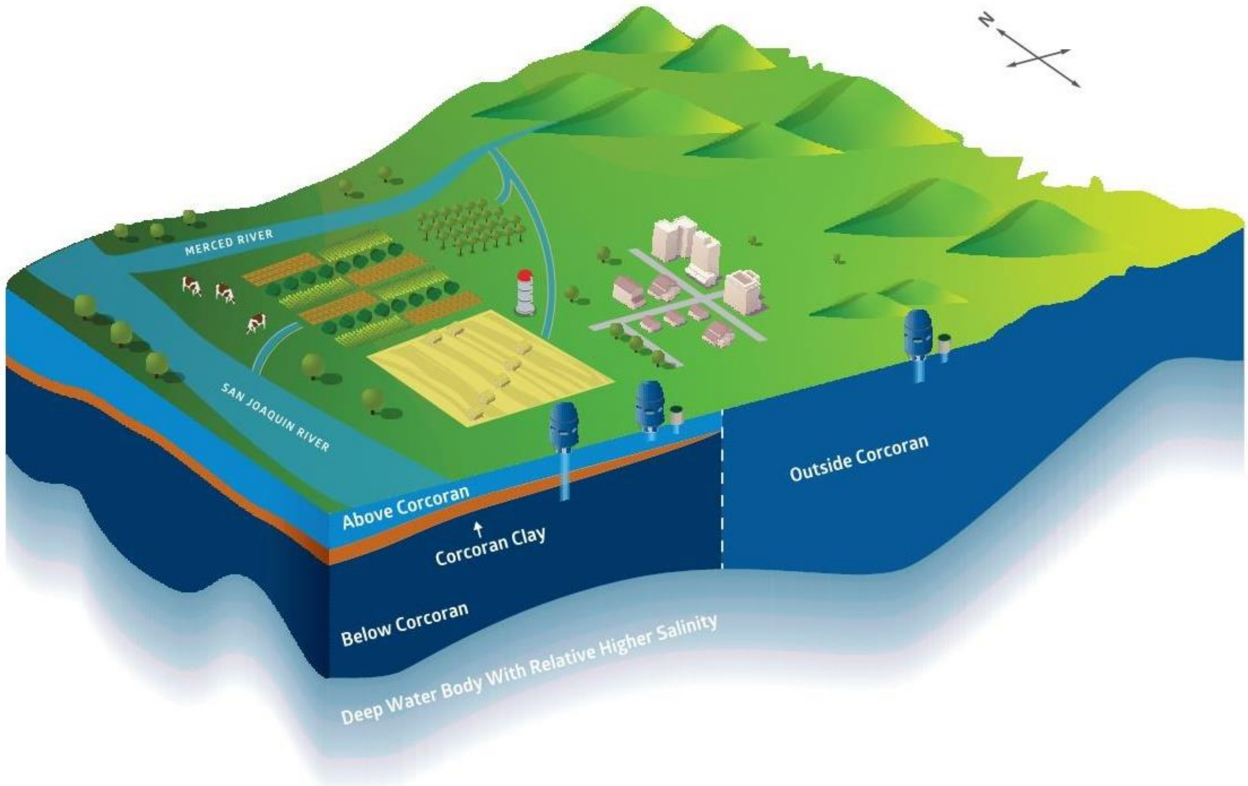
2.1.7.2 Principal Aquifers and Aquitards

The five aquifer systems described in Section 2.1.7.1 interact with each other throughout the basin, except where the Corcoran Clay exists. The three principal aquifers in the Merced Subbasin and their associated characteristics are described below by referencing the specific formations defined earlier. Included in the sections below is a description of general water quality characteristics for the principal aquifers based primarily on the work of Page & Balding (1973). Specific constituents of concern with values and spatial distributions (where applicable) are described later in Section 2.2.4 – Groundwater Quality under Section 2.2 – Current and Historical Groundwater Conditions. Table 2-9 provides a summary of key characteristics of the principal aquifers. Figure 2-38 shows a three-dimensional illustration of the three principal aquifers and the Corcoran Clay aquitard.

Table 2-9: Summary of Characteristics of Principal Aquifers

Parameter	Above Corcoran Principal Aquifer	Below Corcoran Principal Aquifer	Outside Corcoran Principal Aquifer
Aquifer System Names	Intermediate Leaky-Aquifer Shallow Unconfined Aquifer (within Corcoran Clay lateral extent)	Mehrten Formation Confined Aquifer (within Corcoran Clay lateral extent)	Fractured Bedrock Mehrten Formation Intermediate Leaky-Aquifer Shallow Unconfined Aquifer (outside of Corcoran Clay lateral extent)
Geologic Formation Names	Older Alluvium Flood-basin deposits Younger Alluvium (within Corcoran Clay lateral extent)	Valley Springs Formation Mehrten Formation Older Alluvium (within Corcoran Clay lateral extent)	Valley Springs Formation Mehrten Formation Older Alluvium Younger Alluvium (outside of Corcoran Clay lateral extent)
Vertical Extent	From the groundwater surface elevation to top of Corcoran Clay	From bottom of Corcoran Clay to base of Fresh Water	From the groundwater surface elevation to base of fresh water
Lateral Extent	Located within the lateral boundary of the Corcoran Clay	Located within the lateral boundary of the Corcoran Clay	Located outside the lateral boundary of the Corcoran Clay
Hydraulic Conductivity	Defined in Figure 2-34Figure 2-34 and Figure 2-35	Defined in Figure 2-31, Figure 2-32, and Figure 2-33	Defined in Figure 2-31, Figure 2-34, and Figure 2-35
Specific Storage & Specific Yield	Defined in Figure 2-36 and Figure 2-37		
Properties that Restrict Groundwater Flow	Corcoran Clay aquitard (below)	Corcoran Clay aquitard (above)	-
General Water Quality	Changes east to west from a calcium bicarbonate type to a calcium sodium or calcium magnesium bicarbonate type to a sodium bicarbonate type. Hardness is moderately hard to hard to very hard	Mostly a sodium or calcium bicarbonate type with hardness ranging from soft to very hard	Changes east to west from a calcium bicarbonate type to a calcium sodium or calcium magnesium bicarbonate type to a sodium bicarbonate type. Hardness is moderately hard to hard to very hard
Primary Uses	Domestic & Irrigation	Irrigation with some Domestic & Municipal	Irrigation, Domestic, & Municipal

Figure 2-38: 3D Illustration of Merced Subbasin Principal Aquifers and Aquitard



The **Above Corcoran Principal Aquifer** includes all aquifers that exist above the Corcoran Clay Aquitard, namely the Intermediate Leaky-Aquifer (where it overlies the Corcoran Clay) and the Shallow Unconfined Aquifer, both described above. This excludes areas that are located east of the extent of the Corcoran Clay. The related geologic formations are the Older Alluvium, Flood-plain deposits, and Younger Alluvium. While the flood-basin deposits have small hydraulic conductivities and small yields, the Older and Younger Alluvium deposits have moderate to large hydraulic conductivities and yields. Major uses of water in the Above Corcoran Principal Aquifer include domestic and irrigation uses.

The general chemical composition of groundwater in the unconfined aquifers (including both the Above Corcoran Clay and Outside of Corcoran Clay Principal Aquifers) changes spatially across the basin; moving downgradient from east to west, the water quality generally changes from a calcium bicarbonate type to a calcium sodium or calcium magnesium bicarbonate type to a sodium bicarbonate type. In terms of hardness, groundwater was generally moderately hard (61-120 mg/L) east of Highway 99 and hard to very hard (121-180 or >180 mg/L) west of Highway 99 (Page & Balding, 1973).

The **Corcoran Clay Principal Aquitard** is a member of the Pleistocene Tulare Formation. It is a laterally extensive reduced (blue/grey) silt and clay that underlies about 437 square miles in the southwest portion of the Merced Subbasin. The Corcoran Clay is a significant confining layer up to 60 feet thick (Page & Balding, 1973). Numerous silt and clay beds occur above and below the Corcoran Clay, but they could not be correlated over large areas and are therefore only of local importance to the confinement of groundwater (Page & Balding, 1973). The depth (and lateral extent) of the Corcoran Clay is shown on Figure 2-39. Thickness of the Corcoran Clay is shown on Figure 2-40.

The **Below Corcoran Principal Aquifer** includes all aquifers that exist below the Corcoran Clay Aquitard, namely the Confined Aquifer and any portion of the Mehrten Formation or Fractured Bedrock system that underlies the Corcoran Clay, described above. The related geologic formations are the Older Alluvium, Mehrten Formation, and Valley Springs Formation. The Valley Springs Formation has a low water-bearing character (small hydraulic conductivity), while the Mehrten Formation has small to moderate hydraulic conductivity. The Older Alluvium has a moderate to large hydraulic conductivity and yield. Major uses of water in the Below Corcoran Principal Aquifer include irrigation as well as some domestic and municipal use.

Water quality of the Below Corcoran Clay Principal Aquifer is mostly a sodium or calcium bicarbonate type. In terms of hardness, groundwater was found to range from soft (>60 mg/L) to very hard (>180 mg/L) (Page & Balding, 1973).

The **Outside Corcoran Principal Aquifer** includes all aquifers that exist outside of the eastern lateral extent of the Corcoran Clay, namely portions of the Mehrten Formation, Fractured Bedrock, Intermediate Leaky-Aquifer, and Shallow Unconfined Aquifer. This aquifer is connected laterally with the Above Corcoran Principal Aquifer at shallower depths and the Below Corcoran Principal Aquifer at deeper depths. Related geologic formations include all of the geologic formations described above in the Above and Below Corcoran Principal Aquifers with the exception of the flood-plain deposits. Major uses of water in the Outside Corcoran Principal Aquifer include irrigation, domestic, and municipal use.

General water quality of the Outside of Corcoran Clay Principal Aquifer is described several paragraphs above under the section for Above Corcoran Clay where the literature refers to both the Principal Aquifers together as the “unconfined aquifers”. In general, groundwater salinity is lowest in the easterly portion of the Subbasin. Salinity increases westward toward the San Joaquin River and southward toward the Chowchilla River. A small area of predominantly sodium-chloride type water has been identified near the confluence of the Merced and San Joaquin Rivers.

Data gaps and uncertainties related to the principal aquifers are primarily related to water quality and to the extent to which the Corcoran Clay reduces the vertical flow of water. Both the depth below ground and thickness of the clay varies throughout the basin (Figure 2-39 and Figure 2-40), and there are areas where the clay may be thin or not present. Additionally, the presence of numerous wells that penetrate the Corcoran Clay provides conduits for flow. Some of these wells are screened above and below the Corcoran Clay, although this practice is not currently allowed by Merced County Code, greatly increasing opportunities for vertical flow when pumps are not operating. With regards to water quality, there is limited depth-specific water quality data for the basin. The most recent, comprehensive study on general water quality types in the Subbasin dates from the 1970s and should be updated in the future with more recent, depth-specific water quality measurements.

Figure 2-39: Corcoran Clay Depth Below Ground Surface

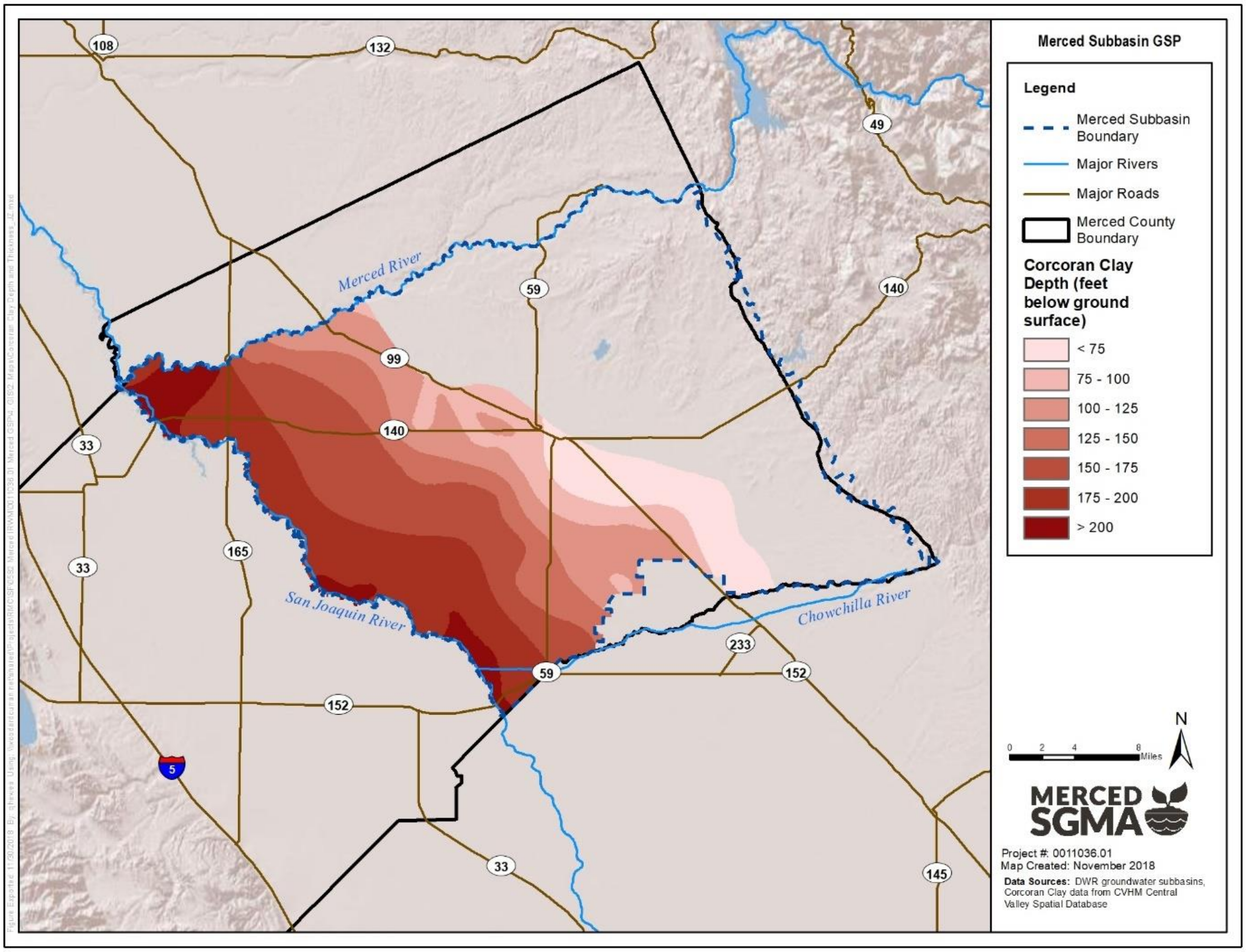


Figure 2-40: Corcoran Clay Thickness

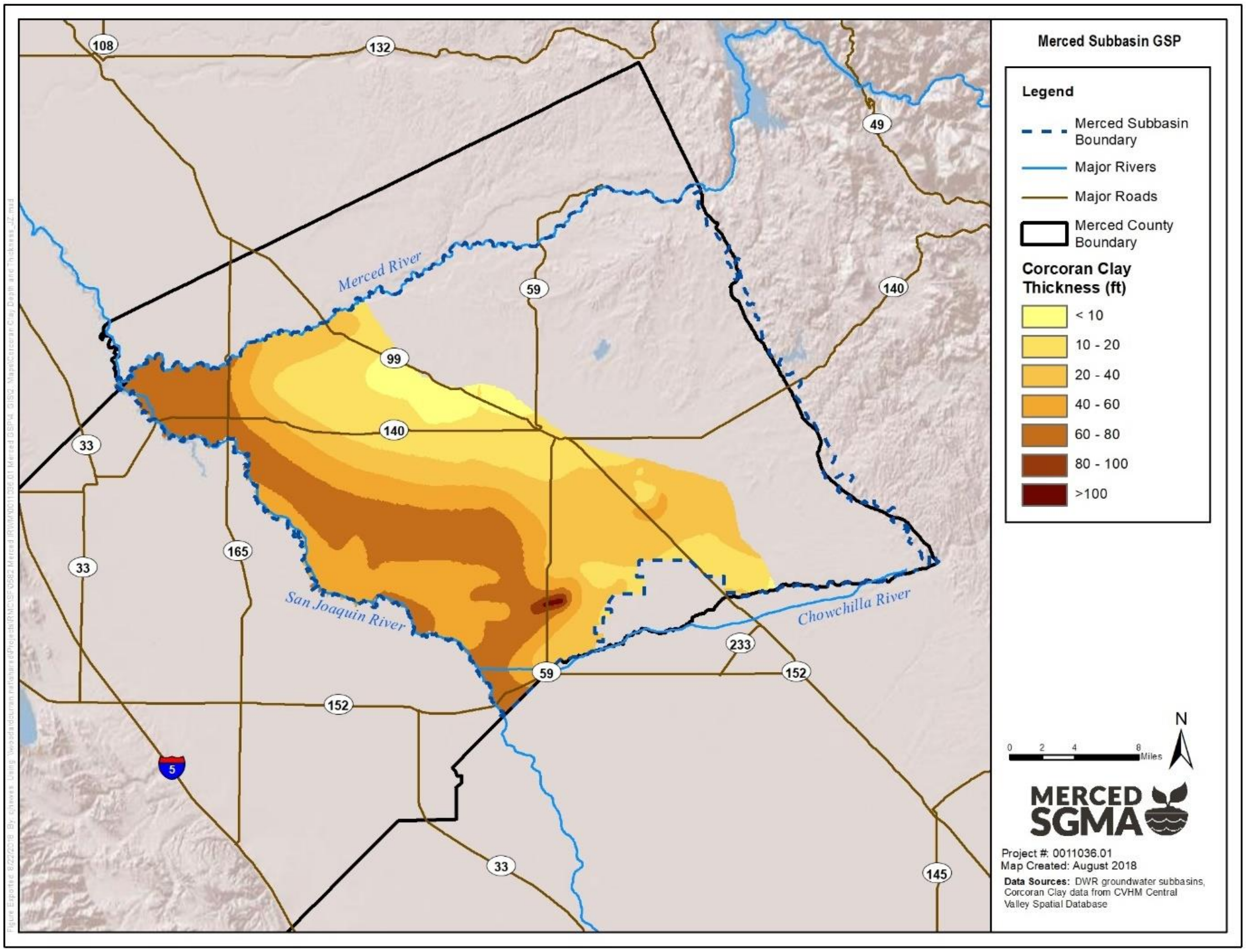
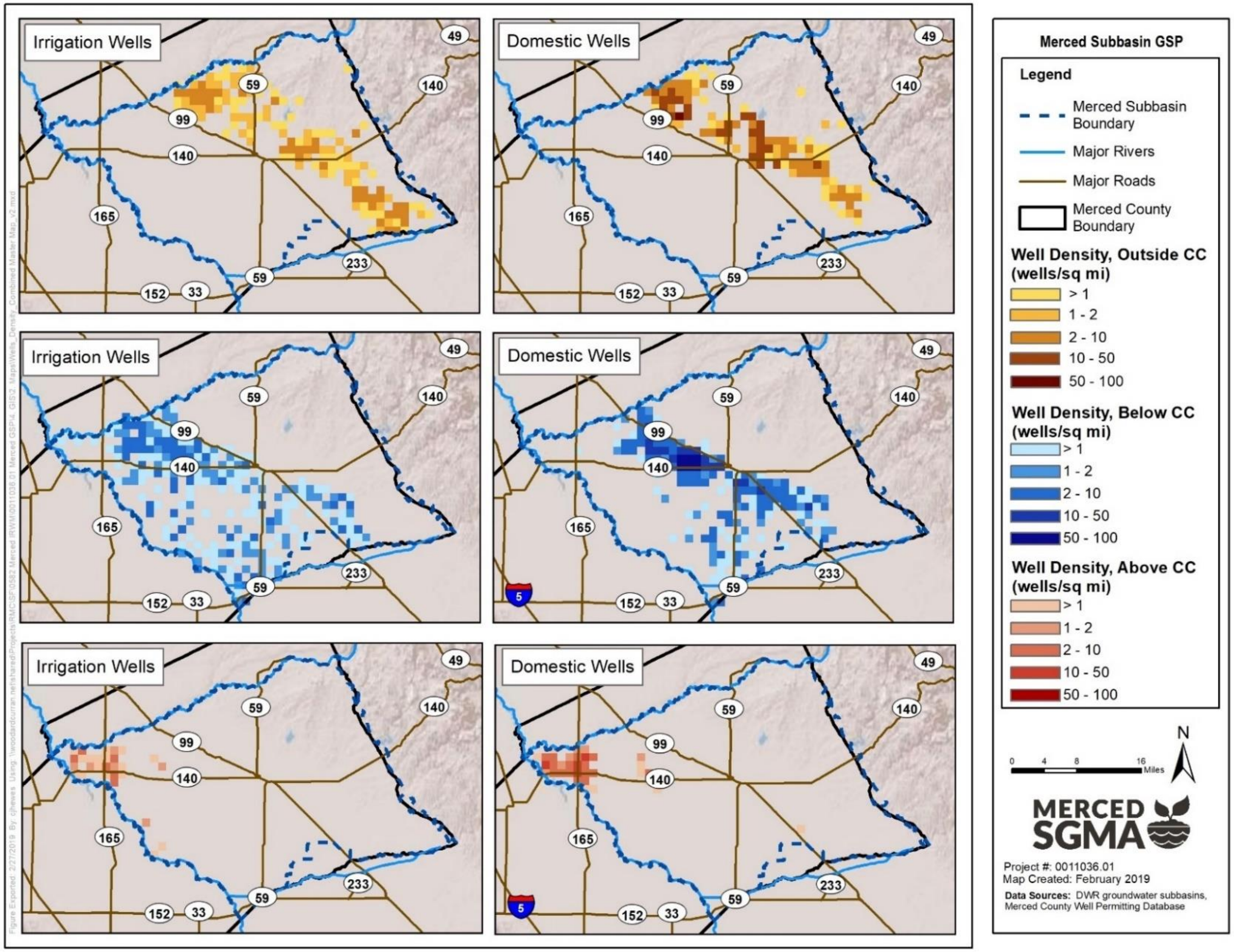


Figure 2-41 contains a series of maps showing the density per square mile of irrigation and domestic wells per principal aquifer. These wells were mapped based on the Merced County Well Permitting Database which contains a record of domestic and irrigation wells permitted from the early to mid-1990s through 2019. Only wells that were flagged with an "active" status (e.g., not flagged as "inactive" or "destroyed") were included. It is possible that some of wells with an "active" flag may have been abandoned but the information is not yet reflected in the database. About 9 percent of active wells in the database either did not have a latitude/longitude recorded or could not be matched to a location by parcel number and are thus not included in the density map. About 7 percent of the remaining wells with locations did not have a depth value and were also not included in the density map. As Figure 2-41 shows, within the Corcoran Clay area, there is a greater density and spatial distribution of both domestic and irrigation wells within the Below Corcoran Clay Principal Aquifer than the Above Corcoran Clay Principal Aquifer.

Figure 2-41: Domestic and Non-Domestic/Non-Observation Well Densities by Principal Aquifer



2.1.8 HCM Data Gaps

All hydrogeologic conceptual models contain a certain amount of uncertainty and can be improved with additional data and analysis. The Merced Subbasin HCM data gaps are present in the understanding of the HCM presented in this GSP. These data gaps will be revised after further research and data gathering for future GSP updates:

- Water quality of principal aquifers
  - Lack of depth-specific water quality data makes it difficult to spatially characterize the water quality in the aquifer.
  - Additional monitoring at various depths that cover all three Principal Aquifers for different constituents will help inform the understanding of water quality. This can be achieved through installation of new monitoring wells or through determination of screened intervals of existing monitoring wells.
- Aquifer Characteristics
  - Aquifer characteristics (such as hydraulic conductivity) have a significant impact on how projects and management action in one part of the basin may influence sustainability in other parts of the basin. Aquifer characteristics should be confirmed through additional aquifer testing or additional monitoring wells.

2.1.9 HCM Data Recommendations

While not necessarily data gaps, the item below is a recommendation for improving or updating existing information:

- Supplement the Page & Balding (1973) and Page (1977) cross-sections with more recent data. While the MercedWRM uses these cross sections as well as more recent supplemental information from the USGS texture model and AEM data, incorporation of additional recent work could be used to provide additional information for updating cross sections in the future.

2.2 CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

This section describes the current and historical groundwater conditions in the Merced Subbasin. As defined by the GSP regulations by DWR, the Groundwater Conditions section is intended to:

- Define current groundwater conditions in the Subbasin
- Describe historical groundwater conditions in the Subbasin
- Describe the distribution, availability, and quality of groundwater

- Identify interactions between groundwater, surface water, groundwater dependent ecosystems, and subsidence
- Establish a baseline of quality and quantity conditions that will be used to monitor changes in the groundwater conditions relative to measurable objectives and minimum thresholds
- Inform development of measurable objectives to maintain or improve specified groundwater conditions
- Support monitoring to demonstrate that the GSP is achieving sustainability goals of the Subbasin

The groundwater conditions described in this section are intended to convey the present and historical availability, quality, and distribution of groundwater. These conditions are used elsewhere in the GSP to identify sustainability indicators, establish undesirable results, and define measurable objectives.

2.2.1 Groundwater Elevation

2.2.1.1 Historical Groundwater Elevations

To visually show long-term trends in groundwater elevations in the Merced Subbasin, 13 wells with long periods of record and that are relatively evenly distributed across the Subbasin were selected from the larger available dataset (see Figure 2-42). Across all three Principal Aquifers, this includes four wells screened above the Corcoran Clay, five wells screened from below the Corcoran Clay, and four wells located outside the extent of the Corcoran Clay. Long-term hydrographs prepared for these wells show that, throughout most of the Merced Subbasin, groundwater elevations are declining with time (see Figure 2-42).

During the development of the original 2020 GSP, average groundwater level decline per Principal Aquifer was quantified for 1996-2015. This period was selected for being a representative hydrologic period which includes an average annual precipitation of 11.6 inches, nearly the same as the long-term average of 12.2 inches. The 1996-2015 period also includes the 2012-2015 drought, the wet years of 1996-1998, and periods of normal precipitation. It also reflects conditions pre-SGMA. This was calculated using all California Statewide Groundwater Elevation Monitoring Program (CASGEM) and Voluntary wells with groundwater level data available for 1996-2015 (totaling 51 wells).

Based on data from 11 wells in the Above Corcoran Clay Principal Aquifer, average groundwater level decline was 1.3 ft/yr from 1996-2015. Based on data from 15 wells in the Below Corcoran Clay Principal Aquifer, average groundwater level decline was 2.4 ft/yr from 1996-2015. Based on data from 25 wells in the Outside Corcoran Clay Principal Aquifer, average groundwater level decline was 1.2 ft/yr from 1996-2015. Note that most of the CASGEM wells for the Outside Corcoran Clay Principal Aquifer were Voluntary wells that did not report beyond 2012. It is possible that some portion of additional groundwater level decline during the 2012-2015 drought is missing from the overall 1996-2015 average for the Outside Corcoran Clay Principal Aquifer.

Figure 2-42: Hydrographs Through 2018 for Selected Wells in the Merced Subbasin

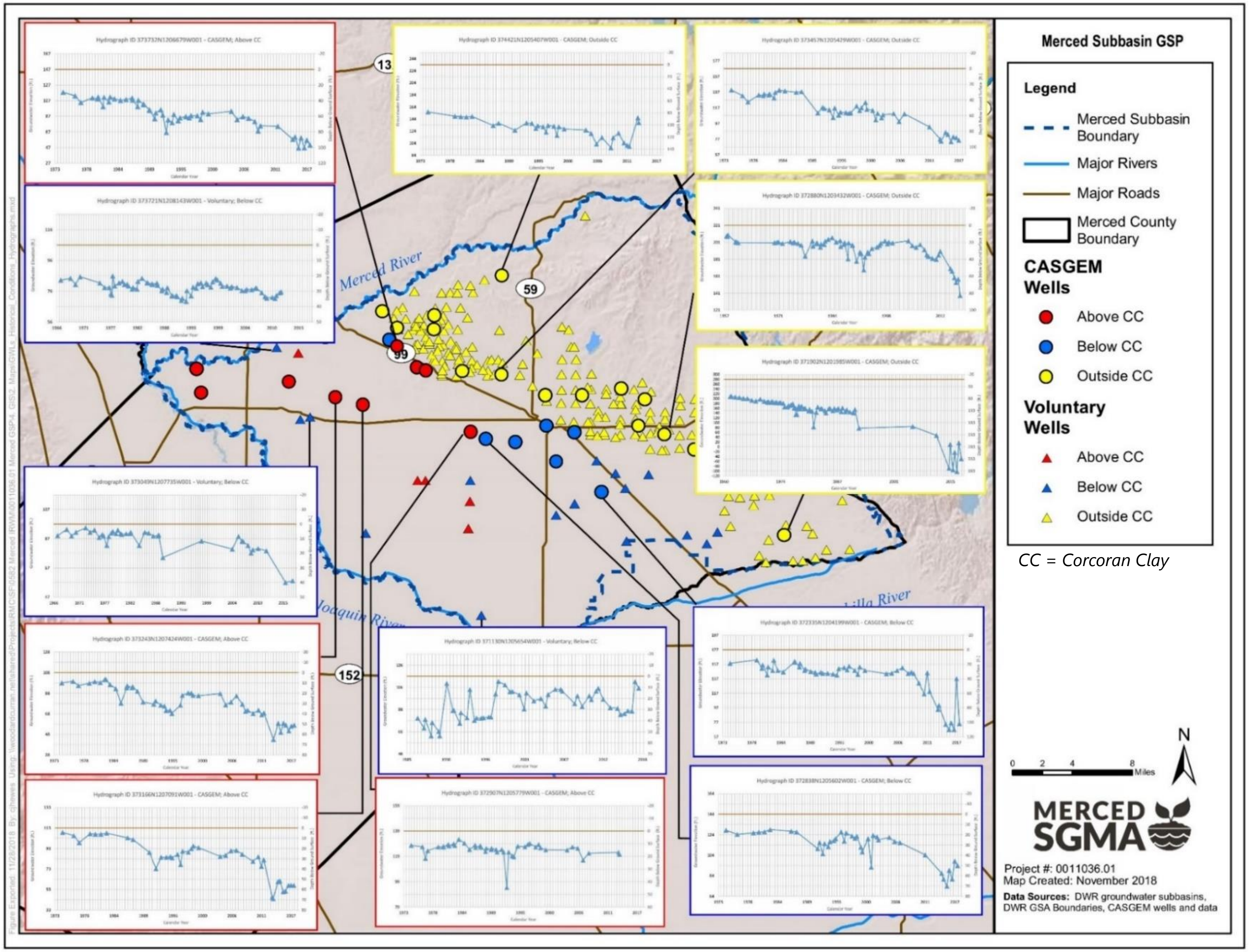


Figure 2-43 through Figure 2-45 show groundwater elevations (in feet above sea level, datum NAVD88) in fall 2014 based on measurements recorded at CASGEM wells, including voluntary wells where data was available. Fall 2014 is the closest season of available CASGEM data to display conditions as of January 1, 2015, representing conditions when SGMA became law. Groundwater elevations are mapped separately for the three principle aquifers: Above, Below, and Outside of the Corcoran Clay.

Figure 2-43: Fall 2014 Groundwater Elevation, Principal Aquifer: Above Corcoran Clay

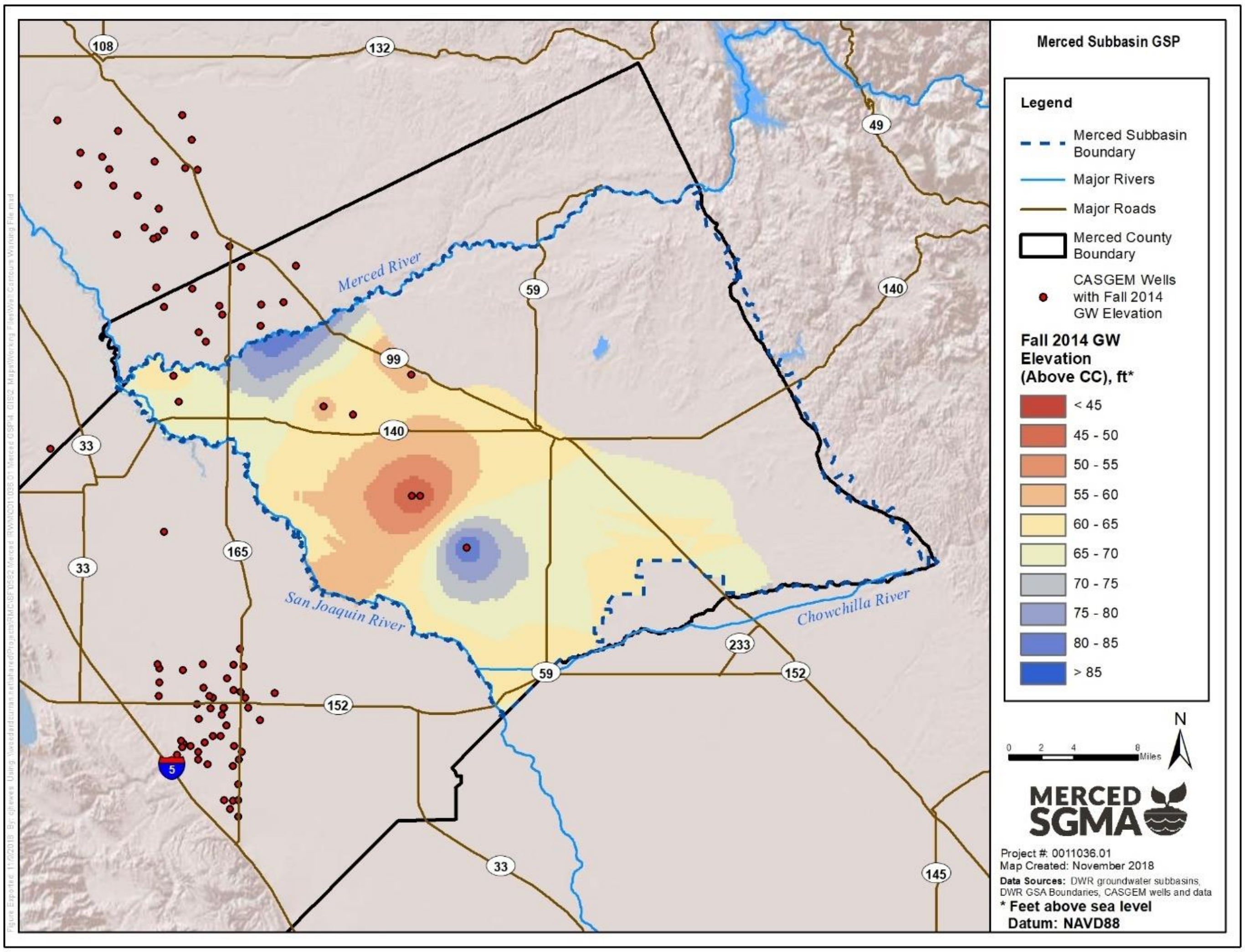


Figure 2-44: Fall 2014 Groundwater Elevation, Principal Aquifer: Below Corcoran Clay

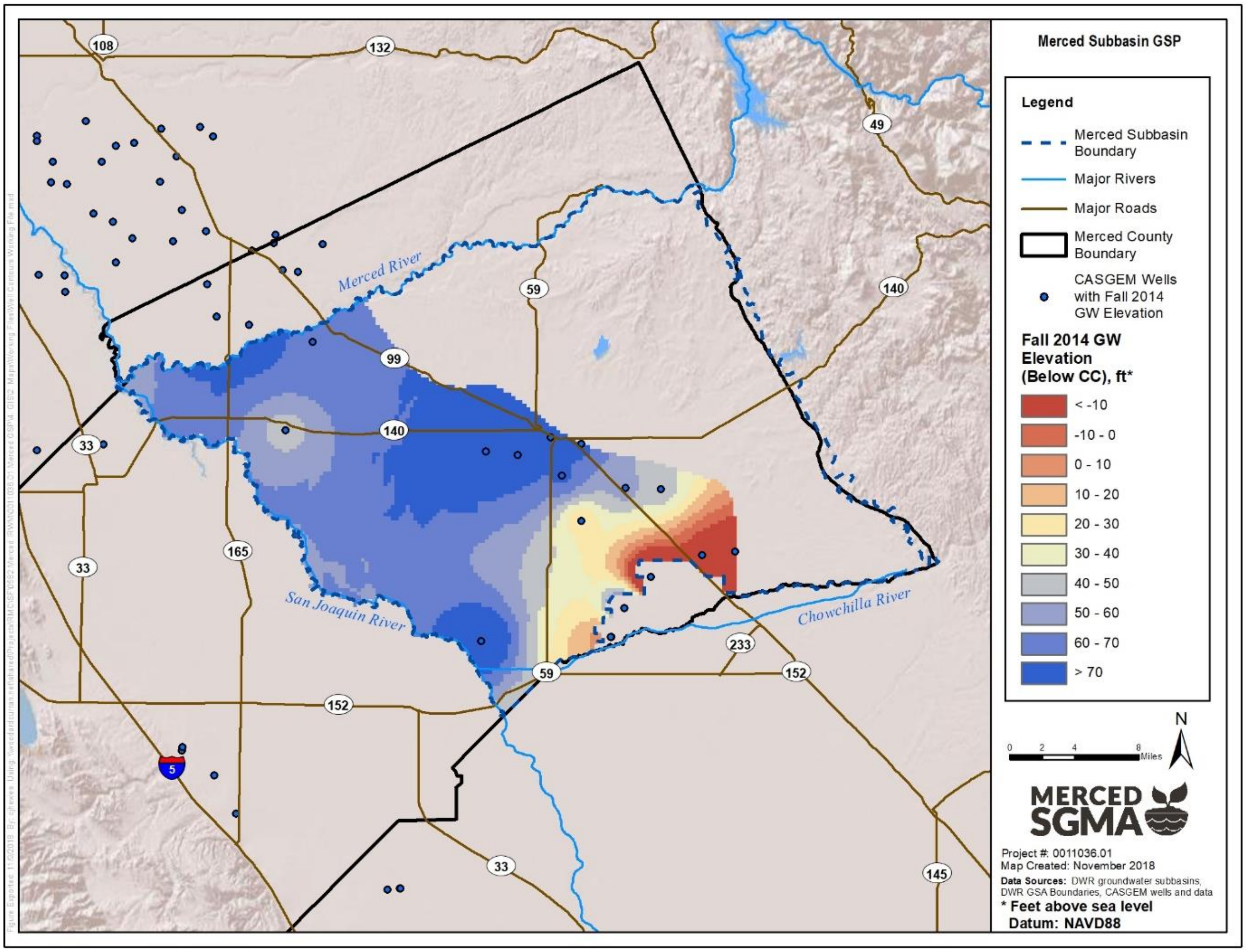
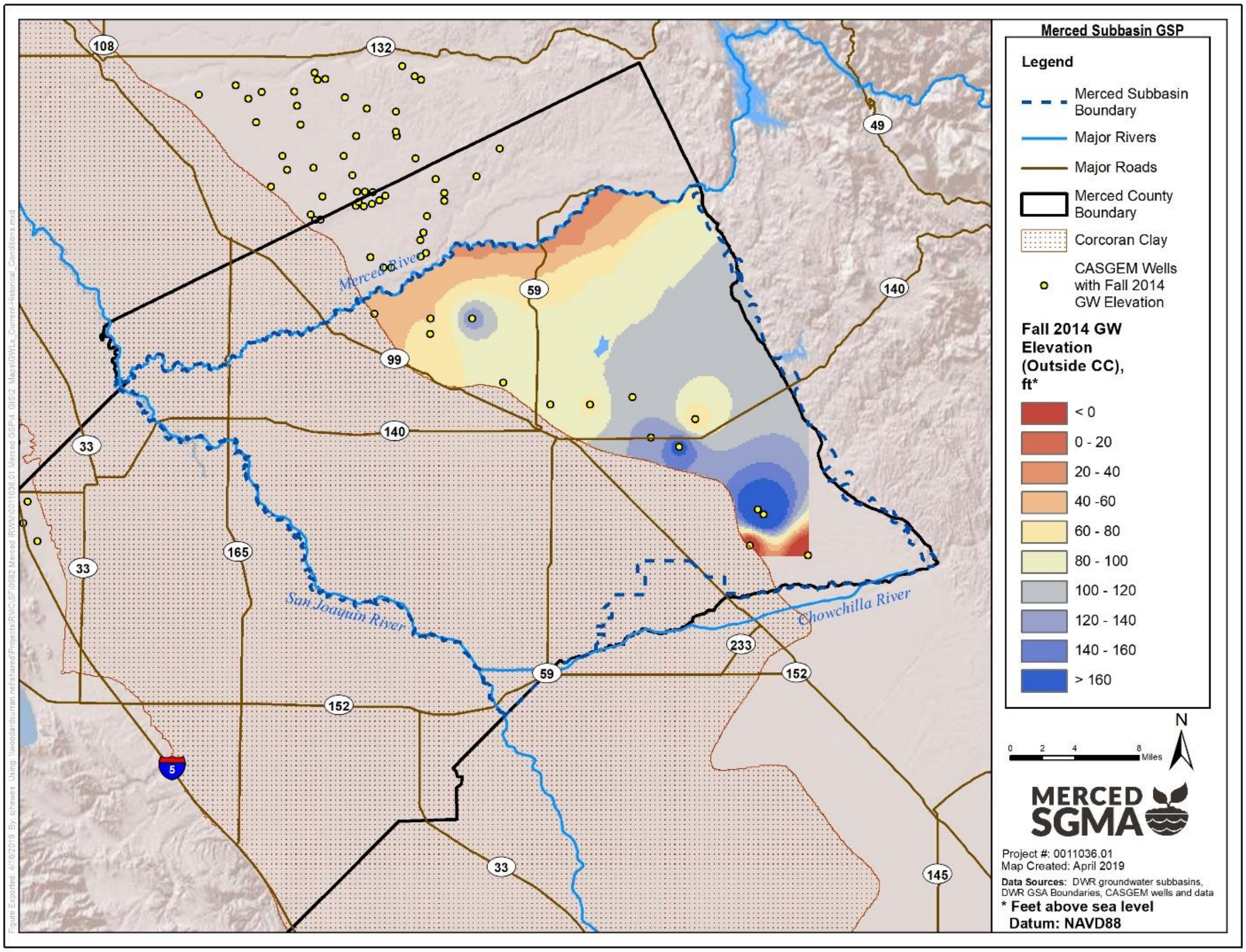


Figure 2-45: Fall 2014 Groundwater Elevation, Principal Aquifer: Outside Corcoran Clay[1]



[1] Groundwater elevations are missing for the southeast corner of the Outside Corcoran Clay Principal Aquifer due to a lack of data in this corner of the Subbasin from Fall 2014.

2.2.1.2 Current Groundwater Conditions

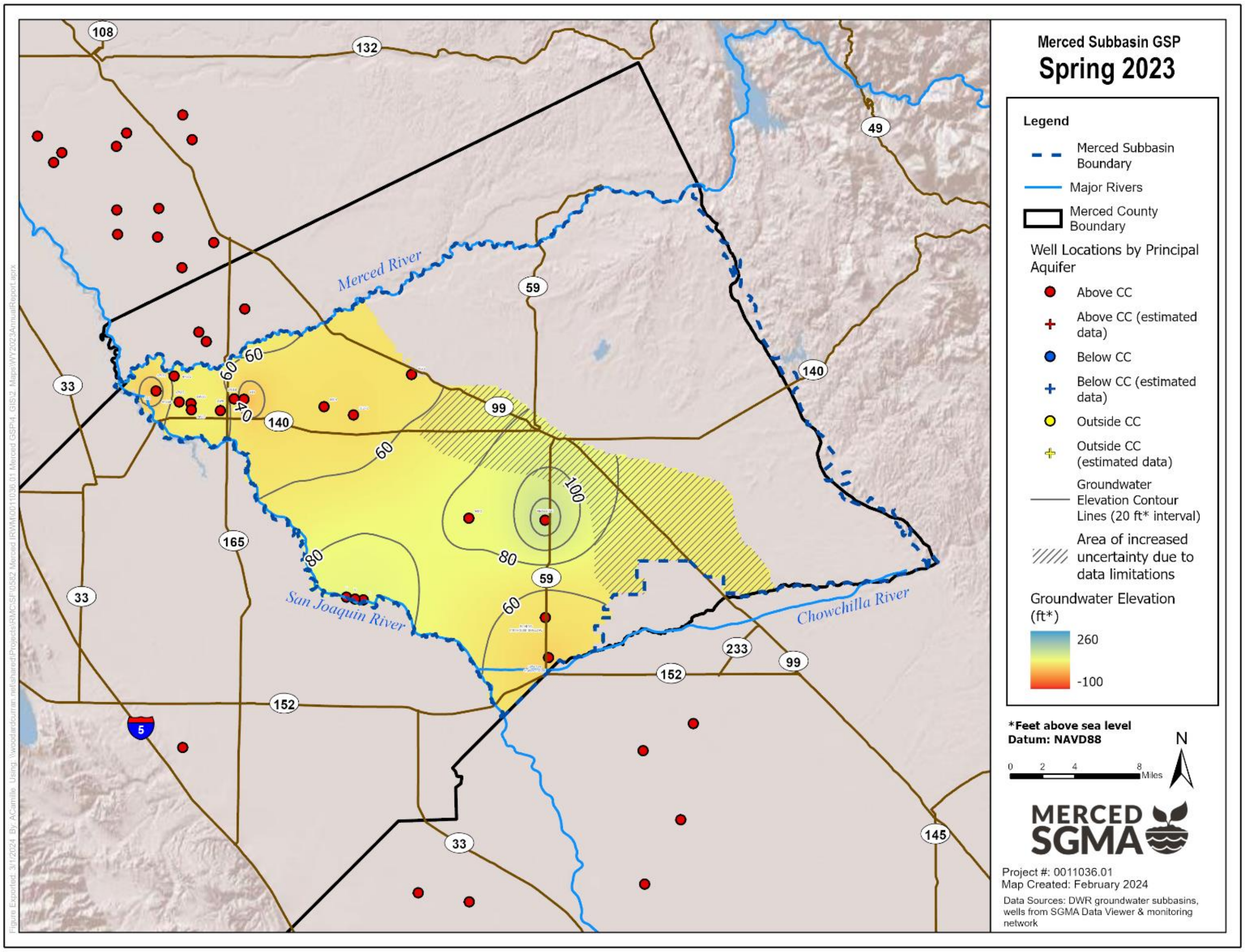
Figure 2-46 through Figure 2-48 show groundwater elevations in spring 2023 (most recent seasonal high), while Figure 2-49 through Figure 2-51 show groundwater elevations in fall 2023 (most recent seasonal low). Groundwater elevations are mapped separately for the three principle aquifers: Above, Below, and Outside of the Corcoran Clay. The maps include measurements from all available wells, including both representative and non-representative monitoring network wells, as well as other wells selected opportunistically that had available measurements in the statewide SGMA data viewer.

Above the Corcoran Clay, groundwater generally flows northerly from the southern portion of the aquifer boundary. The lateral gradient is fairly shallow at approximately 4 ft/mi.

Below the Corcoran Clay, groundwater generally flows in an easterly or westerly direction outwards from a spine of higher-elevation groundwater that exists approximately in the center of the aquifer, running north-south. The lateral gradient ranges from approximately 8 ft/mi to 13 ft/mi.

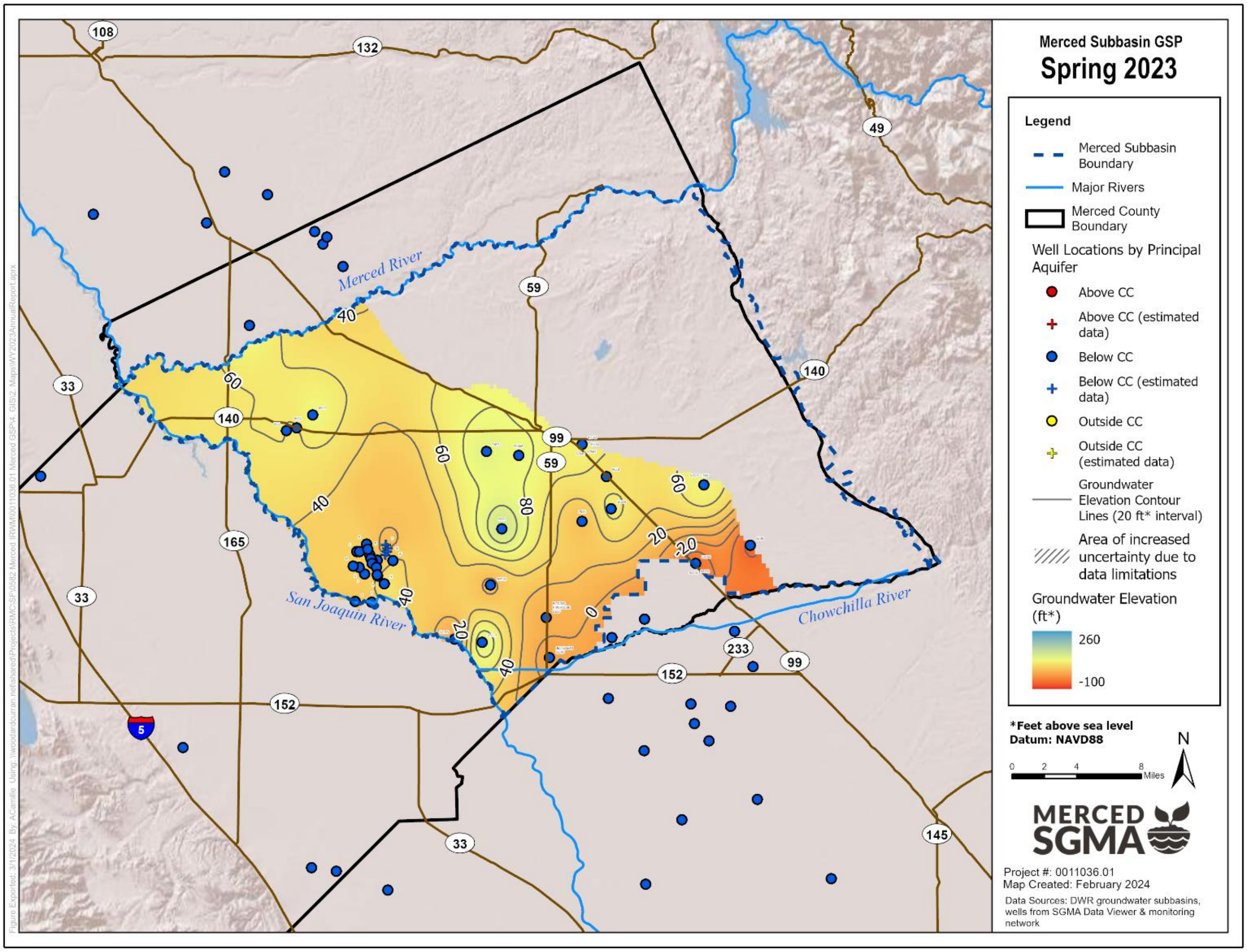
Outside of the Corcoran Clay, groundwater generally flows from the center of the aquifer region to the east and west. The lateral gradient is approximately 4 ft/mi.

Figure 2-46: Spring 2023 Groundwater Elevation, Principal Aquifer: Above Corcoran Clay



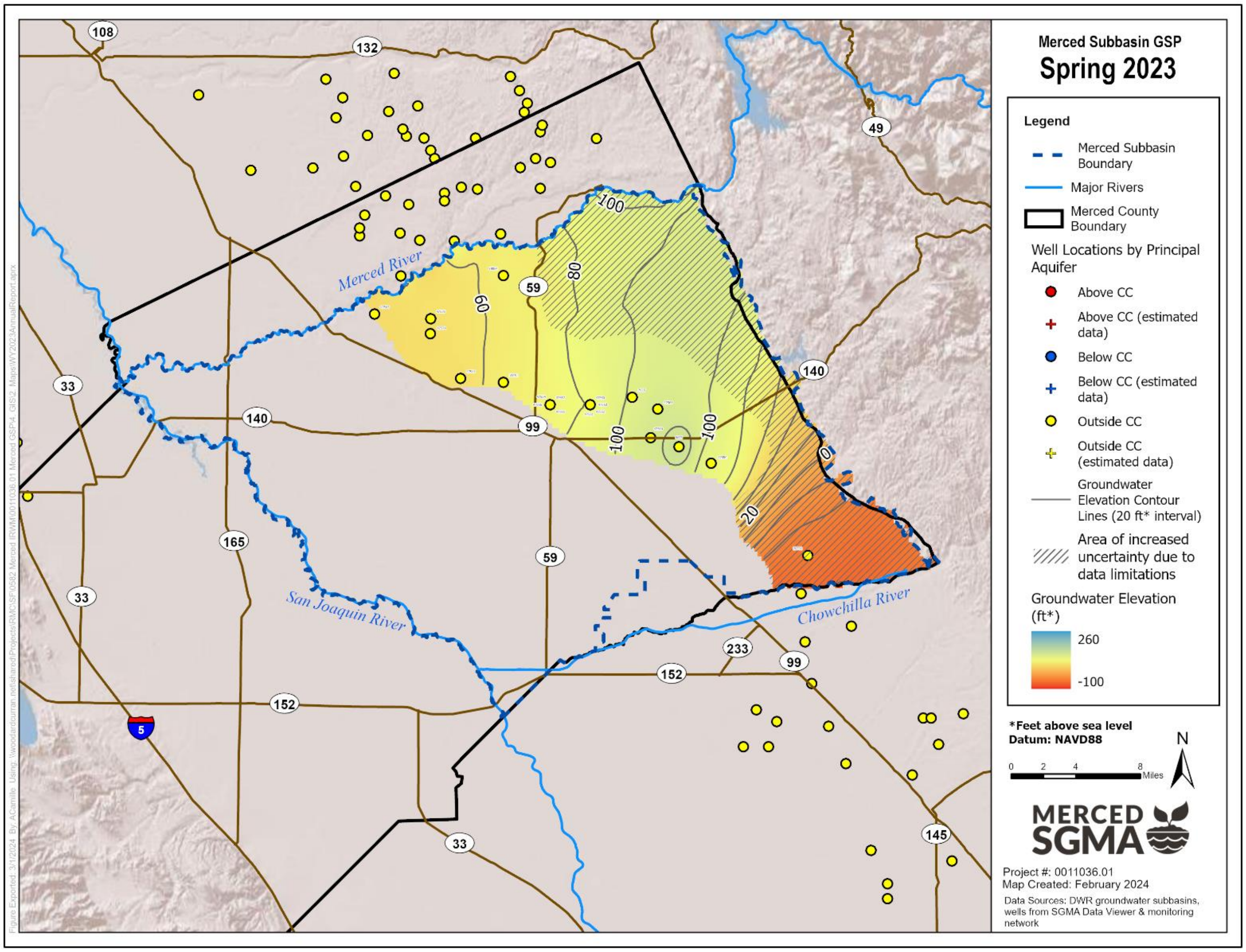
Source: Merced GSP Water Year 2023 Annual Report

Figure 2-47: Spring 2023 Groundwater Elevation, Principal Aquifer: Below Corcoran Clay



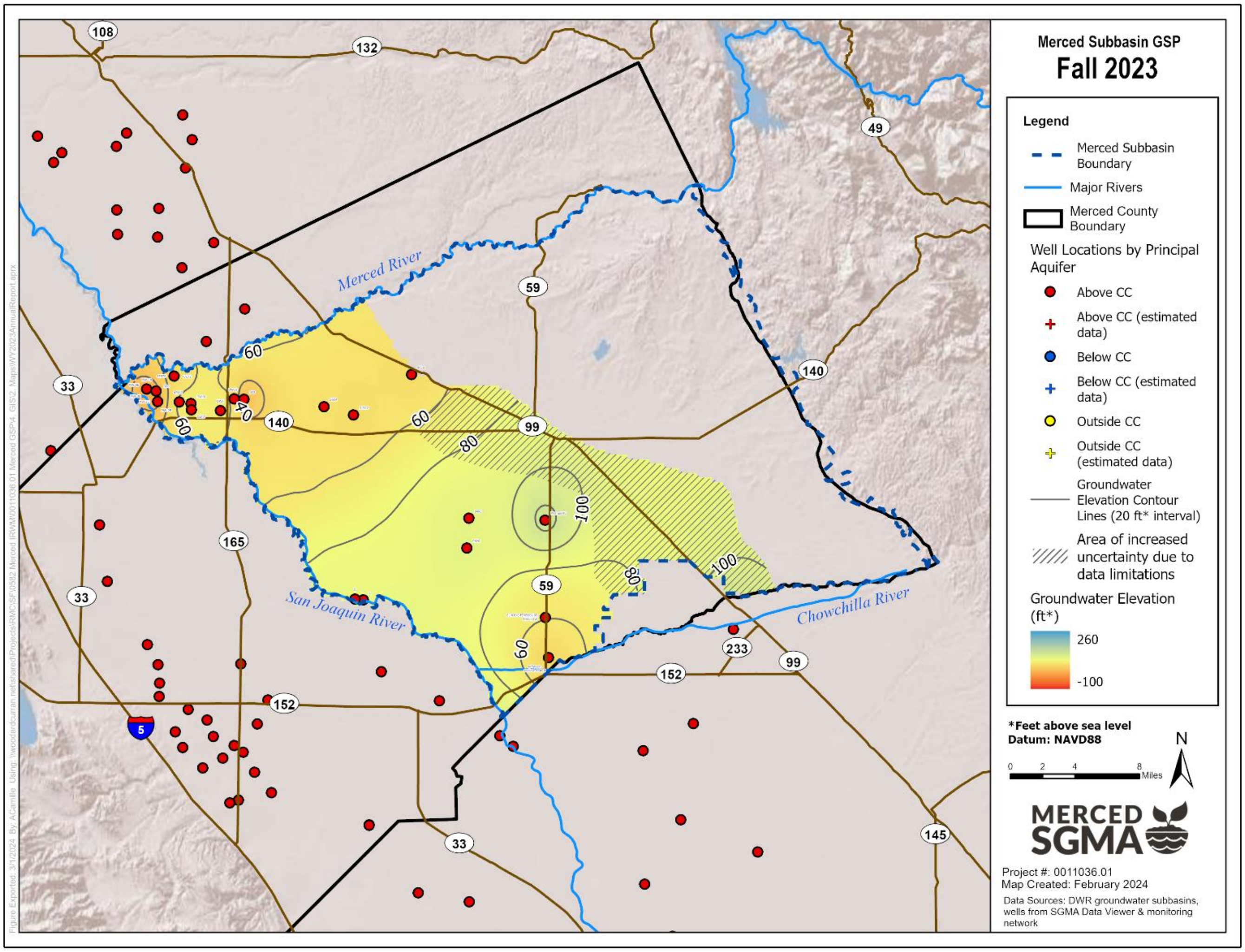
Source: Merced GSP Water Year 2023 Annual Report

Figure 2-48: Spring 2023 Groundwater Elevation, Principal Aquifer: Outside Corcoran Clay



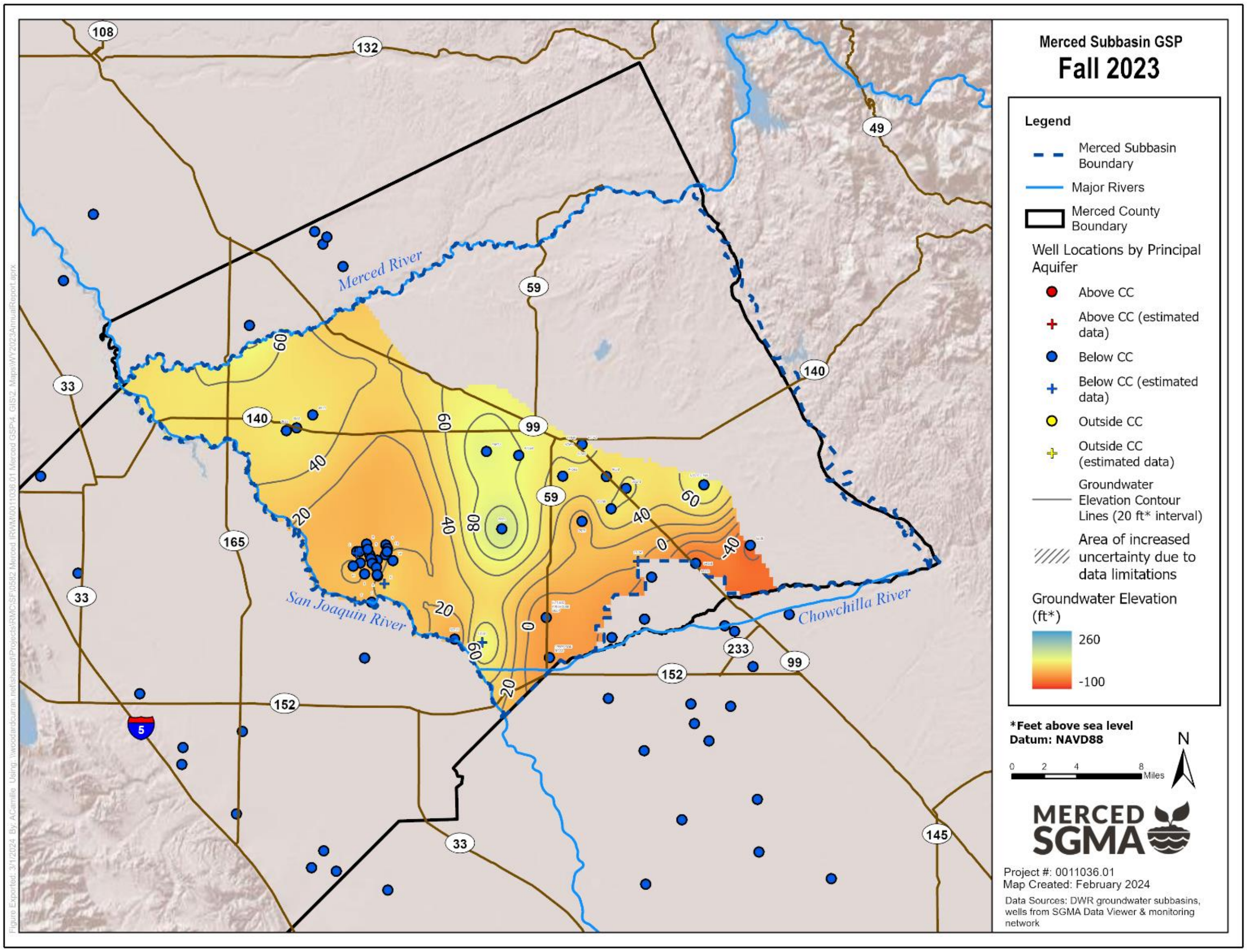
Source: Merced GSP Water Year 2023 Annual Report

Figure 2-49: Fall 2023 Groundwater Elevation, Principal Aquifer: Above Corcoran Clay



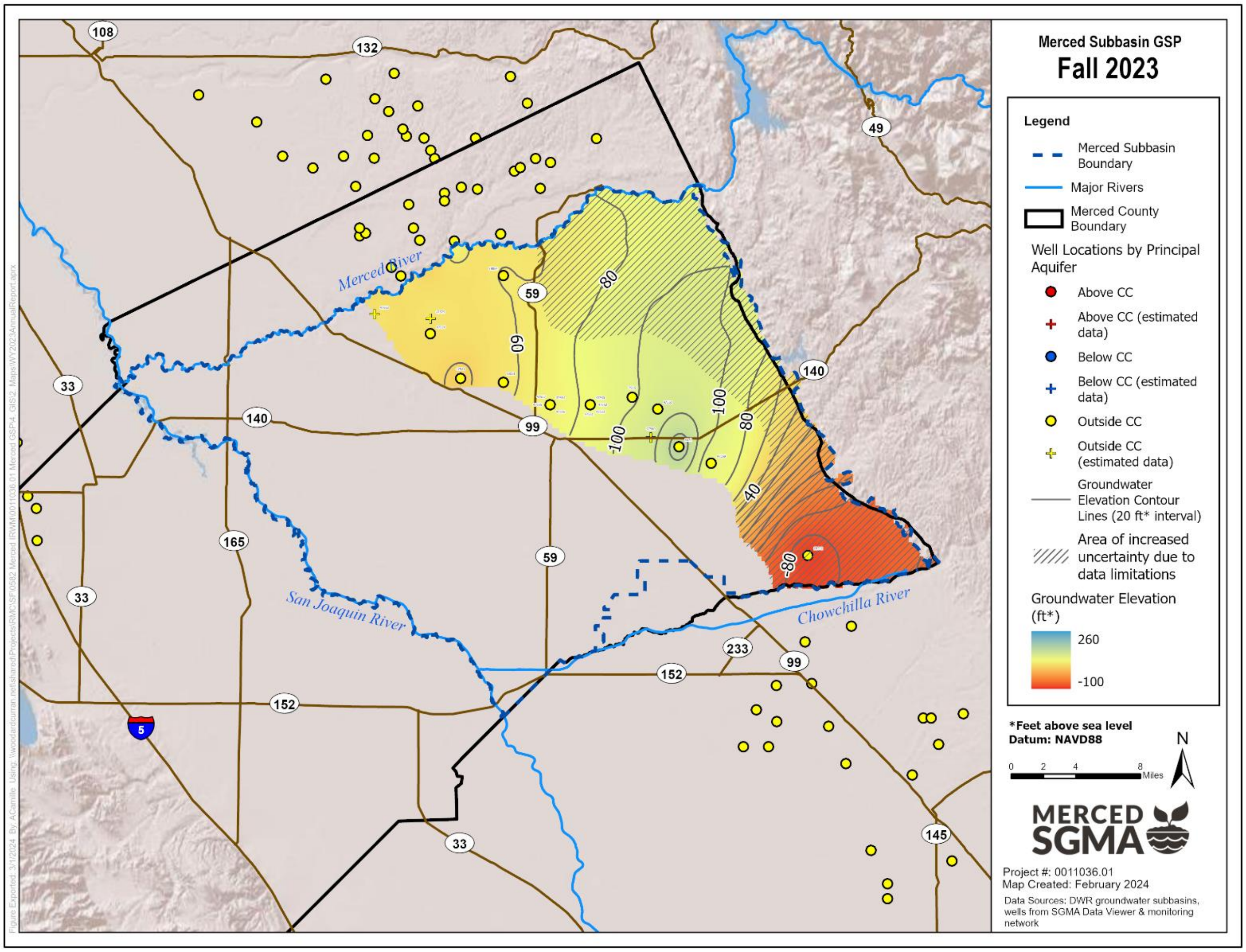
Source: Merced GSP Water Year 2023 Annual Report

Figure 2-50: Fall 2023 Groundwater Elevation, Principal Aquifer: Below Corcoran Clay



Source: Merced GSP Water Year 2023 Annual Report

Figure 2-51: Fall 2023 Groundwater Elevation, Principal Aquifer: Outside Corcoran Clay



Source: Merced GSP Water Year 2023 Annual Report

2.2.1.3 Vertical Gradients

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

At the time of publishing of the original 2020 GSP, there were six site locations with multiple completion wells located in the Merced Subbasin, all of which are monitored through the GSP's monitoring program. From 2020-2025, one site was removed from the network and four additional sites have been installed which include multiple completions (see Section 4.5.7), now totaling nine sites. The most recent locations of multiple completion wells are shown in Figure 2-52. This section has been updated with the latest observations at the five sites with longer term data. Since they were installed so recently and have a limited monitoring period, this section has not been updated with the four new sites.

Hydrographs with groundwater elevations for each respective set of completion wells are shown in Figure 2-53 through Figure 2-57. The three sets of multiple completion wells in the Below and Outside Corcoran Clay Principal Aquifers in the center of the Subbasin are owned and operated by the City of Merced primarily for municipal water quality monitoring. There are no known recent studies dedicated to vertical gradients using groundwater elevations recorded at these wells.

The set of multiple completion wells in the Below Corcoran Clay Principal Aquifer shows a slight indication of an upward gradient but is not significant across all screened intervals (see Figure 2-53). This well set is located right at the edge of the extent of the Corcoran Clay where it is most shallow and thin and the level of confinement is not as well understood. The top of the Corcoran Clay is approximately 55 feet below ground surface (bgs) and 15 feet thick (extending to a depth of approximately 70 feet bgs), while the shallowest wells have screened intervals 89-170 feet bgs.

One of the two sets of multiple completion wells in the Outside Corcoran Clay Principal Aquifer shows evidence of a downward gradient (see Figure 2-55) which is consistent with previous studies (Elliott, 1984), as referenced by (AMEC, 2008). The other set of wells shows a slight indication of a downward gradient (see Figure 2-55) but is not significant across all screened intervals. Consequently, in the Outside Corcoran Clay, degradation of shallow groundwater can potentially affect deeper water supply wells if downward flow is significant and if dilution and chemical/biological processes are insufficient to adequately reduce the concentrations of constituents of concern (AMEC, 2008).

Both sets of multiple completion wells in the Above Corcoran Clay Principal Aquifer show no strong gradient (see Figure 2-56 and Figure 2-57).

Figure 2-52: Multiple-Completion Wells

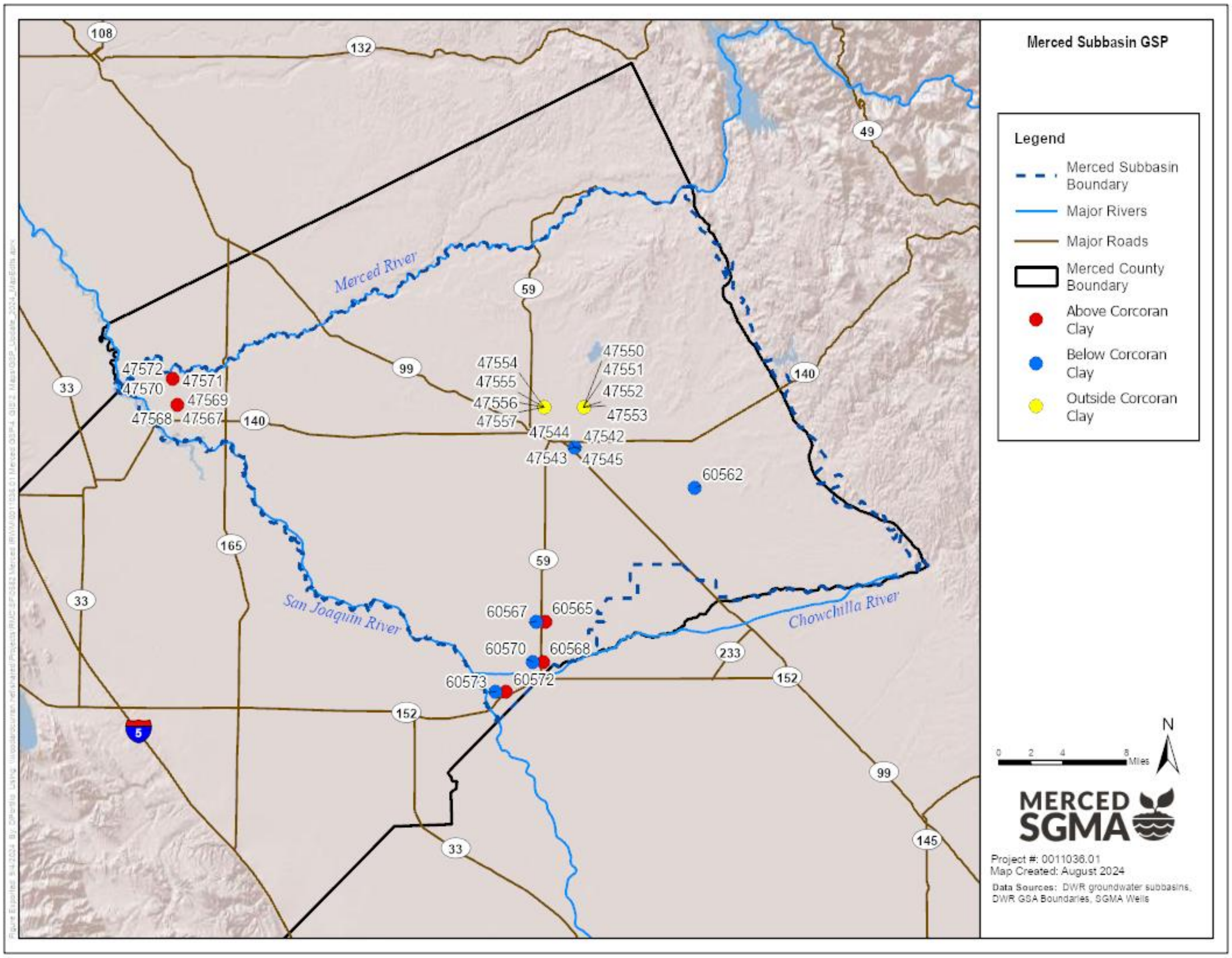


Figure 2-53: Vertical Gradient Series A - Below Corcoran Clay

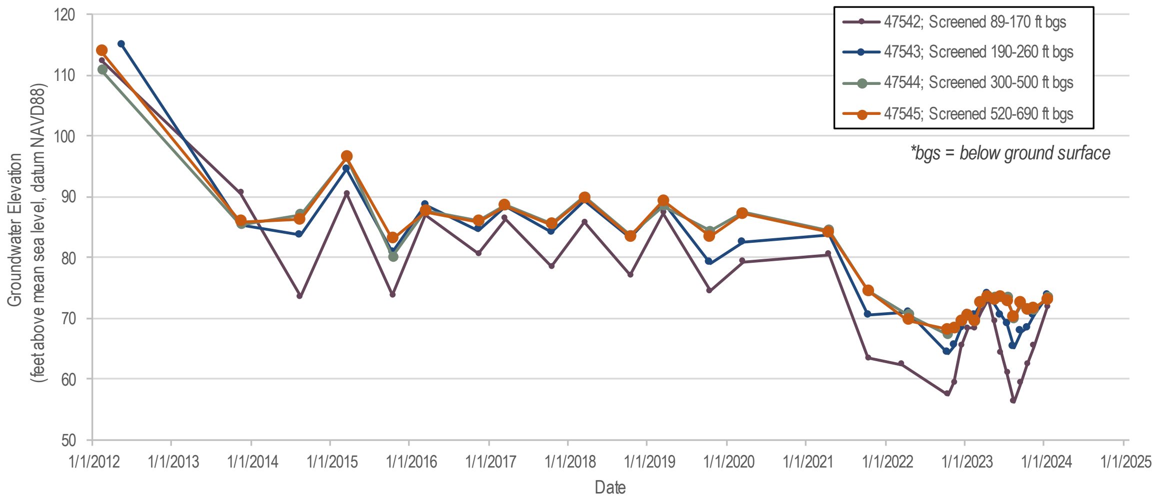


Figure 2-54: Vertical Gradient Series B - Outside Corcoran Clay

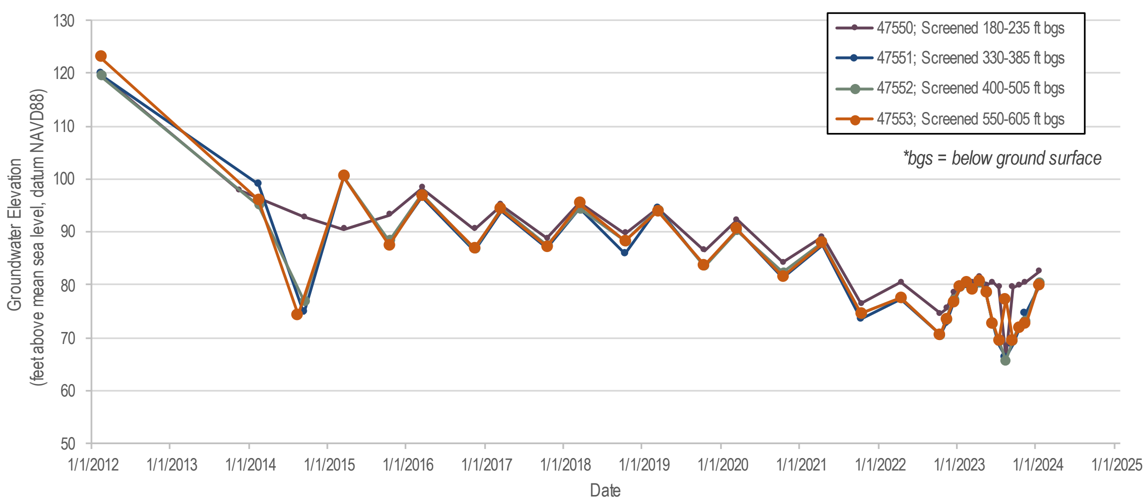


Figure 2-55: Vertical Gradient Series C - Outside Corcoran Clay

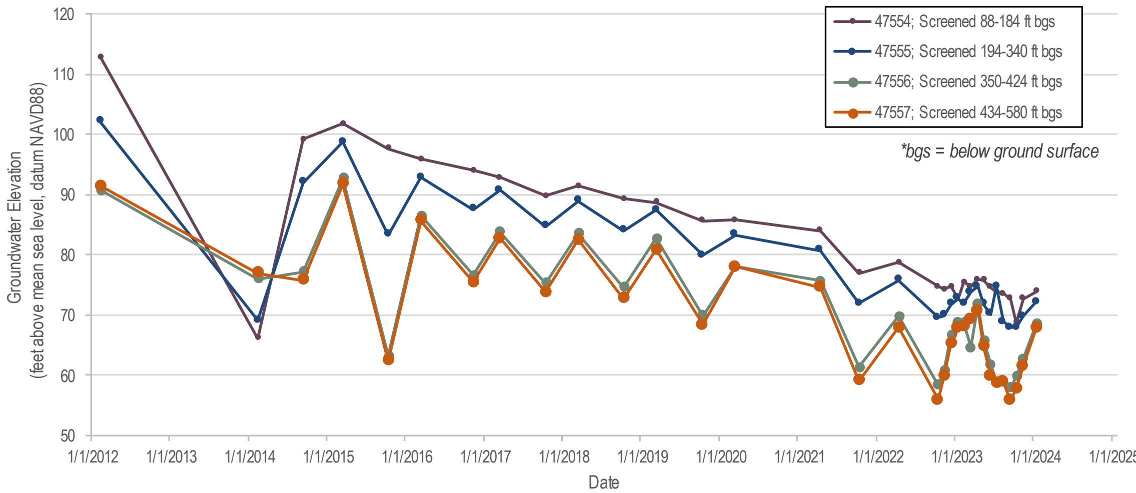


Figure 2-56: Vertical Gradient Series D - Above Corcoran Clay

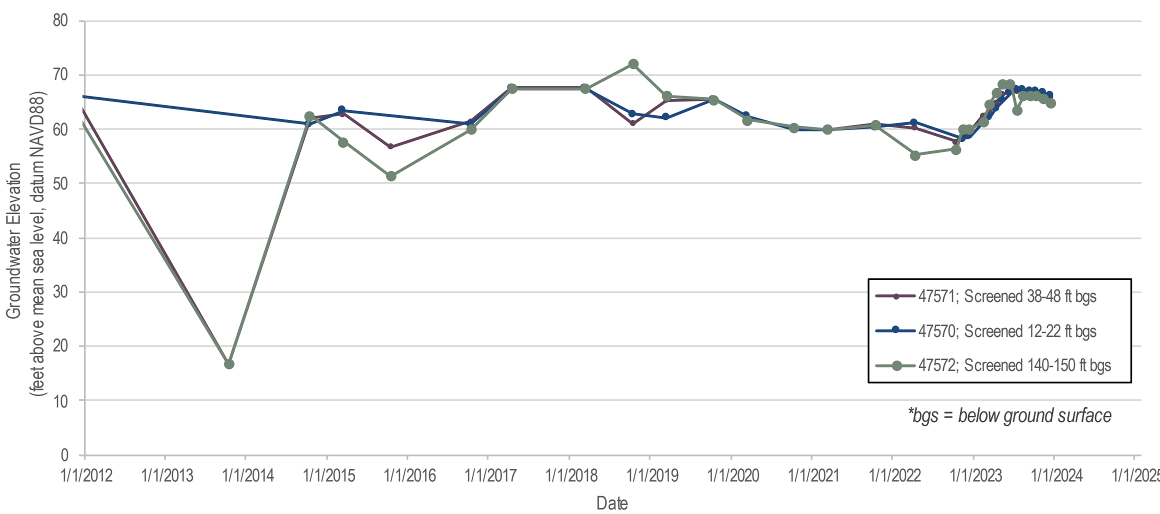


Figure 2-57: Vertical Gradient Series E - Above Corcoran Clay

2.2.2 Groundwater Storage

The MercedWRM was used to estimate historical change in storage of the Merced Subbasin from 1996-2023. Figure 2-58 shows annual total storage for each MercedWRM layer (not including the deep layer of relative higher salinity) as well as the cumulative change in storage. In 2023, the total fresh groundwater storage was estimated as 46.9 million acre-feet (MAF) and the cumulative change in storage from WYs 2006-2023 was estimated as -1.92 MAF, or an average reduction of 107 TAF per year. During WY 2023, the change in storage was estimated as an increase of 280 TAF. An additional 72 MAF of groundwater in Layer 6 of the model (not pictured) is of relatively higher salinity. More information about the layers of the MercedWRM and calculation of storage changes can be found in Appendix D. Figure 2-59 shows the same cumulative change in storage against budgeted groundwater uses and water year type.

Figure 2-58: Historical Modeled Change in Storage by MercedWRM Layer

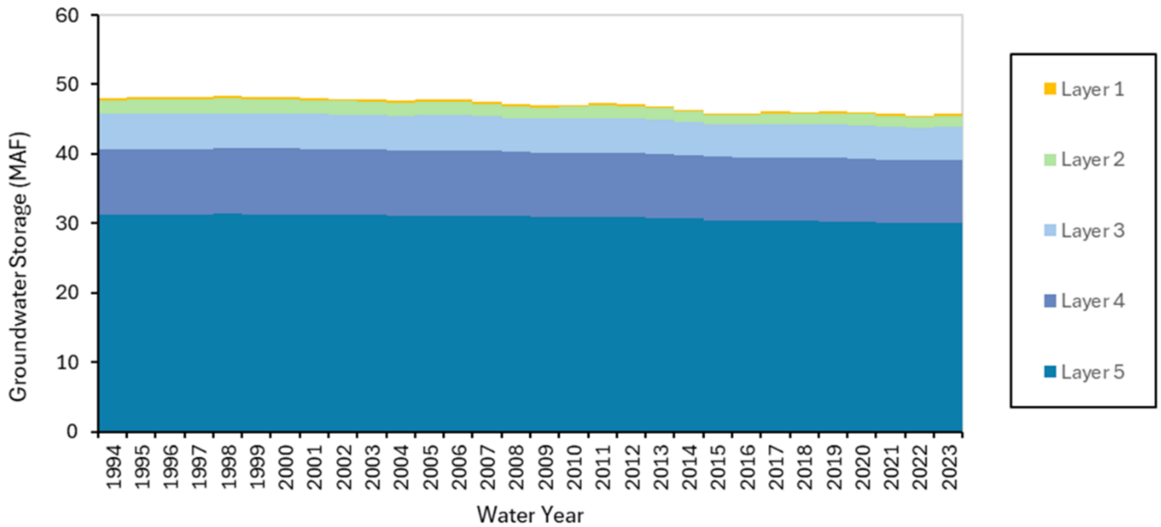
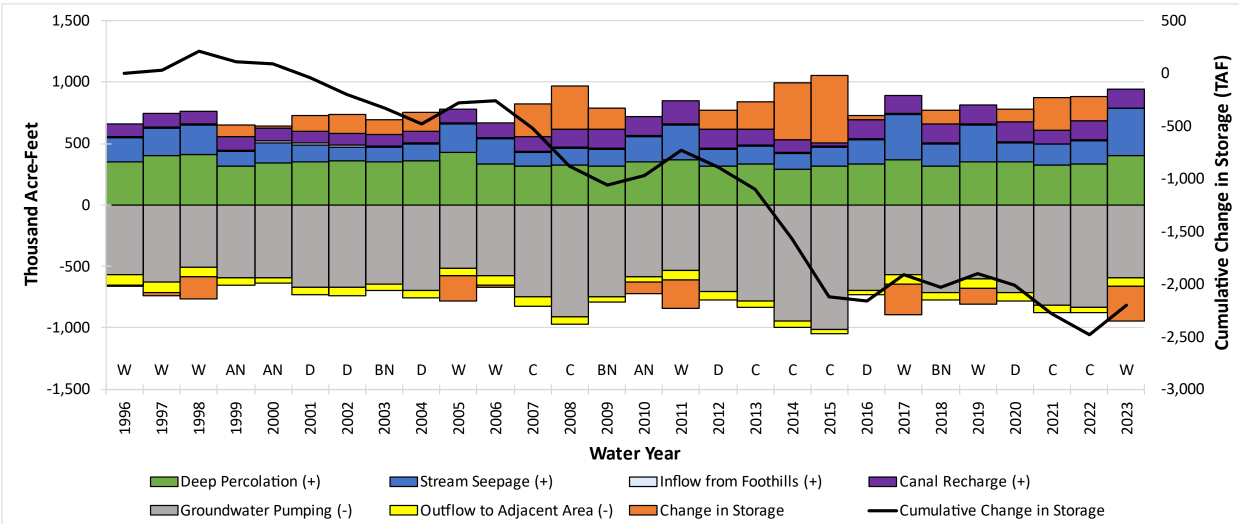


Figure 2-59: Historical Modeled Change in Storage with Groundwater Use and Water Year Type



[1] "Change in Storage" is placed on the chart to balance the water budget. For instance, if annual outflows (-) are greater than inflows (+), there is a decrease in storage, and this is shown on the positive side of the bar chart to balance out the increased outflows on the negative side of the bar chart.

Source: Water year types based on San Joaquin Valley Water Year Index (DWR, 2024)

X-Axis Abbreviation	Water Year Type
W	Wet
AN	Above Normal
BN	Below Normal
D	Dry
C	Critical

2.2.3 Seawater Intrusion

Seawater intrusion is not a potential risk in the Merced Subbasin, as the Subbasin is not near any seawater source. However, groundwater quality conditions related to salinity are described in the following section.

2.2.4 Groundwater Quality

Groundwater in the Merced Subbasin contains both anthropogenic and naturally occurring constituents. While groundwater quality is often sufficient to meet beneficial uses, some of these constituents either currently impact groundwater use within the Subbasin or have the potential to impact it in the future. Depending on the water quality constituent, the issue may be widespread or more of a localized concern.

The primary naturally-occurring water quality constituents of concern are arsenic and uranium. There are also aesthetic issues related to iron and manganese.

The primary water quality constituents of concern related to human activity include salinity, nitrate, hexavalent chromium, petroleum hydrocarbons (such as benzene and MTBE), pesticides (such as DBCP, EDB, 1,2,3 TCP), solvents (such as PCE, TCE), and emerging contaminants (such as PFOA, PFOS). Of these issues, nitrate is the most widespread issue with a direct impact on public health. Salinity is also an issue due to the widespread nature of the problem and difficulty of management given increases in salinity as a result of both urban and agricultural use.

The Merced County Department of Public Health, Division of Environmental Health maintains a list of areas of known adverse water quality in the County, shown below in Table 2-10.

Table 2-10: Adverse Groundwater Quality by Area

Region	Parameters
Atwater	Nitrates, DBCP[2], EDB[2], TCE[3] and 1,2,3 TCP[2&3]
Cressey	Nitrates & DBCP
El Nido	Nitrates, Arsenic, Sodium, & TDS[4]
Le Grand	Hard Water[1]
Livingston	Nitrates, Arsenic, DBCP, EDB, TCE and 1,2,3 TCP
McSwain Area	Nitrates, DBCP, EDB, TCE and 1,2,3 TCP
Merced	Nitrates & Hard Water
Planada	DBCP & Hard Water
Stevinson	Arsenic, Sodium, TDS[4], Manganese, Chlorides, Hard Water, & Tannins
Winton	Nitrates, DBCP, EDB, TCE and 1,2,3 TCP

Source: (Merced County Department of Public Health, Division of Environmental Health, 2018)

1 Hard Water = Total hardness > 150 mg/L (mg/L = milligrams per liter = parts per million)

2 Dibromochloropropane (DBCP), Ethylene Dibromide (EDB) and 1,2,3 Trichloropropane (1,2,3 TCP) are soil fumigants, use of DBCP and EDB was banned in 1977.

3 TCE and 1,2,3 TCP are solvent/degreases.

4 TDS refers to the total dissolved solids in water.

General Notes from the Merced County Department of Public Health, Division of Environmental Health:

a. Chlorides, manganese, hard water, iron, tannins, TDS, and sodium in drinking water are, of themselves, not known causes of health problems.
b. The water quality information above refers to private wells in unincorporated areas and does not necessarily apply to the municipal water supply of the towns and cities.

The sections below provide information on the historical and current groundwater quality conditions for constituents grouped by (1) salinity and nutrient constituents (Section 2.2.4.1), (2) metals (Section 2.2.4.2), (3) pesticides (Section 2.2.4.3), and (4) point-source contamination (Section 2.2.4.3.3), which includes petroleum hydrocarbons, solvents, and emerging contaminants.

Water quality data were retrieved from the State Water Board's GAMA website and merged with a small number of additional field samples collected in 2023 by EJWQC that had not yet been imported to GAMA at the time. All datasets from the GAMA system were incorporated, except for samples from Water Board Cleanup and Permitted Sites, as these were presumed to not reflect the broader water quality conditions in the Subbasin. The dataset underwent further quality assurance by removing duplicate water samples reported to multiple datasets in the GAMA program for the same well, and the elimination of a small number of outliers that were suspected to be data entry errors, typically when a single measurement was one or more orders of magnitude larger than all other measurements located at the same well.

Wells were subsequently assigned to a Principal Aquifer. The mapped extent of the Corcoran Clay was used to identify wells Outside the Corcoran Clay. For wells within the Corcoran Clay extent, well construction information was utilized to identify the Principal Aquifer in which the well was screened. If 80% of the well's screened interval (or total depth, if well screen information was absent) was located above or below the Corcoran Clay, it was assigned to the corresponding aquifer. If the well was screened across the Corcoran Clay, or if no construction information was included for the well, it was classified as an Unknown Aquifer well.

Five-year averages were calculated for each well's set of constituents from 2019-2023. Non-detects were included in this dataset but were valued at the reporting limit listed in GAMA, a conservative assumption as concentrations would be at or below these values. Five-year average concentration maps were subsequently generated by interpolating data for each Principal Aquifer using inverse distance weighted methods via ArcGIS Pro software by Esri. Each contour map also includes the well locations, color-coded by their dataset source, to show the spatial distribution of available input data.

Time concentration plots for each constituent were also produced to illustrate the change in concentrations over time for each well. Non-detects are included in these plots to show when wells were sampled for various constituents, denoted with a white-filled marker. Wells were color-coded by Principal Aquifer to depict trends over time across the aquifers. Contour maps and time series concentration plots have been directly incorporated into the GSP sections below (Sections 2.2.4.1 through 2.2.4.6) along with a discussion of each constituent.

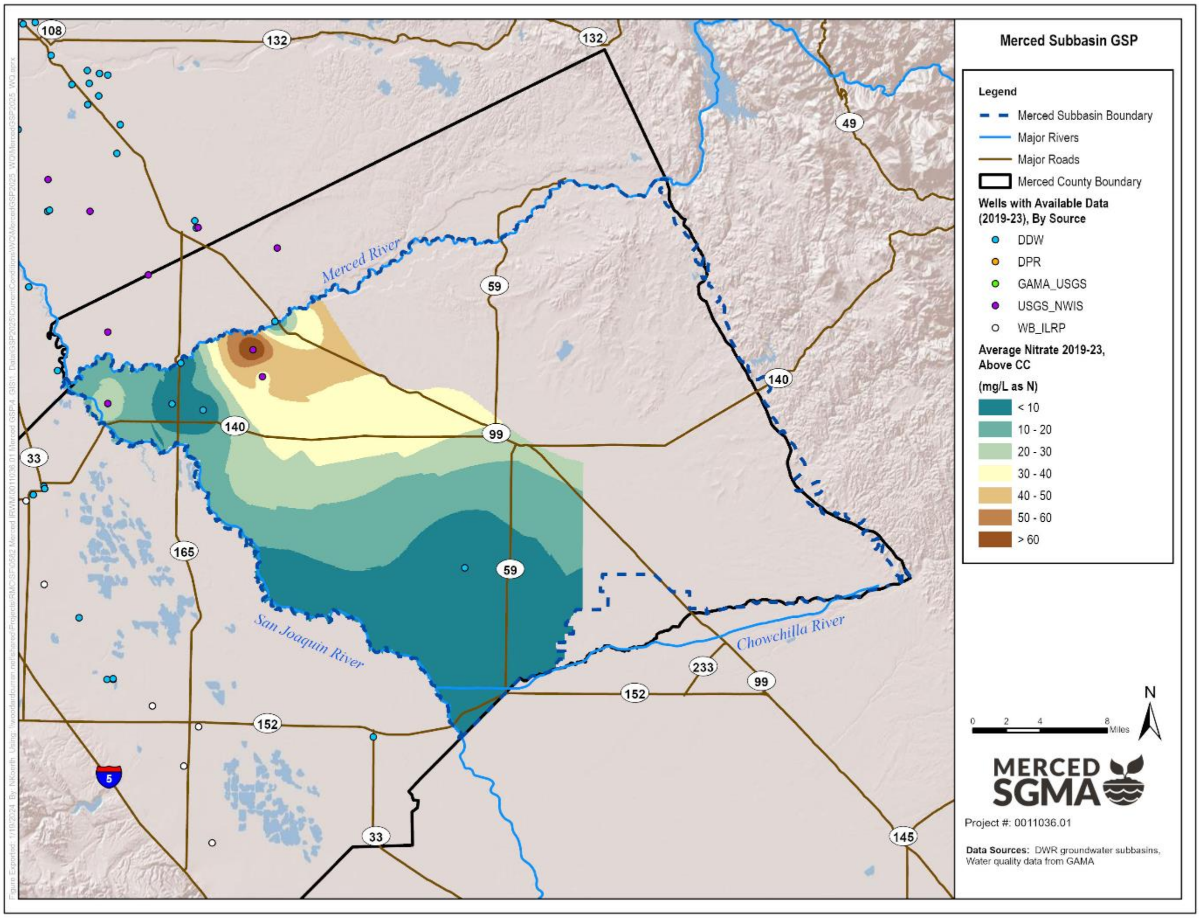
2.2.4.1 Salinity and Nutrient Constituents

2.2.4.1.1 Nitrates

Nitrate (NO_3) occurs from both natural and anthropogenic sources and is widespread in groundwater in many parts of the San Joaquin Valley. High nitrate concentrations in groundwater are often associated with the use of fertilizers (commercial/animal waste) and onsite wastewater treatment systems (OWTS or septic systems).

The primary Maximum Contaminant Level (MCL) for nitrate (as nitrogen) is 10 mg/L (SWRCB, 2018). Large portions of the Merced Subbasin have nitrate (as nitrogen) concentrations below 10 mg/L. In the Above Corcoran Clay and Unknown Aquifers (Figure 2-60 and Figure 2-62) there are a few localized areas where nitrate concentrations exceed 40 mg/L, surrounded by larger areas where nitrate concentrations range from 10 to 40 mg/L. The elevated nitrate concentration in these areas may be associated with animal confinement facilities and other agricultural non-point sources (AMEC, 2013). Elevated nitrate in groundwater exists in small areas south of Merced and southwest of Livingston among areas where high density OWTS occur (Figure 2-62). Identifying the exact sources of nitrates in these areas would require additional study.

Figure 2-60: Average Nitrate (as N) Concentration 2019-2023, Above Corcoran Clay[5]



[5] Nitrate data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-61: Average Nitrate (as N) Concentration 2019-2023, Below Corcoran Clay

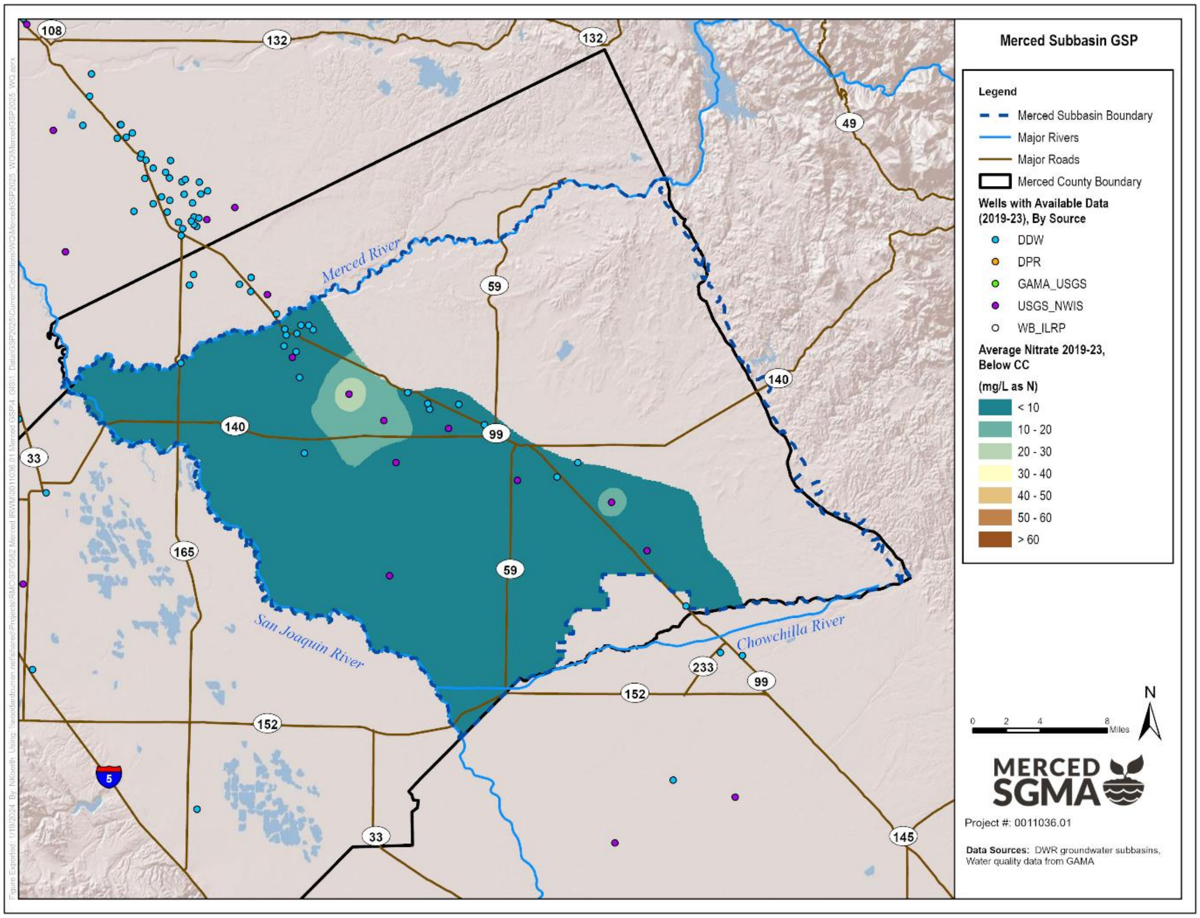


Figure 2-62: Average Nitrate (as N) Concentration 2019-2023, Unknown Aquifer

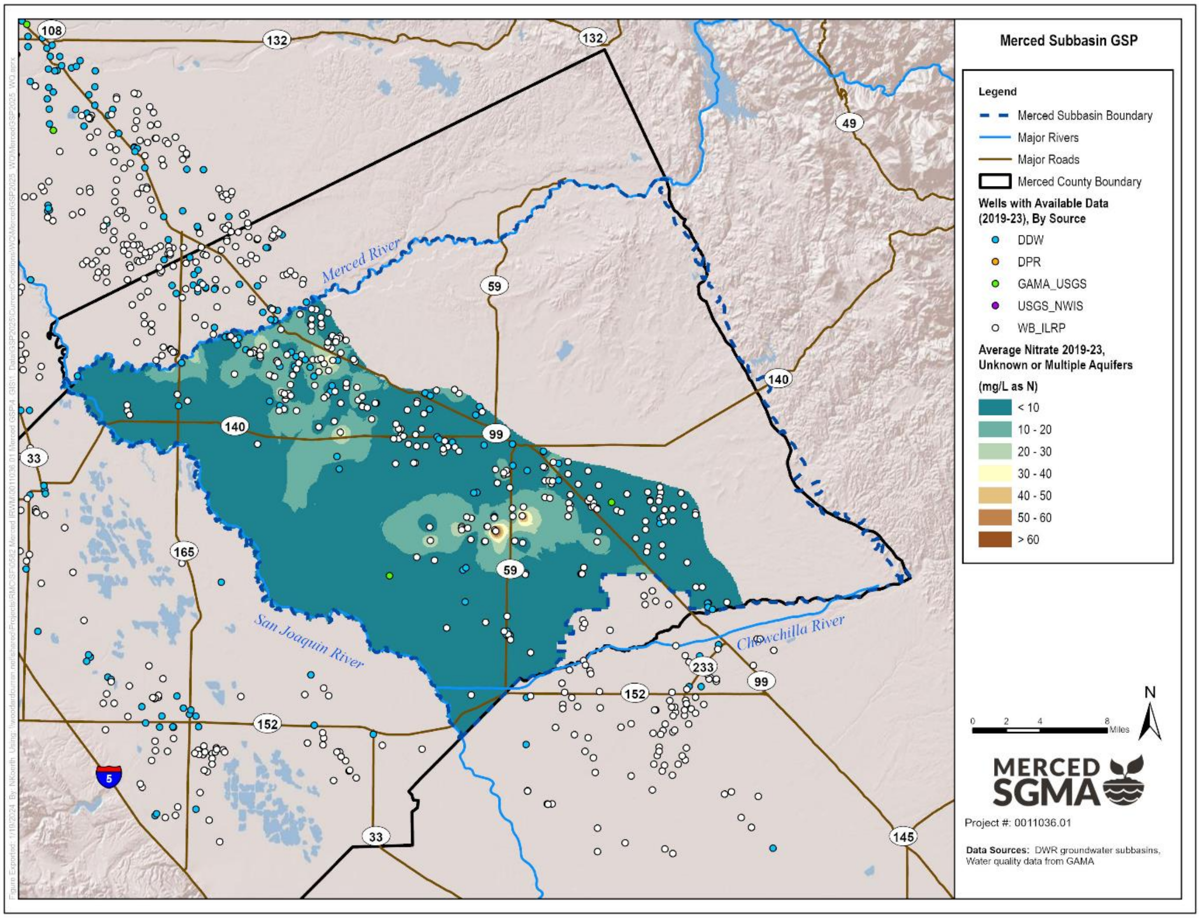


Figure 2-63: Average Nitrate (as N) Concentration 2019-2023, Outside Corcoran Clay

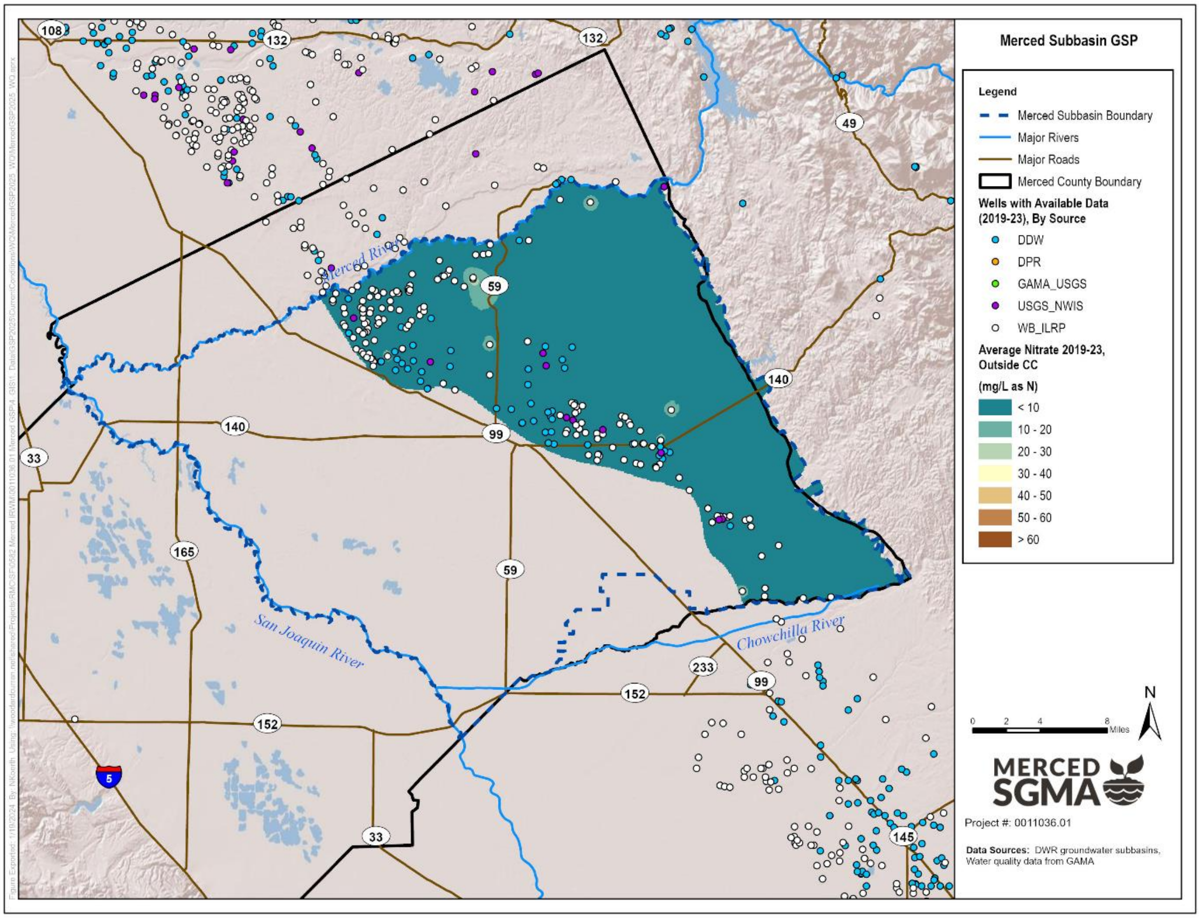


Figure 2-64: Nitrate (as N) Time Series Concentrations from 2015-2023, by Well

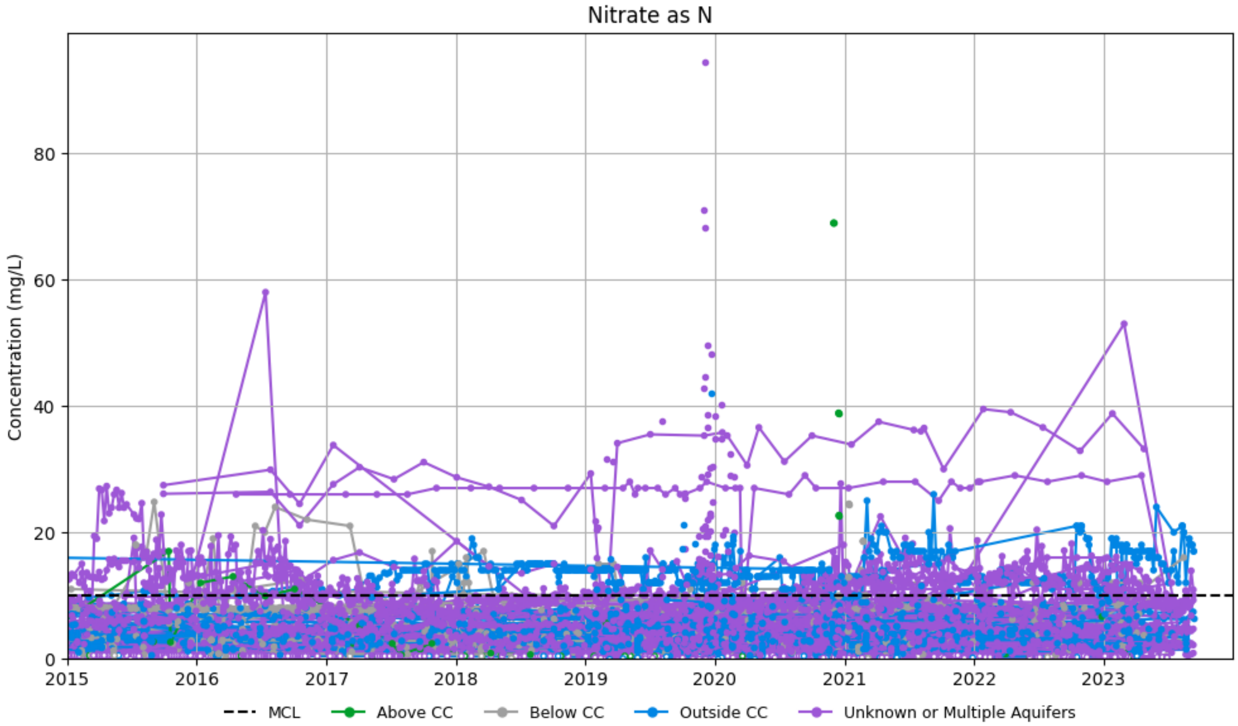
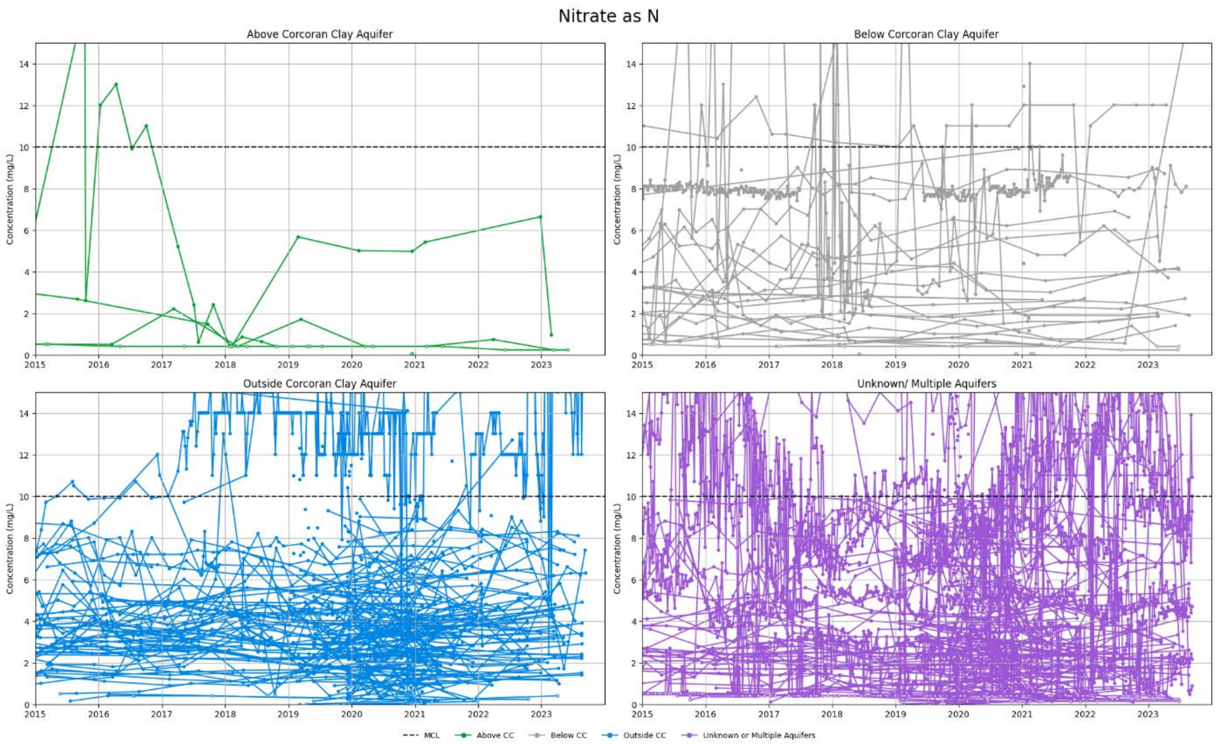


Figure 2-65: Nitrate (as N) Time Series Concentrations from 2015-2023, by Well, Y-Axis Range: 0-15 mg/L



2.2.4.1.2 Salinity

Salinity levels within the Merced Subbasin range from less than 90 to 1,000 mg/L since 2015, as measured by Total Dissolved Solids (TDS). The recommended drinking water secondary MCL for TDS is 500 mg/L, with an upper secondary MCL of 1,000 mg/L and a short-term secondary MCL[6] of 1,500 mg/l (SWRCB, 2006). The secondary MCL is a Secondary Drinking Water Standard that is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns. For agricultural uses, salt tolerance varies by crop, with common crops within the Merced Subbasin tolerant of irrigated water with TDS below 640 mg/L (Ayers & Westcot, 1985). TDS in the northwestern corner of the Subbasin is slightly elevated but remains generally less than 400 mg/L in the eastern two-thirds of the Subbasin (Figure 2-69). In the Below Corcoran and Unknown Aquifers, TDS concentrations are generally higher along the San Joaquin River (Figure 2-67 & Figure 2-68). TDS data for wells screened in the Above Corcoran clay aquifer is limited in

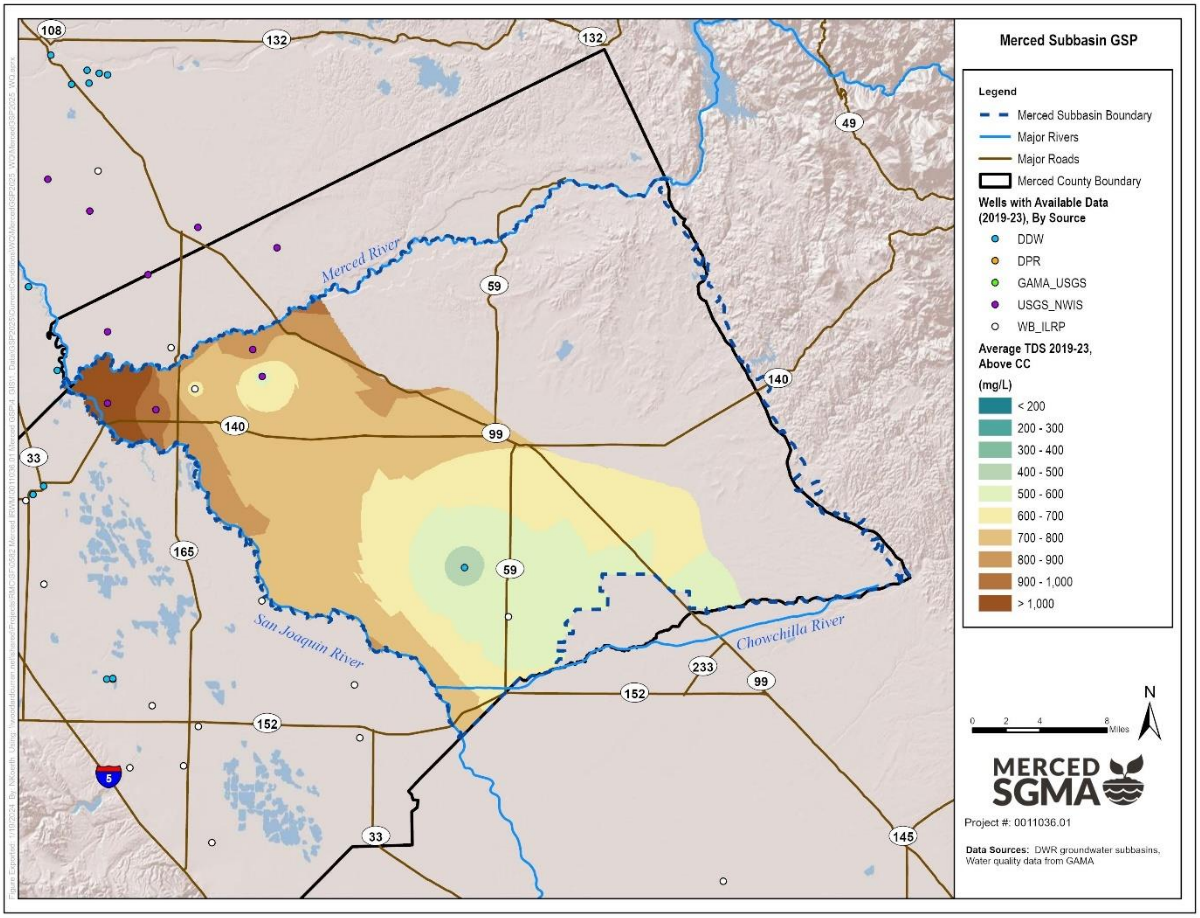
[6] Short-term secondary MCLs are acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources (California Code of Regulations Title 22 § 64449).

areas of the Subbasin. Consequently, the resulting contours may not reflect all conditions within the aquifer (Figure 2-66).

Better quality groundwater (less than 1,000 mg/L) in these western and southwestern areas is generally found at shallower depths. Groundwater with high TDS concentrations in the Merced Subbasin is principally the result of the migration of a deep water body with relative higher salinity which originates in regionally deposited marine sedimentary rocks that underlie the San Joaquin Valley. The depth of this water body with relative higher salinity within the Merced Subbasin boundaries is shallow compared to other parts of the San Joaquin Valley (AMEC, 2008). Groundwater with high concentrations of TDS is present beneath the entire Merced Subbasin at depths from about 400 feet in the west to over 800 feet in the east. The shallowest high TDS groundwater occurs in zones 5 to 6 miles wide adjacent and parallel to the San Joaquin River and the lower part of the Merced River west of Hilmar, where high TDS groundwater is upwelling (AMEC, 2008).

Under natural pressure, the groundwater body of relative higher salinity is migrating upward. Brines move up through permeable sedimentary rocks and also through wells, faults, and fractures. The chemistry of groundwater in the Merced Subbasin indicates that mixing is occurring between the shallow fresh groundwater and the brines, which produces the high TDS groundwater observed. Pumping of deep wells in the western and southern parts of the Merced Subbasin may be causing these saline brines to upwell and mix with freshwater aquifers more rapidly than under natural conditions (AMEC, 2008).

Figure 2-66: Average TDS Concentration 2019-2023, Above Corcoran Clay[7]



[7] T.D.S. data availability for wells screened in the Above Corcoran Clay aquifer is limited in portions of the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-67: Average TDS Concentration 2019-2023, Below Corcoran Clay

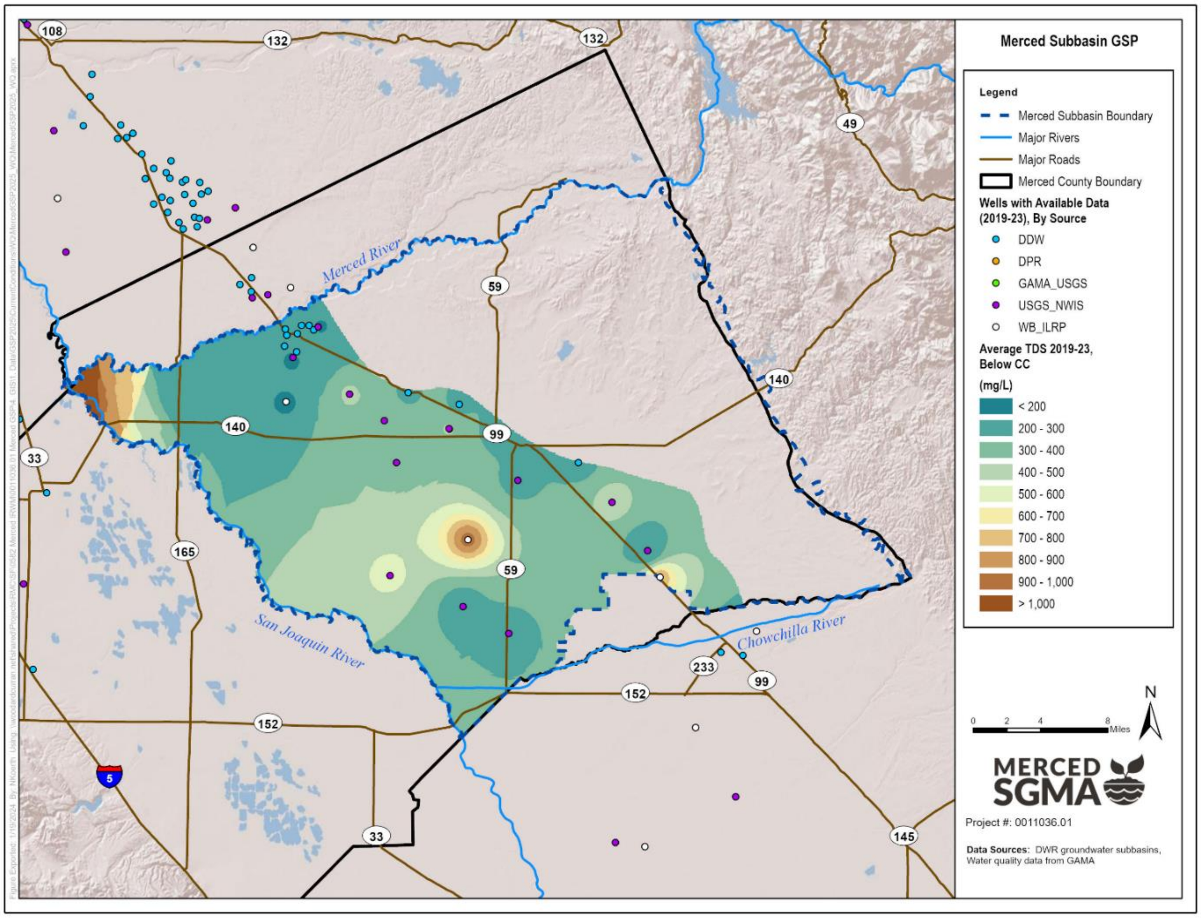


Figure 2-68: Average TDS Concentration 2019-2023, Unknown Aquifer

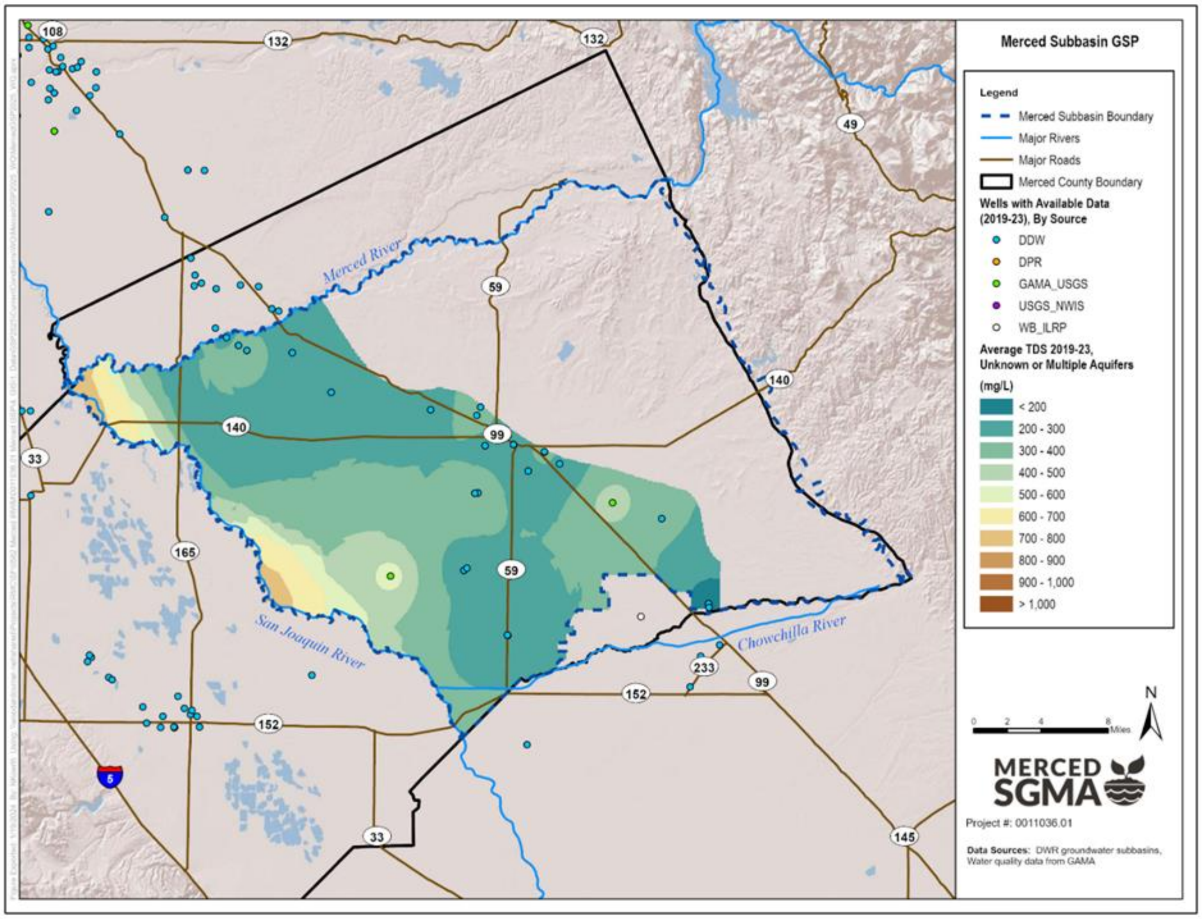


Figure 2-69: Average TDS Concentration 2019-2023, Outside Corcoran Clay

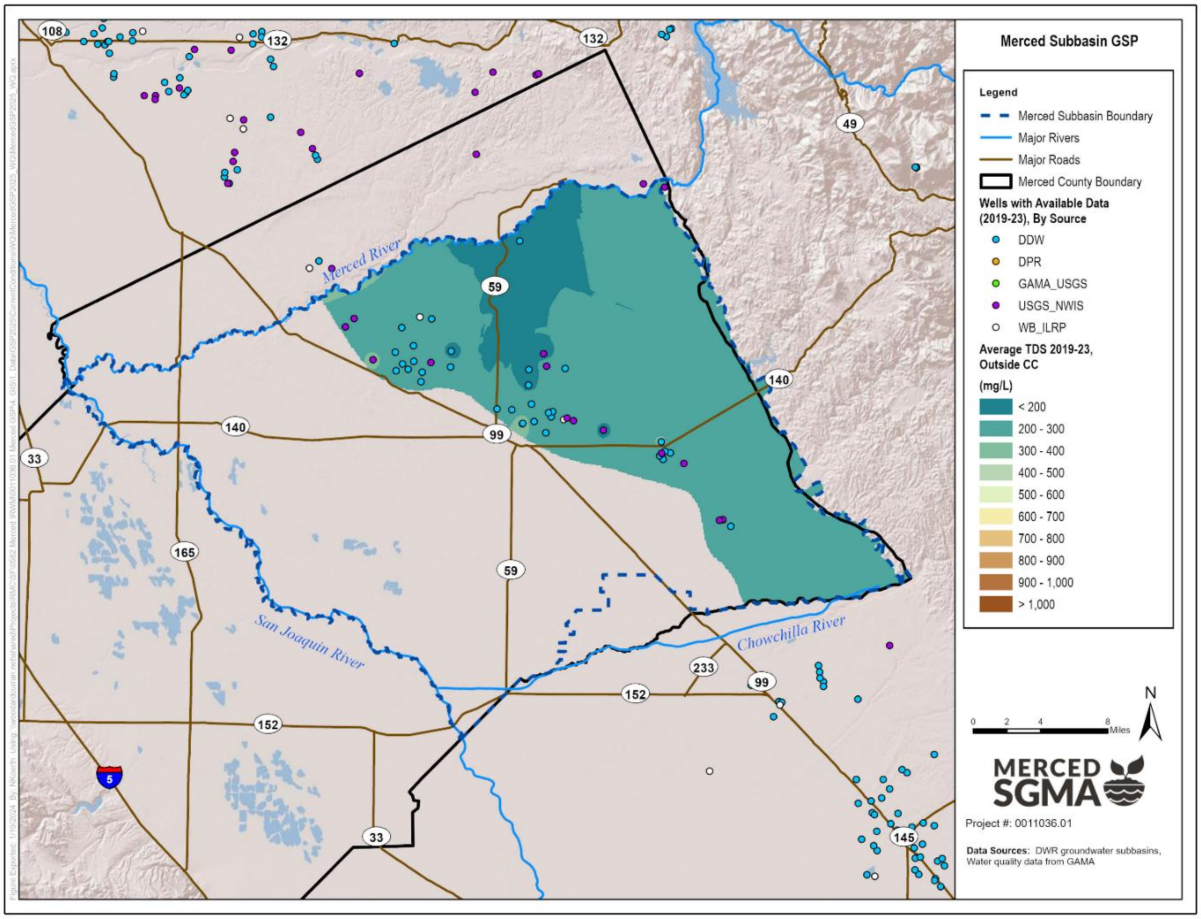
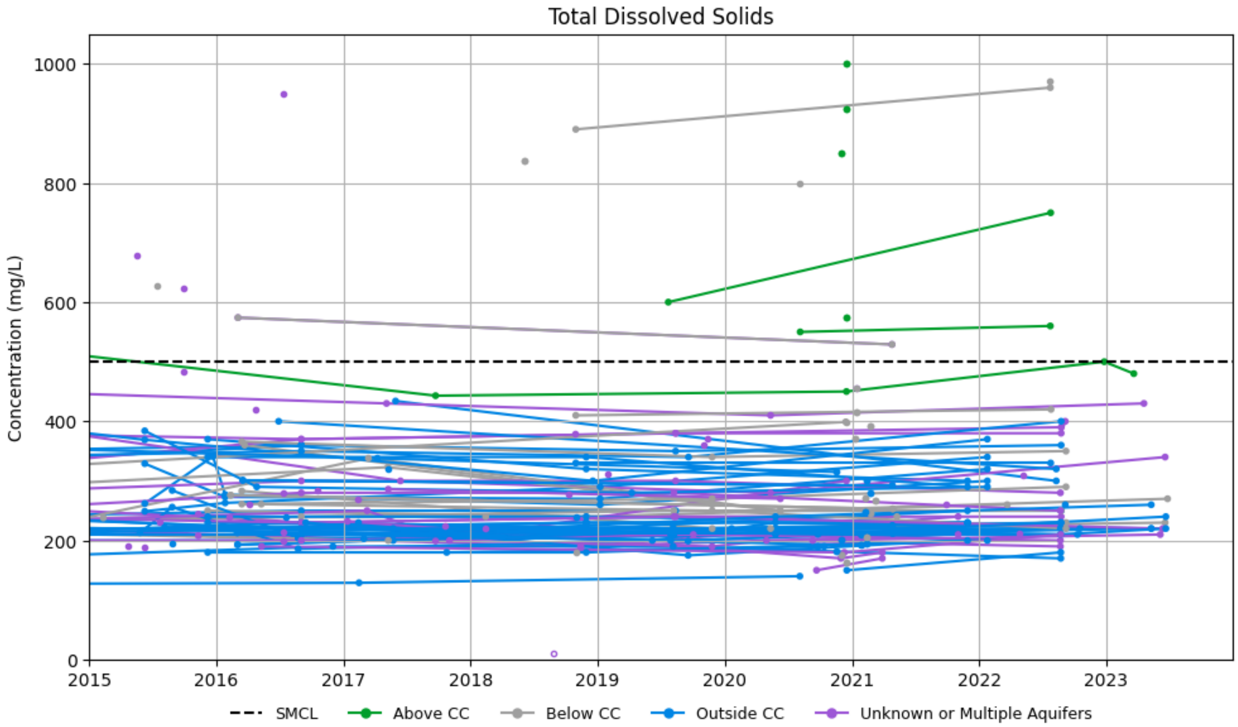


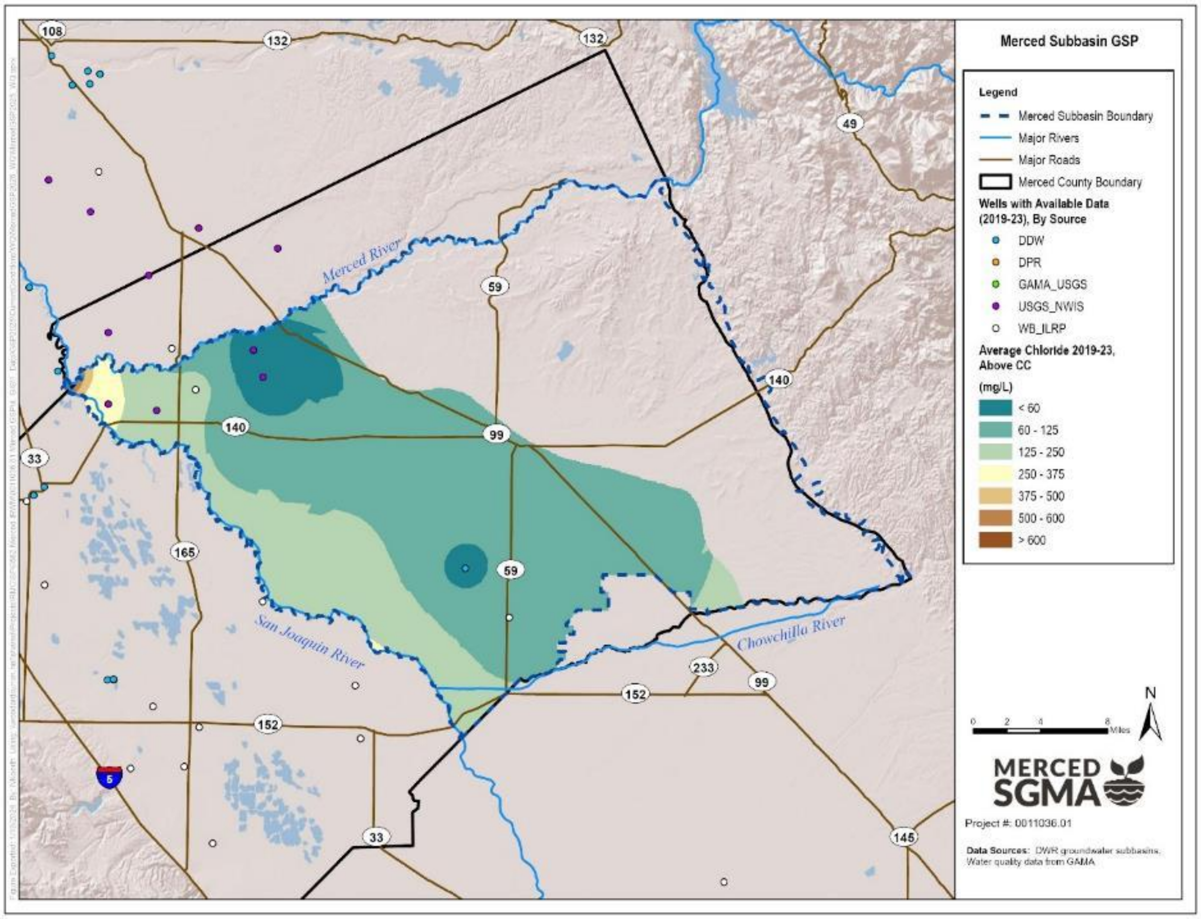
Figure 2-70: TDS Time Series Concentrations from 2015-2023, by Well



2.2.4.1.3 Chloride

Chloride (Cl) is a dissolved salt commonly associated with saline groundwater. Within the Merced Subbasin area, chloride concentrations range from non-detect (typically less than 2 mg/L) to 400 mg/L. The recommended drinking water secondary MCL for chloride is 250 mg/L, with an upper secondary MCL of 500 mg/L and a short-term second MCL of 600 mg/l (SWRCB, 2006). The secondary MCL is a Secondary Drinking Water Standard that is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns. The 5-year average (2019-2023) Cl concentration in groundwater in the eastern two-thirds of the Merced Subbasin area are generally less than 60 mg/L. Like TDS, Cl in groundwater increases in the western portions towards the San Joaquin River in the Above Corcoran Clay and Unknown Aquifers (Figure 2-71 and Figure 2-73). Most wells sampled in the Merced Subbasin have remained below 250 mg/L chloride since 2015 (Figure 2-75).

Figure 2-71: Average Chloride Concentration 2019-2023, Above Corcoran Clay[8]



[8] Chloride data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-72: Average Chloride Concentration 2019-2023, Below Corcoran Clay

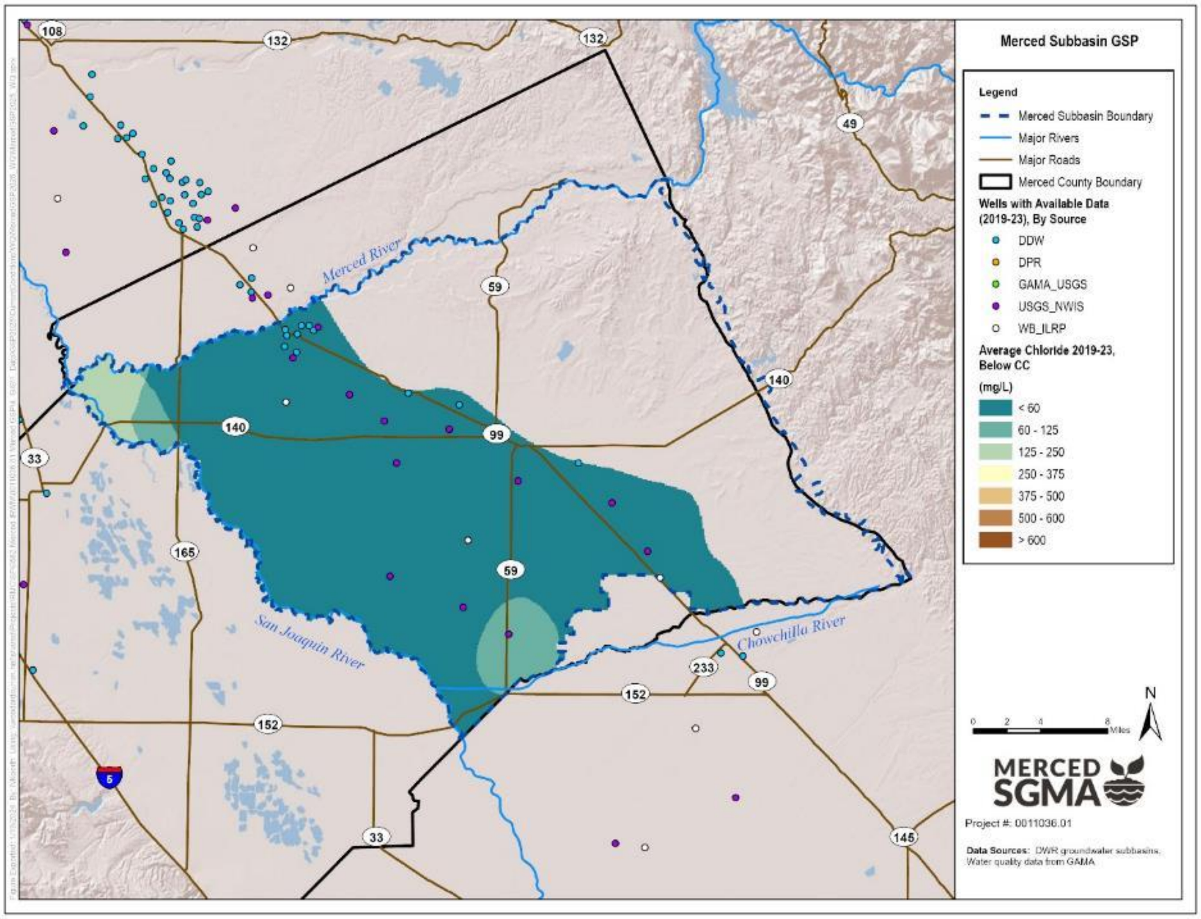


Figure 2-73: Average Chloride Concentration 2019-2023, Unknown Aquifer

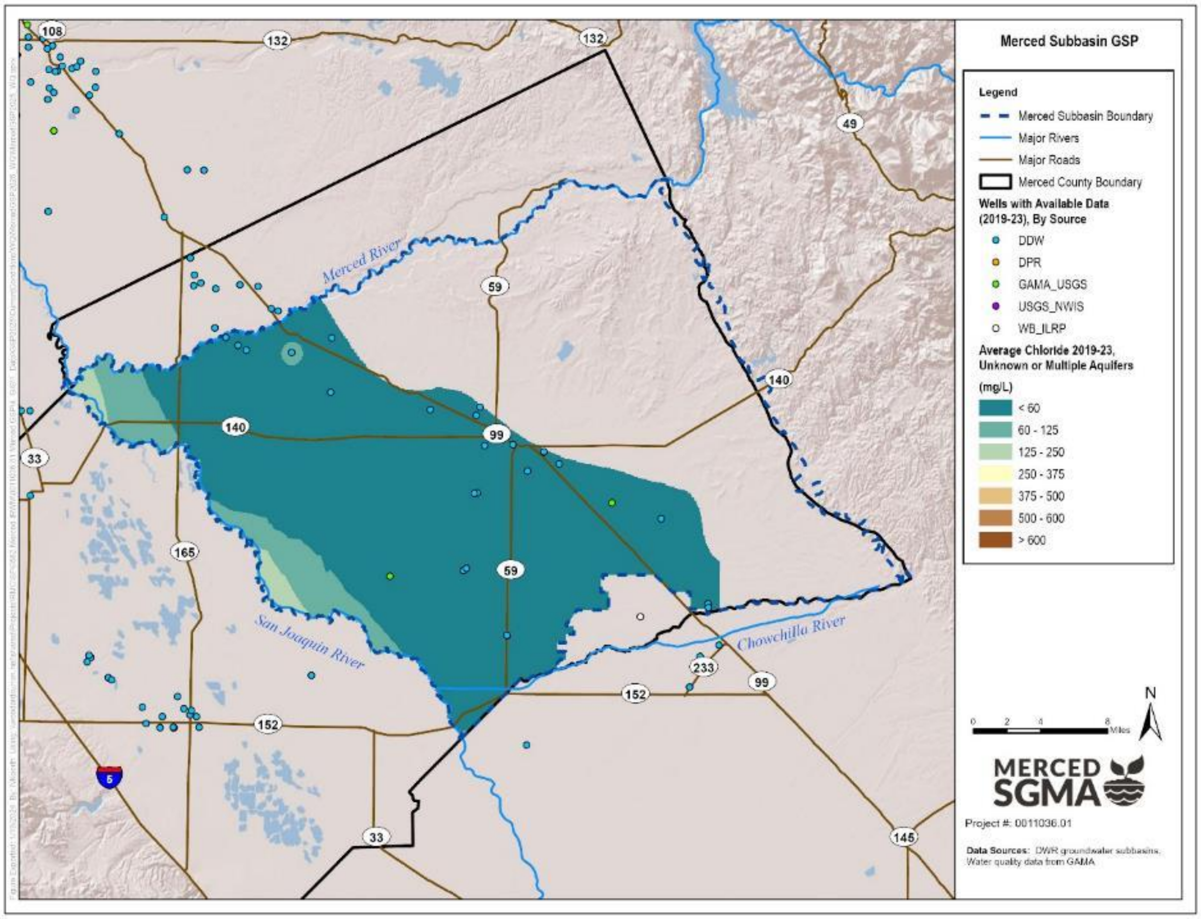


Figure 2-74: Average Chloride Concentration 2019-2023, Outside Corcoran Clay

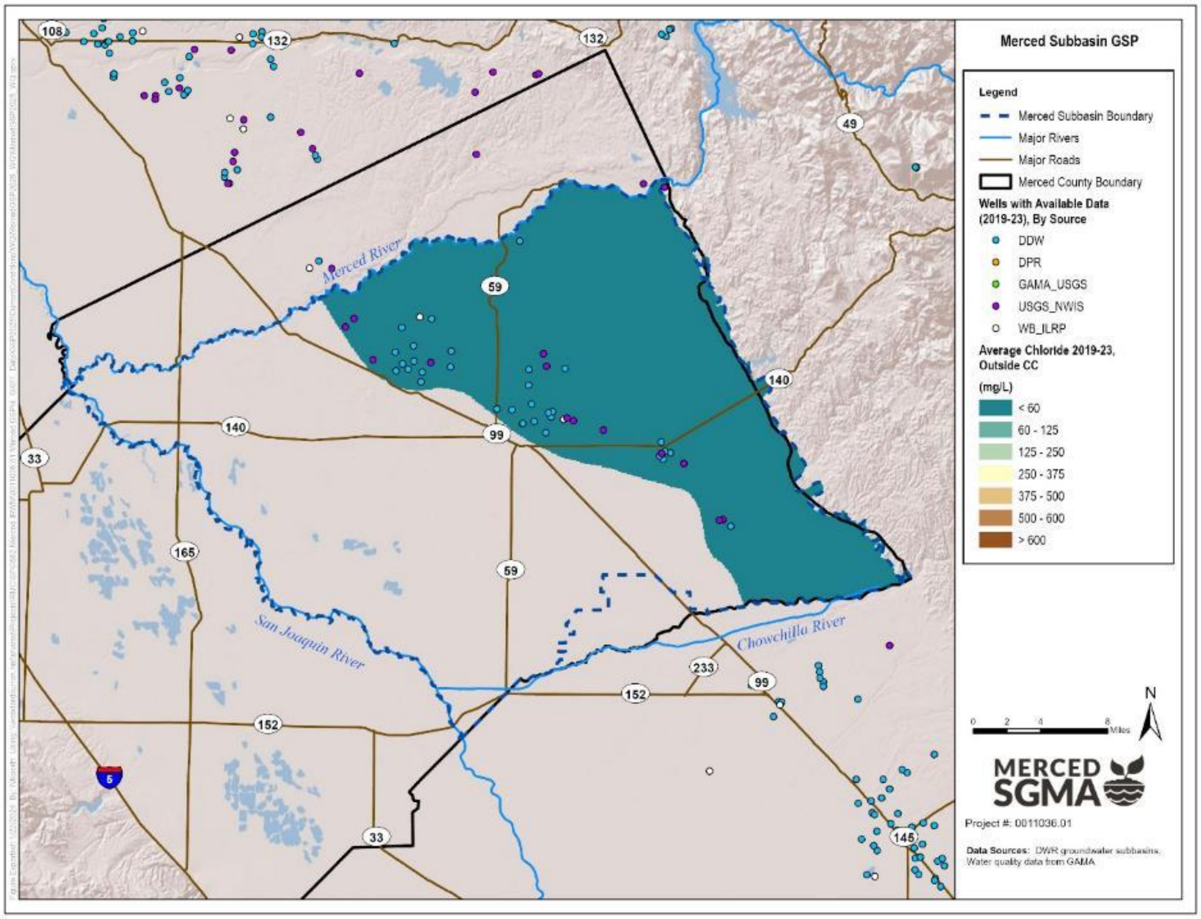
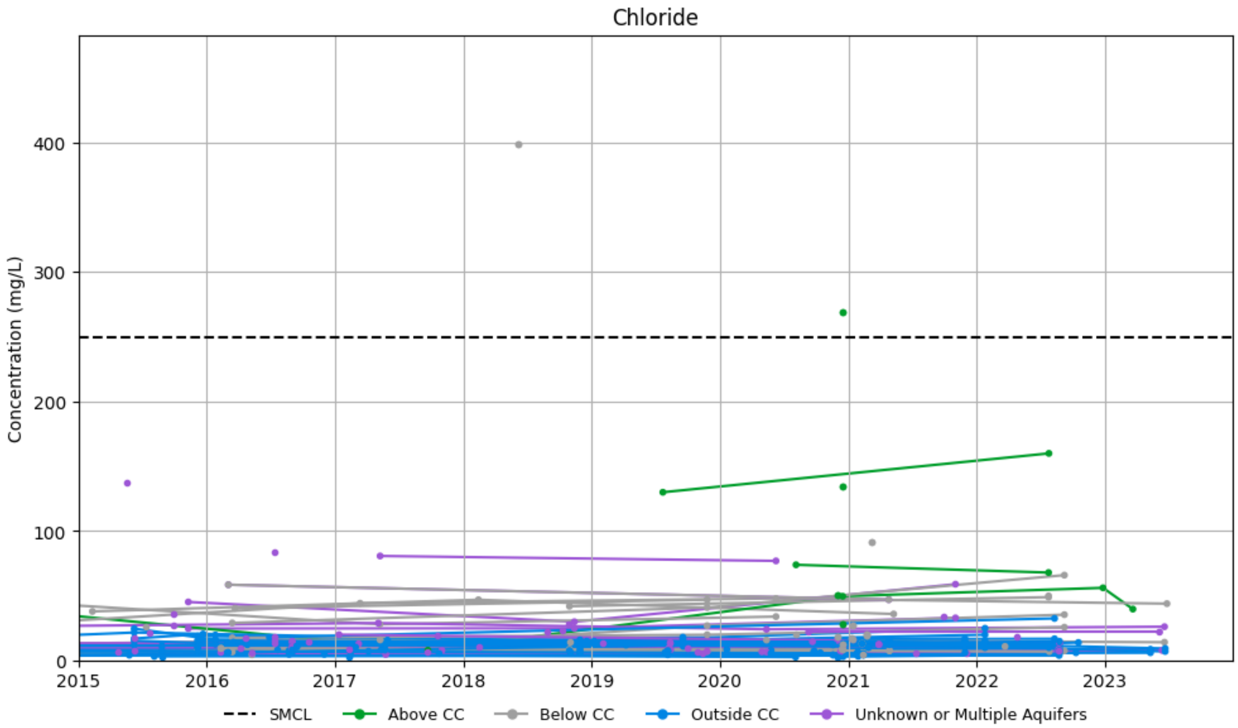


Figure 2-75: Chloride Time Series Concentrations from 2015-2023, by Well



2.2.4.1.4 Specific Conductivity

Specific conductivity is a measure of a water's ability to pass an electric current and is generally proportional to the amount of dissolved ions in water. The recommended drinking water secondary MCL for specific conductivity is 900 µmhos/cm, with an upper secondary MCL of 1,600 µmhos/cm and a short-term secondary MCL of 2,200 µmhos/cm (SWRCB, 2006). The secondary MCL is a Secondary Drinking Water Standard that is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns. The 5-year average (2019-2023) specific conductivity has remained below 1,600 µmhos/cm in most of the Subbasin, though values increase in the western portions towards the San Joaquin River. With the exception a few wells, specific conductivity values have remained below the upper secondary MCL since 2015 (Figure 2-80).

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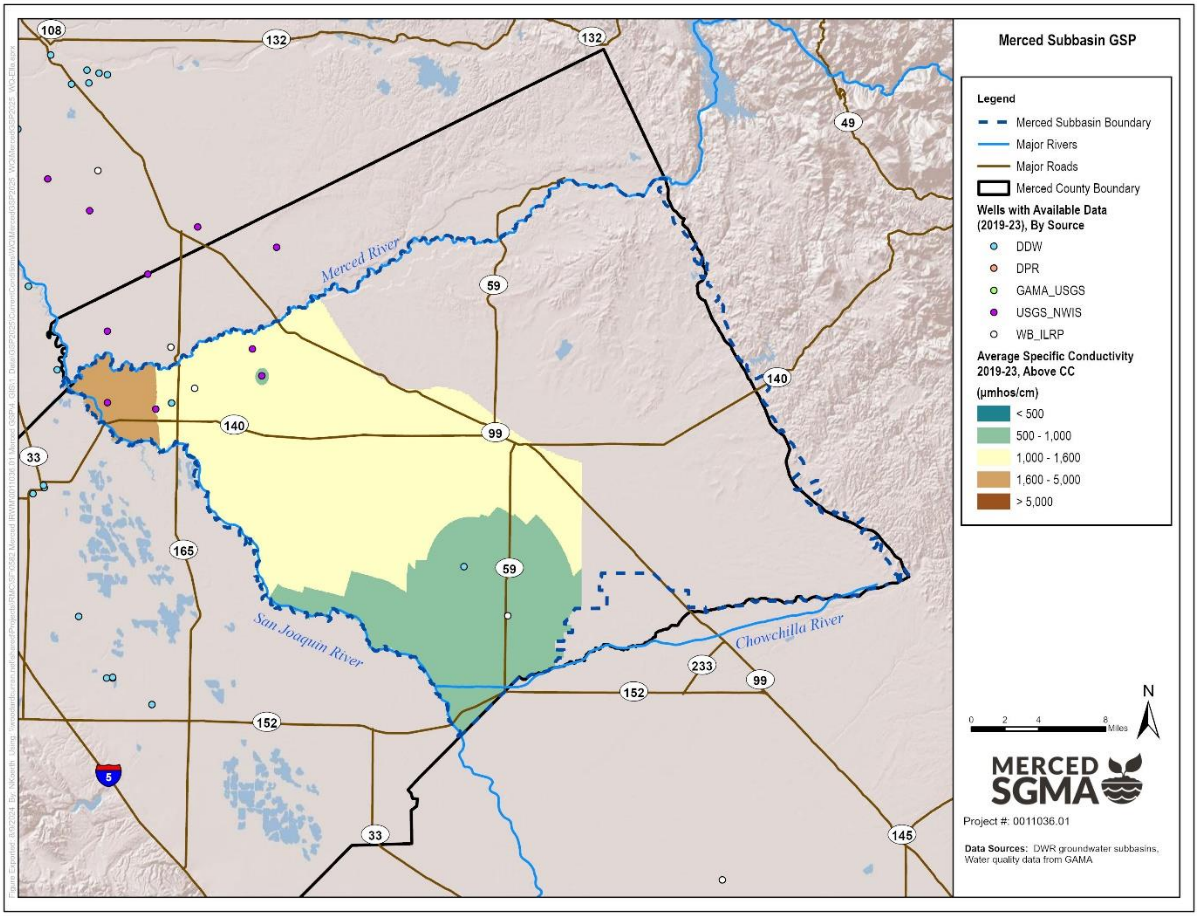
Figure 2-76: Average Specific Conductivity 2019-2023, Above Corcoran Clay[9]



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9 Specific Conductivity data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-77: Average Specific Conductivity 2019-2023, Below Corcoran Clay

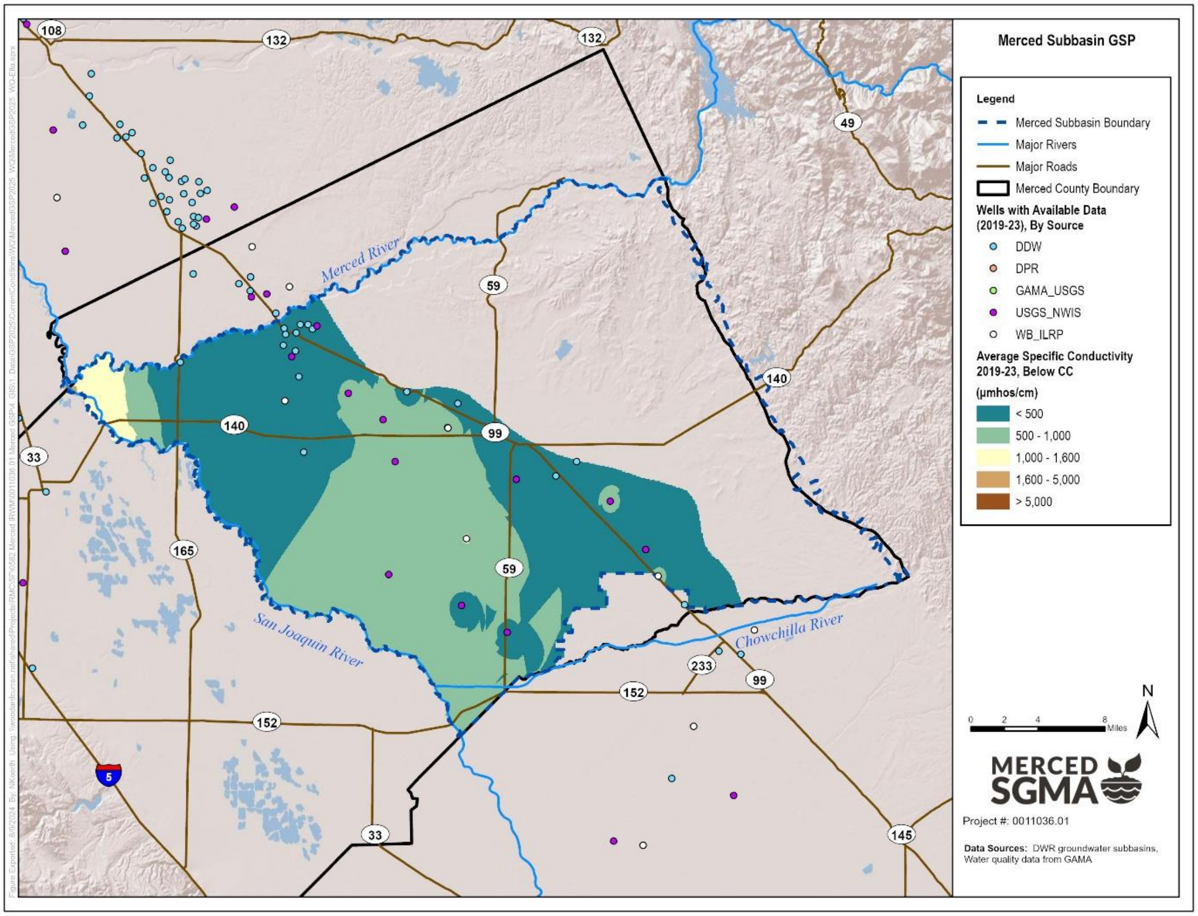


Figure 2-78: Average Specific Conductivity 2019-2023, Unknown Aquifer

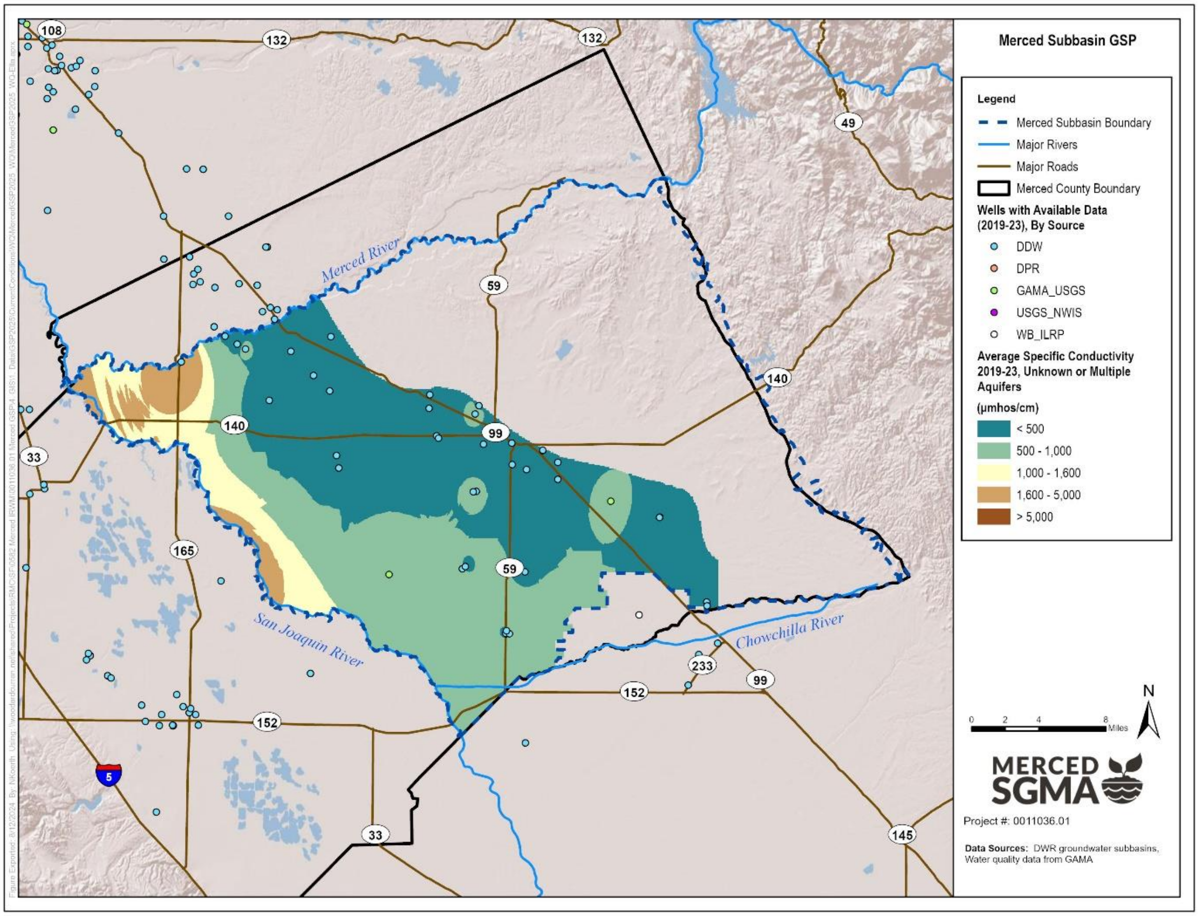


Figure 2-79: Average Specific Conductivity 2019-2023, Outside Corcoran Clay

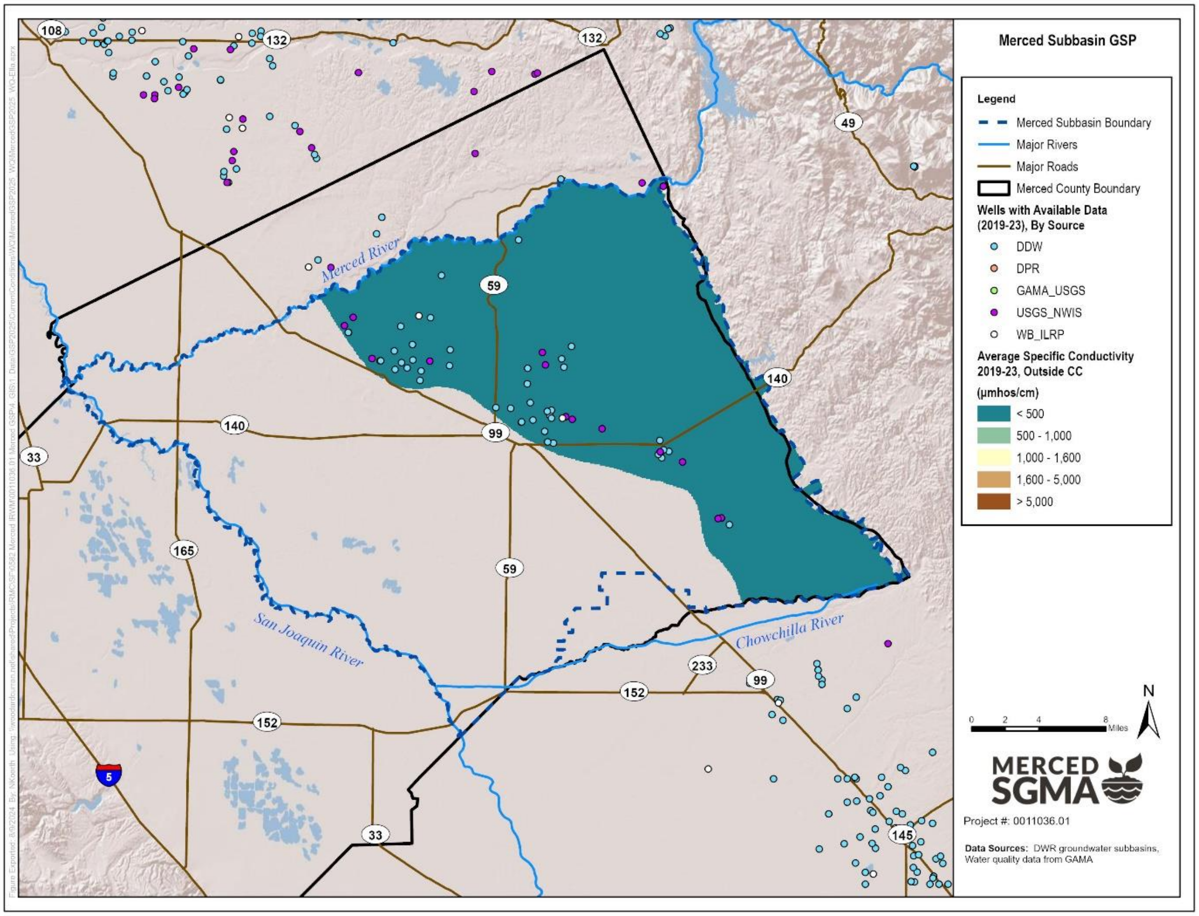
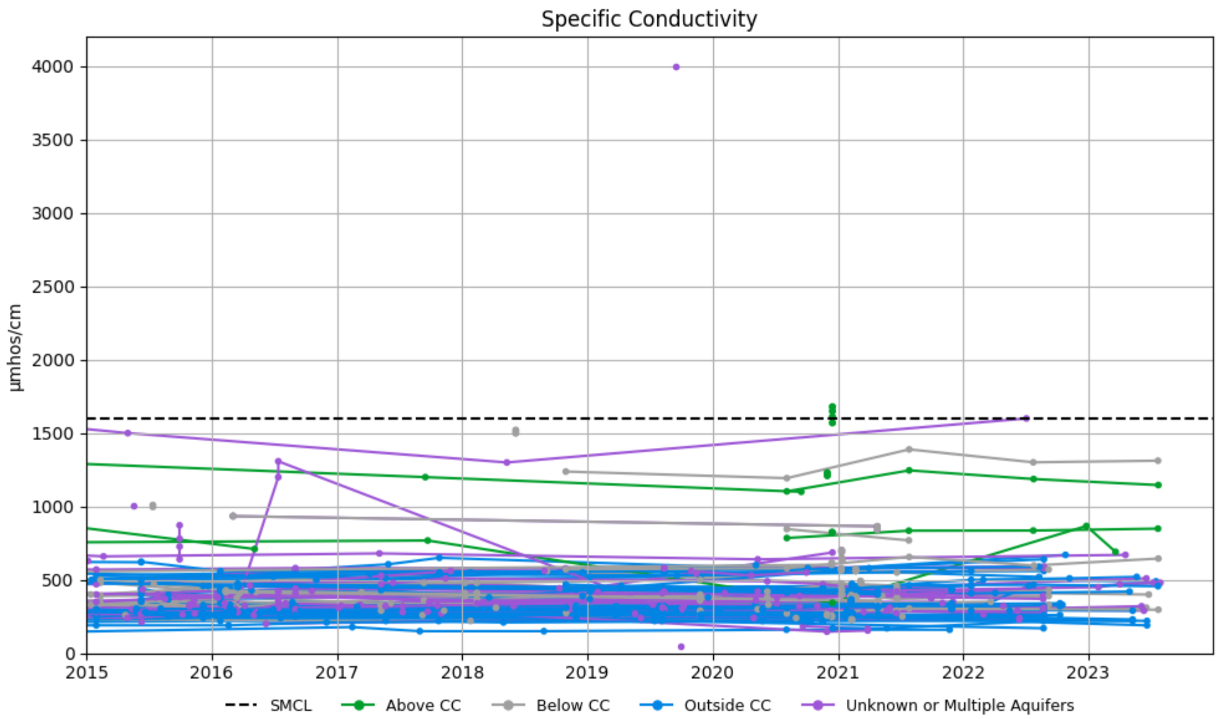


Figure 2-80: Specific Conductivity Time Series from 2015-2023, by Well

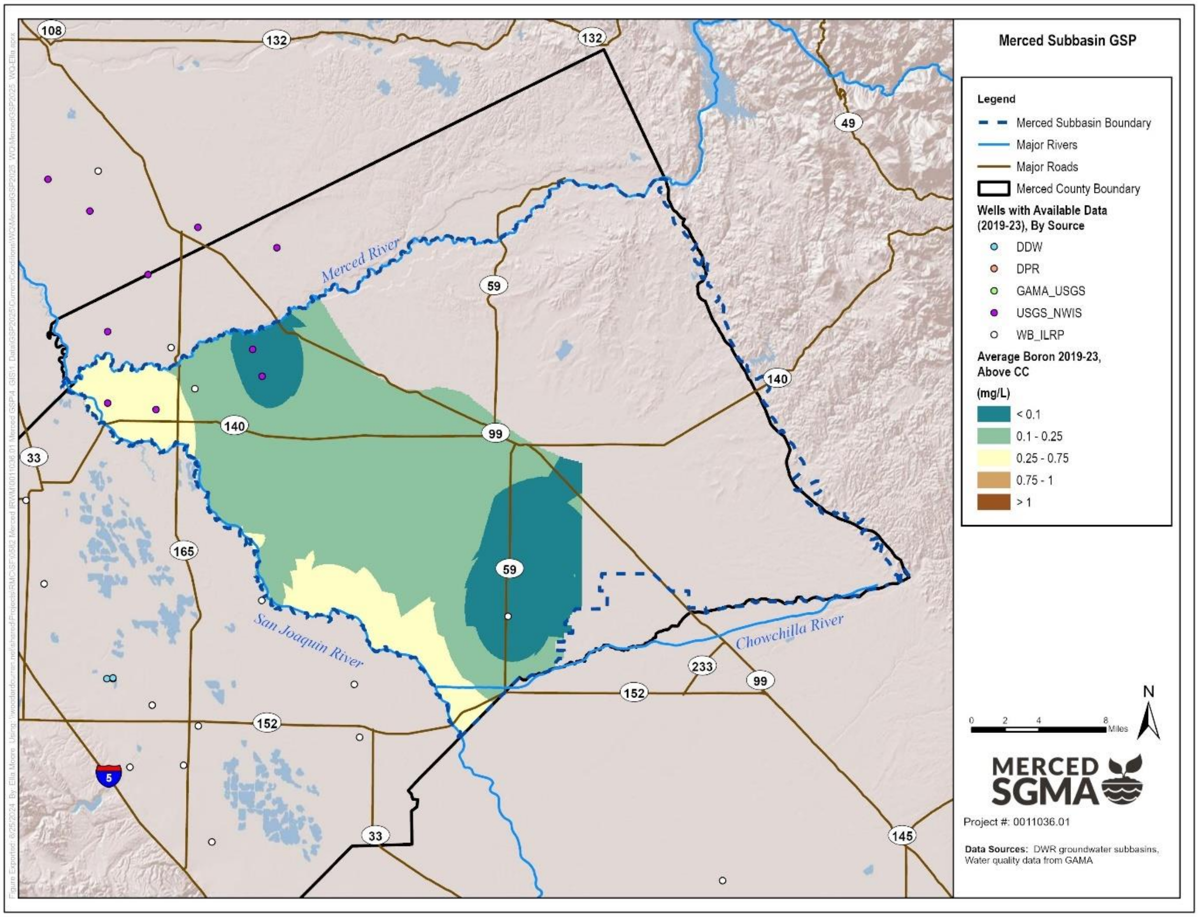


2.2.4.1.5 Boron

Boron (B) is a naturally occurring element found in groundwater resulting from the leaching of rocks and soils that contain borate and borosilicate minerals. Boron can also be introduced from anthropogenic sources including industrial wastewater discharges, municipal waste discharges, and agricultural fertilizers and pesticides. There is no drinking water MCL for boron, however California has an established Notification Level[10] of 1 mg/L. Boron is included mainly included in this analysis due to crop sensitivities which are slight to moderate at 1-3 mg/L and severe at >3 mg/L (Ayers & Westcot, 1985). The 5-year average (2019-2023) boron concentrations remain well below the notification level for most of the Subbasin, with a slight increase seen in the western portions towards the San Joaquin River. The time series from 2015-2023 shows that Boron concentrations in the Merced Subbasin have remained below 0.4 mg/L (Figure 2-85).

[10] Notification levels are non-regulatory health-based advisory levels established by SWRCB for chemicals for which maximum contaminant levels (MCL) have not been established.

Figure 2-81: Average Boron Concentration 2019-2023, Above Corcoran Clay[11]



[11] Boron data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-82: Average Boron Concentration 2019-2023, Below Corcoran Clay

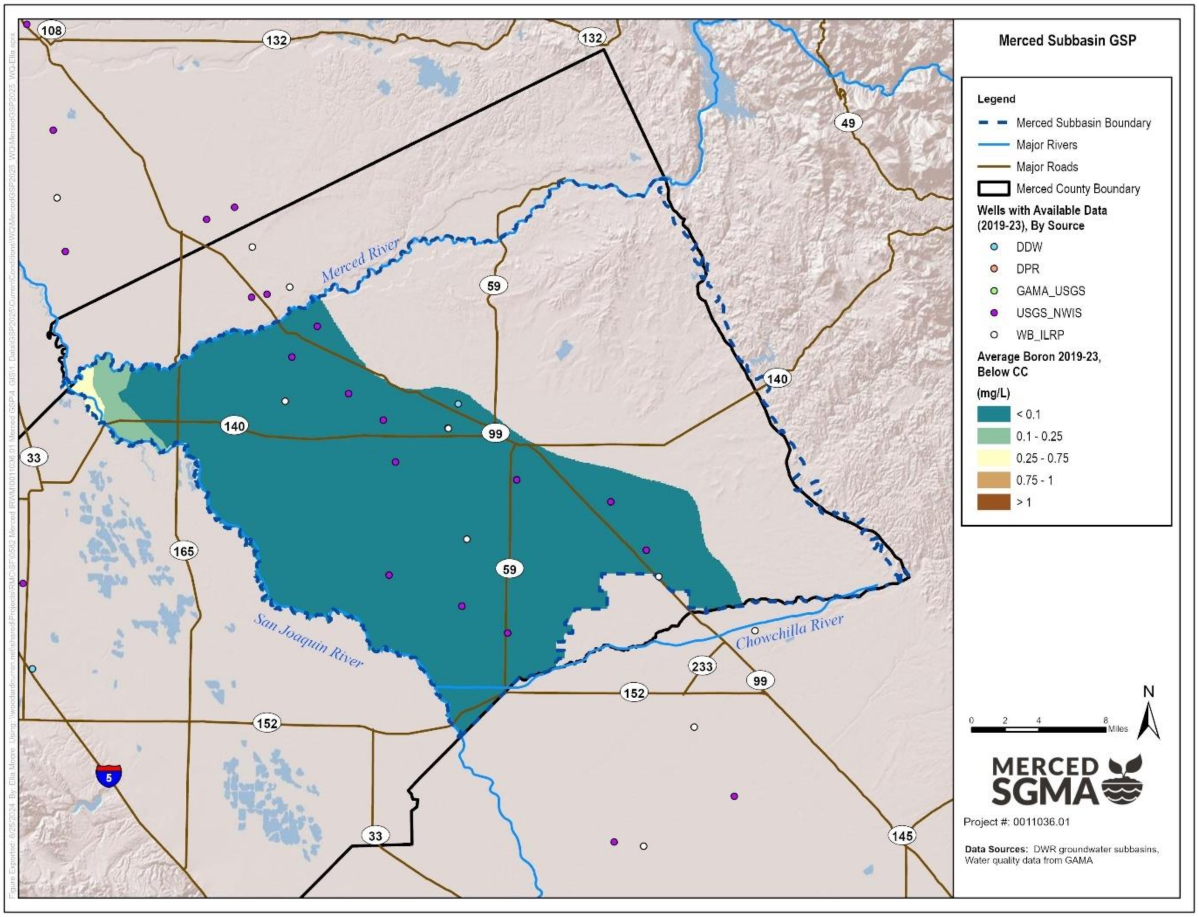
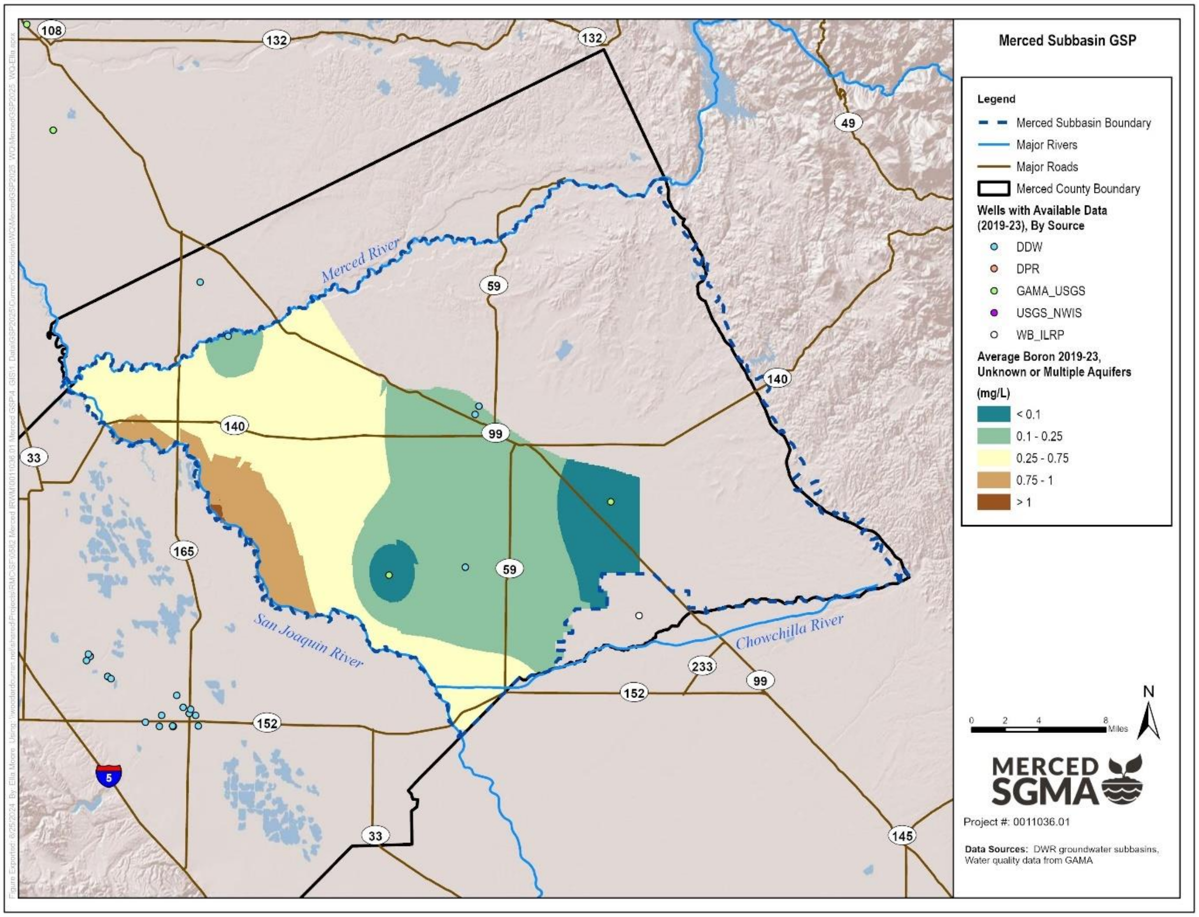


Figure 2-83: Average Boron Concentration 2019-2023, Unknown Aquifer[12]



[12] Boron data availability for wells in the Unknown/Multiple Aquifers is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-84: Average Boron Concentration 2019-2023, Outside Corcoran Clay

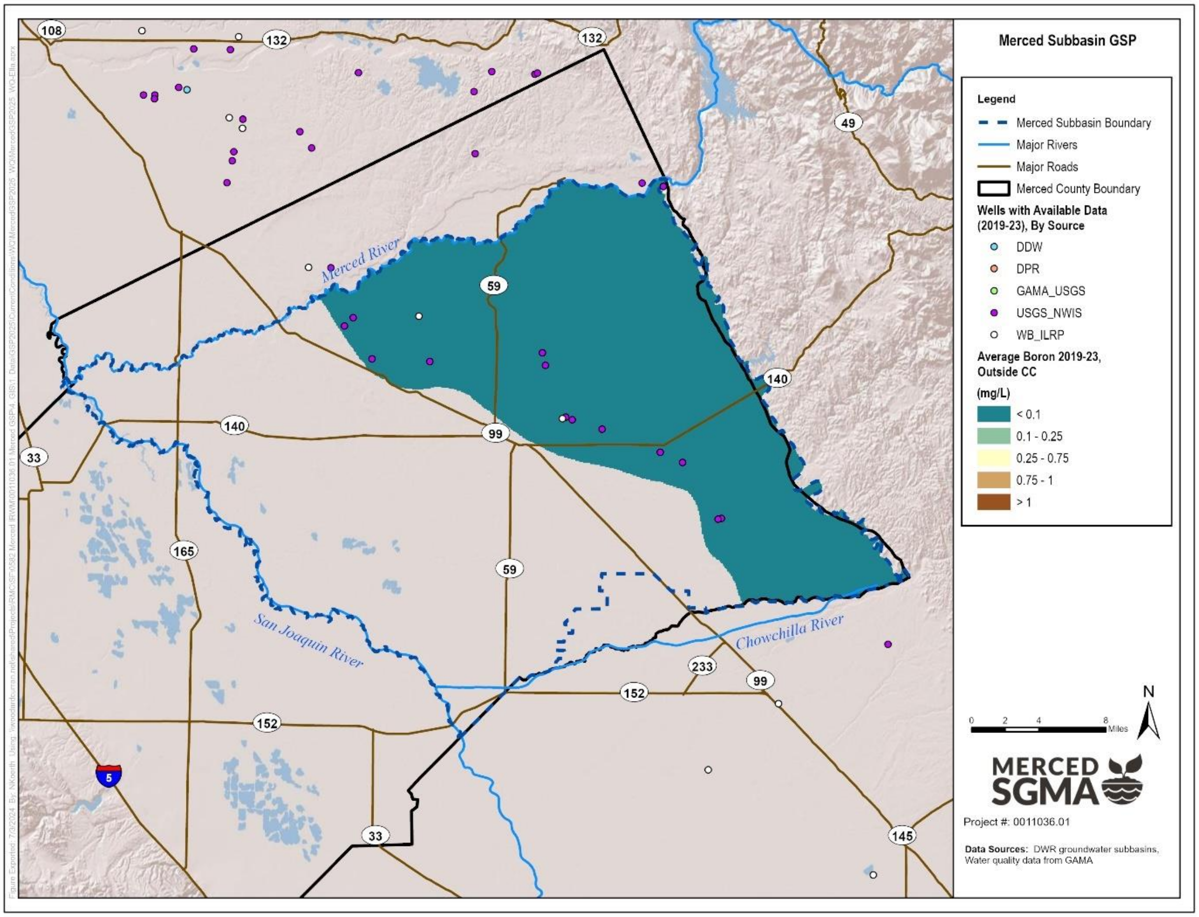
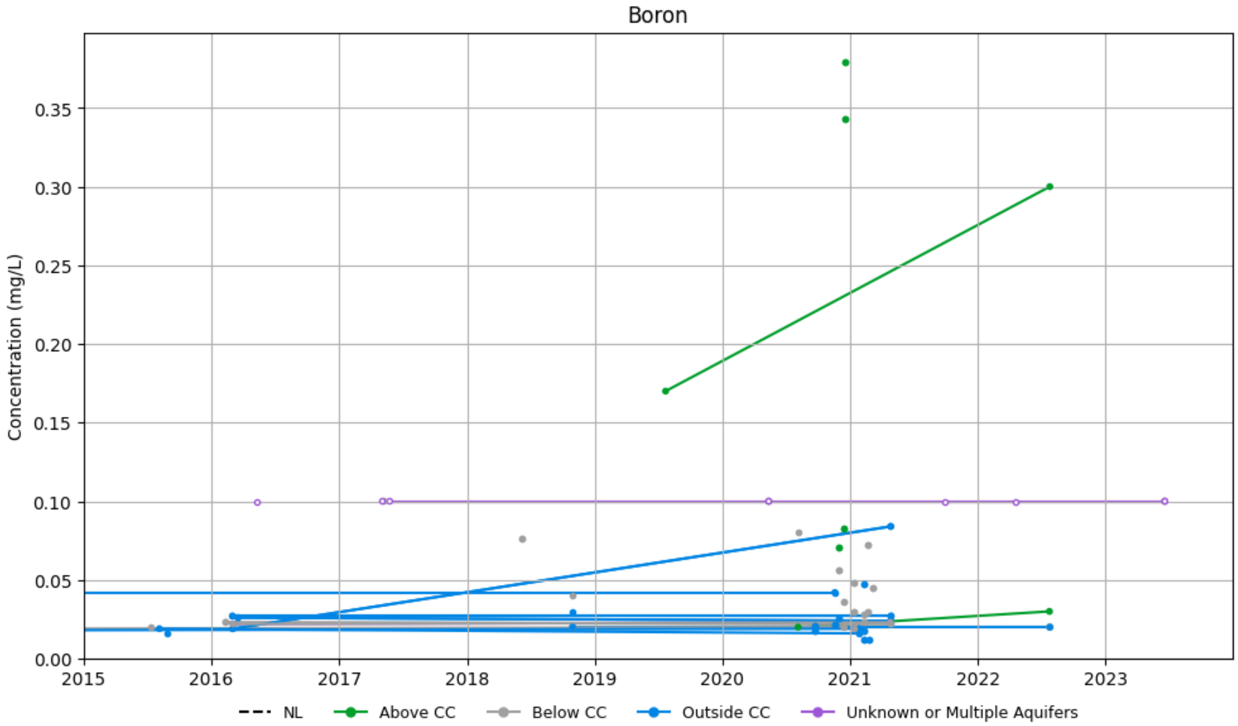


Figure 2-85: Boron Time Series Concentrations from 2015-2023, by Well



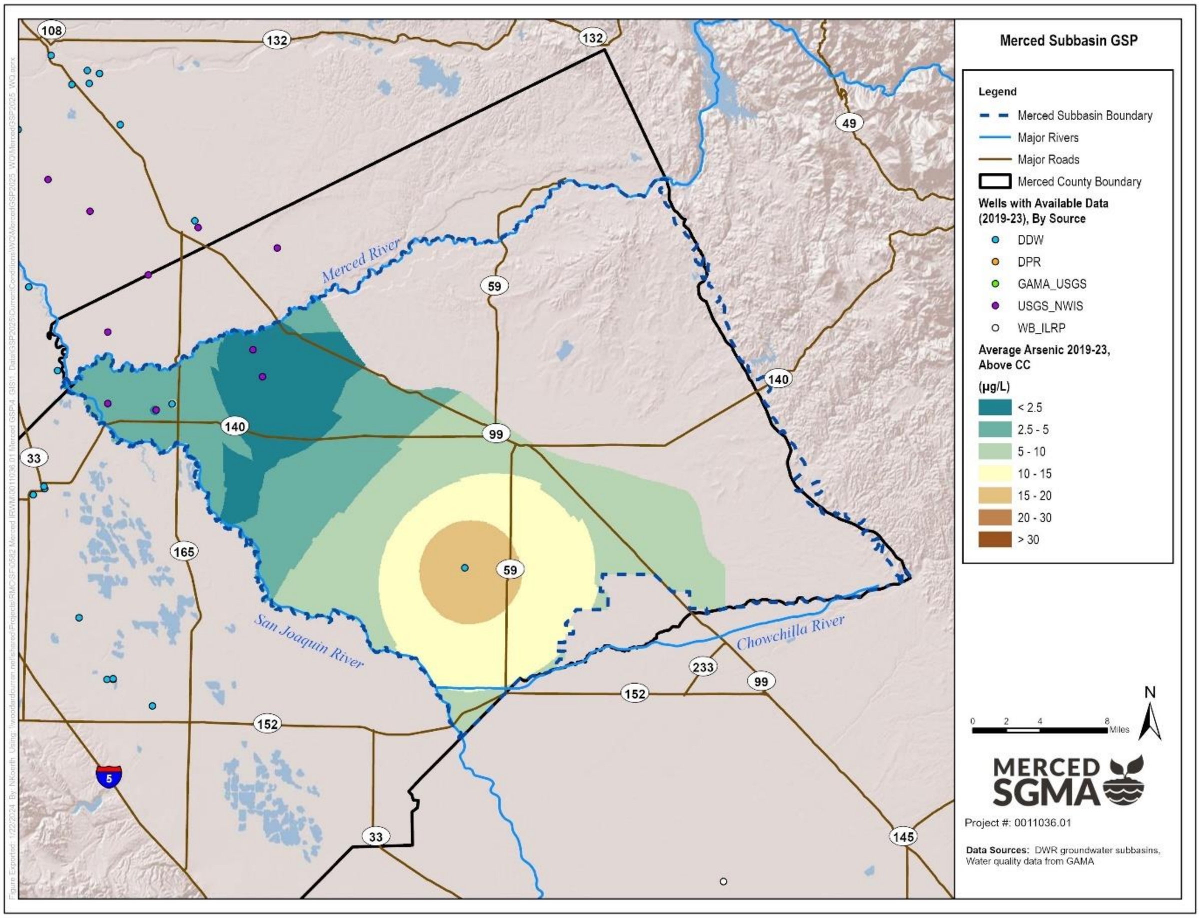
2.2.4.2 Metals

2.2.4.2.1 Arsenic

Arsenic (As) is a dissolved metal found in many bedrock formations which can have human health impacts. Within the Merced Subbasin area, As concentrations range from non-detect (less than 1 microgram per liter [μg/L]) to as much as 150 μg/L. The primary MCL for As is 10 μg/L (SWRCB, 2018). The 5-year average (2019-2023) As concentration in groundwater in the north-eastern two quadrants of the Merced Subbasin area is generally less than 10 μg/l (Figure 2-89). There are localized areas where the average As concentrations are seen exceeding 20 mg/L, northeast of Atwater, near Stevinson, and in the southwest Merced Subbasin area south of the intersection of Sandy Mush Road and Highway 59 (

Figure 2-86, Figure 2-87 and Figure 2-88). The City of Livingston previously had wells with raw water concentrations of As at or above the MCL. The City has constructed groundwater treatment systems at multiple wells to reduce As concentrations below the MCL (City of Livingston, 2022). The time series from 2015-2023 shows concentrations in Unknown Aquifer wells remain the highest in the subbasin (Figure 2-90).

Figure 2-86: Average Arsenic Concentration 2019-2023, Above Corcoran Clay[13]



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[13] Arsenic data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-87: Average Arsenic Concentration 2019-2023, Below Corcoran Clay

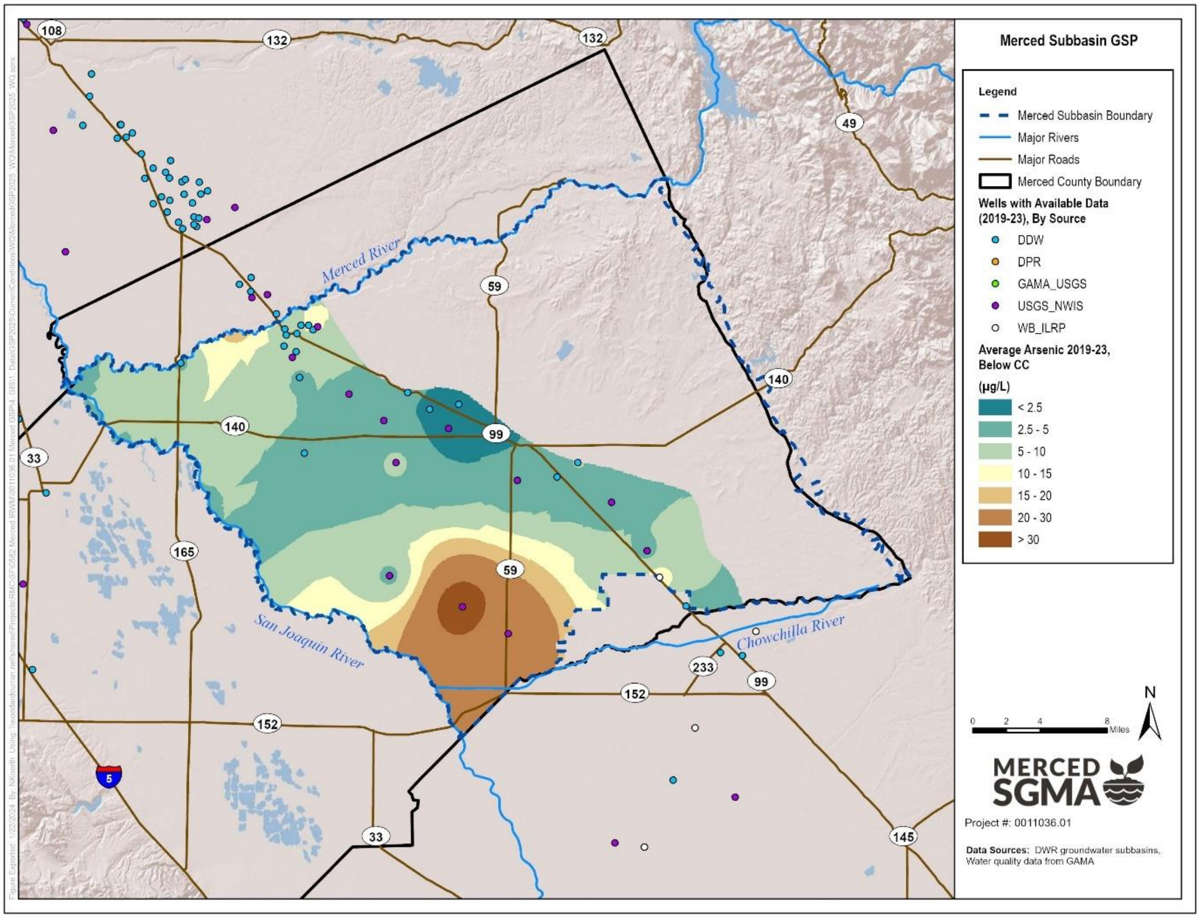


Figure 2-88: Average Arsenic Concentration 2019-2023, Unknown Aquifer

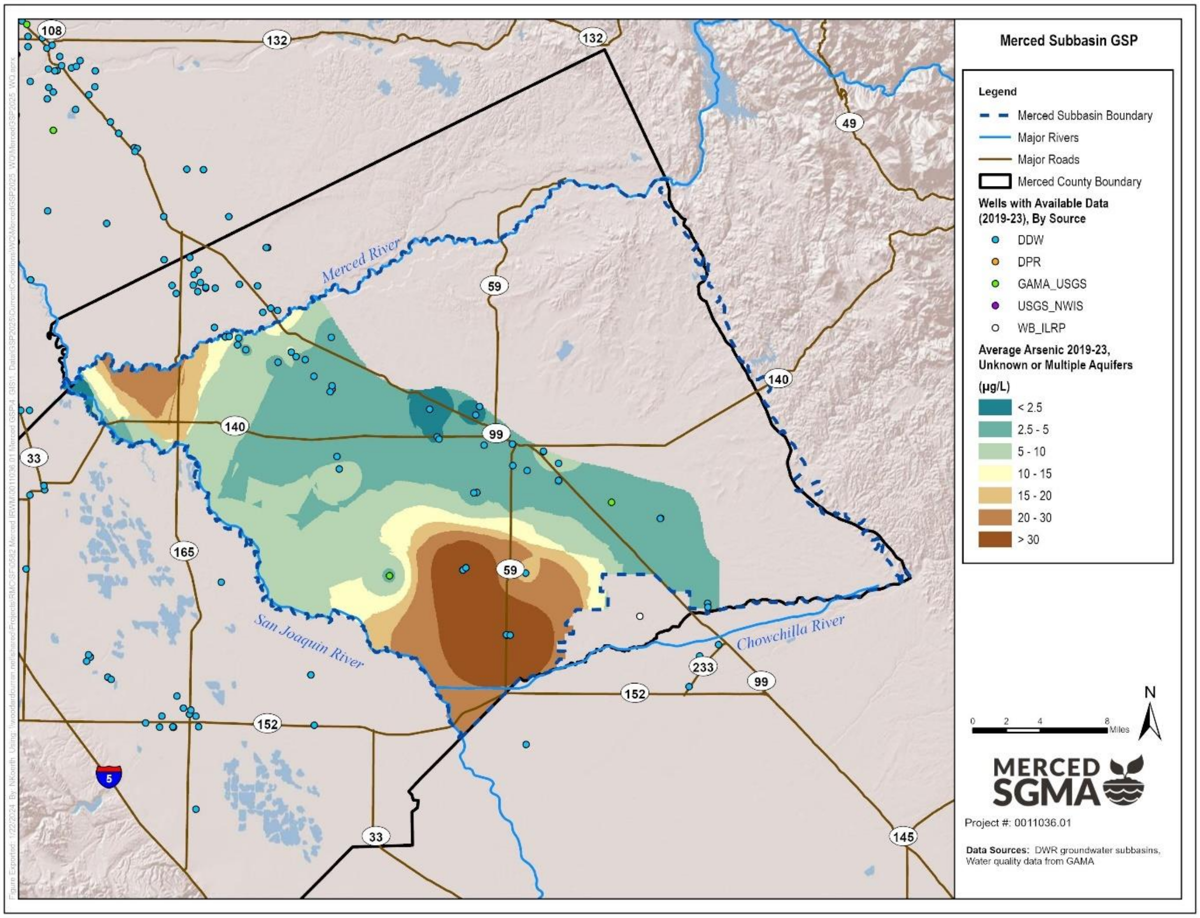


Figure 2-89: Average Arsenic Concentration 2019-2023, Outside Corcoran Clay

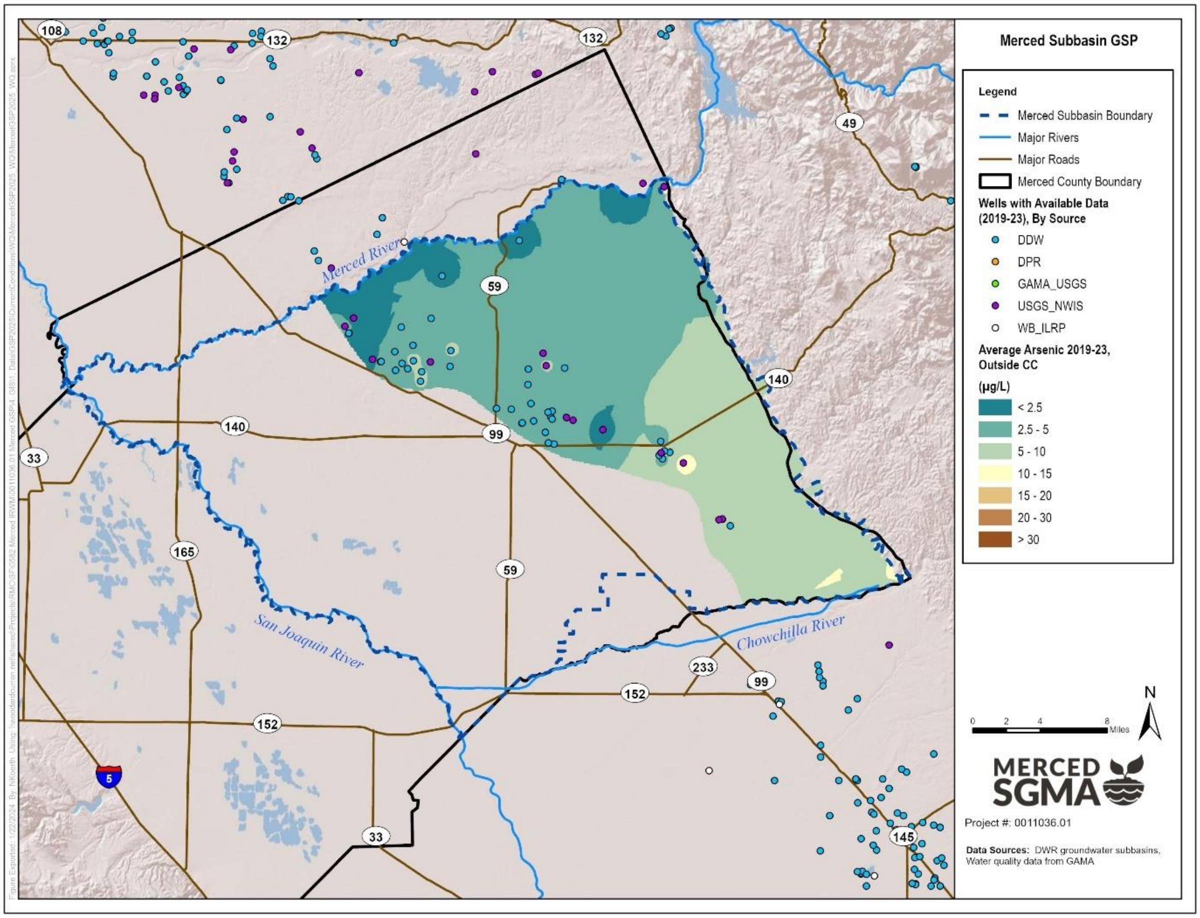


Figure 2-90: Arsenic Time Series Concentrations from 2015-2023, by Well

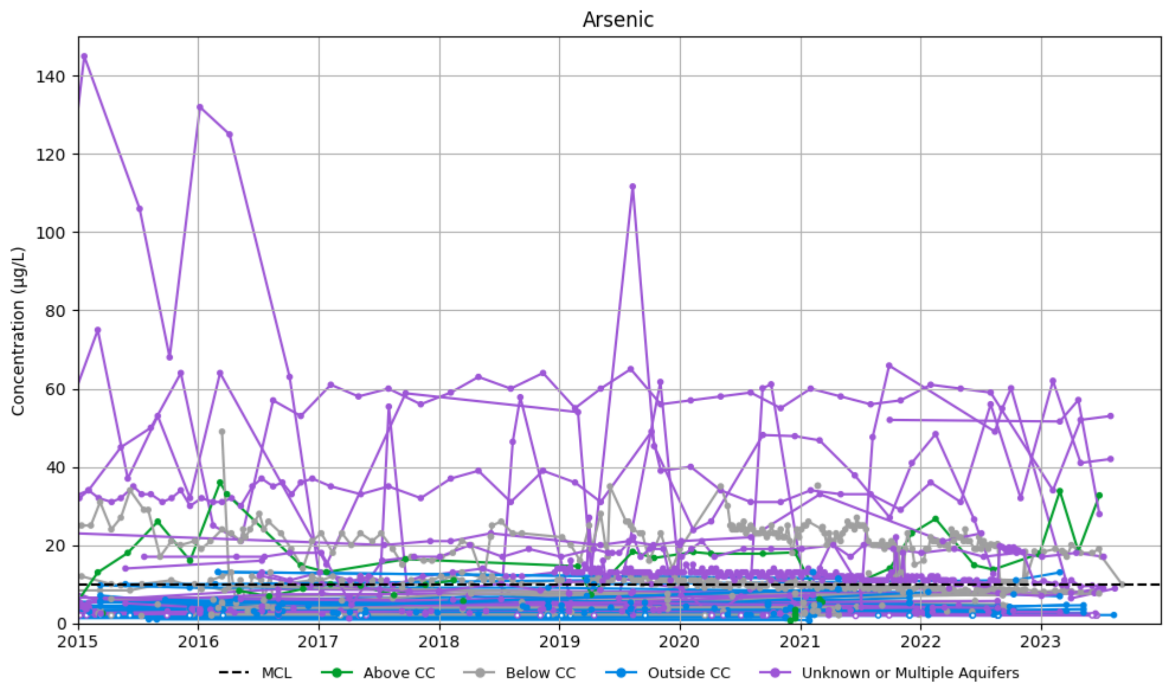
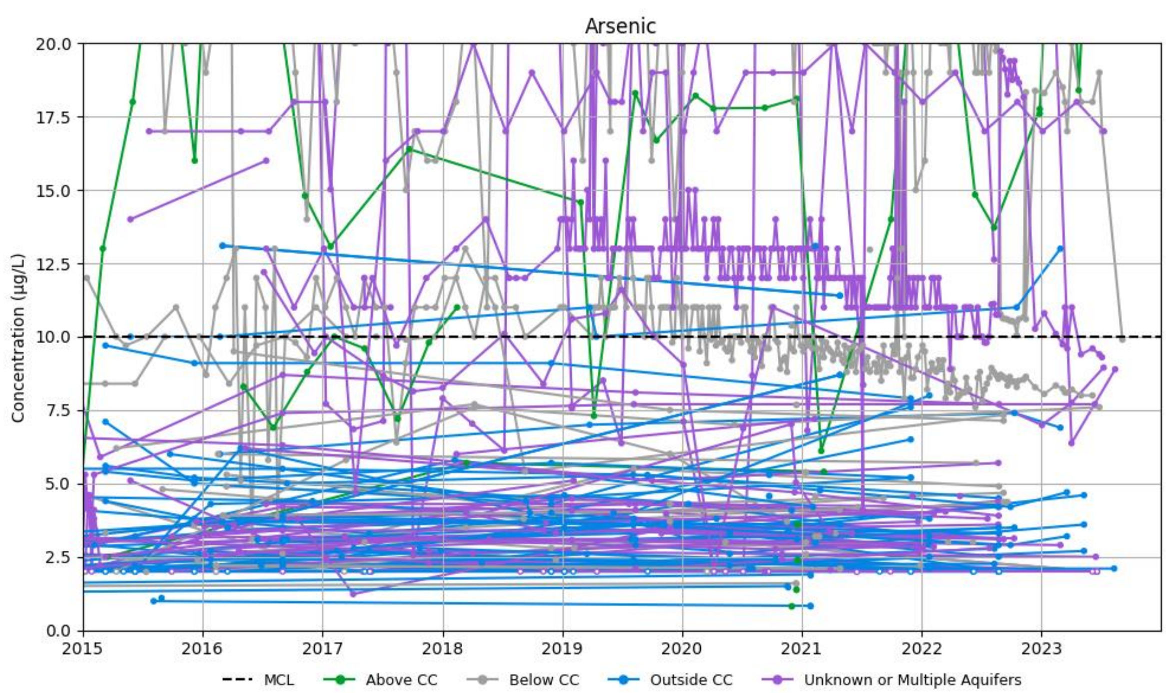


Figure 2-91: Arsenic Time Series Concentrations from 2015-2023, by Well (Y Axis Range: 0:15 mg/L)

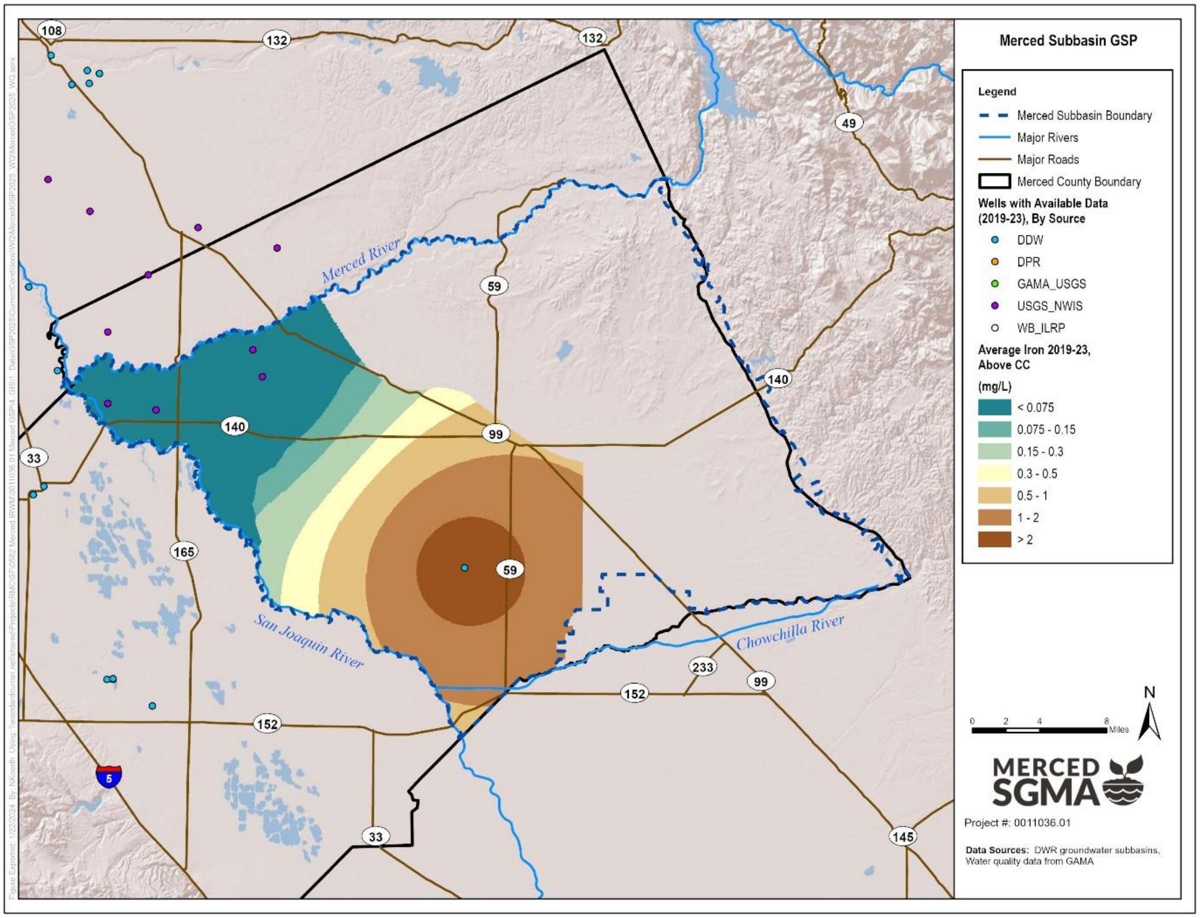


2.2.4.2.2 Iron

Iron (Fe) is a dissolved metal commonly associated with mineralized groundwater. Within the Merced Subbasin area, Fe concentrations range from non-detect (varies, but often less than 0.1 mg/L) to 7 mg/L. The secondary MCL for Fe is 0.3 mg/L (SWRCB, 2006). The secondary MCL is established for aesthetic reasons such as taste, odor, and color and is not based on public health concerns.

The 5-year average (2019-2023) Fe concentration in groundwater often remains below 0.3 mg/L in the Merced Subbasin, with scattered wells reporting average concentrations greater than 0.5 mg/L. The time series from 2015-2023 shows that some of these wells have concentrations as high as 7 mg/L (Figure 2-96). The elevated Fe concentration in the eastern portion of the Merced Subbasin area is likely a result of leaching of Fe from the subsurface materials in the source area. The Fe in groundwater oxidizes and precipitates as the groundwater moves west towards the San Joaquin River (AMEC, 2013).

Figure 2-92: Average Iron Concentration 2019-2023, Above Corcoran Clay[14]



[14] Iron data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-93: Average Iron Concentration 2019-2023, Below Corcoran Clay

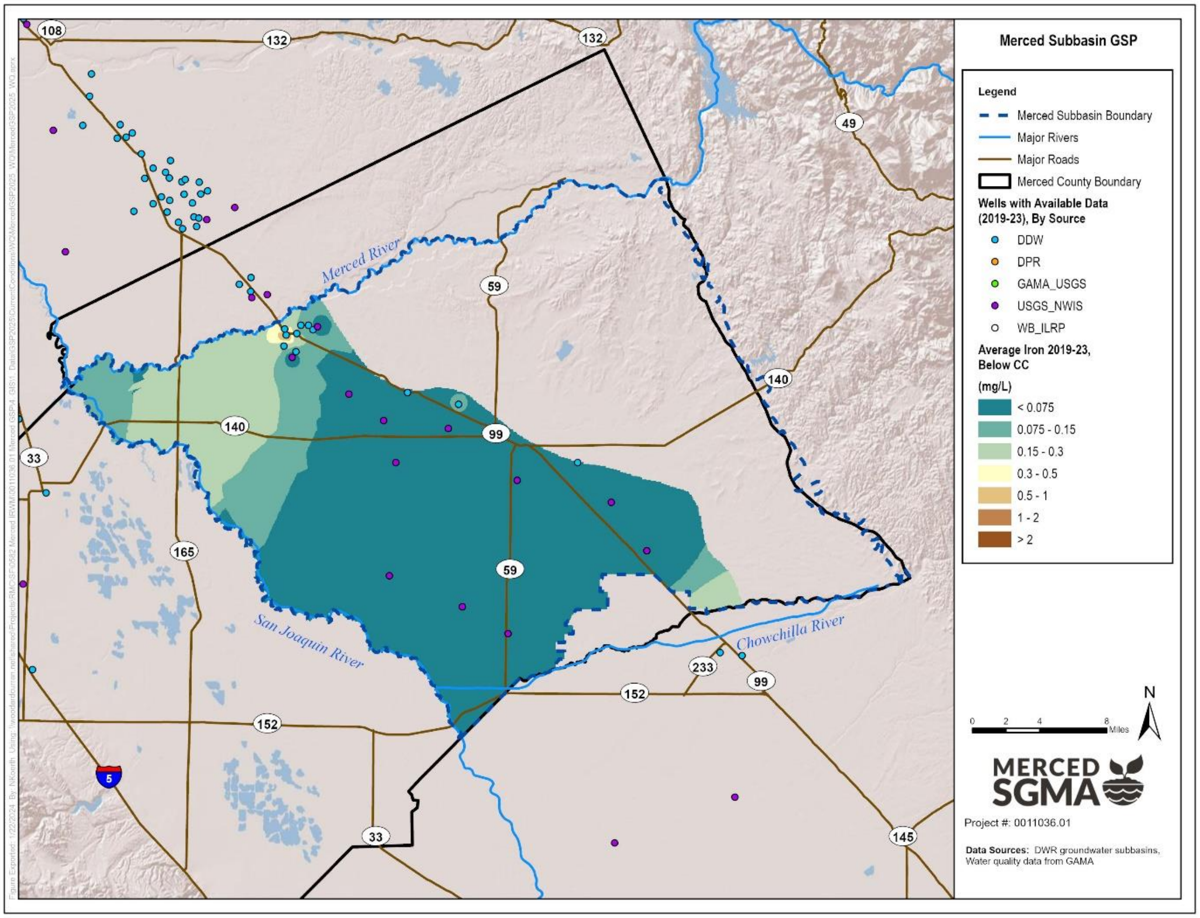


Figure 2-94: Average Iron Concentration 2019-2023, Unknown Aquifer

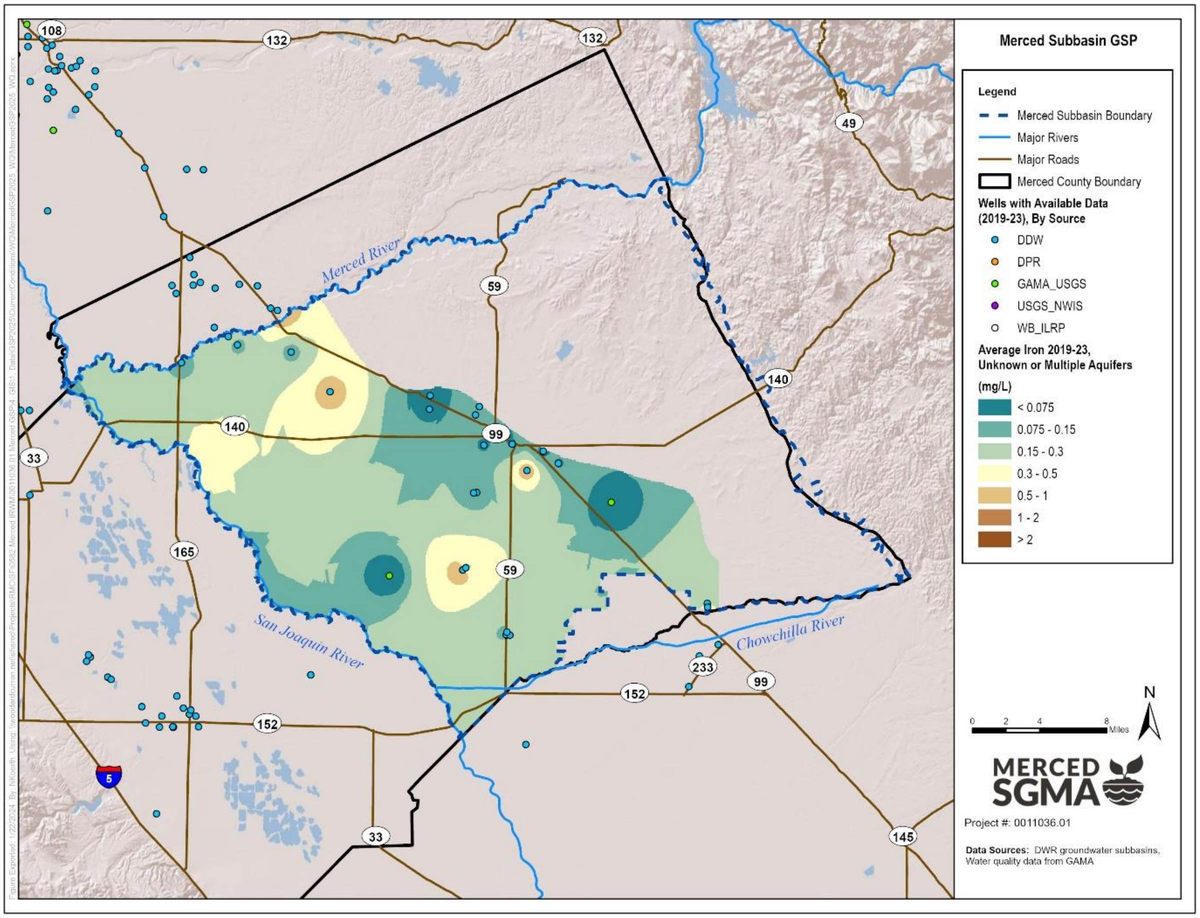


Figure 2-95: Average Iron Concentration 2019-2023, Outside Corcoran Clay

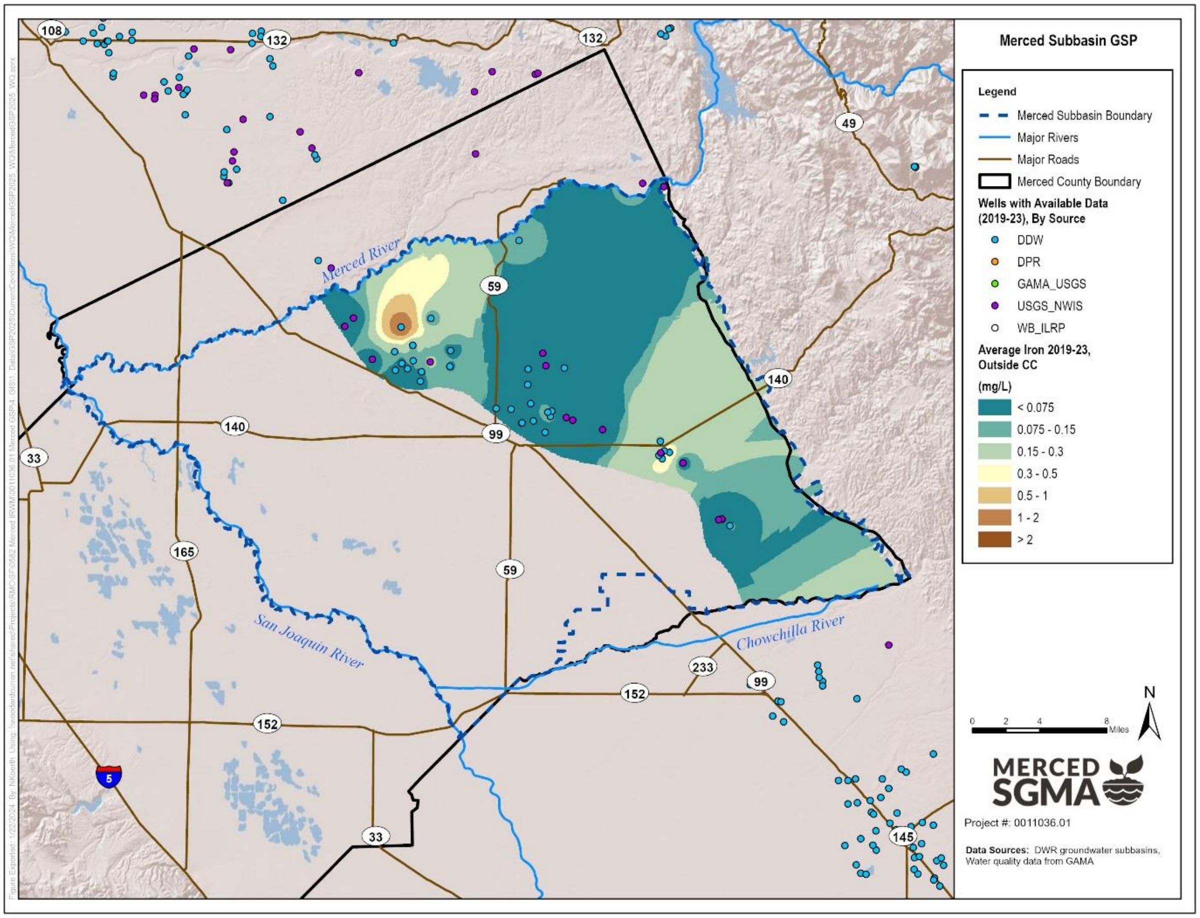
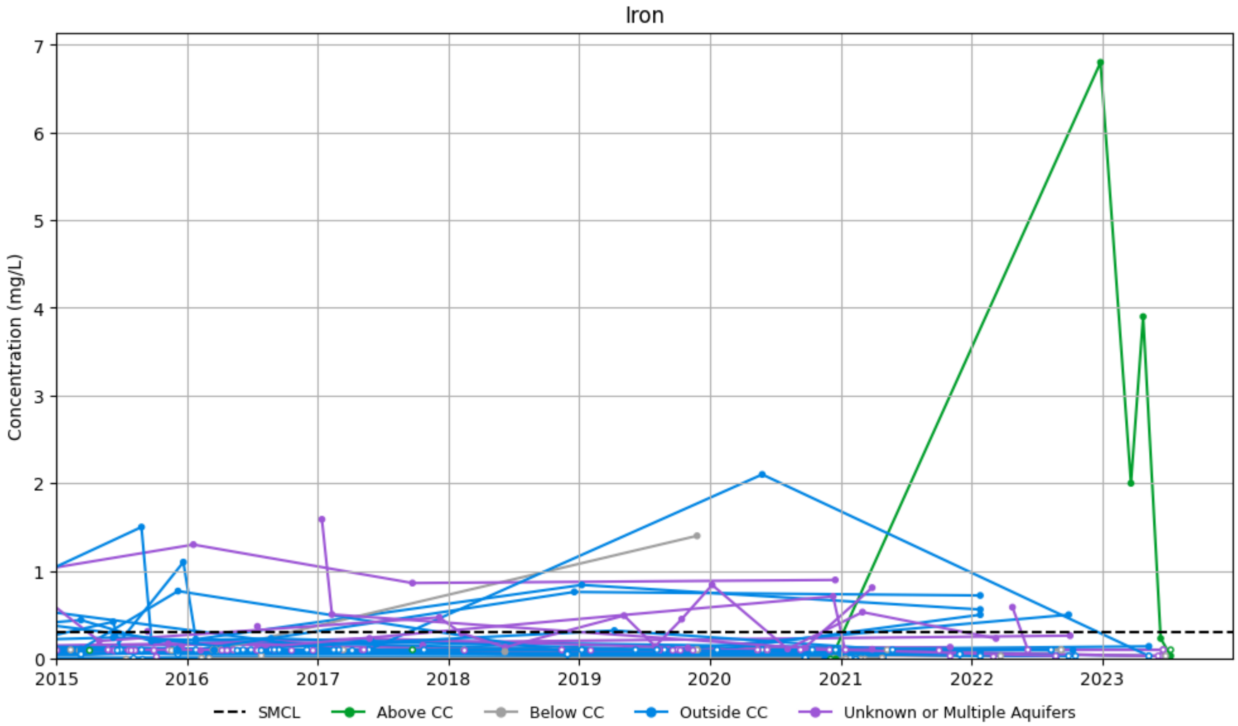


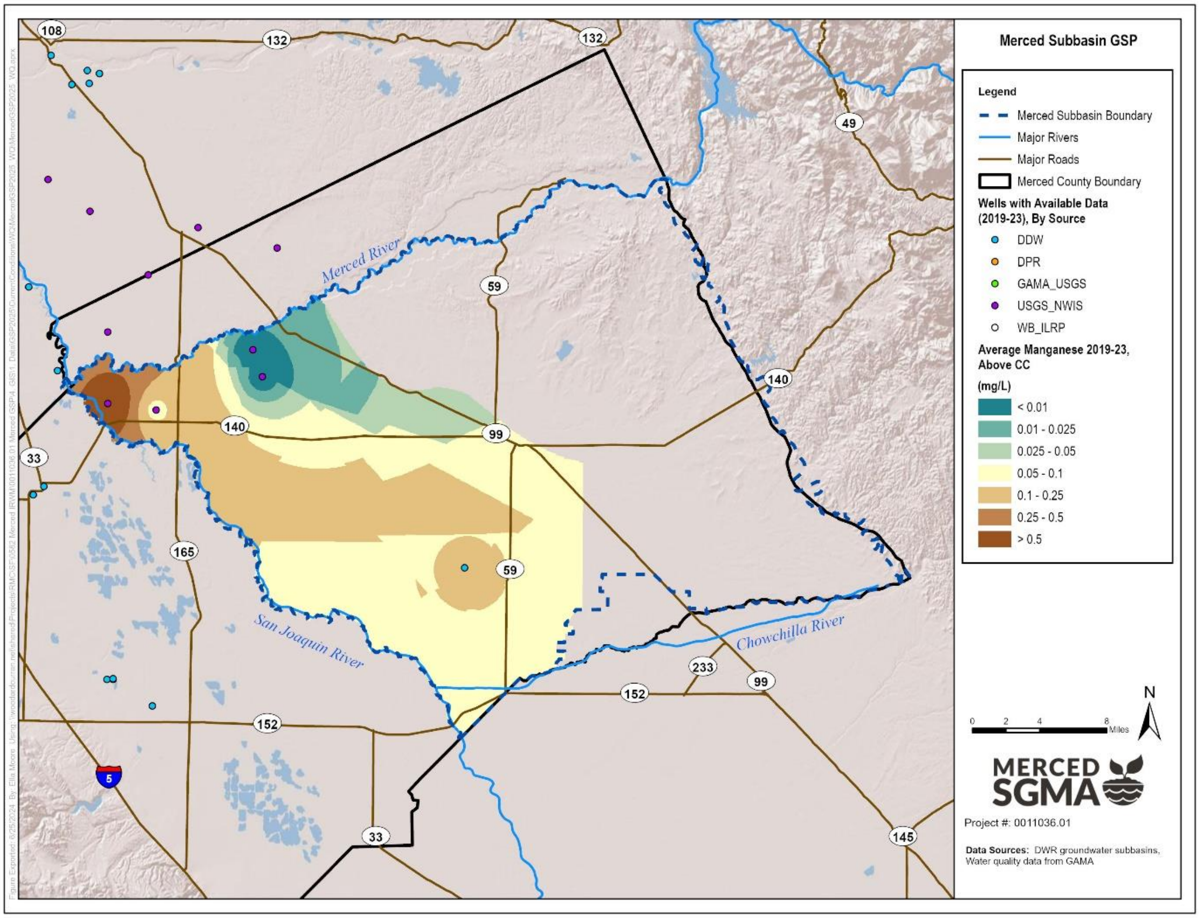
Figure 2-96: Iron Time Series Concentrations from 2015-2023, by Well



2.2.4.2.3 Manganese

Manganese (Mn) is a dissolved metal commonly associated with mineralized groundwater. Within the Merced Subbasin area, Mn concentrations range from non-detect (less than 0.02 mg/L) to as much as 1 mg/L. The secondary MCL for Mn is 0.05 mg/L (SWRCB, 2006). The 5-year average (2019-2023) Mn concentration in groundwater in the Below and Outside Corcoran Clay Aquifers is mostly below 0.05 mg/L (Figure 2-98 and Figure 2-100) with elevated levels exceeding 0.1 mg/L at several sites in the Above Corcoran Clay and Unknown Aquifers (Figure 2-97 and Figure 2-99). Like TDS, the Mn concentration in groundwater often increases in the western portions towards the San Joaquin River.

Figure 2-97: Average Manganese Concentration 2019-2023, Above Corcoran Clay[15]



[15] Manganese data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-98: Average Manganese Concentration 2019-2023, Below Corcoran Clay

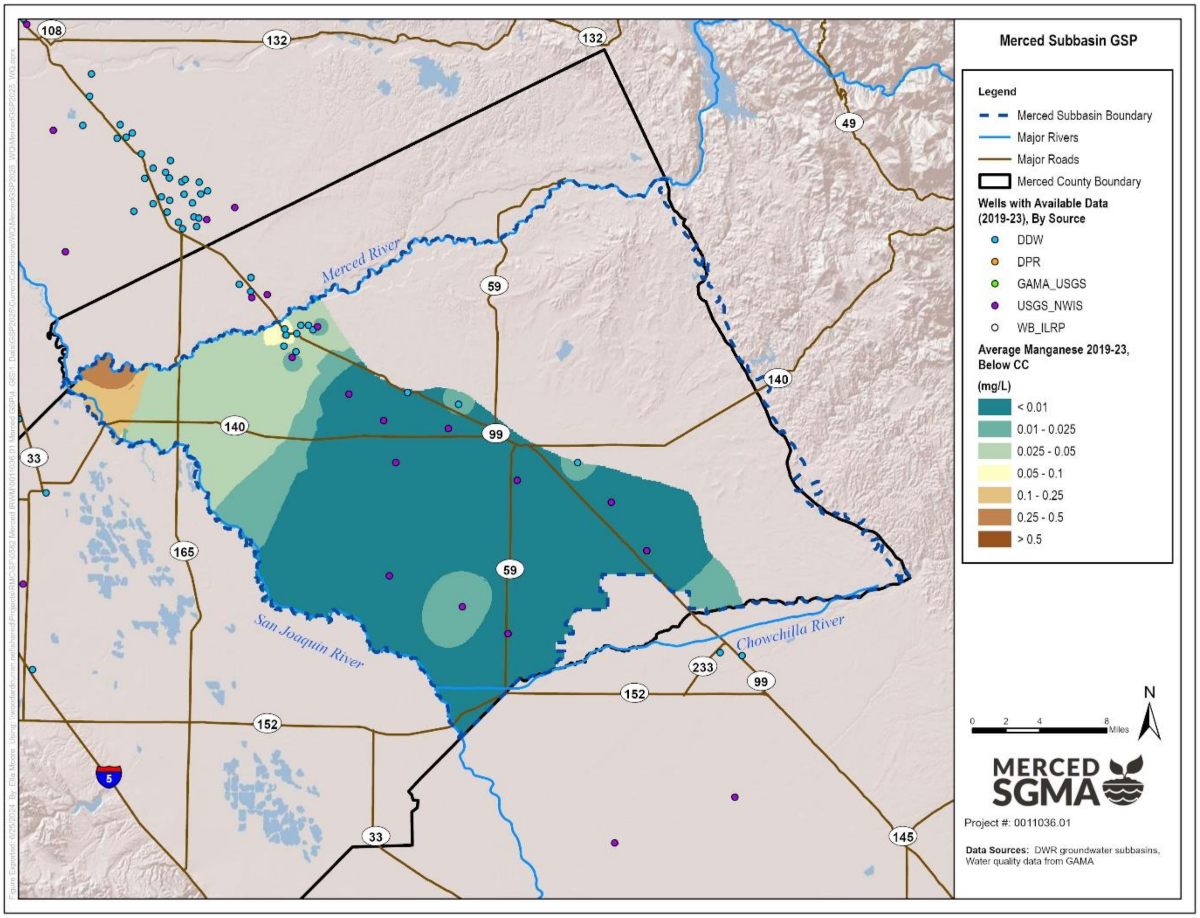


Figure 2-99: Average Manganese Concentration 2019-2023, Unknown Aquifer

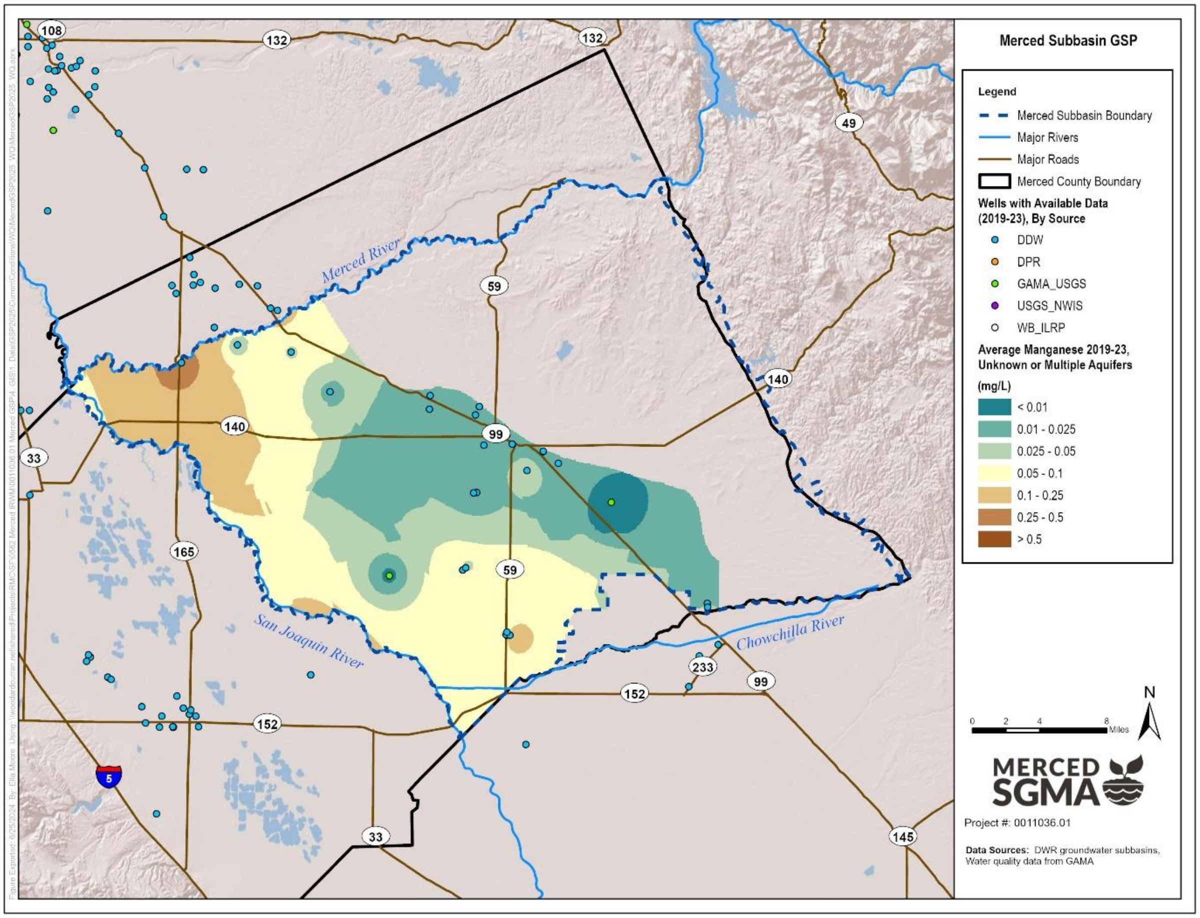


Figure 2-100: Average Manganese Concentration 2019-2023, Outside Corcoran Clay

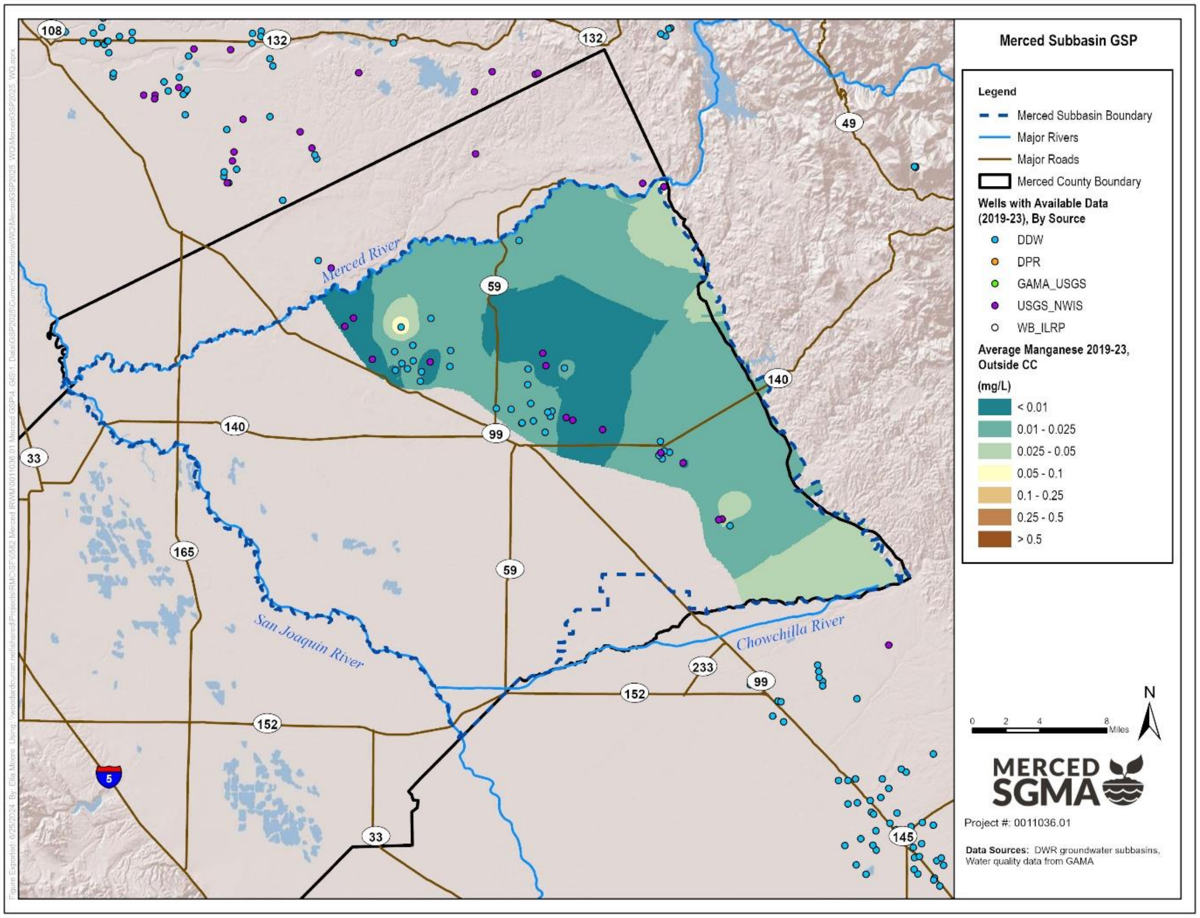
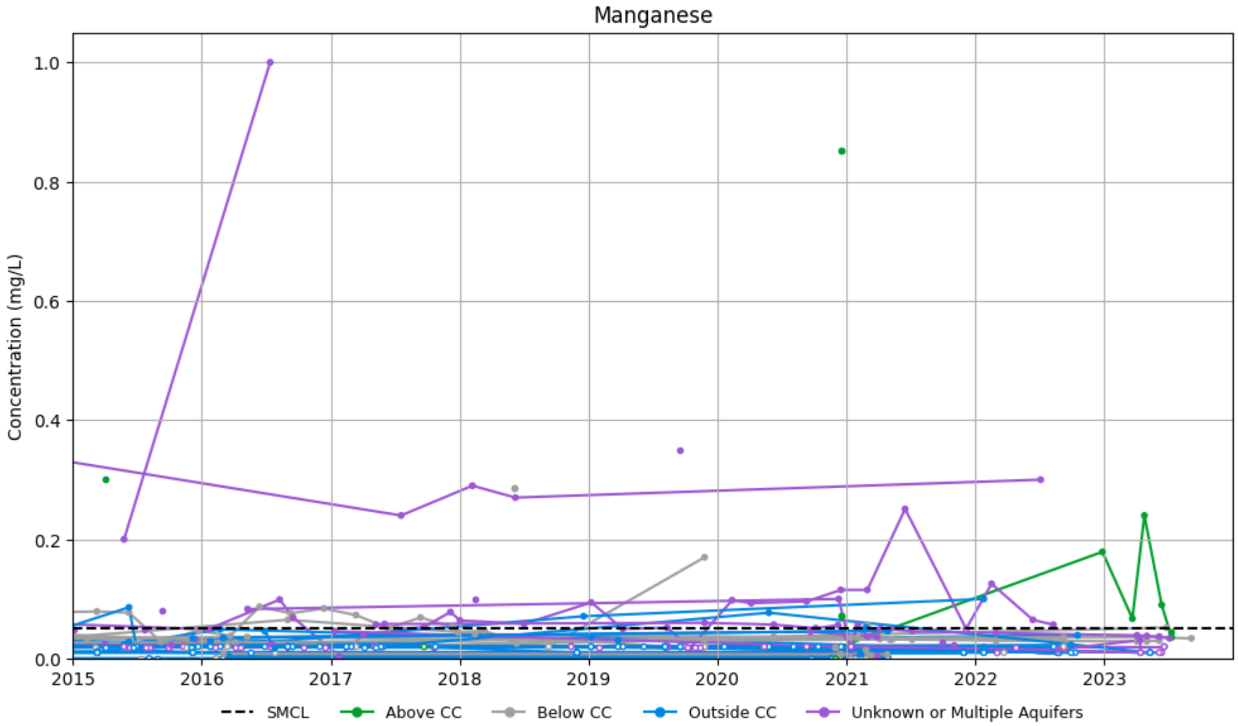


Figure 2-101: Manganese Time Series Concentrations from 2015-2023, by Well



2.2.4.2.4 Hexavalent Chromium

Hexavalent Chromium (Cr6) is a dissolved metal that has been used in industrial applications and that is found naturally occurring throughout the environment. . Within the Merced Subbasin area, Cr6 concentrations range from non-detect (less than 0.01 µg/L) to as much as 370 µg/L. The SWRCB established an MCL for Cr6 of 10 µg/L in 2014, but it was withdrawn in August 2017 due to a state court ruling. In 2024 the State Water Board adopted a resolution that reestablished the MCL for Cr6 at 10 µg/L (SWRCB, 2024) The 5-year average (2019-2023) Cr6 concentration in groundwater in the Merced Subbasin area is generally less than 5 µg/L. The elevated concentrations in the Unknown Aquifer map are an artifact of elevated Cr6 concentrations from wells located outside of the Merced Subbasin (Figure 2-104). Previously, there was a small area in the northwest quadrant of the Subbasin with concentrations exceeding 100 µg/L resulting from a point source in the Beachwood subdivision (Central Valley RWQCB, 2011). However, the time series from 2015-2023 show that Cr6 concentrations in the Merced Subbasin have remained below 7 µg/L (Figure 2-106).

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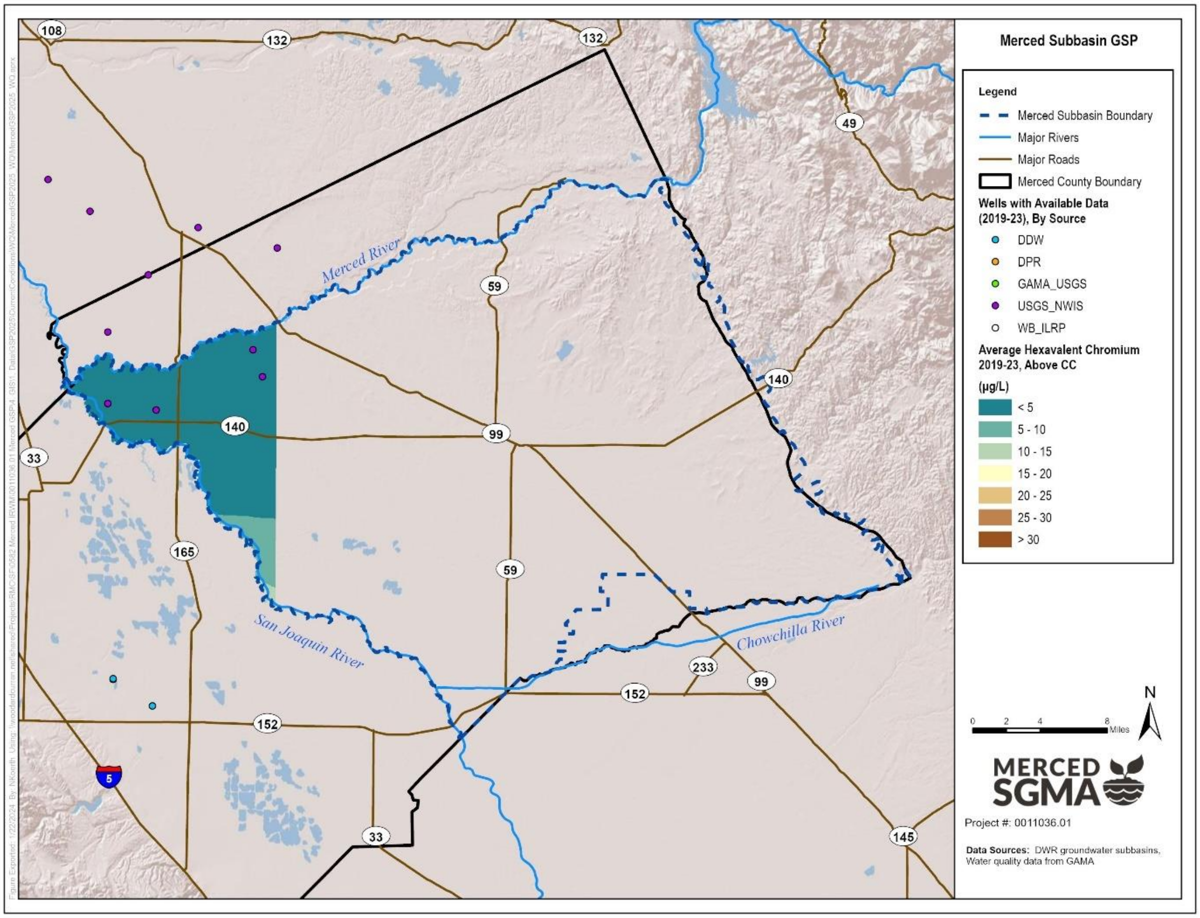
Figure 2-102: Average Hexavalent Chromium Concentration 2019-2023, Above Corcoran Clay[16]



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[16] Hexavalent Chromium data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-103: Average Hexavalent Chromium Concentration 2019-2023, Below Corcoran Clay

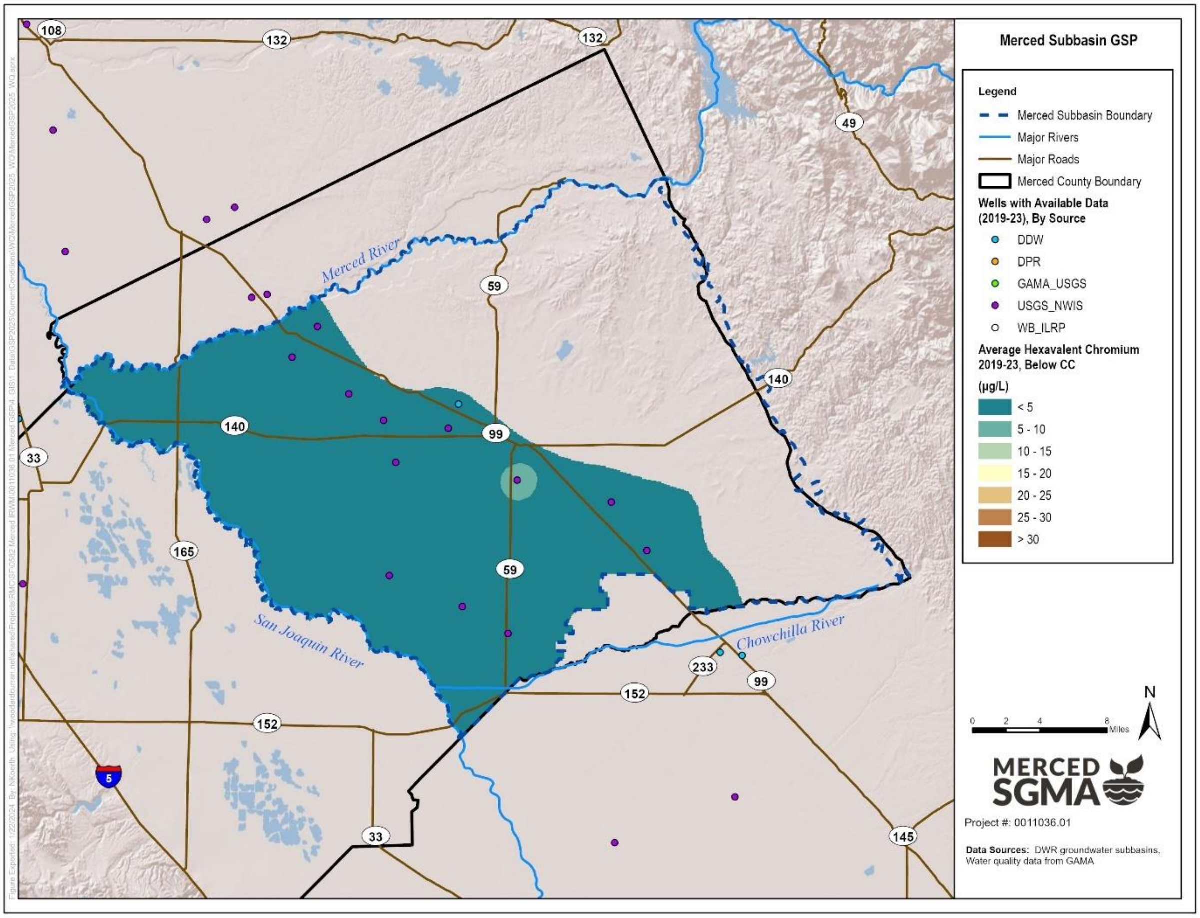
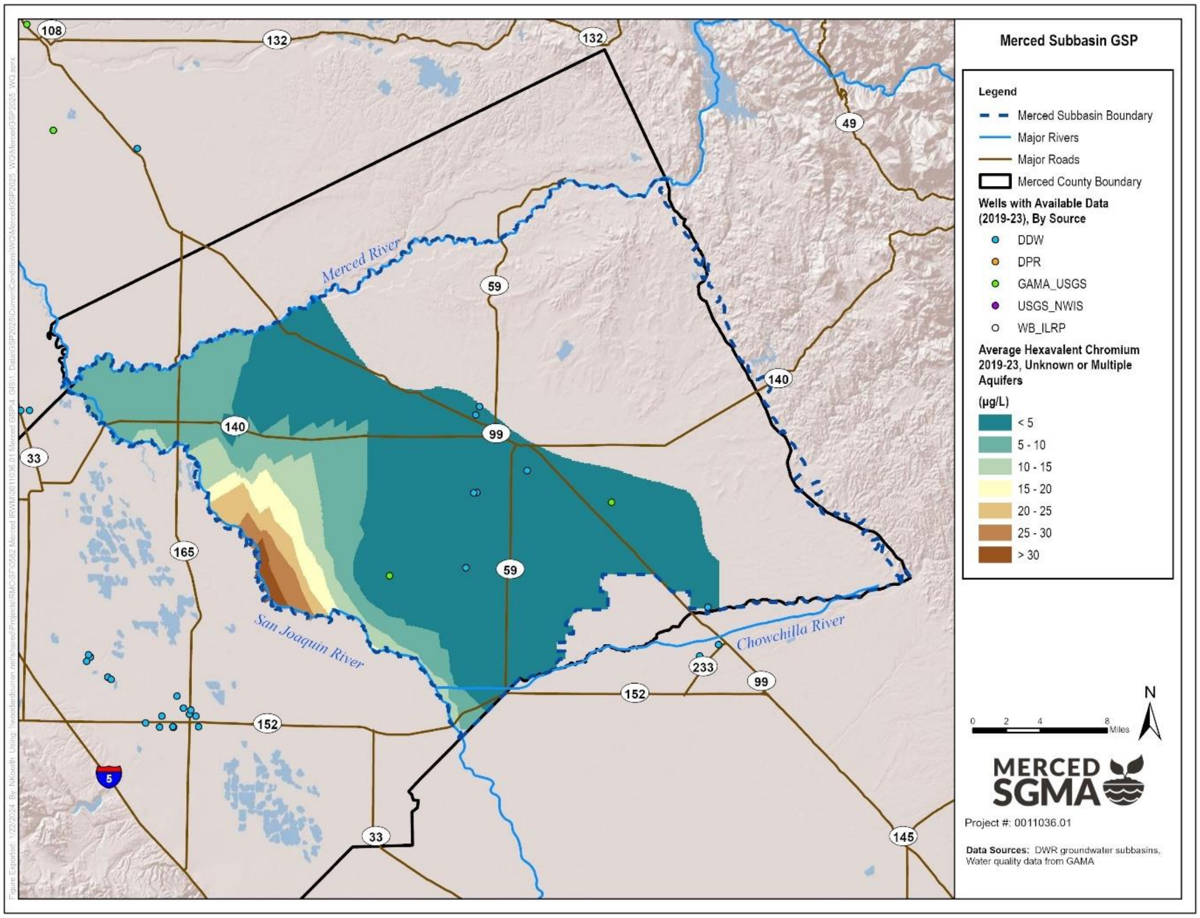


Figure 2-104: Average Hexavalent Chromium Concentration 2019-2023, Unknown Aquifer[17]



[17] Hexavalent Chromium data availability for wells in the Unknown/Multiple aquifers is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-105: Average Hexavalent Chromium Concentration 2019-2023, Outside Corcoran Clay

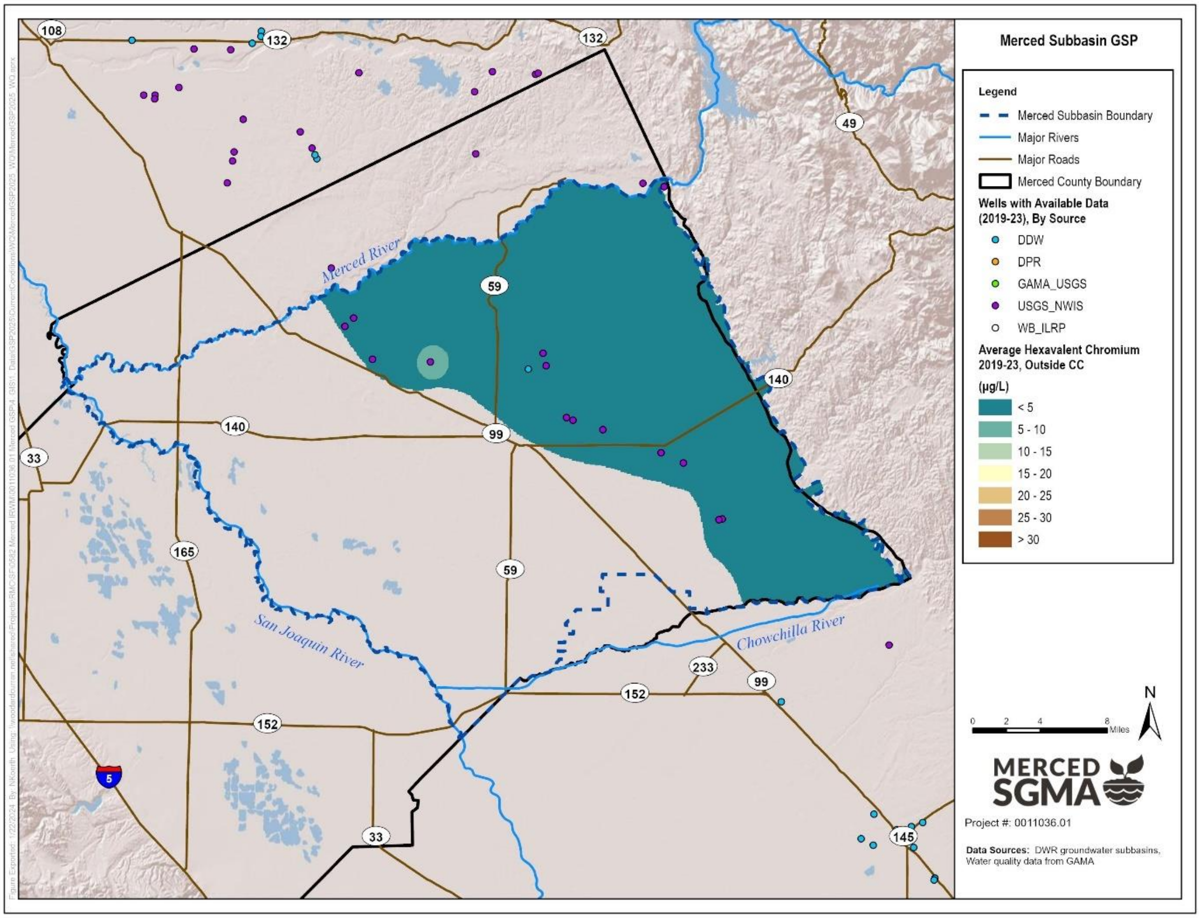
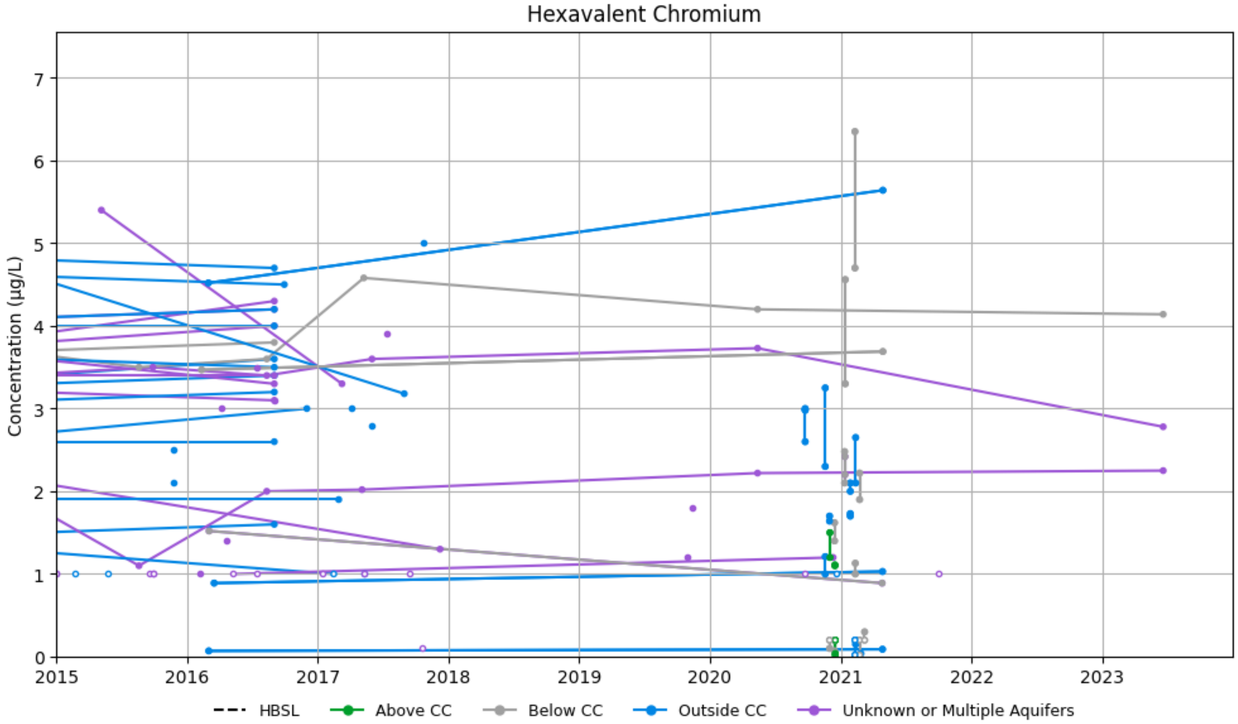


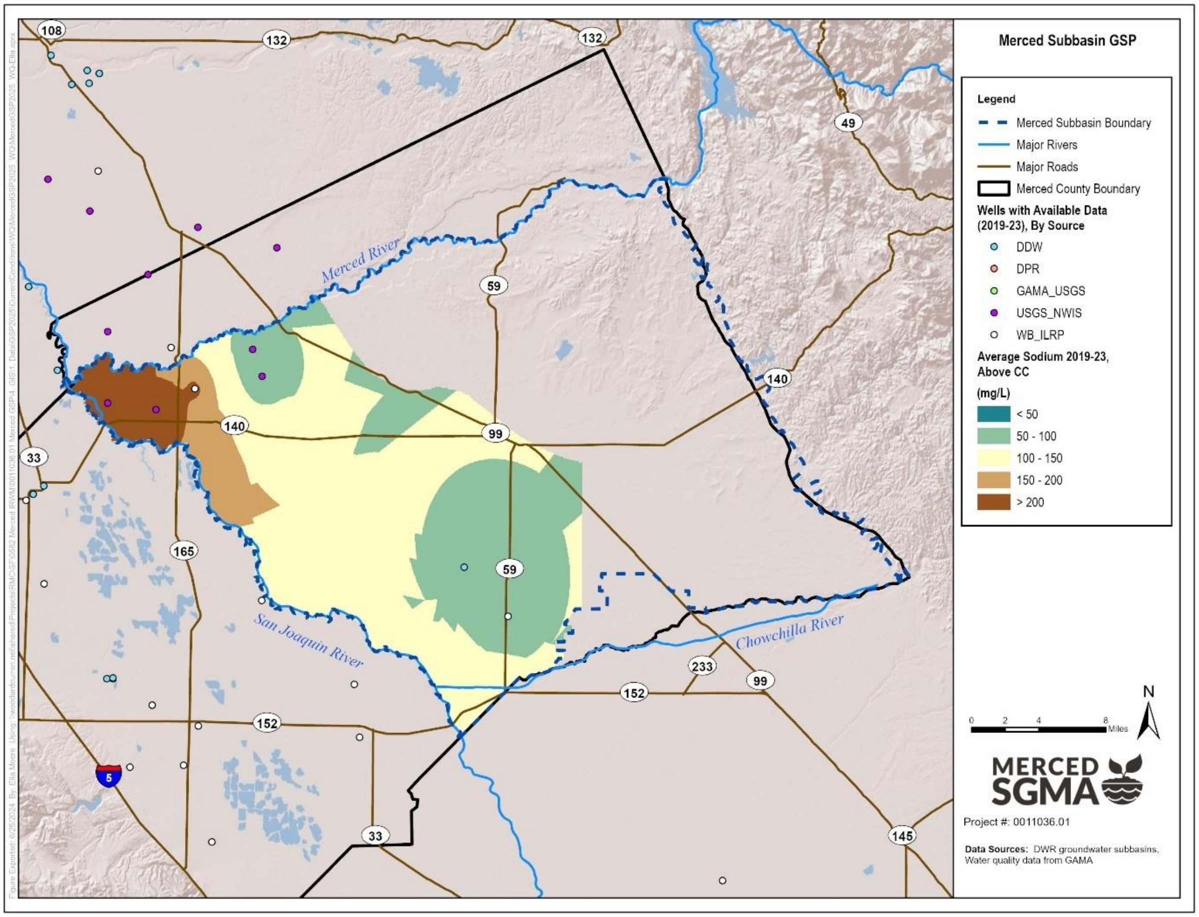
Figure 2-106: Hexavalent Chromium Time Series Concentrations from 2015-2023, by Well



2.2.4.2.5 Sodium

Sodium is a naturally occurring element that can be dissolved from rocks and soils, or resulting from anthropogenic sources such as deicing chemicals, water treatment chemicals, domestic water softeners, or wastewater effluent. There is no primary or secondary MCL established for sodium. The 5-year average concentrations (2019-2023) show sodium is often below 50 mg/L in the eastern portions of the Subbasin. Elevated concentrations exceeding 200 mg/L are seen in the Above Corcoran Clay Aquifer, and along the western portions towards the San Joaquin River (Figure 2-107). The time series from 2015-2023 shows that, with the exception of a few wells, sodium concentrations in the Merced Subbasin are generally below 100 mg/L (Figure 2-111).

Figure 2-107: Average Sodium Concentration 2019-2023, Above Corcoran Clay[18]



[18] Sodium data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-108: Average Sodium Concentration 2019-2023, Below Corcoran Clay

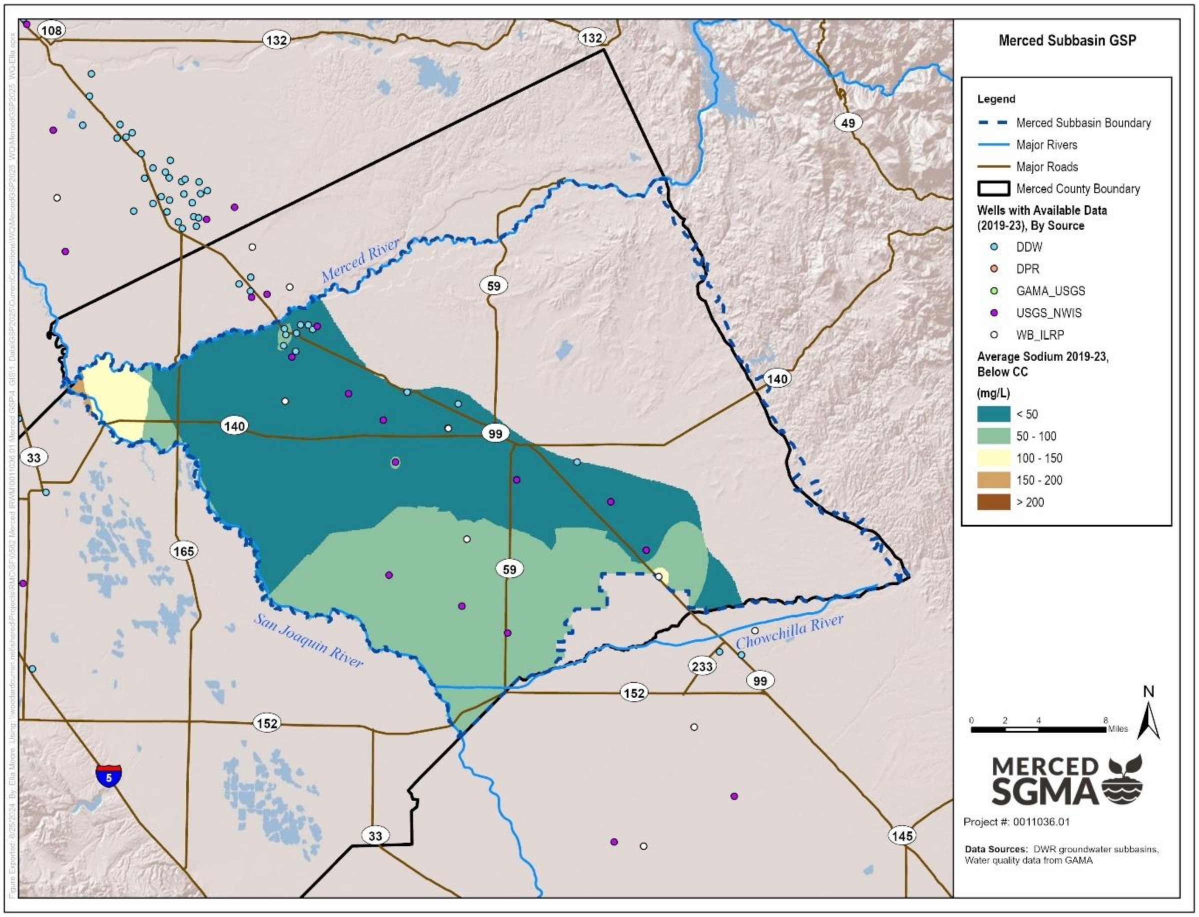


Figure 2-109: Average Sodium Concentration 2019-2023, Unknown Aquifer

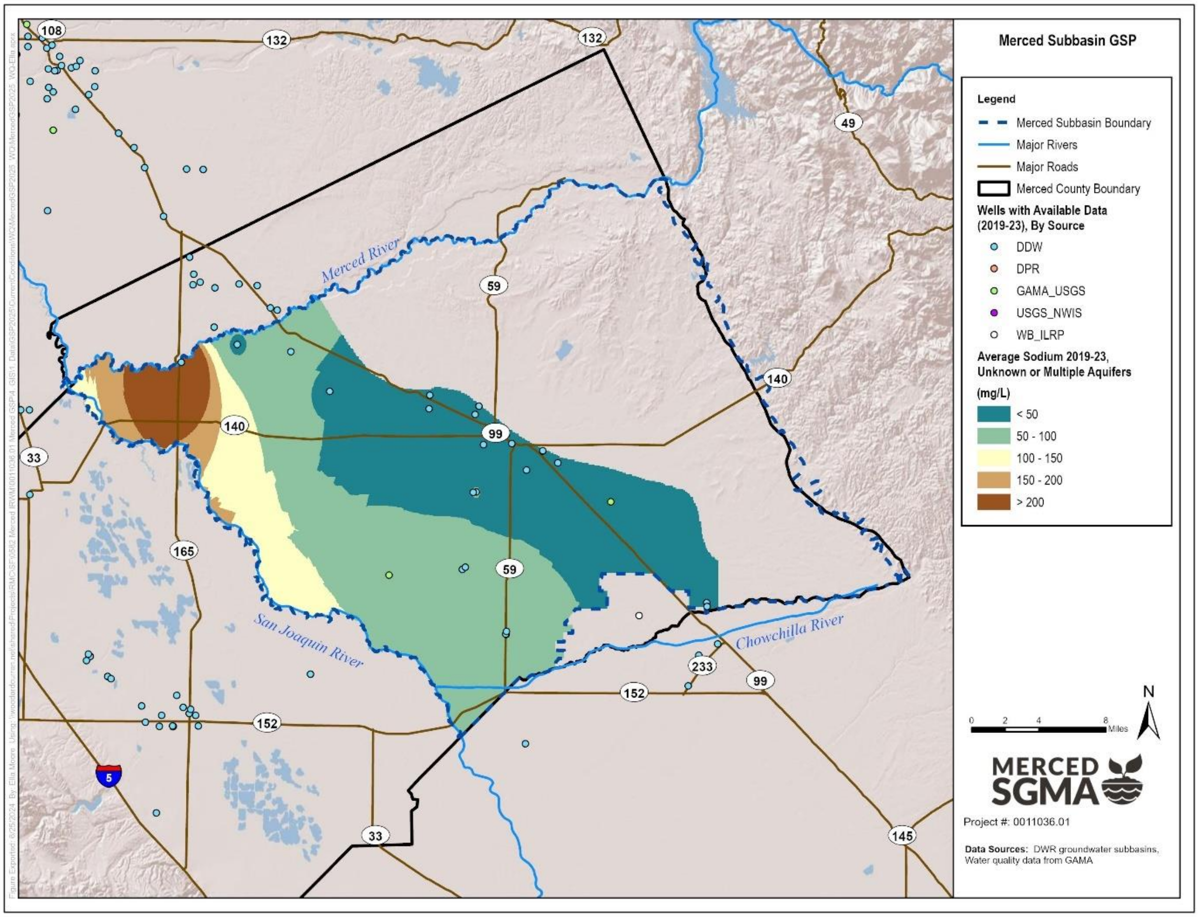


Figure 2-110: Average Sodium Concentration 2019-2023, Outside Corcoran Clay

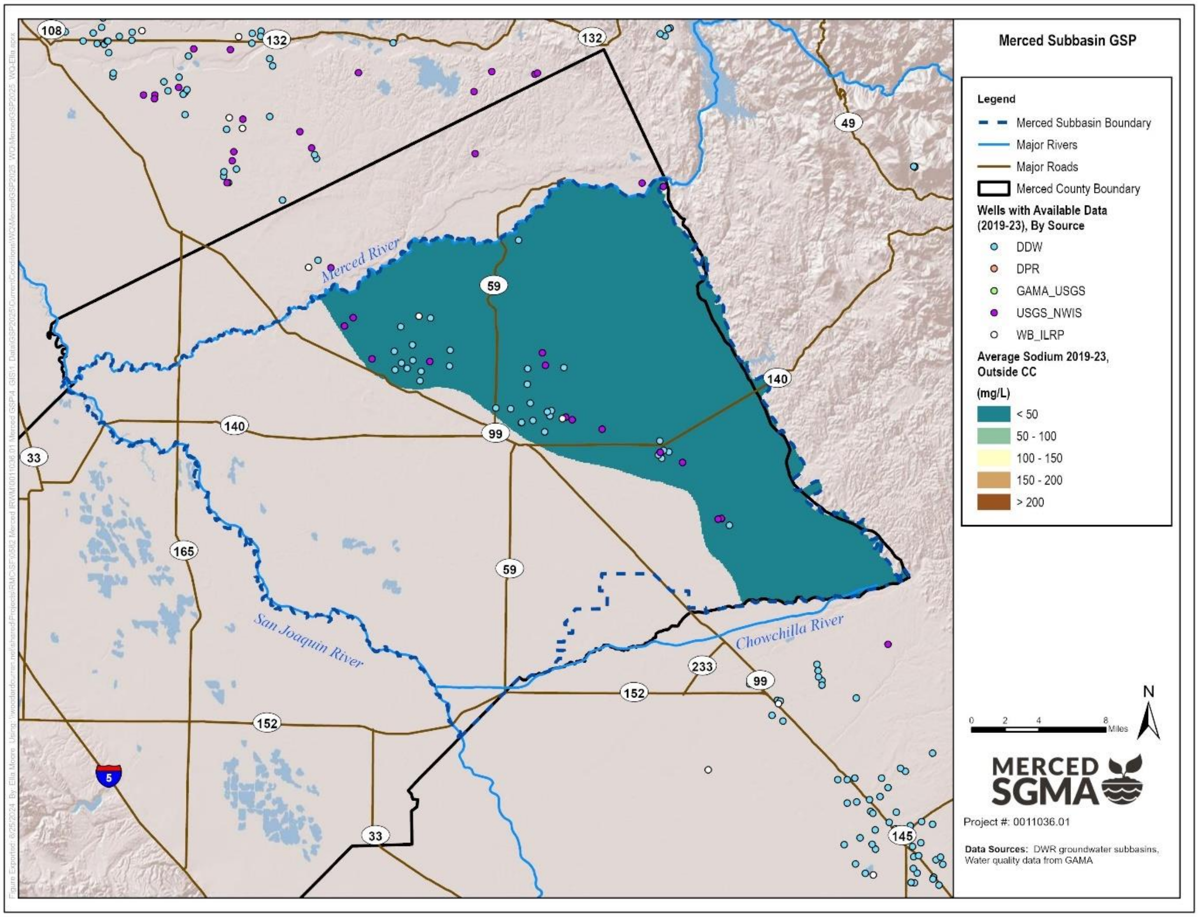
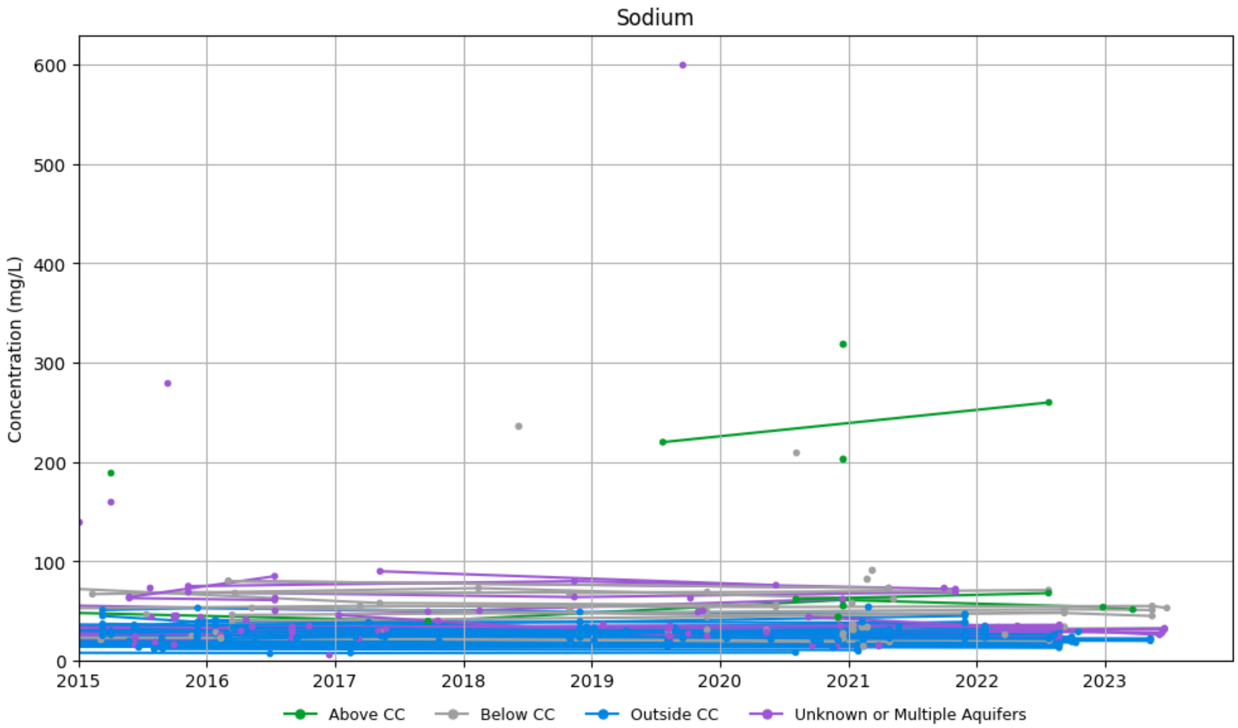


Figure 2-111: Sodium Time Series Concentrations from 2015-2023, by Well



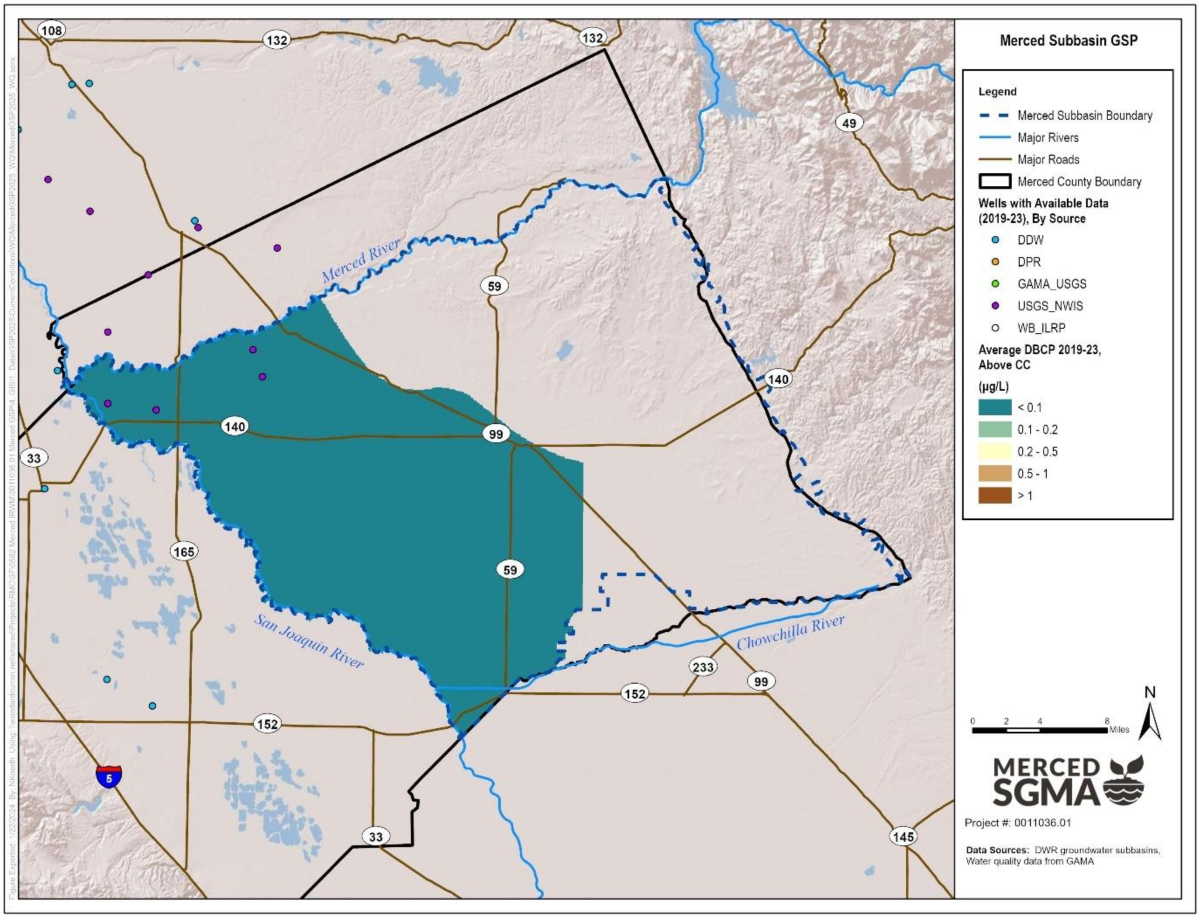
2.2.4.3 Pesticides

The following information on pesticides includes subsections for Dibromochloropropane (DBCP), 1,2,3-Trichloropropane (123-TCP), and 1,2-Dibromoethane (EDB).

2.2.4.3.1 Dibromochloropropane (DBCP)

The pesticide DBCP was a common pesticide used to control nematodes in vineyards prior to 1977. DBCP concentrations in groundwater in the Merced Subbasin range from non-detect (variable, but typically 0.02 µg/L) to 0.3 µg/L. The primary MCL for DBCP is 0.2 µg/L (SWRCB, 2018). The 5-year average (2019-2023) DBCP concentration in groundwater throughout the Merced Subbasin is generally less than 0.1 µg/L. The time series from 2015- 2023 shows concentrations remaining below 0.3 µg/L, and generally decreasing in wells in recent years (Figure 2-116).

Figure 2-112: Average DBCP Concentration 2019-2023, Above Corcoran Clay[19]



[19] DBCP data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-113: Average DBCP Concentration 2019-2023, Below Corcoran Clay

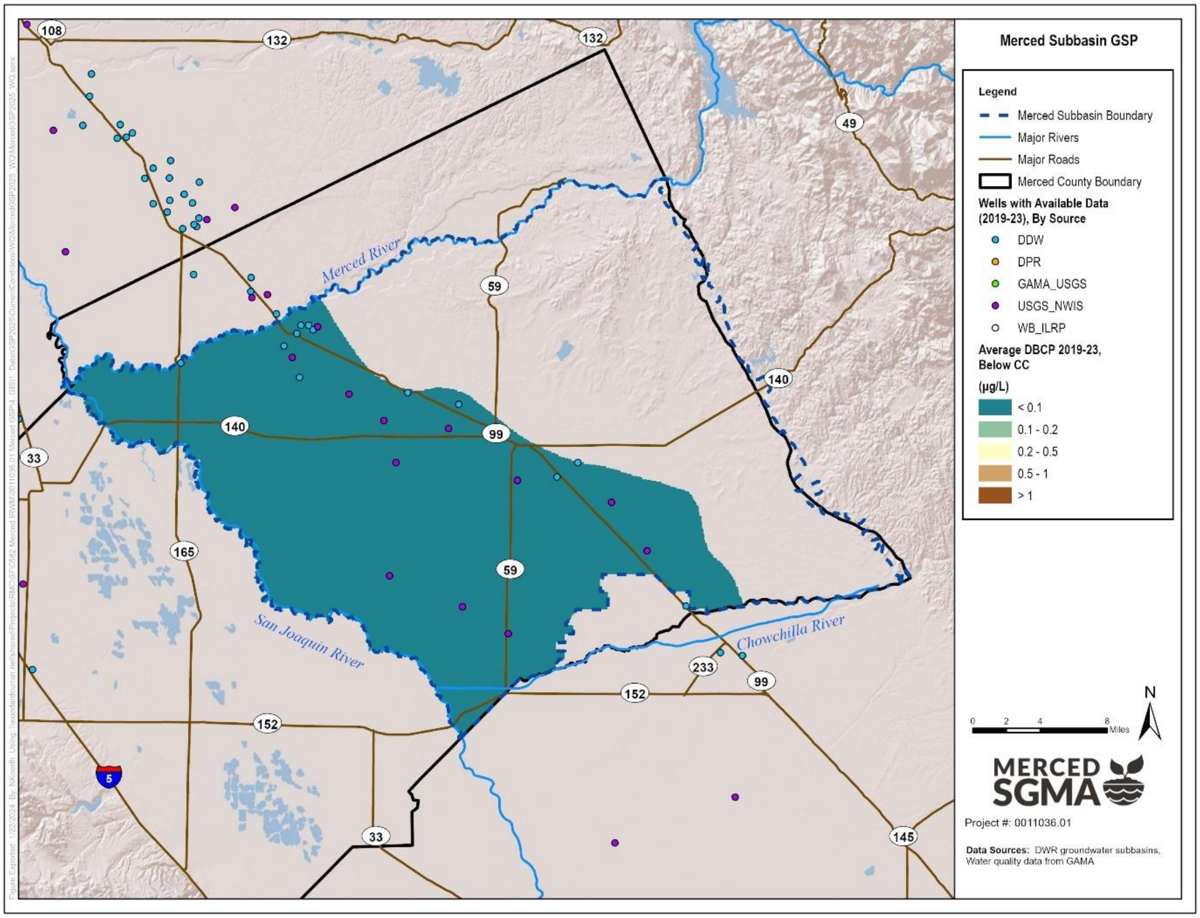


Figure 2-114: Average DBCP Concentration 2019-2023, Unknown Aquifer

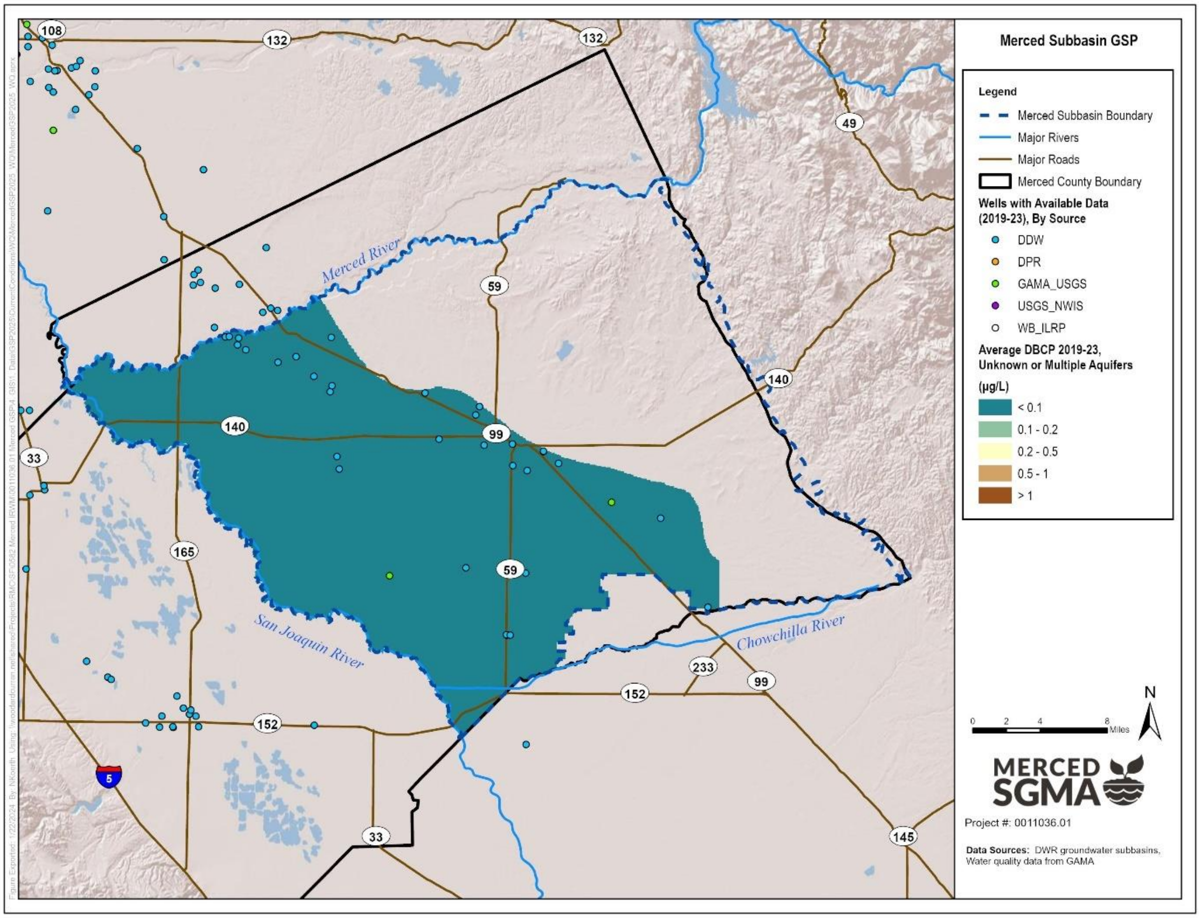


Figure 2-115: Average DBCP Concentration 2019-2023, Outside Corcoran Clay

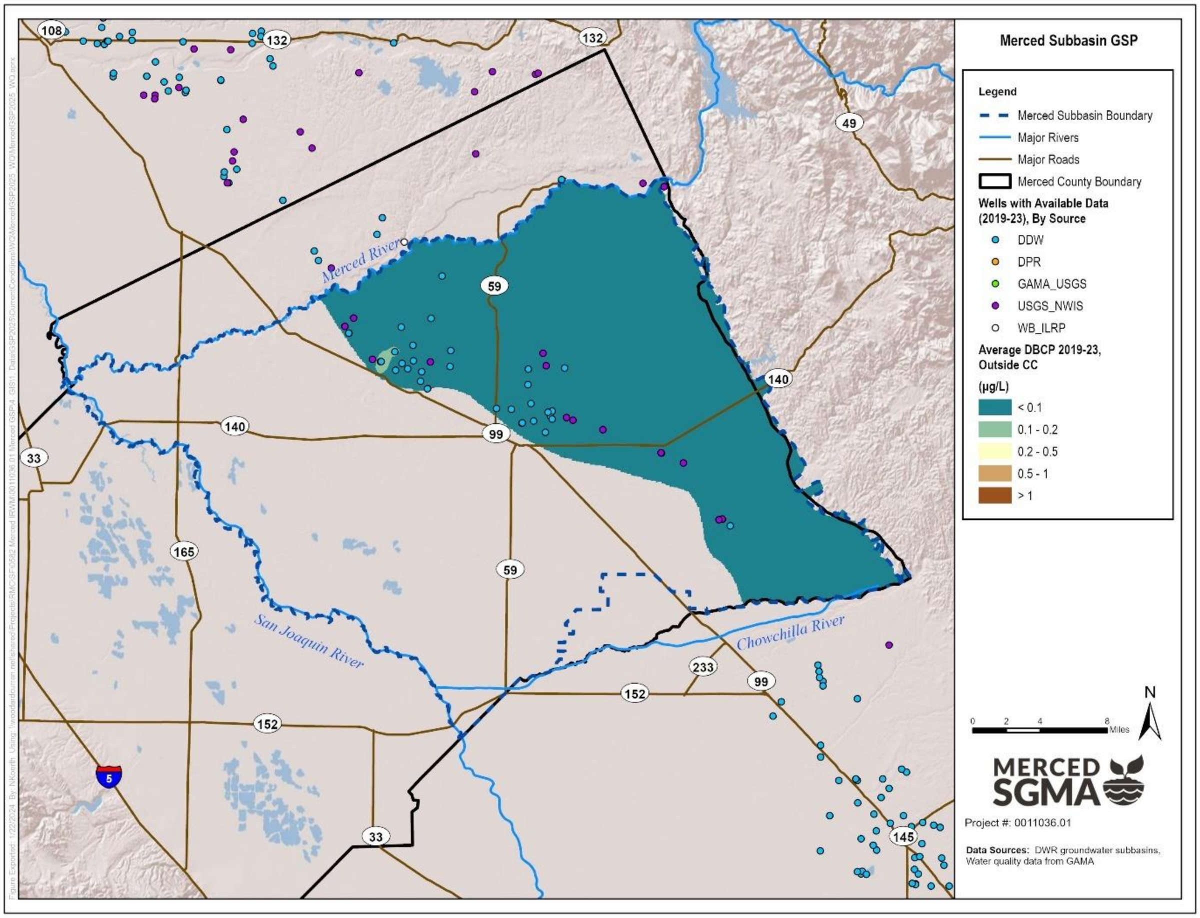
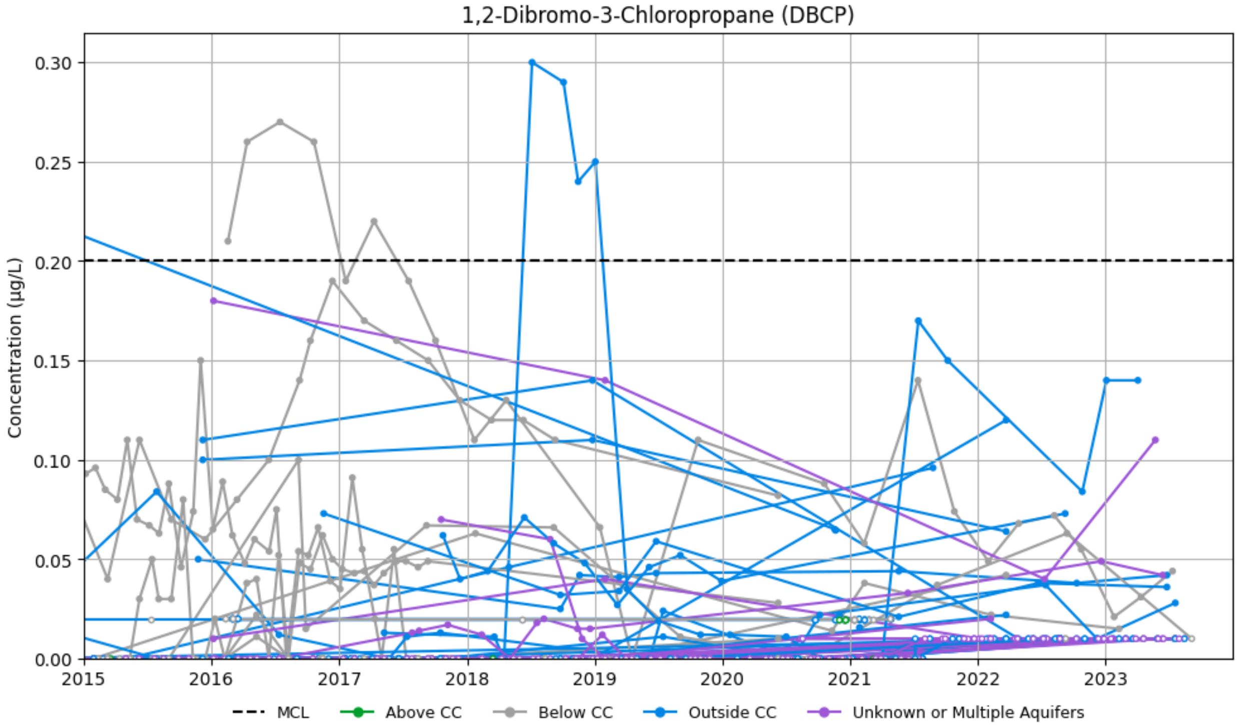


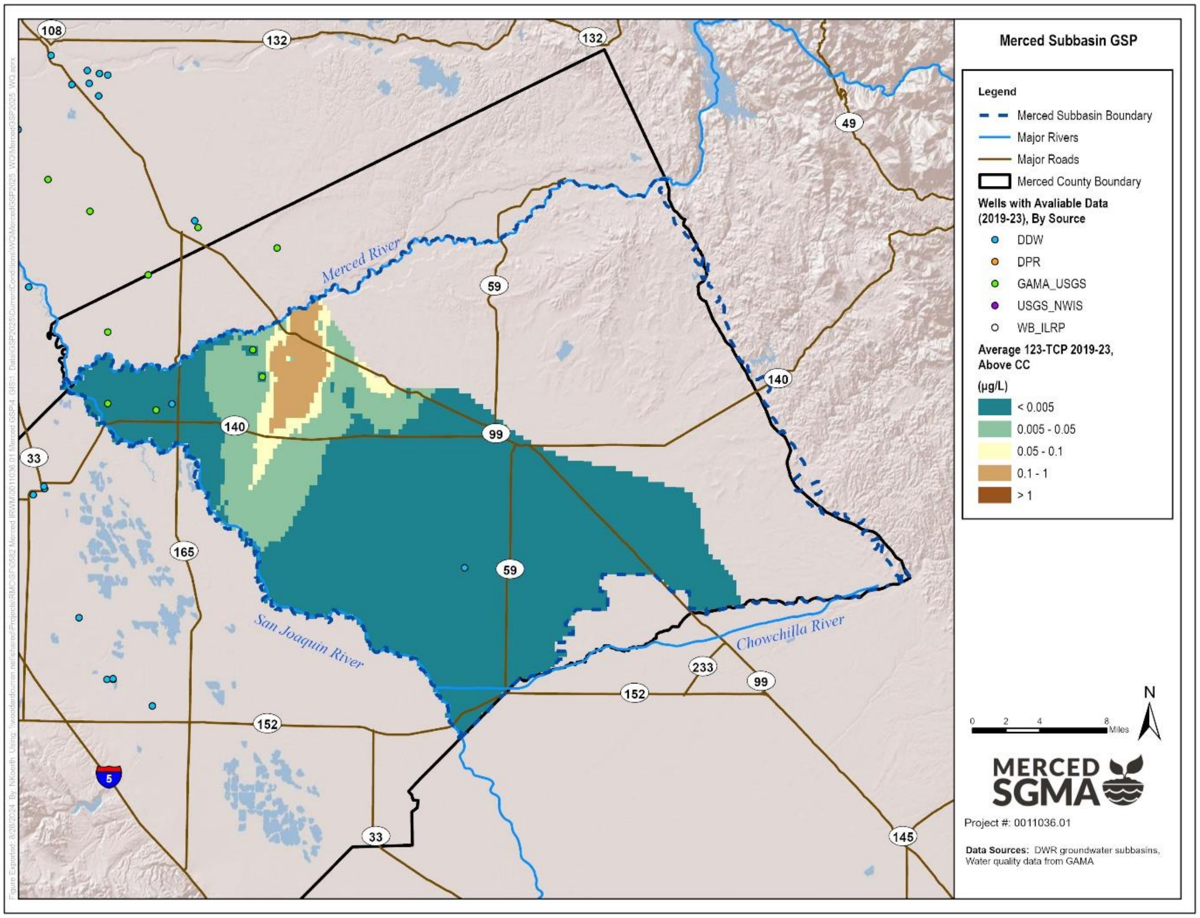
Figure 2-116: DBCP Time Series Concentrations from 2015-2023, by Well



2.2.4.3.2 1,2,3-Trichloropropane (123-TCP)

The volatile organic compound (VOC) 123-TCP is a commonly used solvent in manufacturing facilities and as a carrier solvent for DBCP and other pesticides. 123-TCP concentrations in groundwater in the Merced Subbasin range from non-detect (variable, but typically 0.05 µg/L) to just over 0.8 µg/L. The primary MCL for 123-TCP is 0.005 µg/L (SWRCB, 2018). The 5-year average (2019-2023) 123-TCP concentration in groundwater throughout the Merced Subbasin is generally between 0.05 µg/L and 1 µg/L. Note, however, that the typical detection limit of 0.05 µg/L is greater than the 0.005 µg/L MCL, meaning that non-detects could still indicate MCL exceedances. This indicates better lab analysis is needed for detection of 123-TCP at lower concentrations.

Figure 2-117: Average 123-TCP Concentration 2019-2023, Above Corcoran Clay[20]



20 123-TCP data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-118: Average 123-TCP Concentration 2019-2023, Below Corcoran Clay

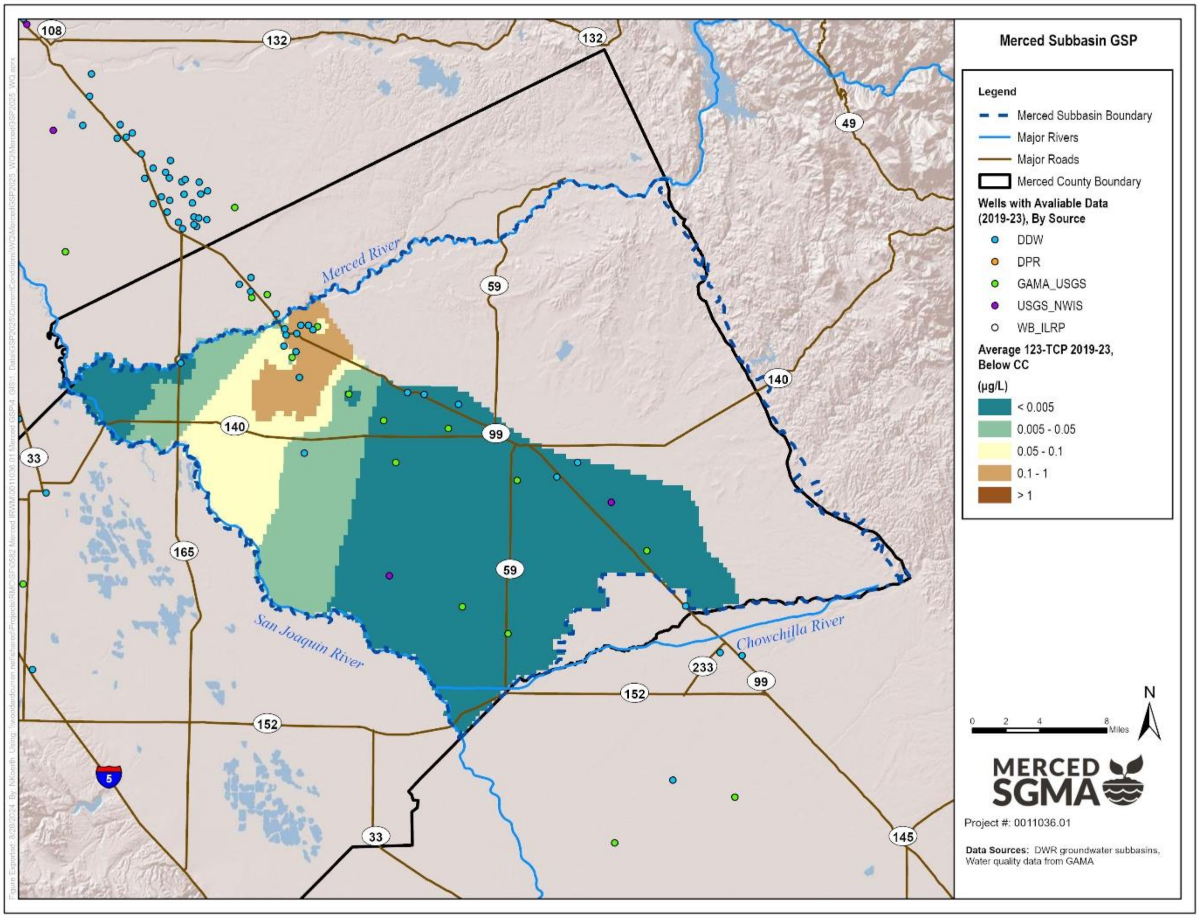


Figure 2-119: Average 123-TCP Concentration 2019-2023, Unknown Aquifer

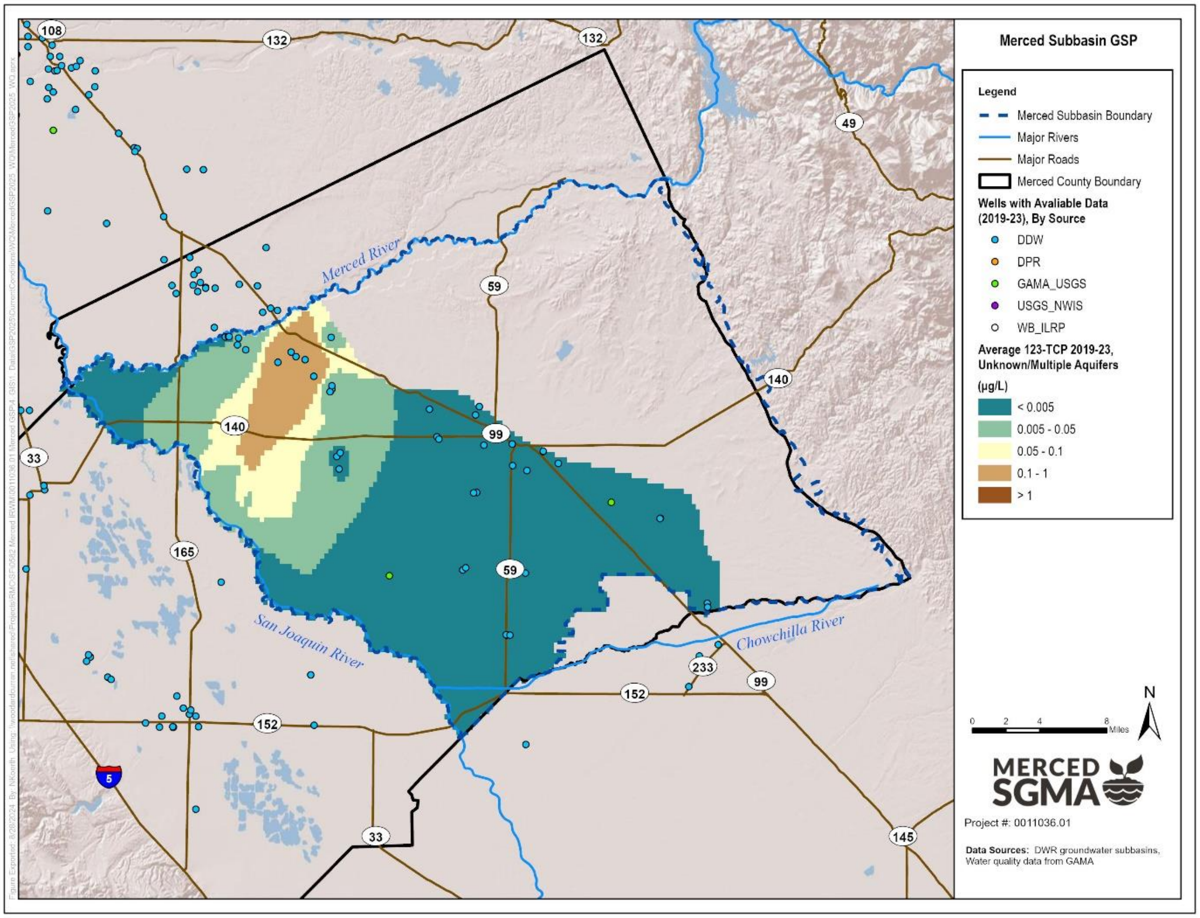


Figure 2-120: Average 123-TCP Concentration 2019-2023, Outside Corcoran Clay

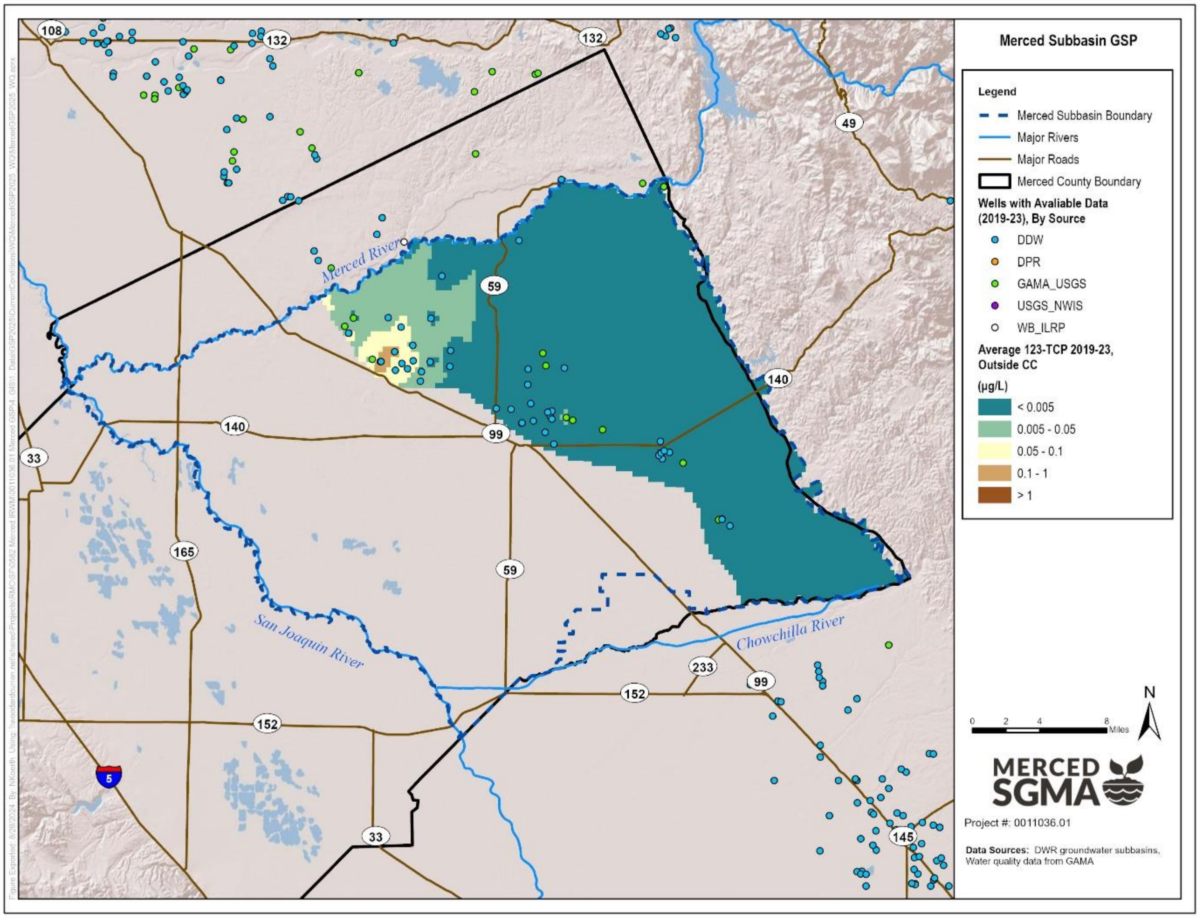
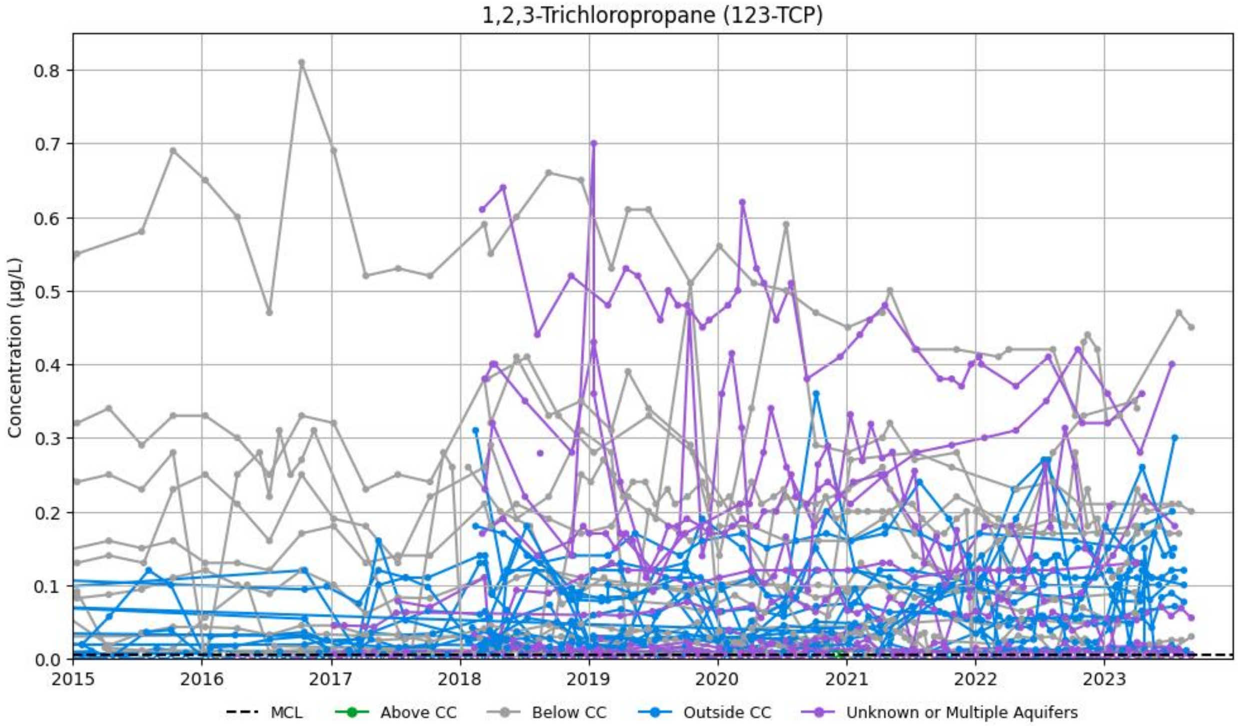


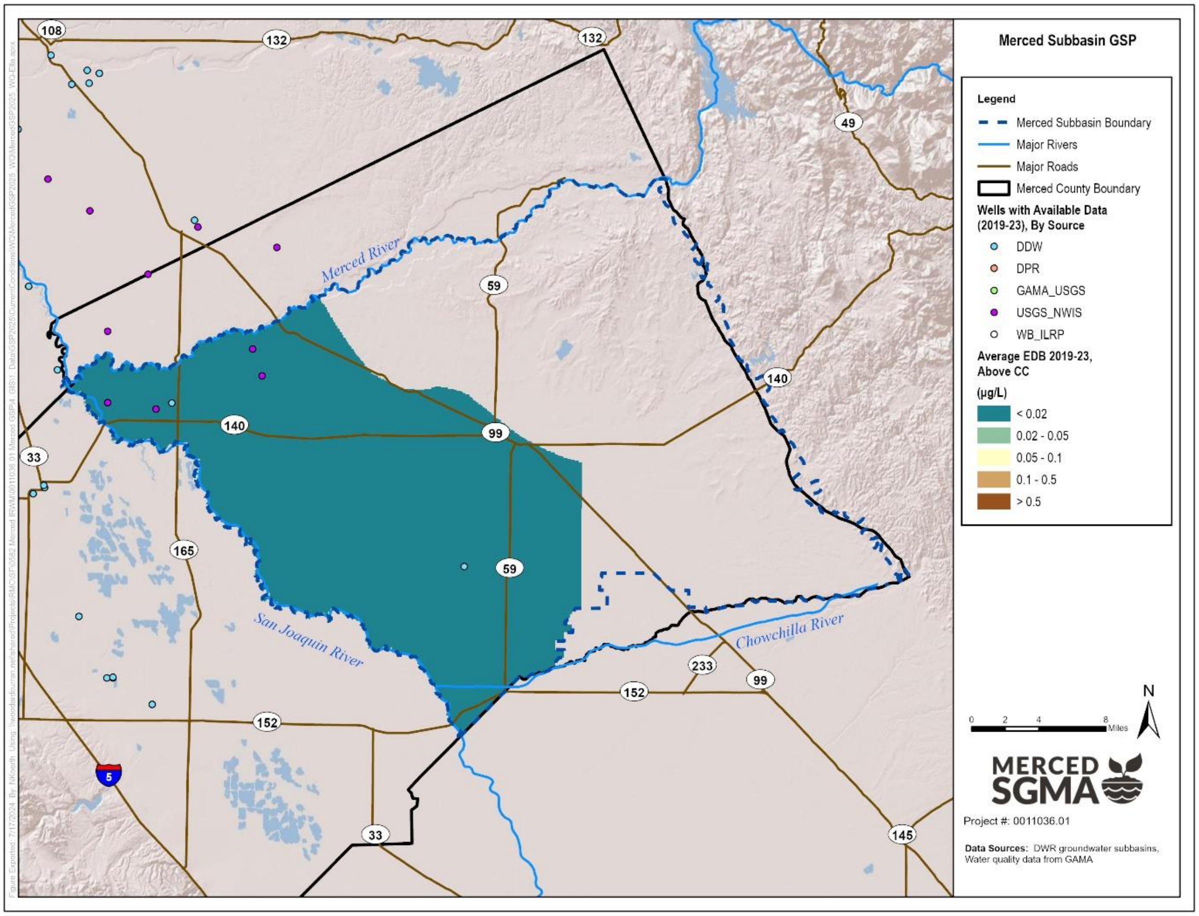
Figure 2-121: 123-TCP Time Series Concentrations from 2015-2023, by Well



2.2.4.3.3 1,2-Dibromoethane (EDB)

1,2-Dibromoethane (EDB) is a compound that has been used historically as a pesticide and as an additive in gasoline. The primary MCL for EDB is 0.05 µg/L (SWRCB, 2018). EDB concentrations in Merced Subbasin have remained at concentrations below the detection limit (variable, but typically 0.02 µg/) since at least 2015.

Figure 2-122: Average EDB Concentration 2019-2023, Above Corcoran Clay[21]



[21] EDB data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-123: Average EDB Concentration 2019-2023, Below Corcoran Clay

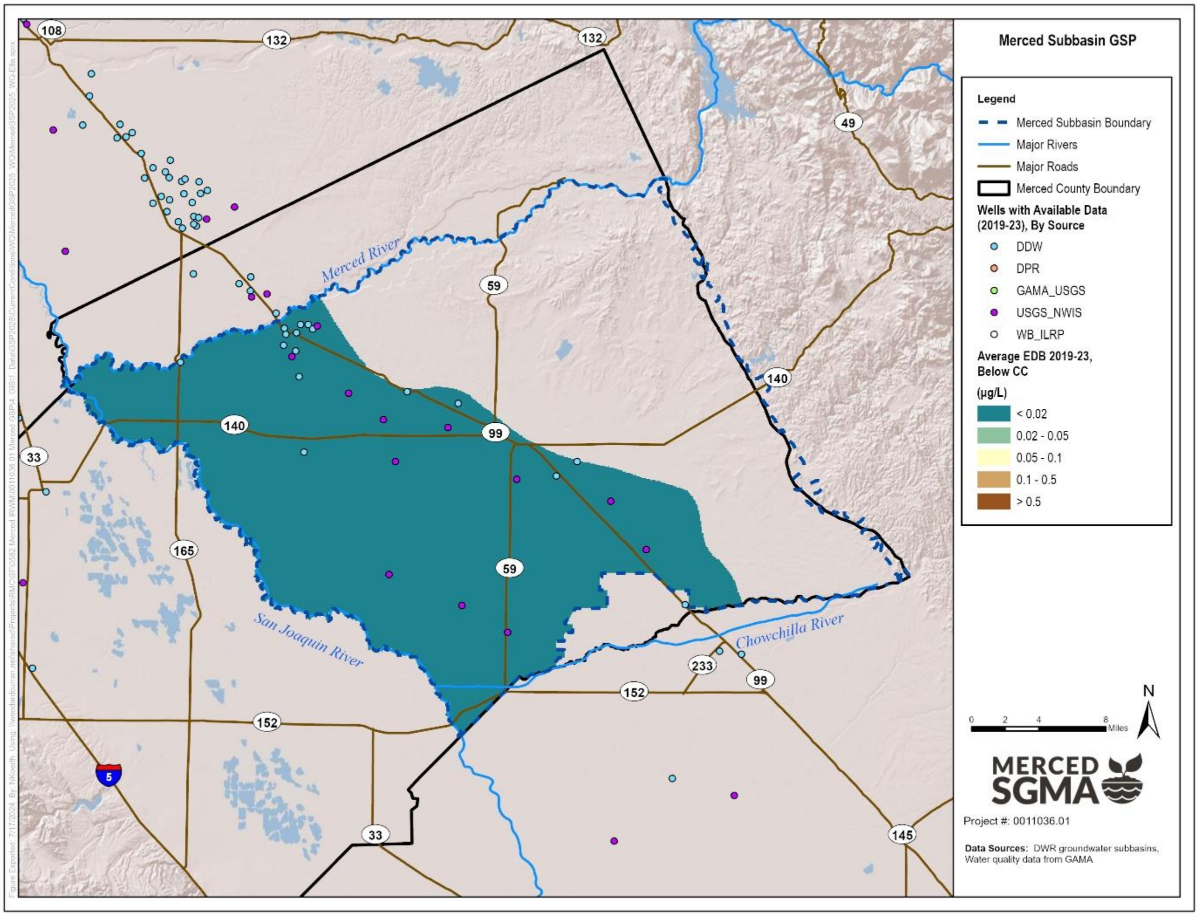


Figure 2-124: Average EDB Concentration 2019-2023, Unknown Aquifer

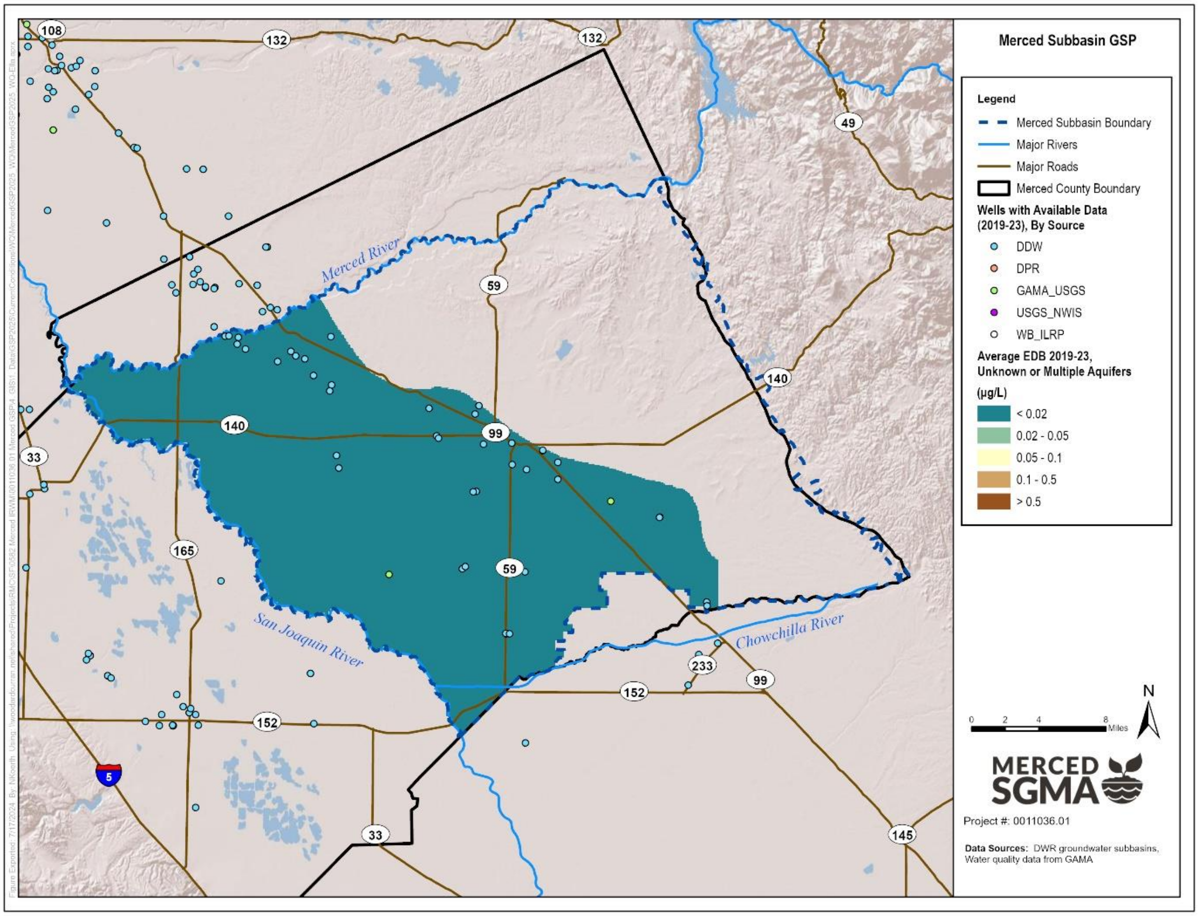
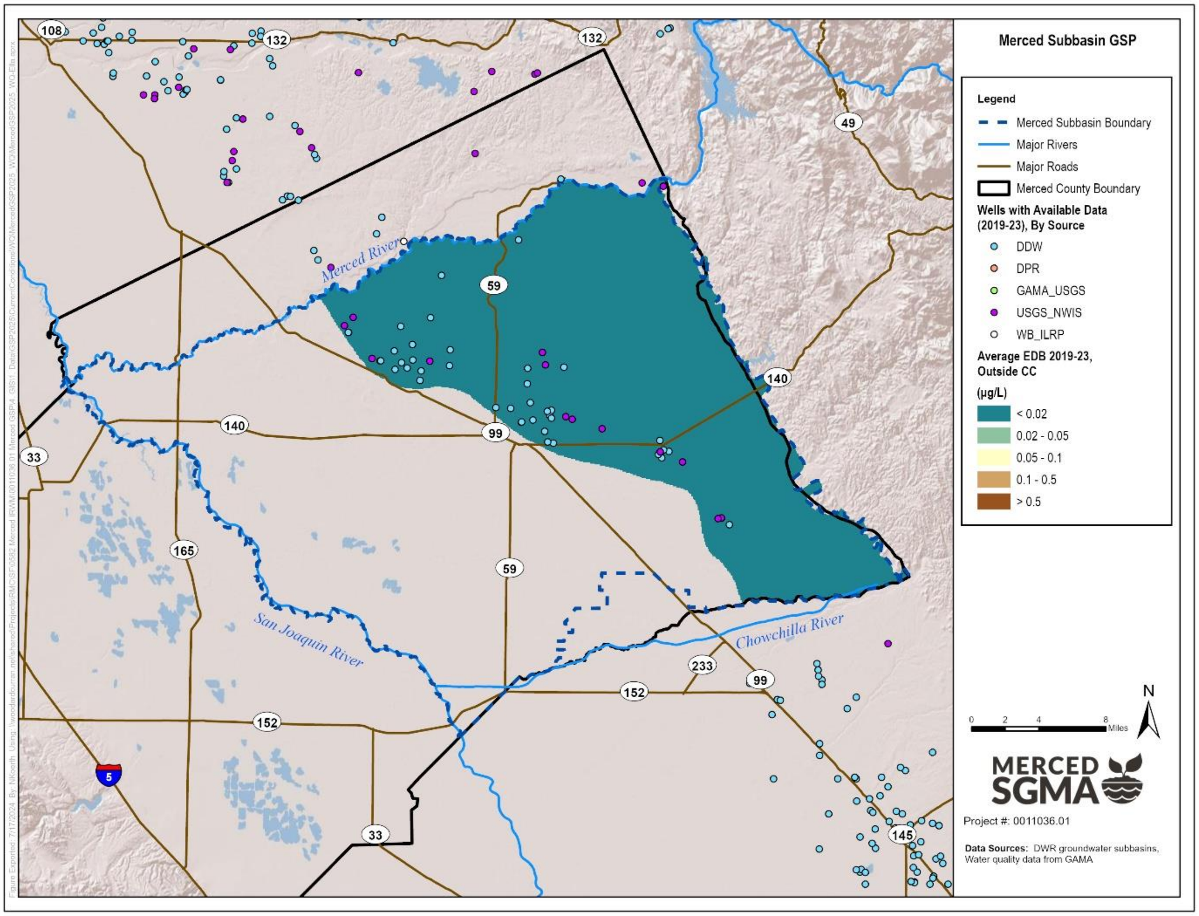


Figure 2-125: Average EDB Concentration 2019-2023, Outside Corcoran Clay

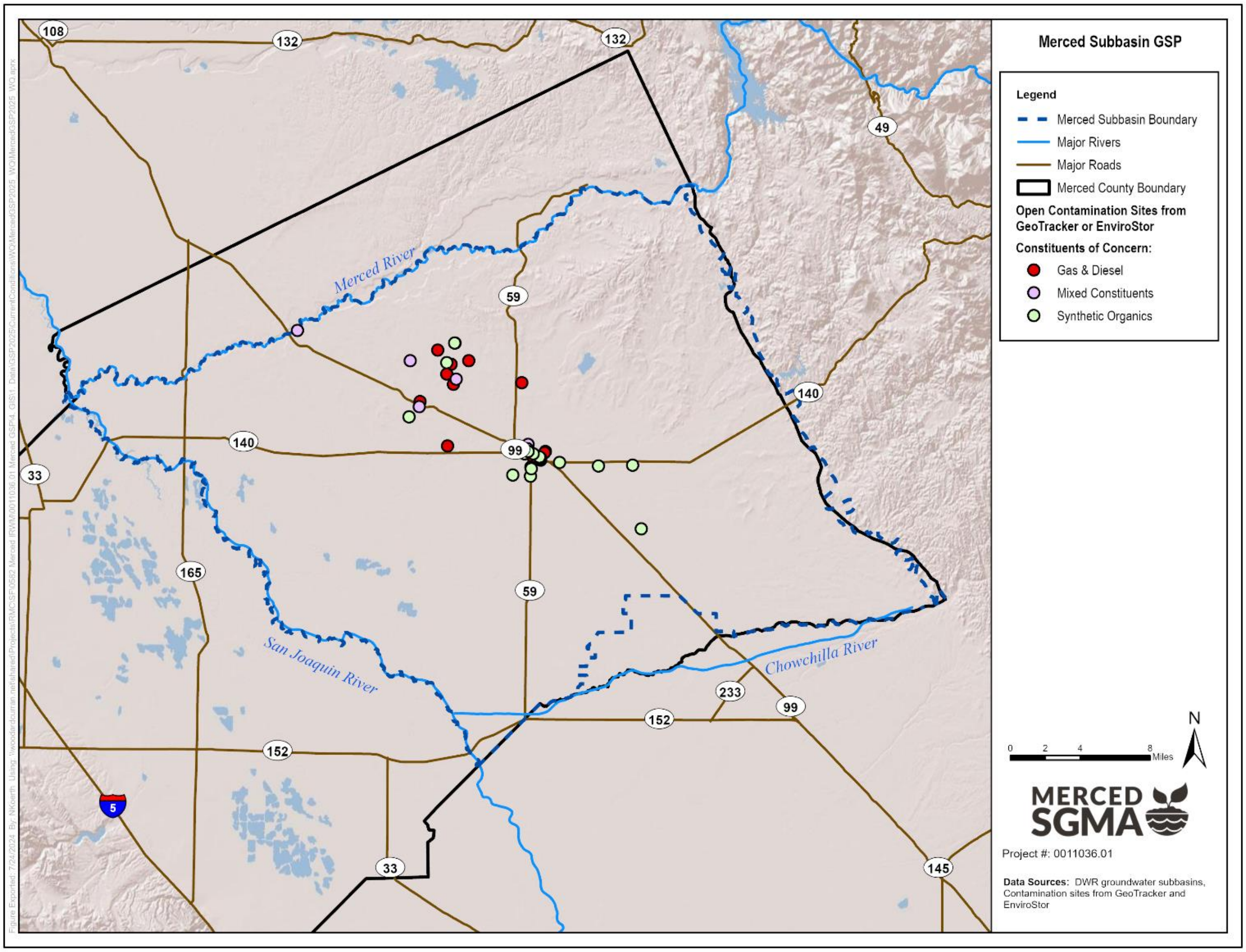


2.2.4.4 Point-Source Contamination

Data collection activities also take place in the Merced Subbasin in response to known or potential sources of groundwater contamination. These sources include areas in and around the former Castle Air Force Base, leaking underground storage tanks, landfills, and others. Groundwater has been monitored and evaluated at the former Castle Air Force Base since the 1980s and has resulted in the removal of contaminant sources and the implementation of remedial activities such as the installation of groundwater treatment facilities (SWRCB - GeoTracker).

The Regional Water Quality Control Board's (RWQCB) GeoTracker GAMA database shows 37 open Leaking Underground Storage Tank (LUST) or other cleanup sites with potential or known groundwater contamination located within the Merced Subbasin. The California Department of Toxic Substances Control (DTSC) EnviroStor database shows 24 additional open cleanup sites with potential or known groundwater contamination located within the Merced Subbasin. Figure 2-126 shows the location of the combined sites from GAMA and EnviroStor, color-coding the sites based on groupings of constituents of concern: gas and diesel, synthetic organics (pesticides, herbicides, etc.), or mixed constituents (multiple categories, such as heavy metals and pesticides).

Figure 2-126: Contaminated Sites (GeoTracker and EnviroStor)



2.2.4.4.1 Petroleum Hydrocarbons

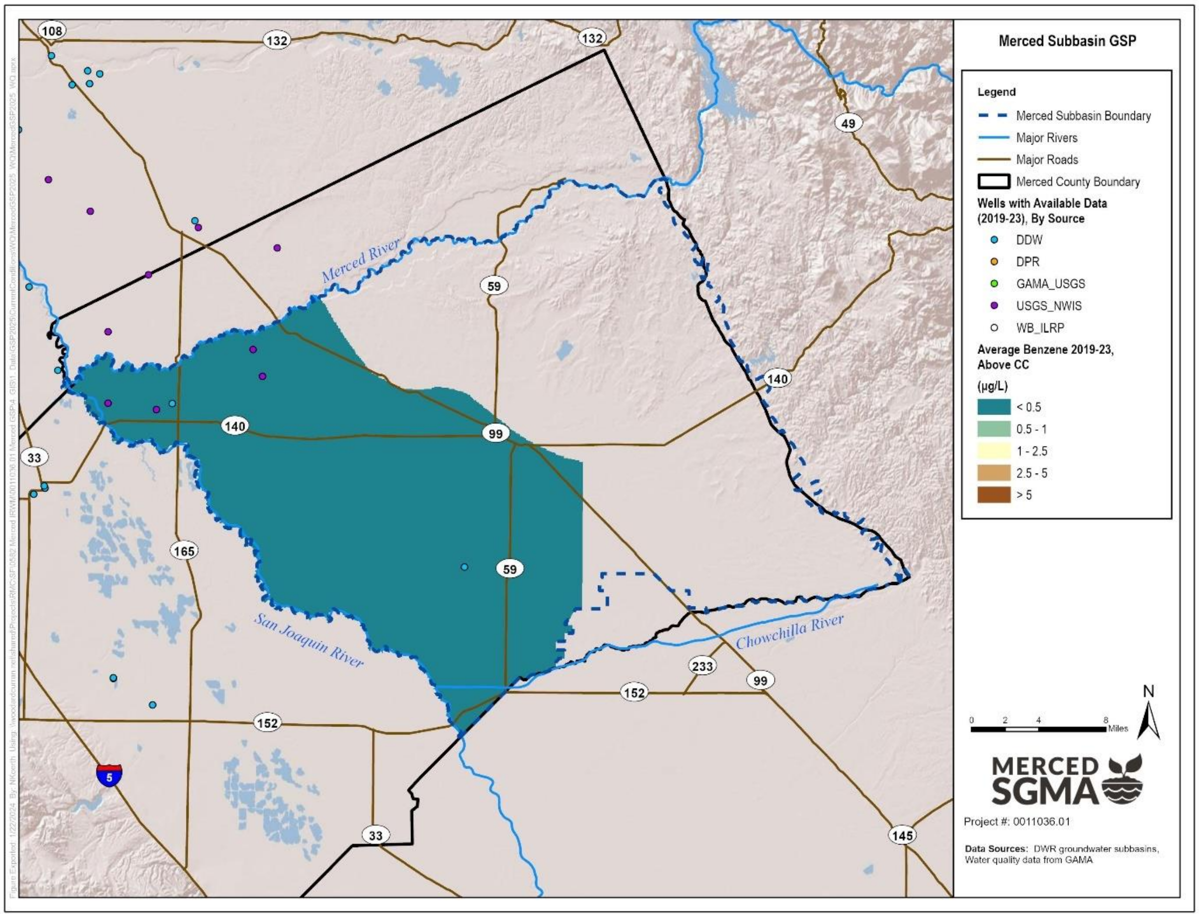
More than 212 unauthorized releases of petroleum hydrocarbons from underground storage tanks have occurred in the Merced Subbasin, according to the SWRCB GeoTracker database. The primary hydrocarbons of concern are benzene and MTBE, both of which are suspected carcinogens.

2.2.4.4.2 Benzene

Benzene concentrations in groundwater in the Merced Subbasin have been below detection limits (variable, but typically less than 0.5 µg/L) since 2015. The primary MCL for benzene is 1 µg/L

(SWRCB, 2018). The 5-year average (2019-2023) benzene concentration in groundwater throughout Merced Subbasin has also remained below detection limits.

Figure 2-127: Average Benzene Concentration 2019-2023, Above Corcoran Clay[22]



[22] Benzene data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-128: Average Benzene Concentration 2019-2023, Below Corcoran Clay

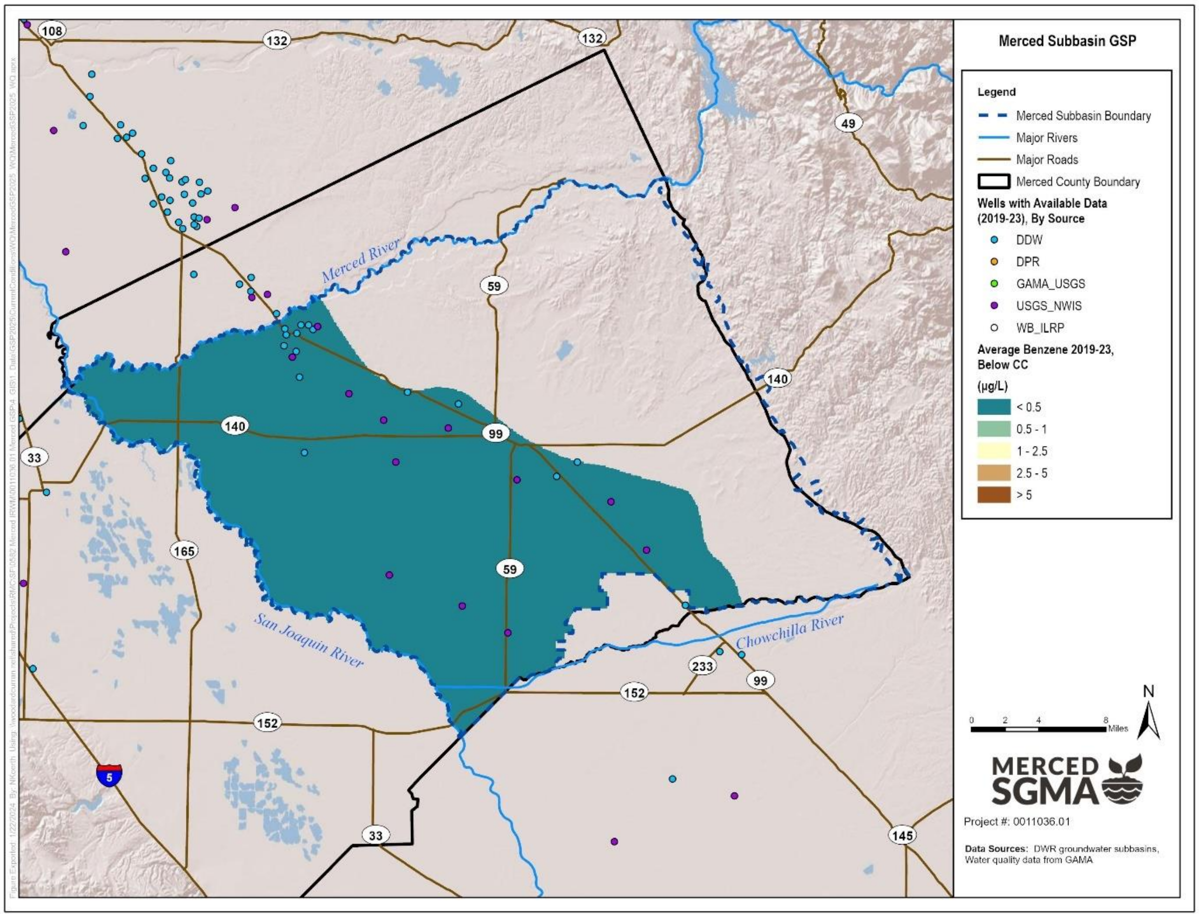


Figure 2-129: Average Benzene Concentration 2019-2023, Unknown Aquifer

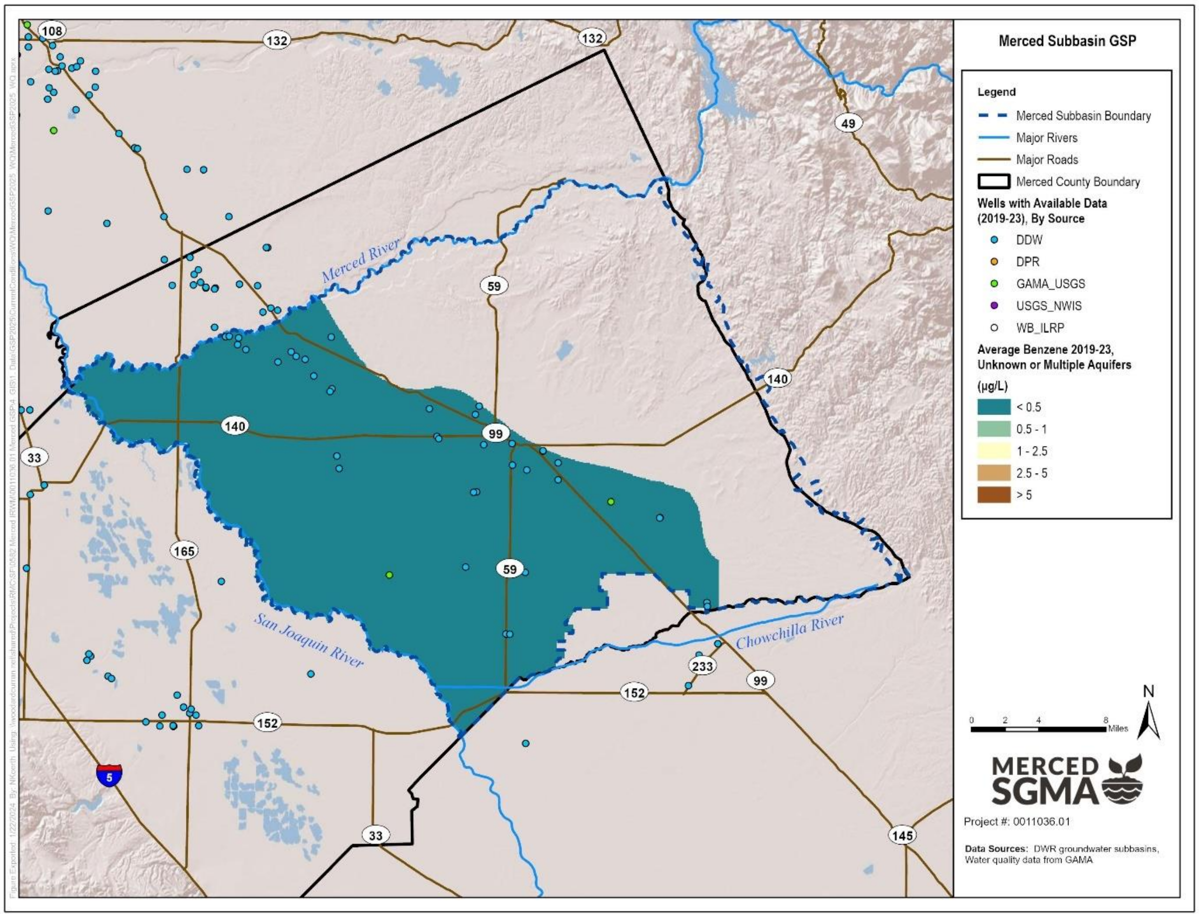
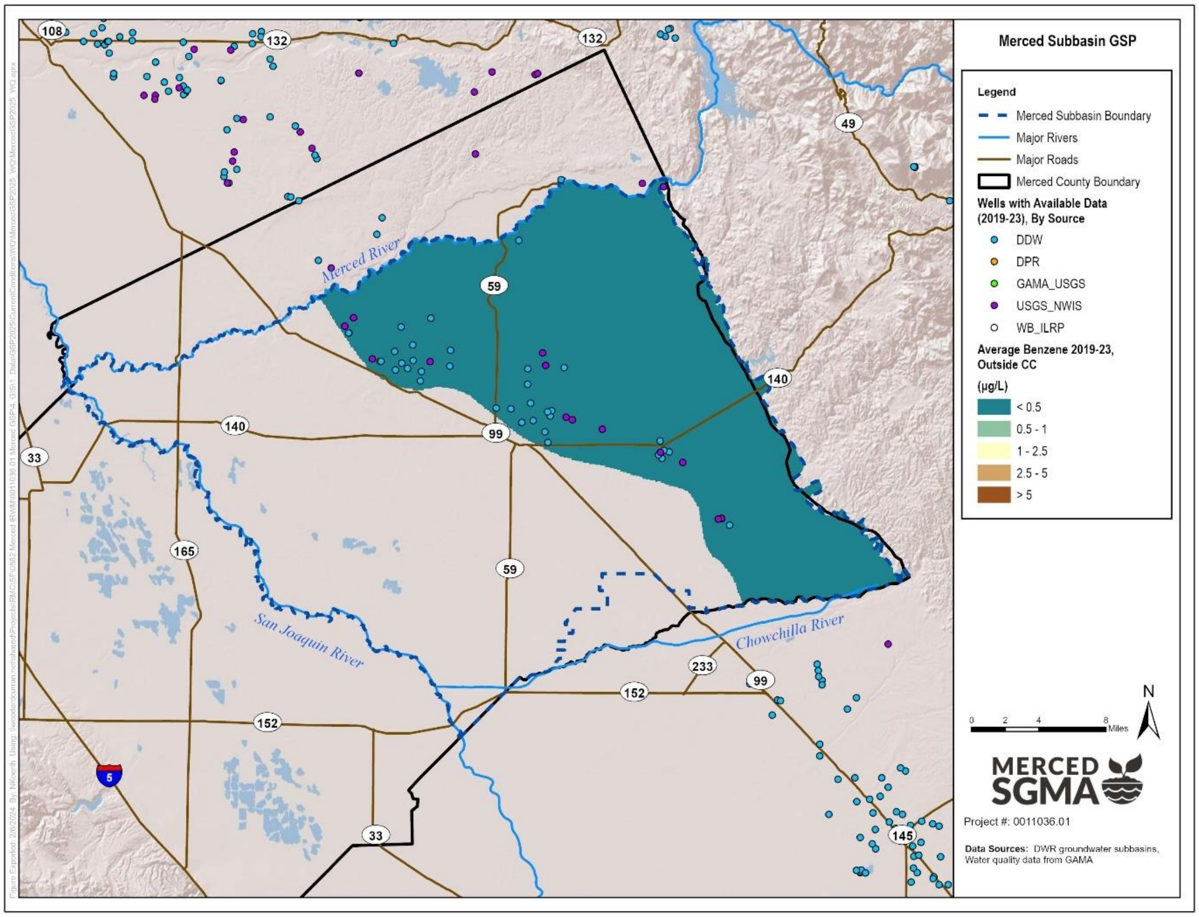


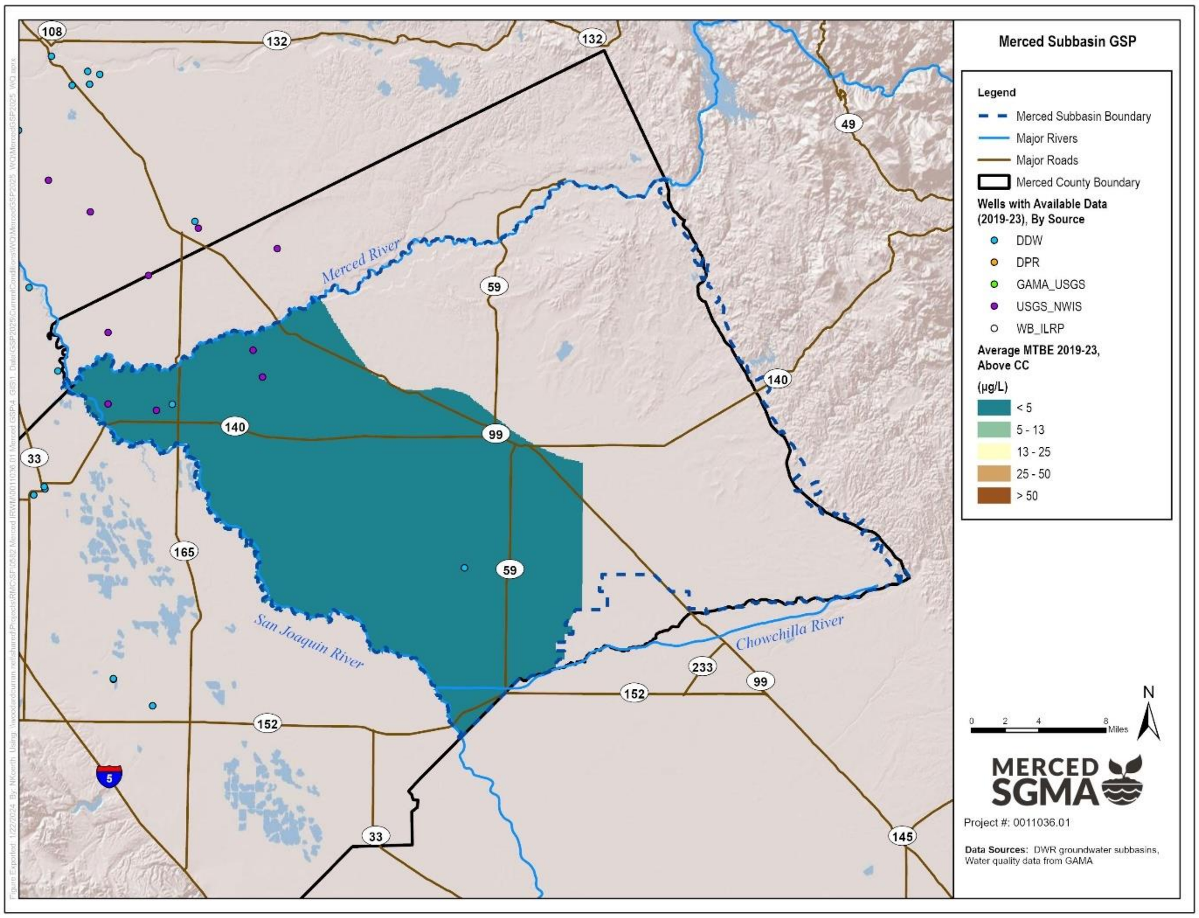
Figure 2-130: Average Benzene Concentration 2019-2023, Outside Corcoran Clay



2.2.4.4.4 Methyl Tertiary Butyl Ether (MTBE)

MTBE concentrations in groundwater in the Merced Subbasin have remained below detection limits (variable, but typically less than 3 µg/L[23]) since 2015. The primary MCL for MTBE is 13 µg/L (SWRCB, 2018). A secondary MCL of 5 µg/L was established to address taste and odor concerns. The 5-year average (2019-2023) MTBE concentration in groundwater throughout the Merced Subbasin remains below 5 µg/L.

Figure 2-131: Average MTBE Concentration 2019-2023, Above Corcoran Clay[24]



[23] The detection limit for the purpose of reporting to the Division of Drinking Water is 3 µg/L. This is the level DDW is confident about the quantity being reported, though some labs may report results at lower concentrations.

[24] MTBE data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-132: Average MTBE Concentration 2019-2023, Below Corcoran Clay

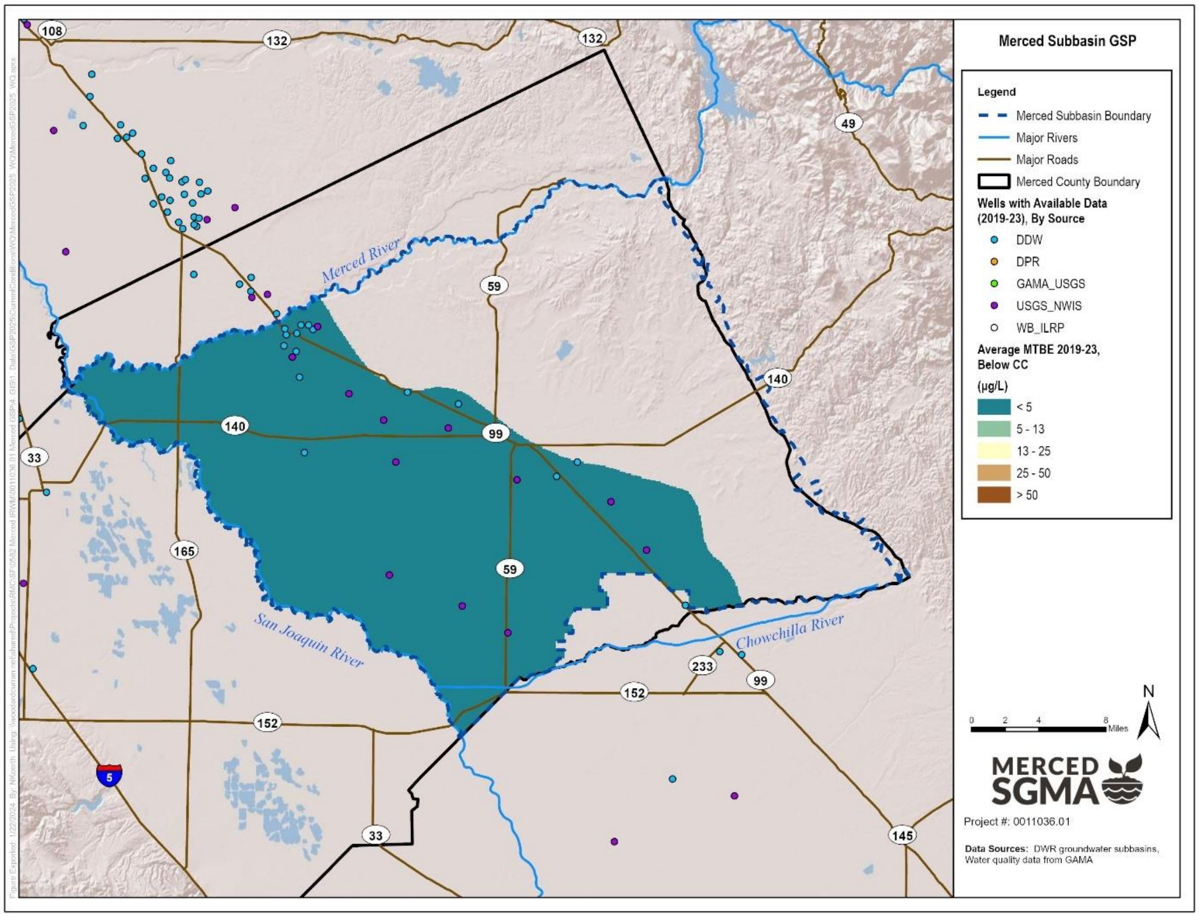


Figure 2-133: Average MTBE Concentration 2019-2023, Unknown Aquifer

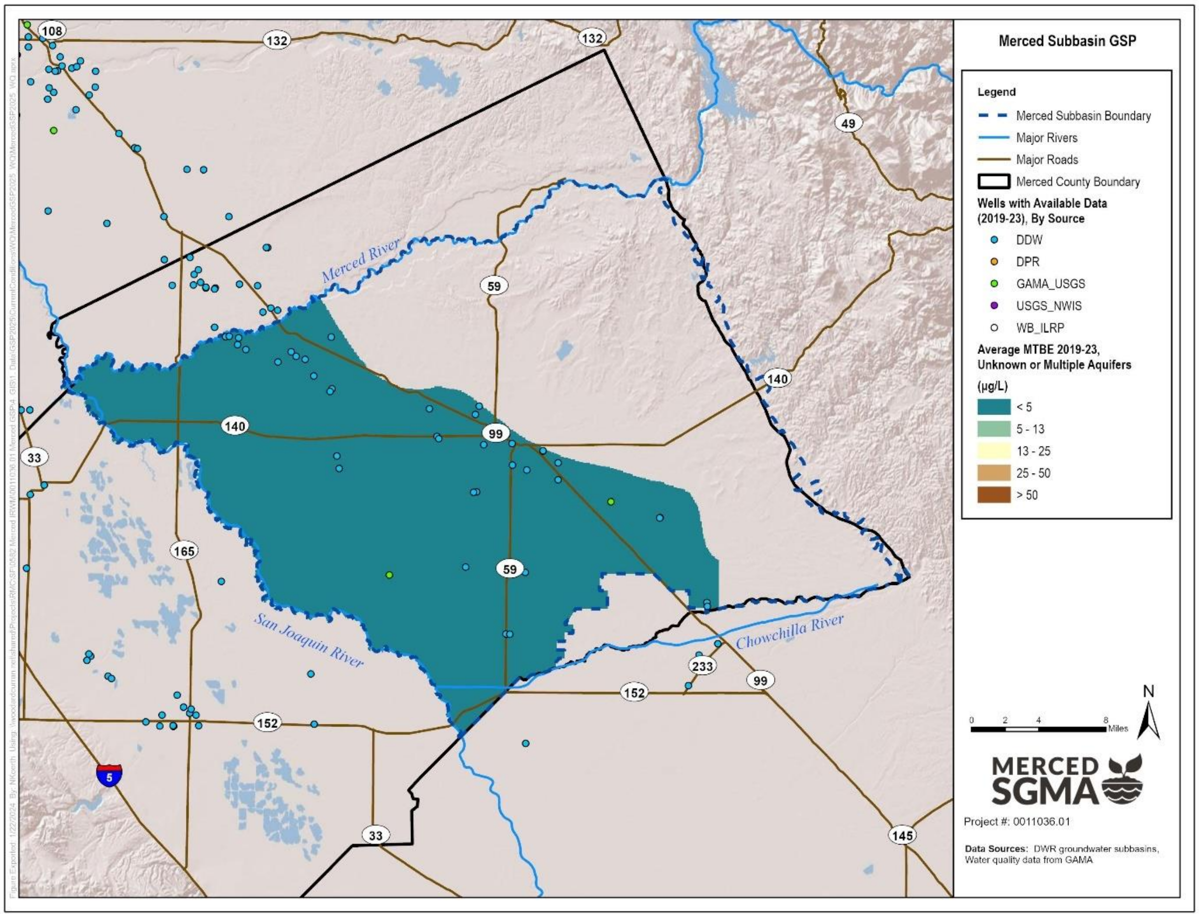
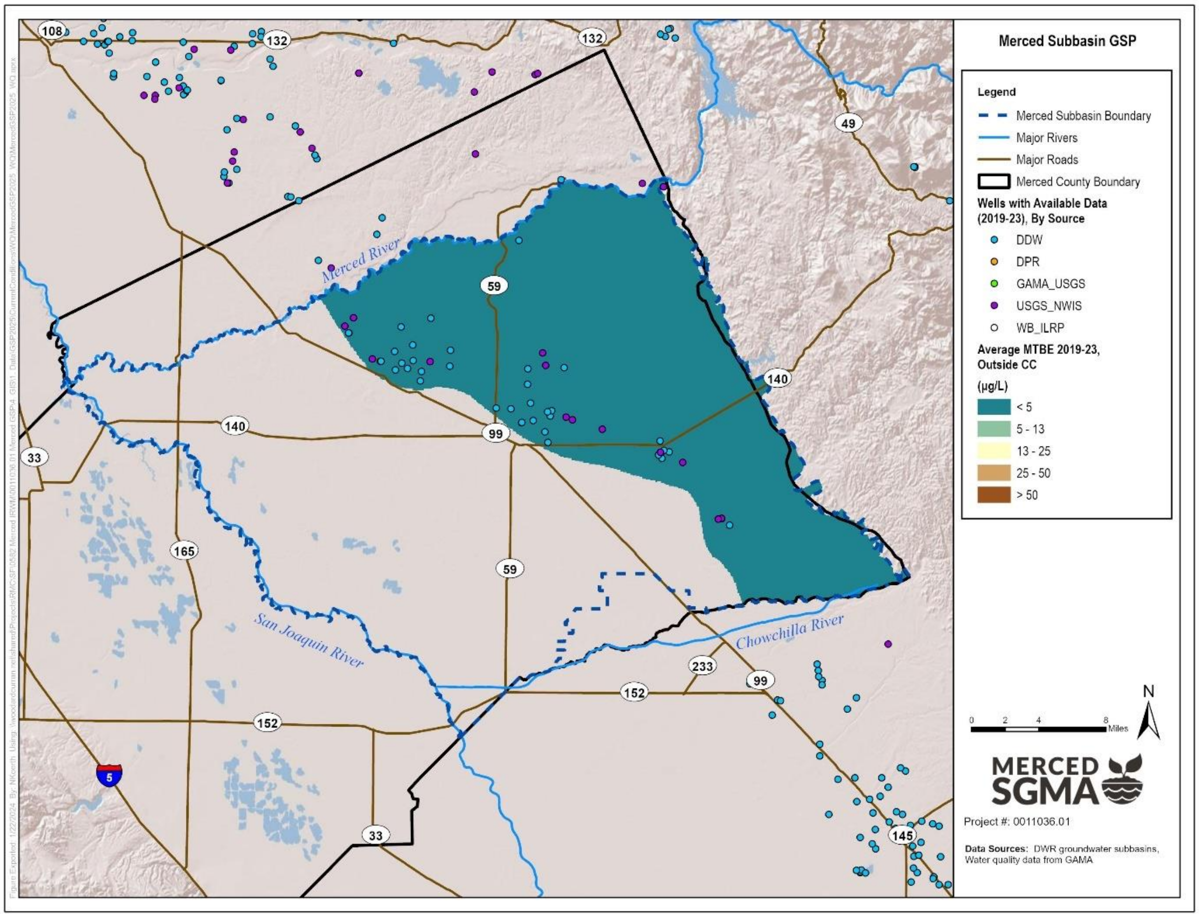


Figure 2-134: Average MTBE Concentration 2019-2023, Outside Corcoran Clay



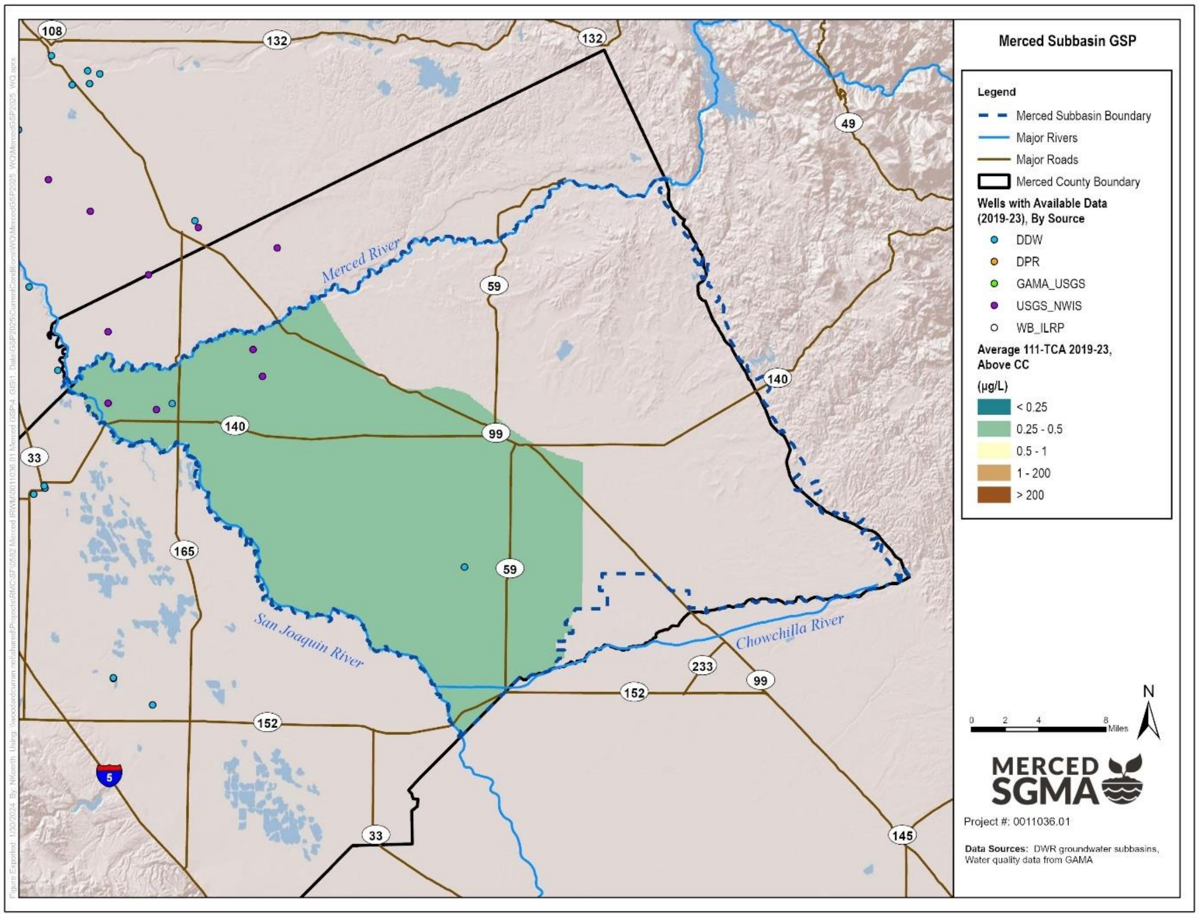
2.2.4.5 Solvents

Solvents includes subsections for 1,1,1-Trichloroethane (111-TCA), Tetrachloroethylene (PCE), and Trichloroethylene (TCE).

2.2.4.5.1 1,1,1-Trichloroethane (111-TCA)

The VOC 111-TCA is a commonly used solvent utilized in manufacturing facilities, auto repair shops, and various other uses within the Merced Subbasin. 111-TCA concentrations in groundwater in the Merced Subbasin have remained below detectable limits (variable, but typically 0.5 µg/L) since 2015. The primary MCL for 111-TCA is 200 µg/L (SWRCB, 2018). The 5--year average (2019-2023) 111-TCA concentration in groundwater throughout the Merced Subbasin has remained below 0.5 µg/L.

Figure 2-135: Average 111-TCA Concentration 2019-2023, Above Corcoran Clay[25]



[25] 111-TCA data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-136: Average 111-TCA Concentration 2019-2023, Below Corcoran Clay

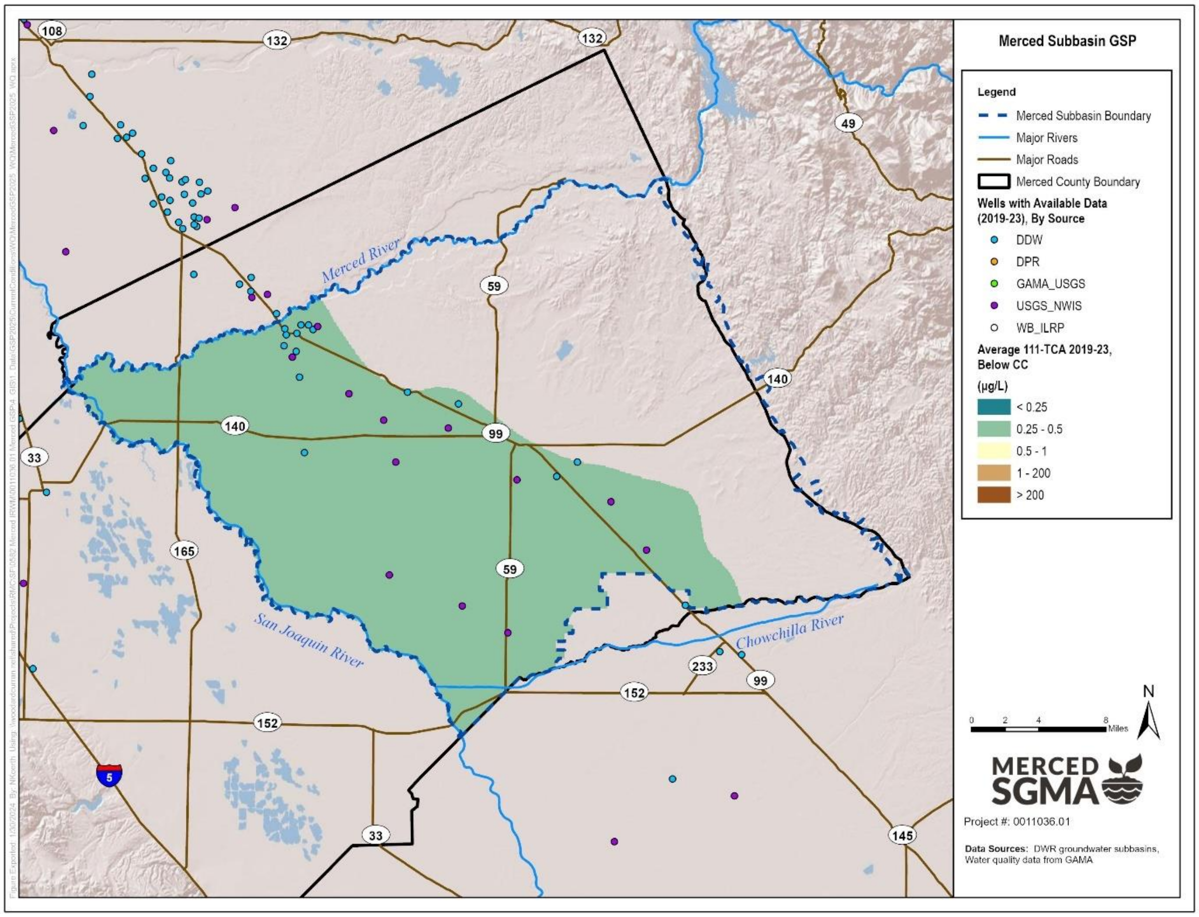


Figure 2-137: Average 111-TCA Concentration 2019-2023, Unknown Aquifer

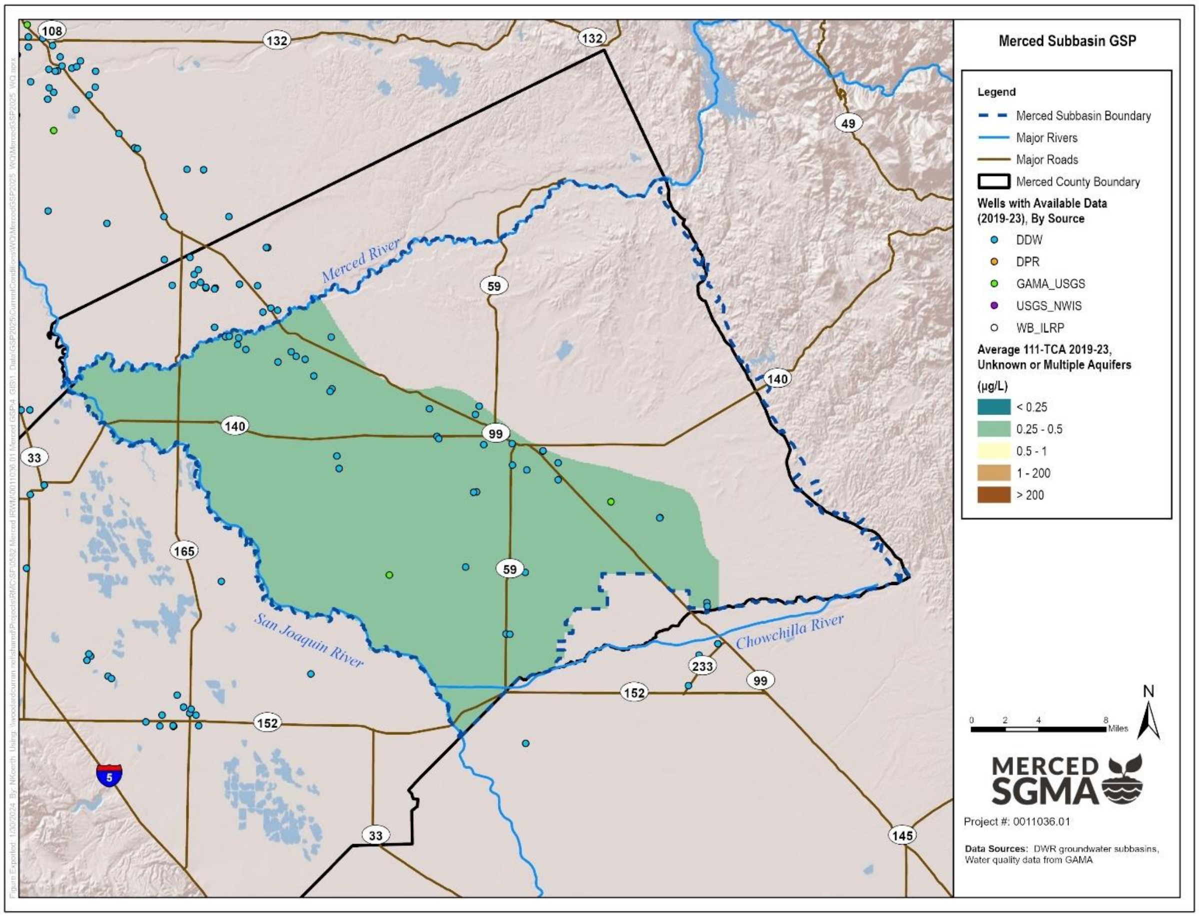
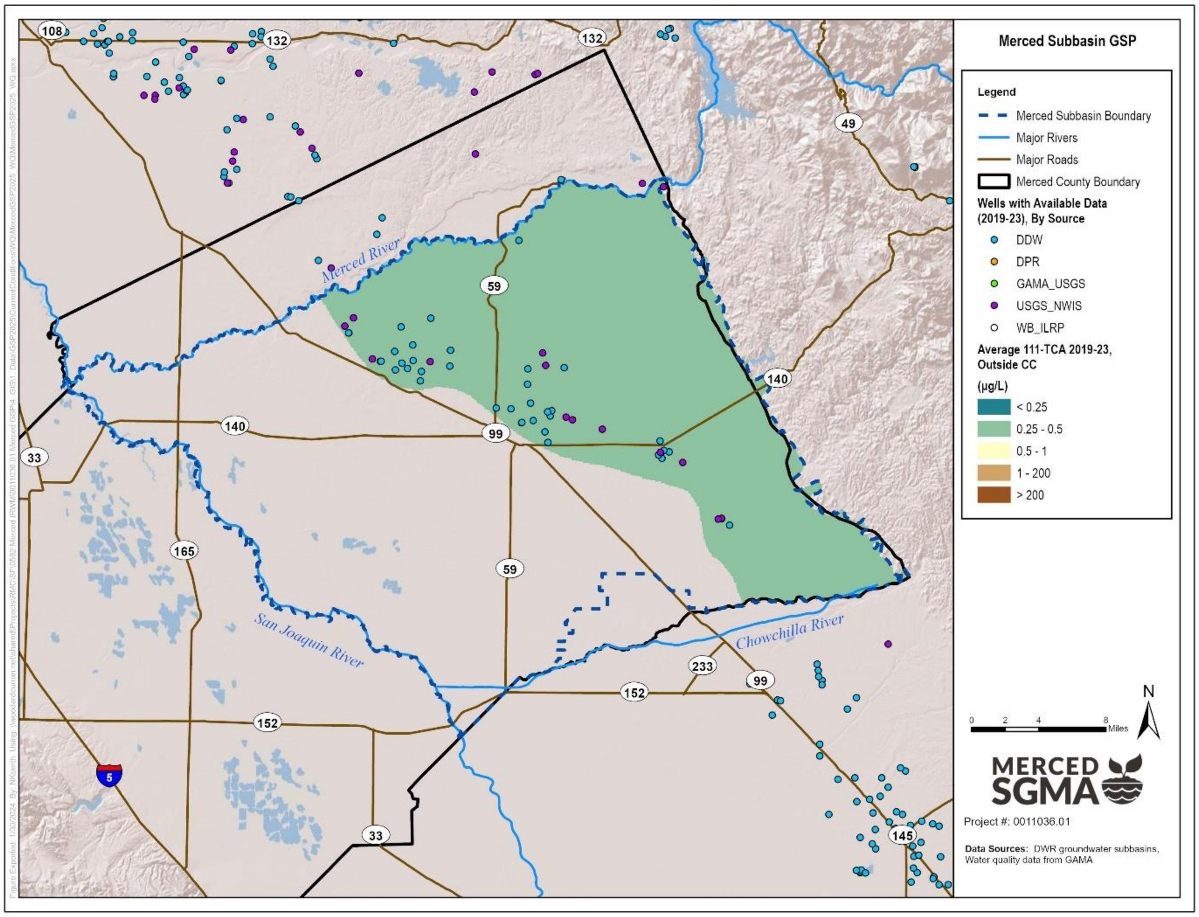


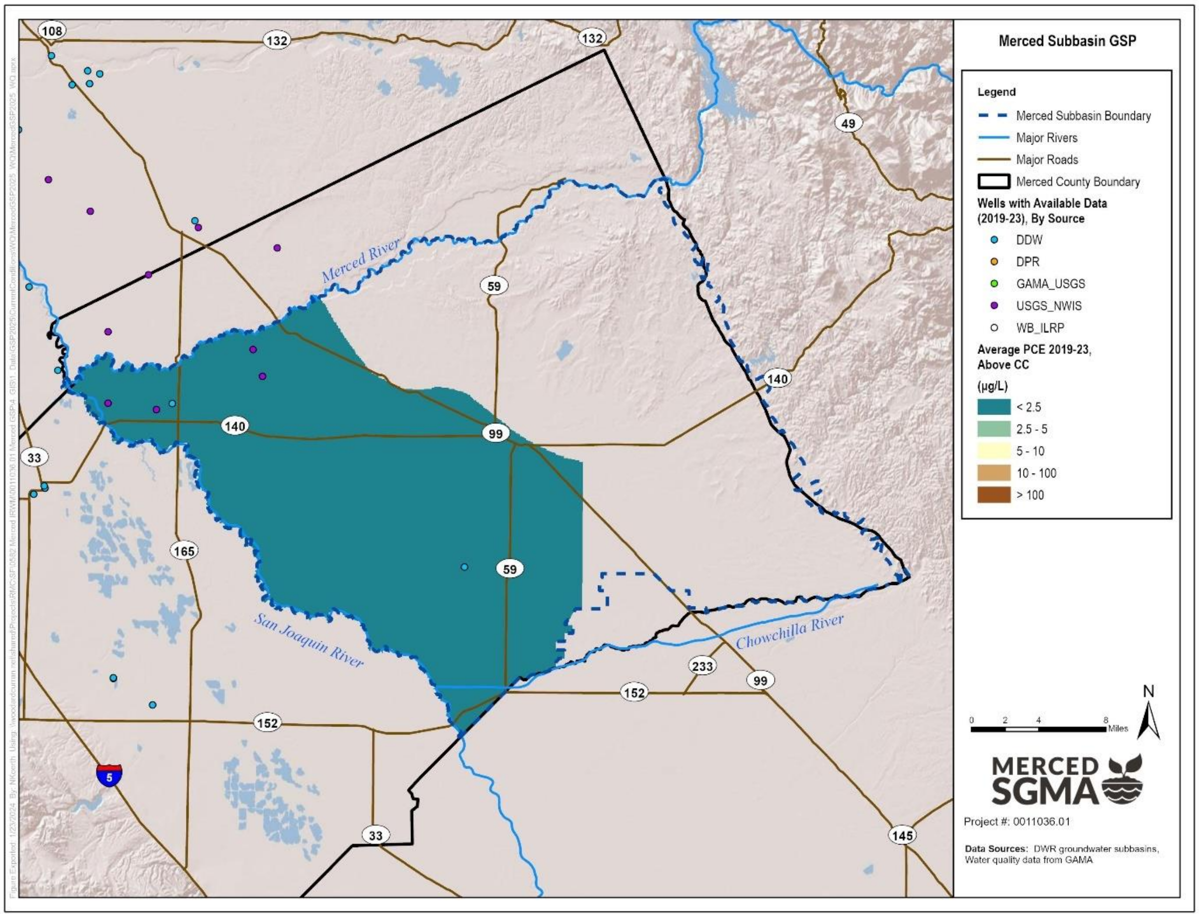
Figure 2-138: Average 111-TCA Concentration 2019-2023, Outside Corcoran Clay



2.2.4.5.2 Tetrachloroethylene (PCE)

The VOC PCE is a commonly used solvent in manufacturing facilities and dry cleaners. PCE concentrations in groundwater in the Merced Subbasin range from non-detect (0.5 µg/L) to over 3.5 µg/L since 2015 (Figure 2-143). The primary MCL for PCE is 5 µg/L (SWRCB, 2018). The 5-year average (2019-2023) PCE concentration in groundwater in the Merced Subbasin is generally less than 2.5 µg/L.

Figure 2-139: Average PCE Concentration 2019-2023, Above Corcoran Clay[26]



[26] PCE data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-140: Average PCE Concentration 2019-2023, Below Corcoran Clay

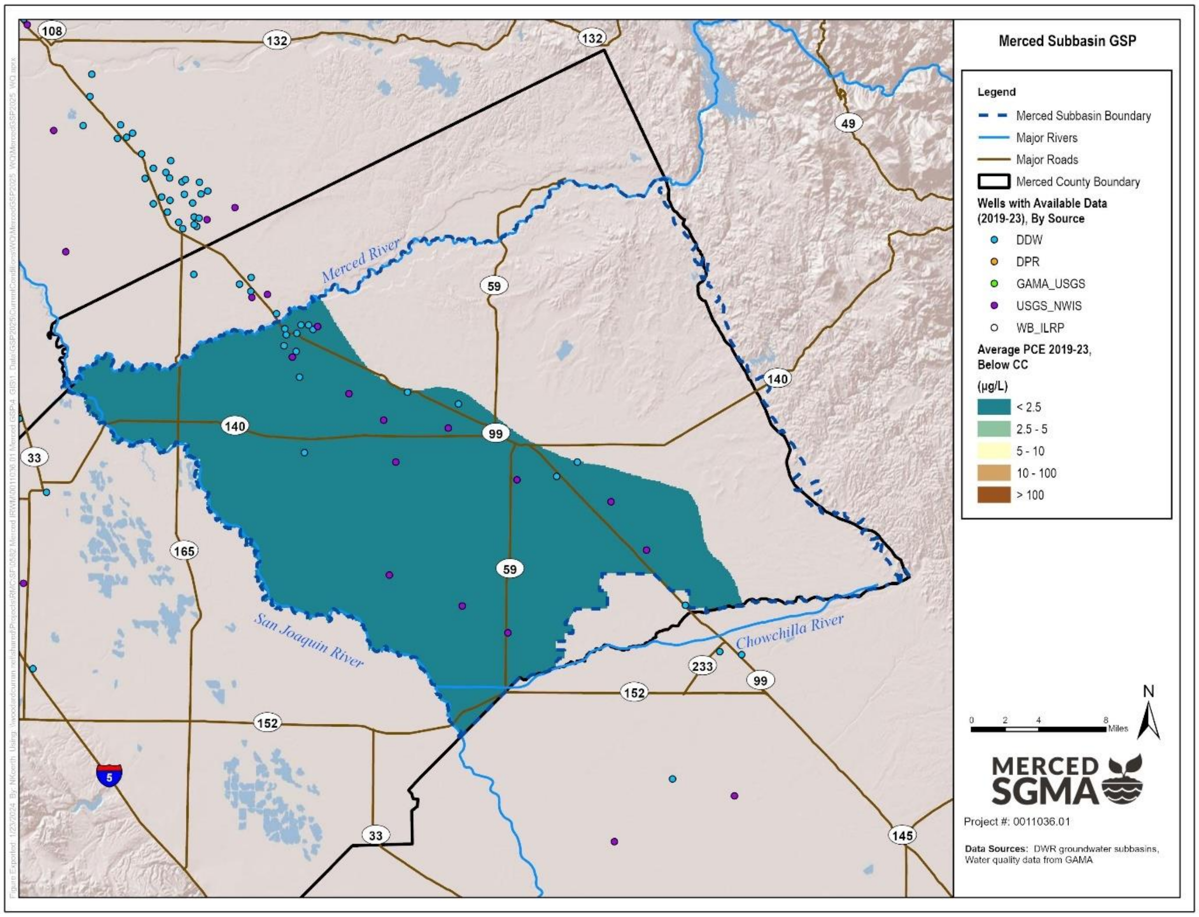


Figure 2-141: Average PCE Concentration 2019-2023, Unknown Aquifer

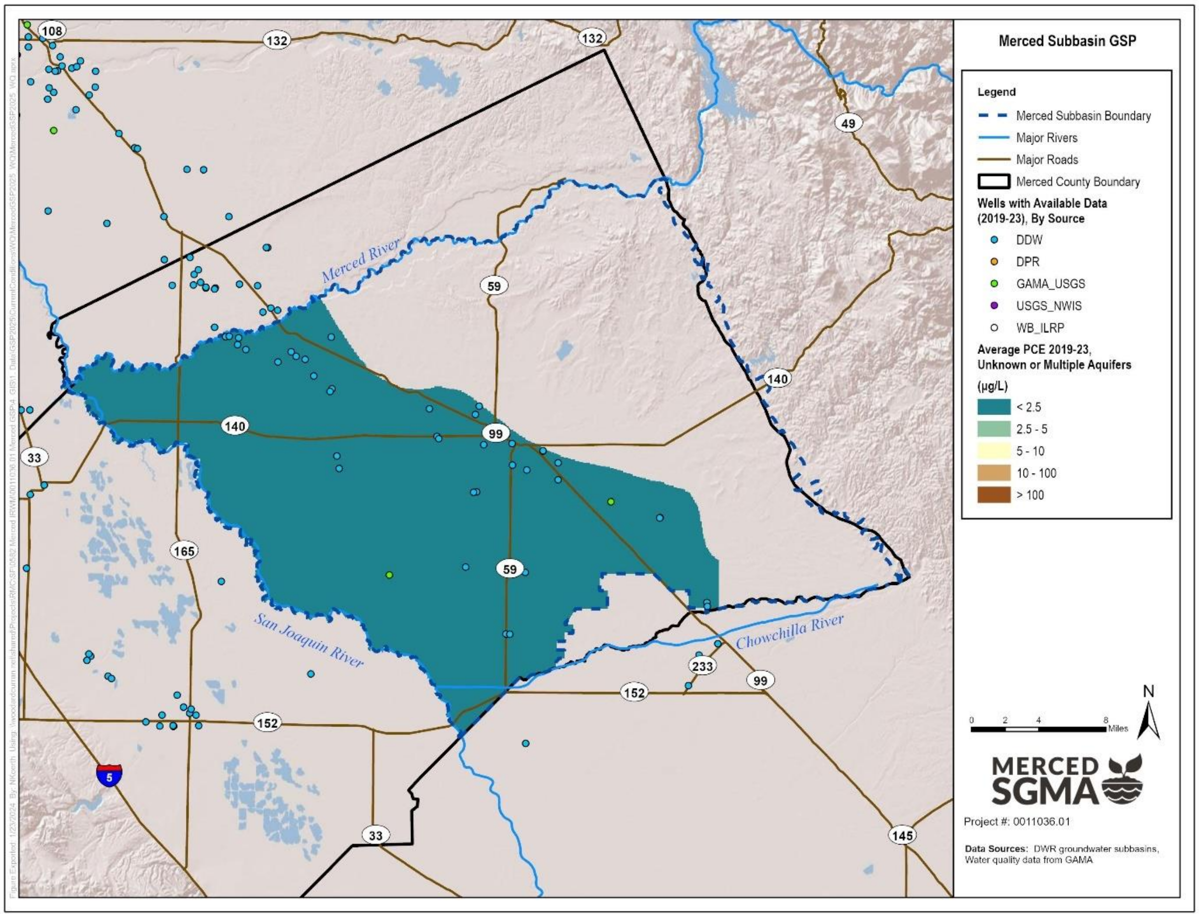


Figure 2-142: Average PCE Concentration 2019-2023, Outside Corcoran Clay

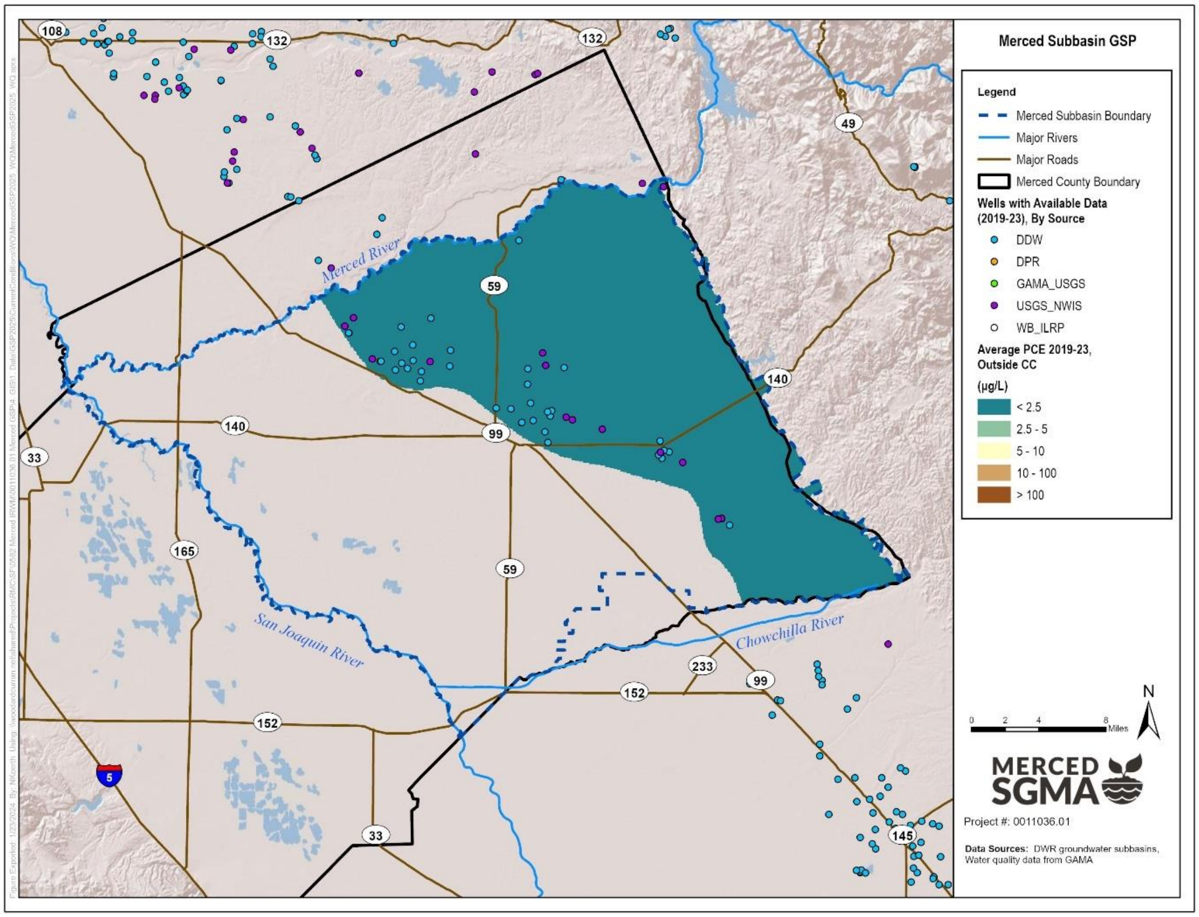
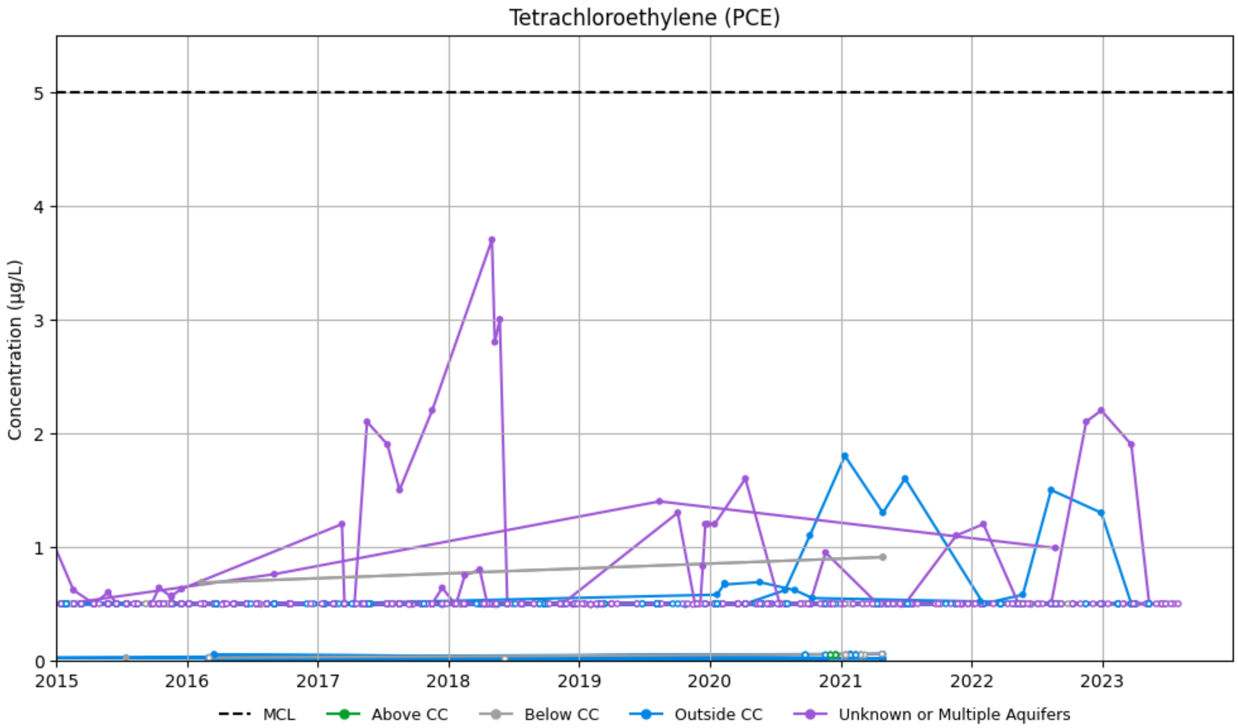


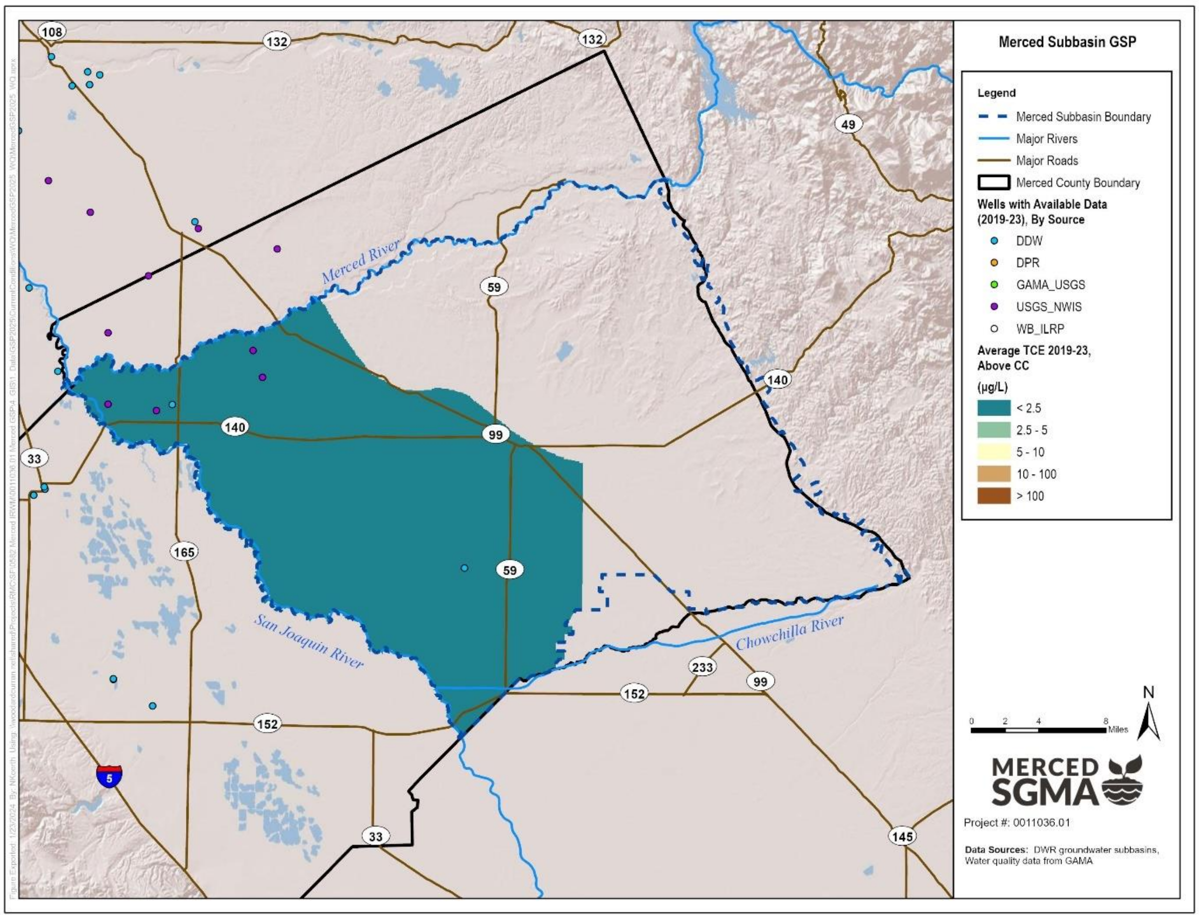
Figure 2-143: PCE Time Series Concentrations from 2015-2023, by Well



2.2.4.5.3 Trichloroethylene (TCE)

The VOC TCE is a commonly used solvent in manufacturing facilities. TCE concentrations in groundwater in the Merced Subbasin range from non-detect (0.5 µg/L) to 2 µg/L. The primary MCL for TCE is 5 µg/L (SWRCB, 2018). The 5-year average (2019-2023) TCE concentration in groundwater in the Merced Subbasin is generally less than 2.5 µg/L. While not shown directly in the figure, the Merced IRWMP indicates that elevated concentrations can be found in localized areas in the northwest quadrant and along Highway 140 beneath a point source (RMC Water and Environment, 2013a).

Figure 2-144: Average TCE Concentration 2019-2023, Above Corcoran Clay[27]



[27] TCE data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-145: Average TCE Concentration 2019-2023, Below Corcoran Clay

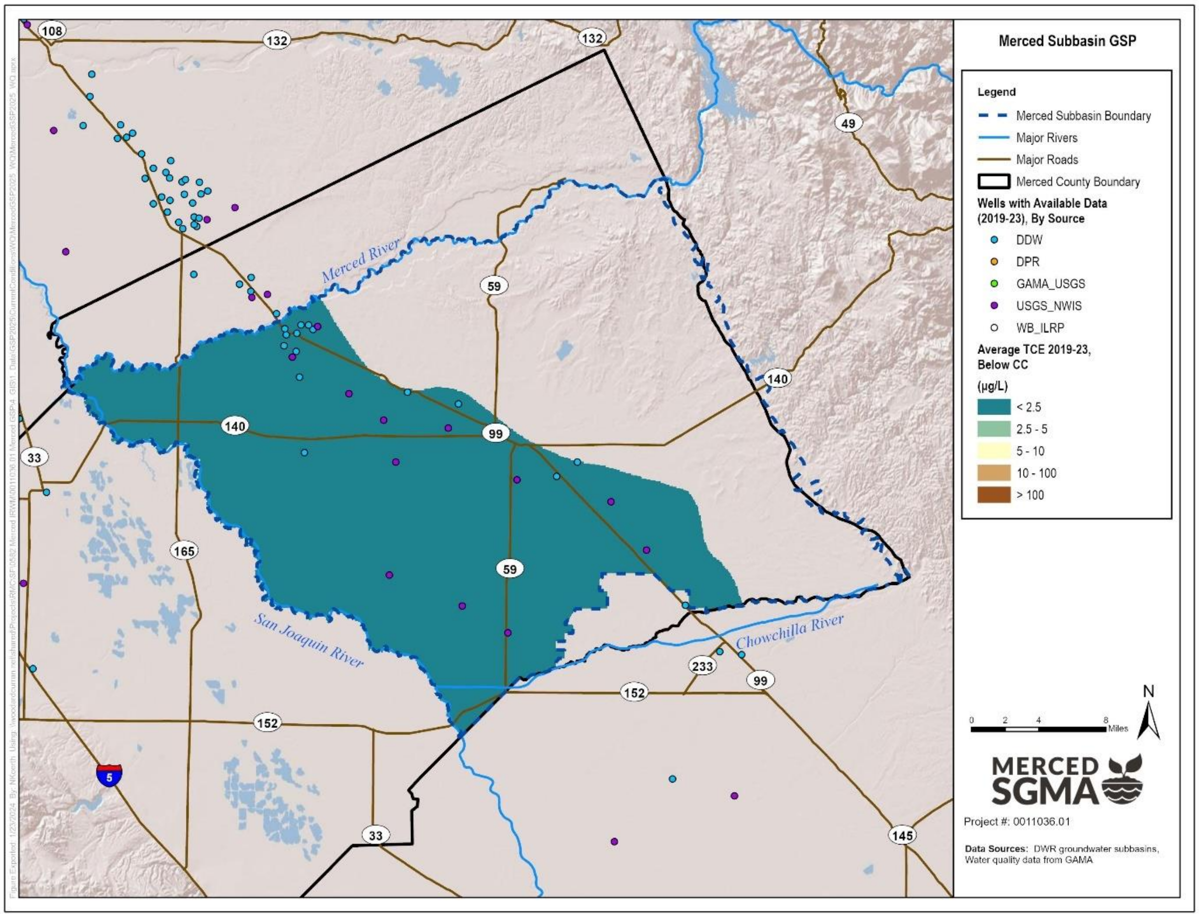


Figure 2-146: Average TCE Concentration 2019-2023, Unknown Aquifer

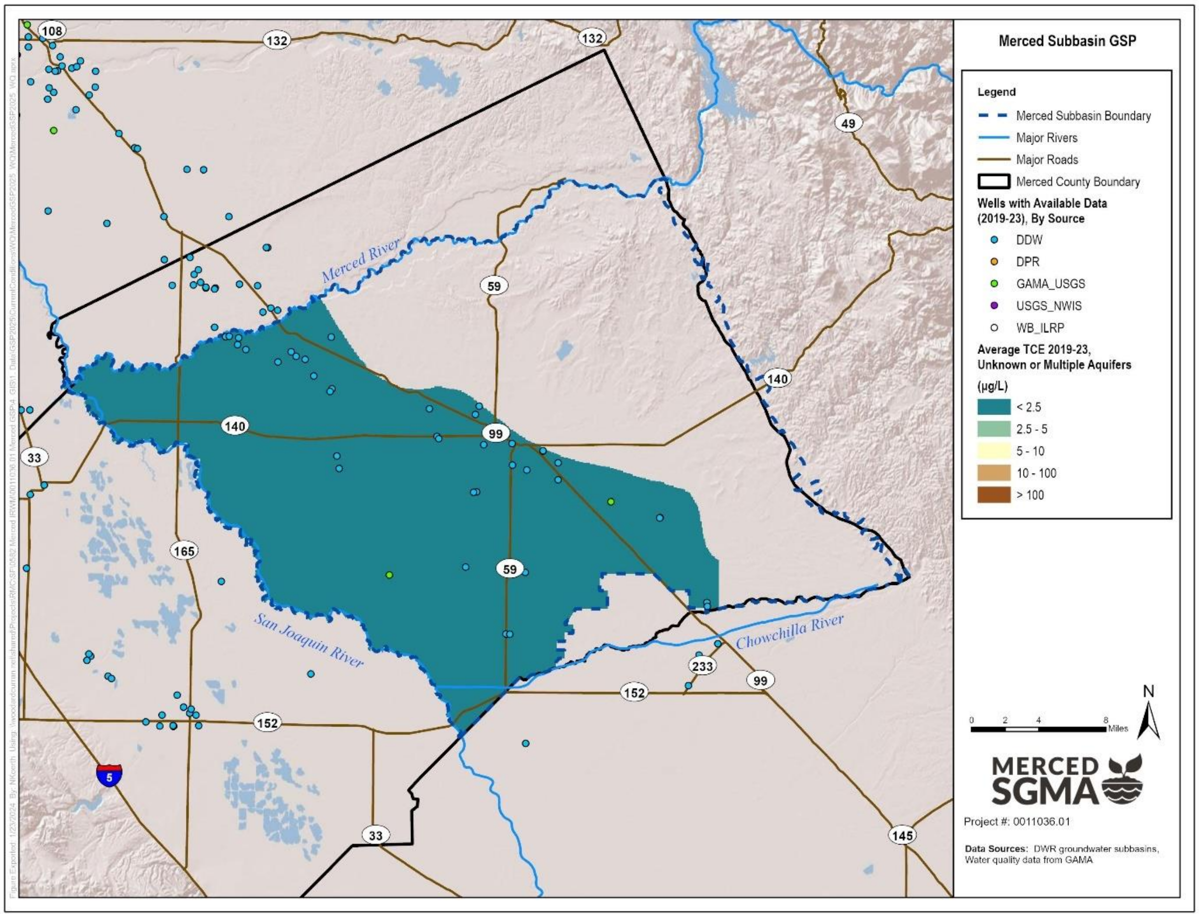


Figure 2-147: Average TCE Concentration 2019-2023, Outside Corcoran Clay

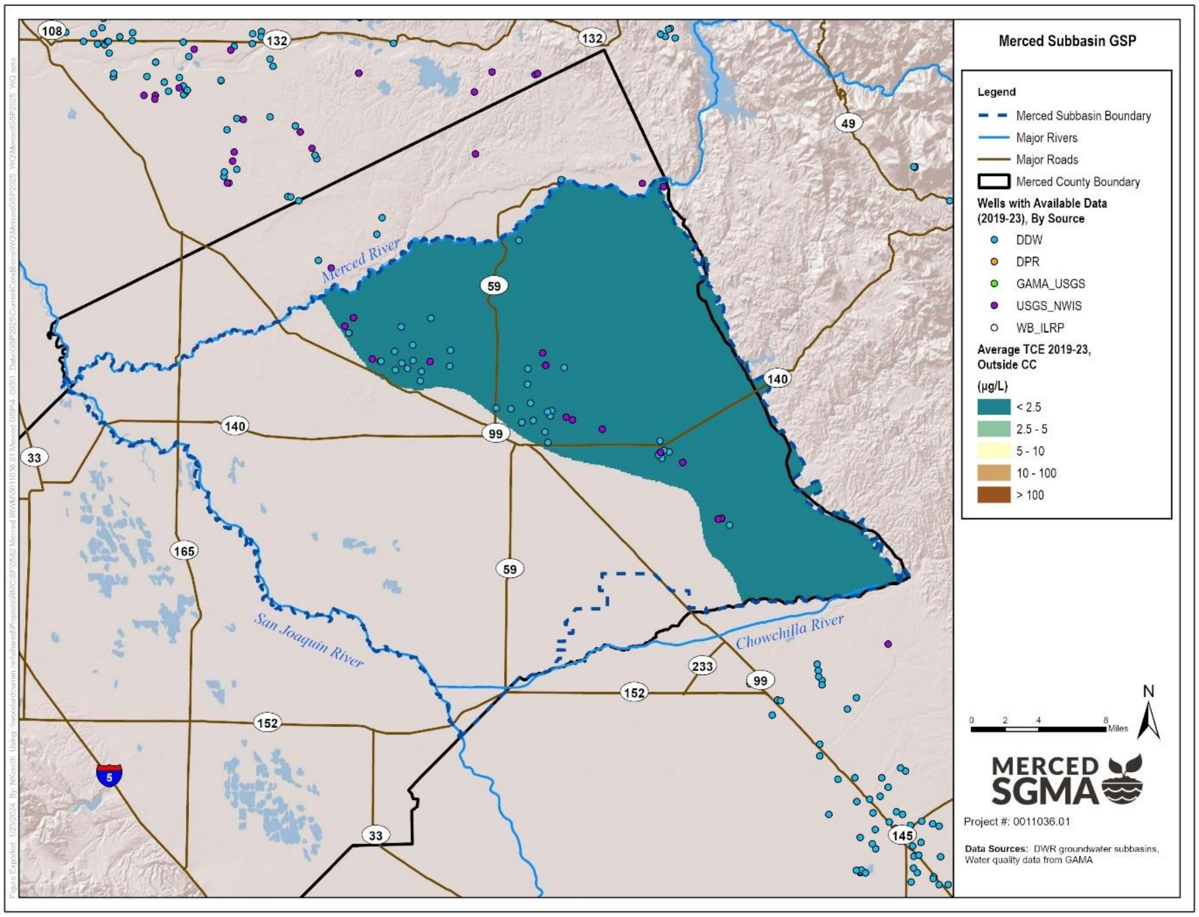
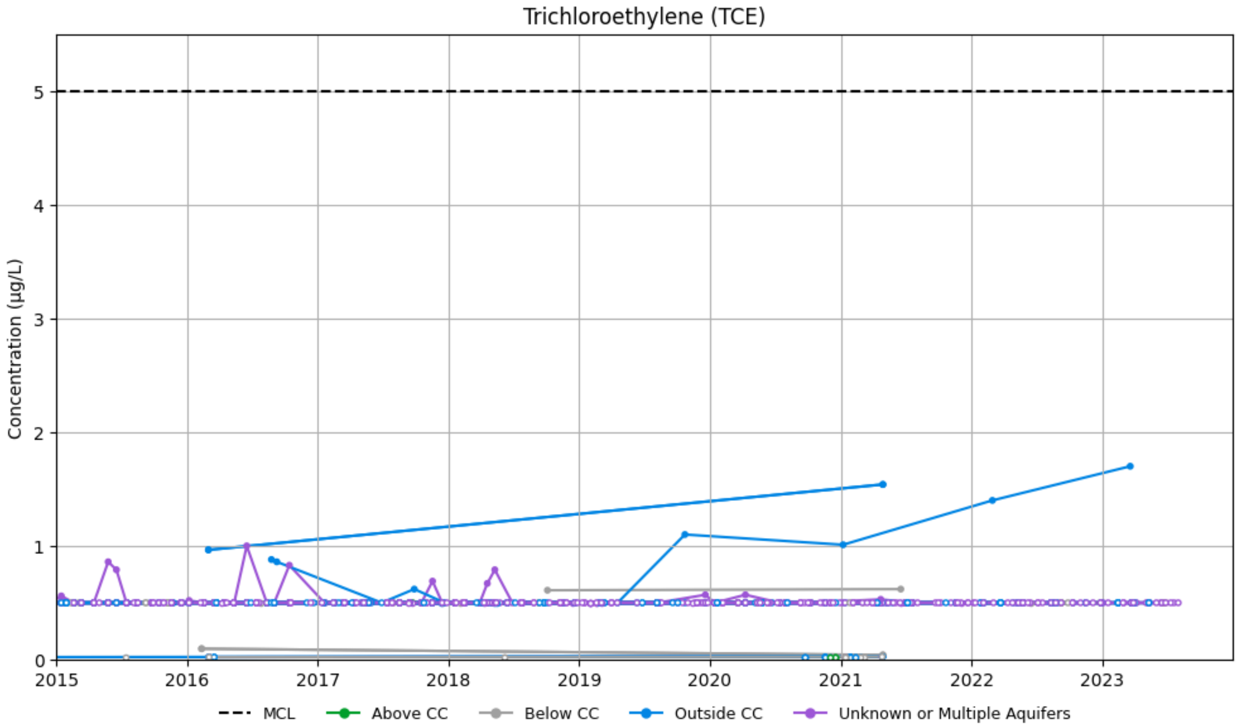


Figure 2-148: TCE Time Series Concentrations from 2015-2023, by Well



2.2.4.6 Emerging Contaminants

Many chemical and microbial constituents that have not historically been considered as contaminants are occasionally, and in some cases with increasing frequency, detected in groundwater. These newly recognized (or emerging) contaminants are commonly derived from municipal, agricultural, industrial wastewater, and domestic wastewater sources and pathways. These newly recognized contaminants are dispersed to the environment from domestic, commercial, and industrial uses of common household products and include caffeine, artificial sweeteners, pharmaceuticals, cleaning products, and other personal care products. Residual waste products of genetically modified organisms are also of potential concern. A survey for pharmaceuticals at dairies in the Merced Subbasin area completed by UC Davis and the USGS detected pharmaceuticals in shallow groundwater (Watanabe, Harter, and Bergamaschi, 2008 as cited by (AMEC, 2013)).

Perfluorooctanesulfonic acid (PFOS) and perfluorooctantoic acid (PFOA) are organic chemicals synthesized for water and lipid resistance, used in a wide variety of consumer products as well as fire-retarding foam and various industrial processes. These chemicals tend to accumulate in groundwater, though typically in a localized area in association with a specific facility, such as a factory or airfield (California Water Boards, 2018). In 2024, the EPA established MCL and MCL goals for six PFAS compounds, including PFOS and PFOA. The EPA also set a health-based, non-enforceable MCL goal of zero for PFOS and PFOA. However, the primary enforceable MCL for

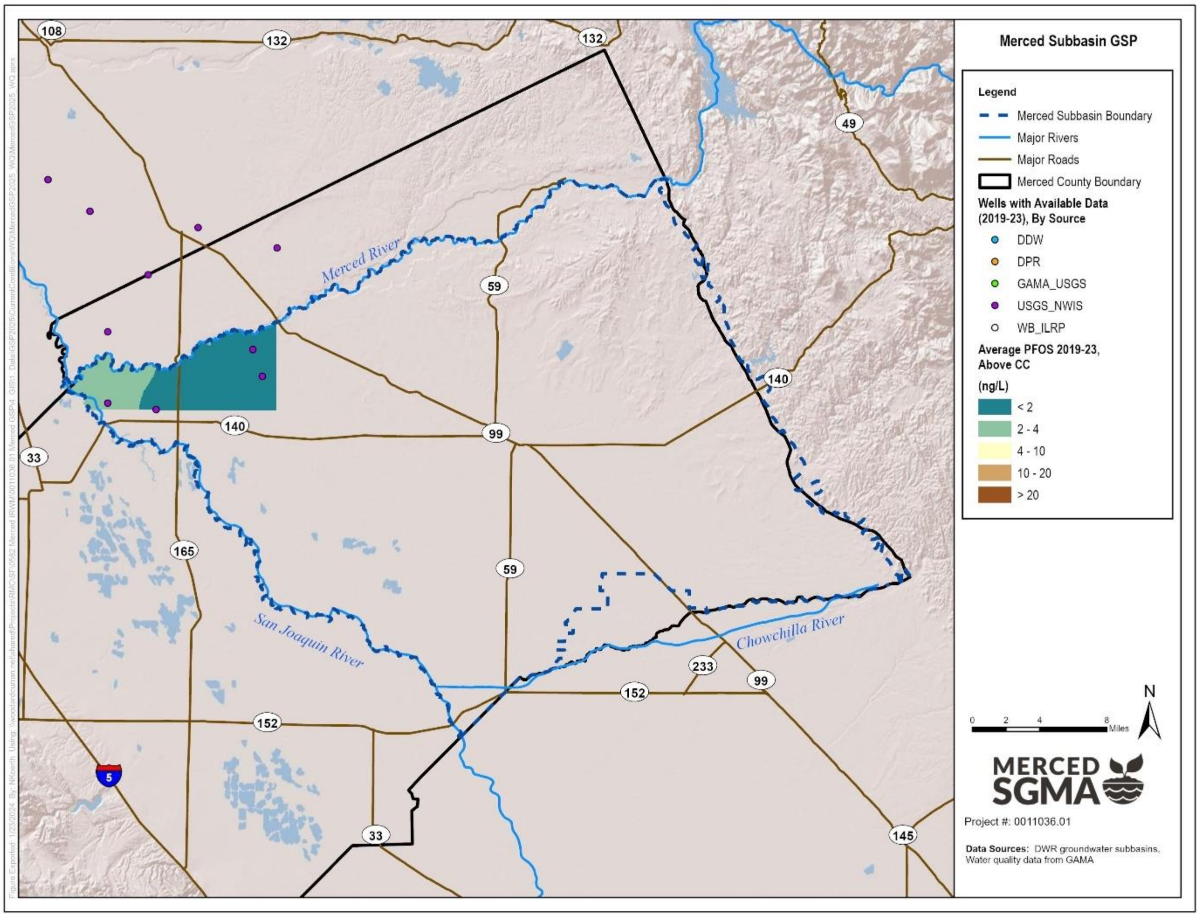
PFOS and PFAS was set at 4 nanograms per liter (ng/L). Public water systems are required to begin initial monitoring for these compounds by 2027 and must start implementing solutions to reduce PFAS concentrations and comply with the MCLs by 2029 (EPA, 2024).

Currently, data on PFOS and PFOA is limited in the Merced Subbasin since these are emerging contaminants. 5-year average (2019-2023) concentrations show PFOS concentrations below 4 ng/L in the Above and Below Corcoran Clay Aquifers (Figure 2-149 and Figure 2-150). However, elevated PFOS concentrations have been seen along Highway 99 between Livingston and Merced in the Unknown Aquifers, and concentrations exceeding 20 ng/L have been detected in the Outside Corcoran Clay Aquifer northeast of Atwater (Figure 2-152). According to the GeoTracker database, both PFOA and PFOS have been detected at the former Castle Air Force Base military cleanup sites. In 2004, USEPA and the State of California concurred that the Air Force was suitably implementing plume capture and cleanup, as measured by TCE concentrations (SWRCB - GeoTracker). However, recent groundwater monitoring reports show PFOS concentrations sampled at the site ranging from 26-264 ng/L[28] (Jacobs, 2024). In 2019, the Department of Defense (DoD) established up a PFAS Task Force to coordinate efforts addressing past PFAS releases related to DoD activities, in compliance with federal cleanup law. A preliminary assessment and site inspection has been completed for the former Castle Air Force Base. A remedial investigation and feasibility study to understand the nature and extent of the PFAS release and develop potential cleanup actions is underway and expected to be completed by 2026[29].

[28] No discharge standards were set for PFAS in the original 1997 Comprehensive Basewise Program for Castle Air Force Base

[29] Based on progress at the 717 instillations being assessed for PFAS use or potential release as of March 31, 2024.

Figure 2-149: Average PFOS Concentration 2019-2023, Above Corcoran Clay[30]



[30] PFOS data availability for wells screened in the Above Corcoran Clay aquifer is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-150: Average PFOS Concentration 2019-2023, Below Corcoran Clay

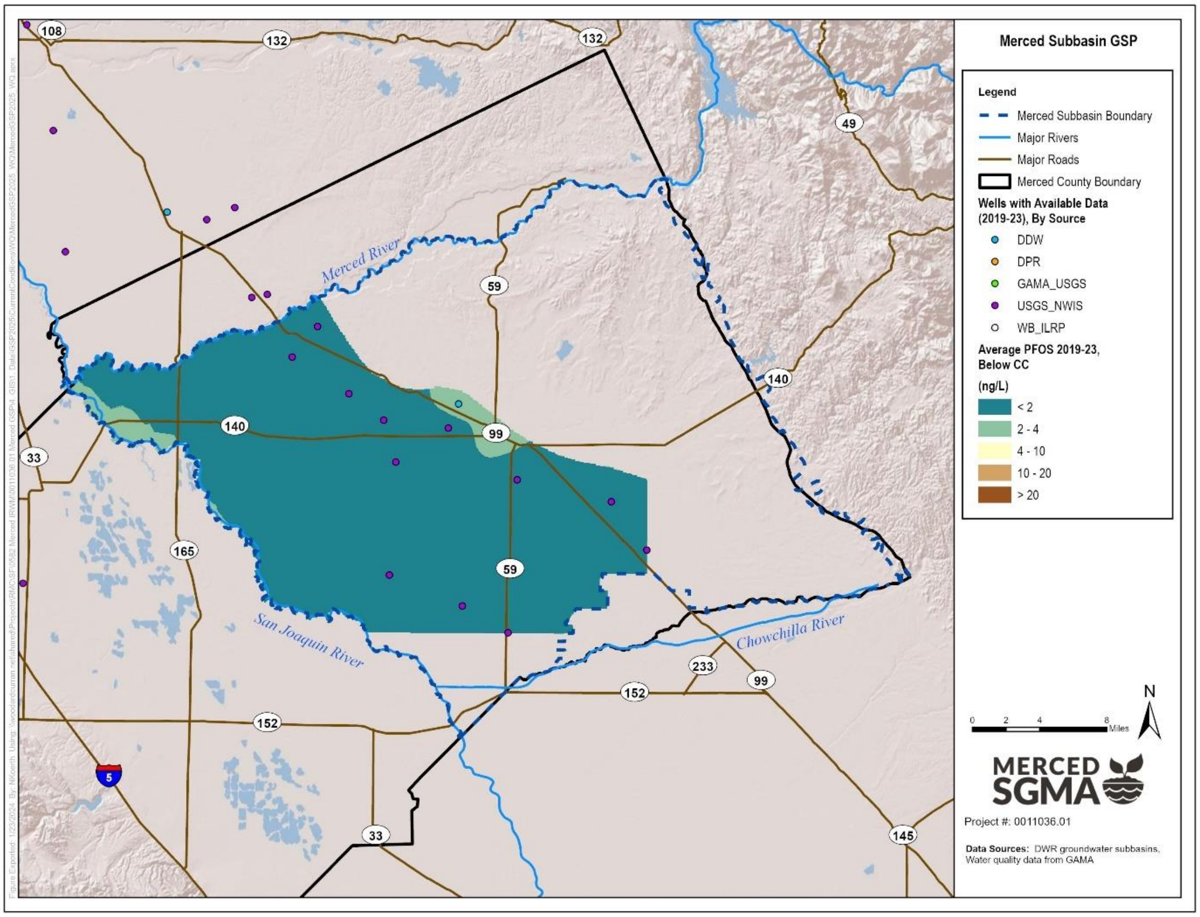
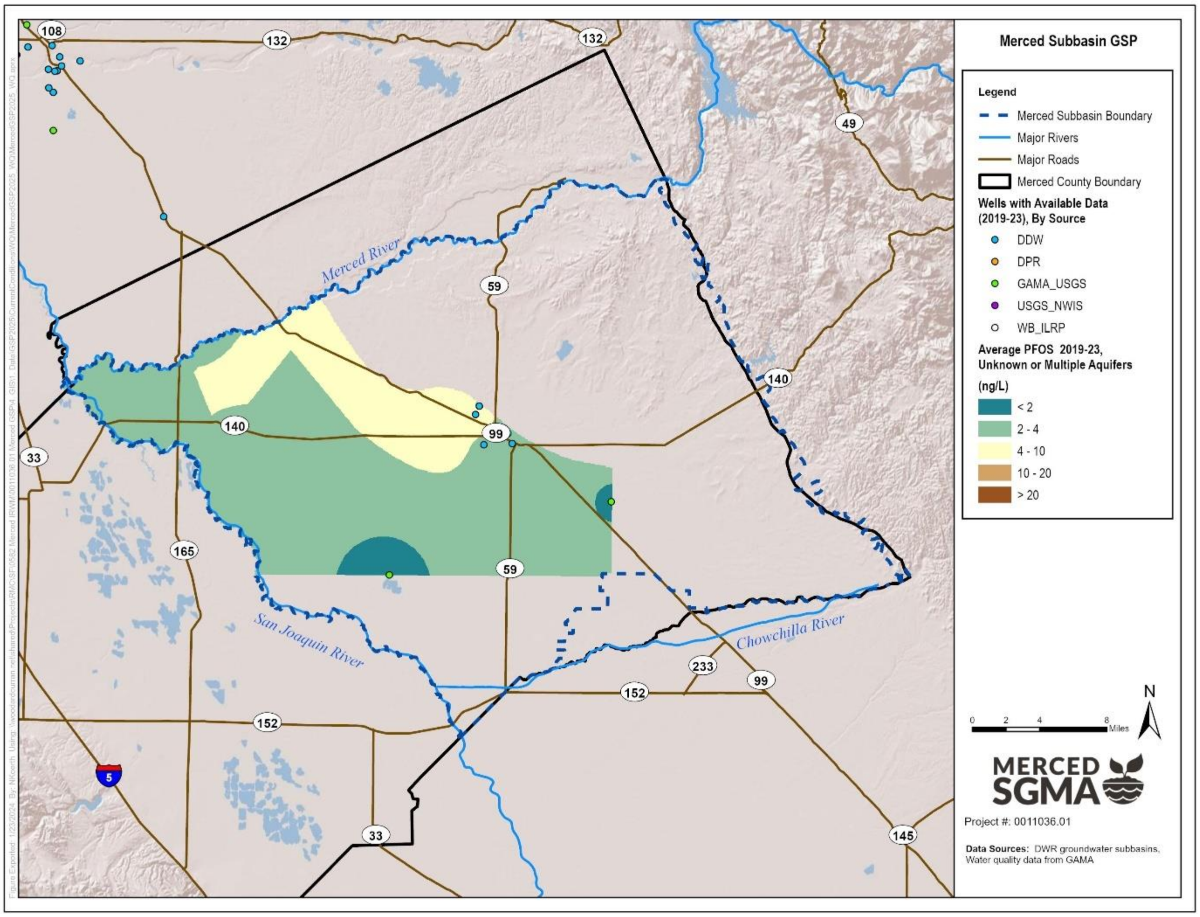


Figure 2-151: Average PFOS Concentration 2019-2023, Unknown Aquifer[31]



[31] PFOS data availability for wells in the Unknown/Multiple aquifers is limited in the Merced Subbasin for the period 2019-2023. Consequently, the spatial interpolation across the aquifer area may yield results with lower accuracy.

Figure 2-152: Average PFOS Concentration 2019-2023, Outside Corcoran Clay

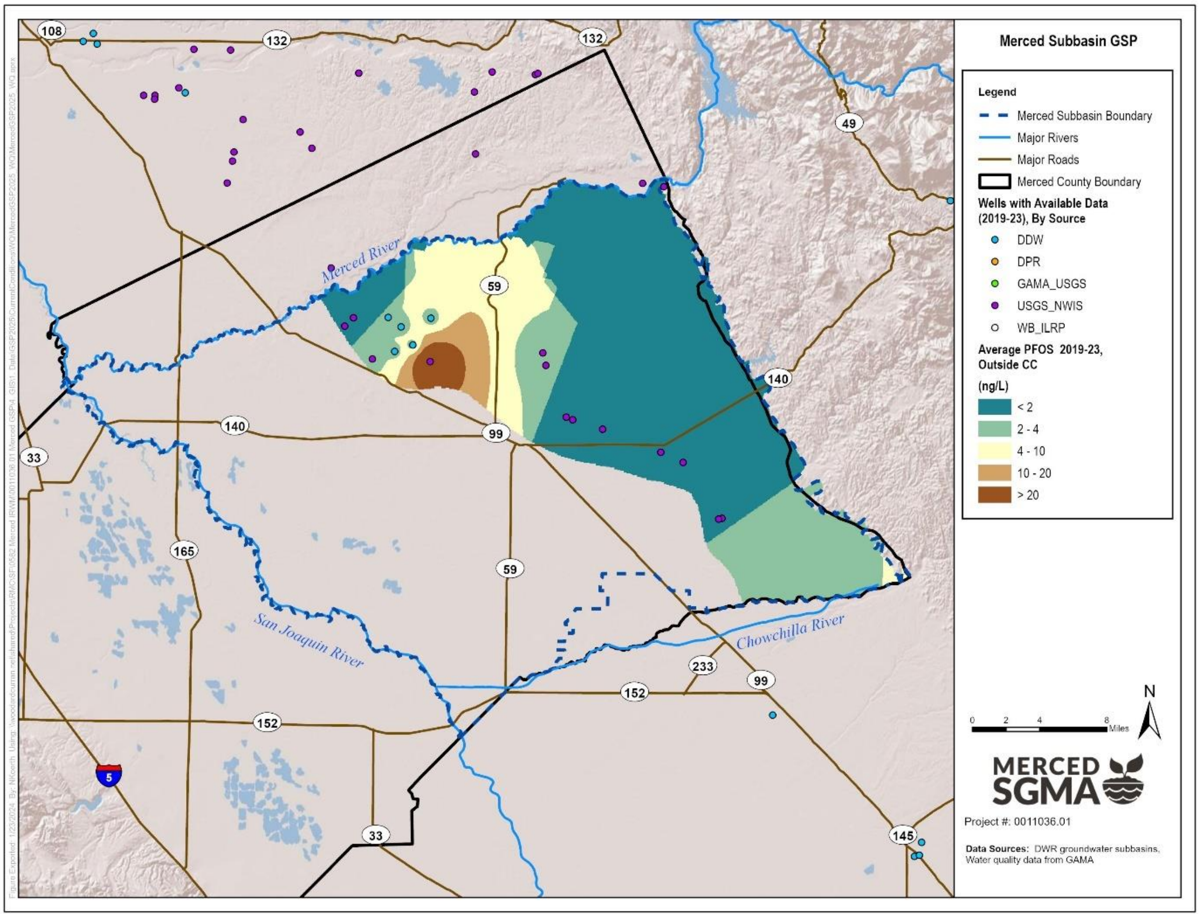
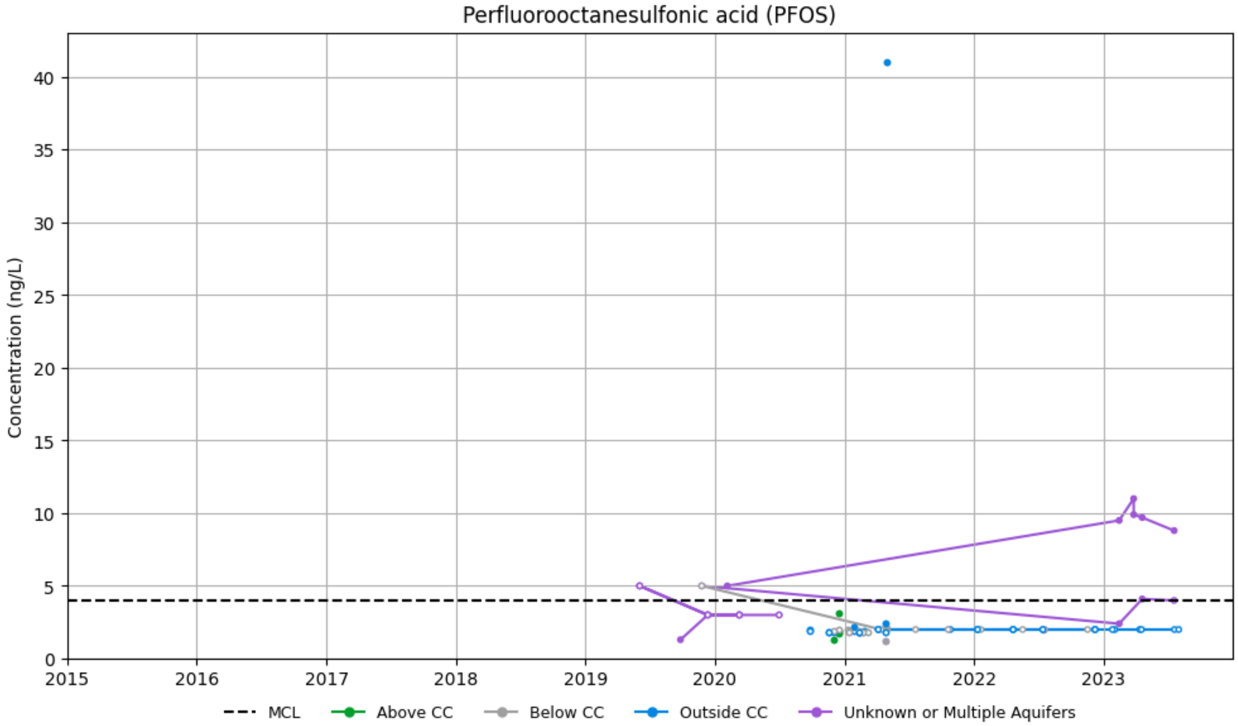


Figure 2-153: PFOS Time Series Concentrations from 2015-2023, by Well



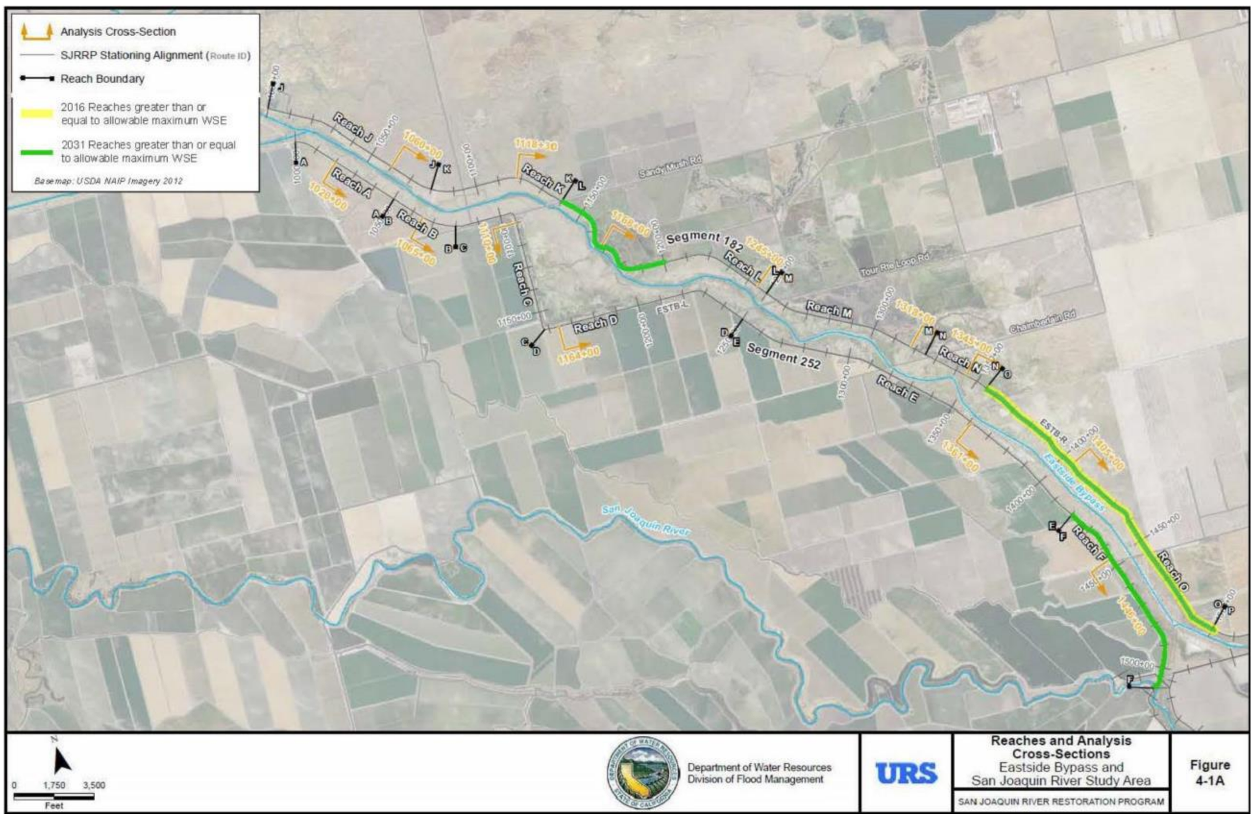
2.2.5 Land Subsidence

Land subsidence is a significant issue in the southwestern portion of the Subbasin and in the neighboring Delta-Mendota and Chowchilla Subbasins. While there are no extensometers in the area to provide data on the depths at which compaction is occurring, the subsidence is thought to be caused by groundwater extraction below the Corcoran Clay and compaction of clays below the Corcoran Clay (DWR, 2017b).

The transition from pasture or fallowed land to row and permanent crops adjacent to the San Joaquin River is thought to have created an increased groundwater pumping demand in an area that is not, at this time, serviced by an irrigation district or alternate surface water supply (Reclamation, 2016). This demand is thought to have resulted in recent increases in land subsidence along the river. The subsidence poses difficulties for local, state, and federal agencies with existing or planned infrastructure in the area (Reclamation, 2016).

The San Joaquin River Restoration Program's *2020 Channel Capacity Report* analyzed the impacts of future subsidence on the flow capacity of the Middle Eastside Bypass, which is located in the southwest corner of the Merced Subbasin. The analysis projected total subsidence from 2016 through 2031 by extrapolating average subsidence measured 2011-2018. It estimated that by 2031, three reaches will encroach upon or exceed the maximum allowable water surface elevation under 2,500 cfs conditions (see Figure 2-154), with indirect impacts on a fourth reach upstream (DWR, 2020). The flowrate is based on a SJRRP goal of having 2,500 cfs channel capacity by the end of 2024. In 2020, levee improvements were implemented in one of the three reaches to resolve flow capacity concerns which also eliminated the projected 2031 subsidence impacts in this particular reach (DWR & Reclamation, 2022). The *2022 Channel Capacity Report* stated that "…capacities through the Middle Eastside Bypass are equal to or greater than 2,600 cfs. However, because subsidence continues, the capacity will continue to be reduced over time" (DWR & Reclamation, 2022).

Figure 2-154: 2020 Channel Capacity Report Subsidence and Flow Capacity Analysis Findings



Source: (DWR, 2020)

Subsidence rates are variable and tend to be highest in magnitude during drought periods. Average annual subsidence was as large in magnitude as -0.47 feet per year (at one site in the Madera Subbasin to the south) from December 2015 to December 2023, as shown in Figure 2-155 based on data from USBR's SJRRP (see description of program in Section 1.2.2.3 - Land Subsidence Monitoring). This relatively long period averages years of drought and years of normal or wet precipitation. Noting that these measurements incorporate both elastic and inelastic subsidence, the highest maximum annual rate of subsidence reported in Reclamation's regular mapping program was -0.67 feet per year, seen from December 2012 to December 2013 (see Figure 2-156), closely followed by -0.65 feet per year from December 2014 to December 2015 and -0.52 feet per year from December 2021 to December 2022. The lowest maximum annual rate of subsidence reported in Reclamation's regular mapping program was -0.29 feet per year, seen from December 2022 to December 2023 at one particular site in the Madera Subbasin to the south (see Figure 2-157).

Figure 2-155: Average Land Subsidence December 2015 – December 2023

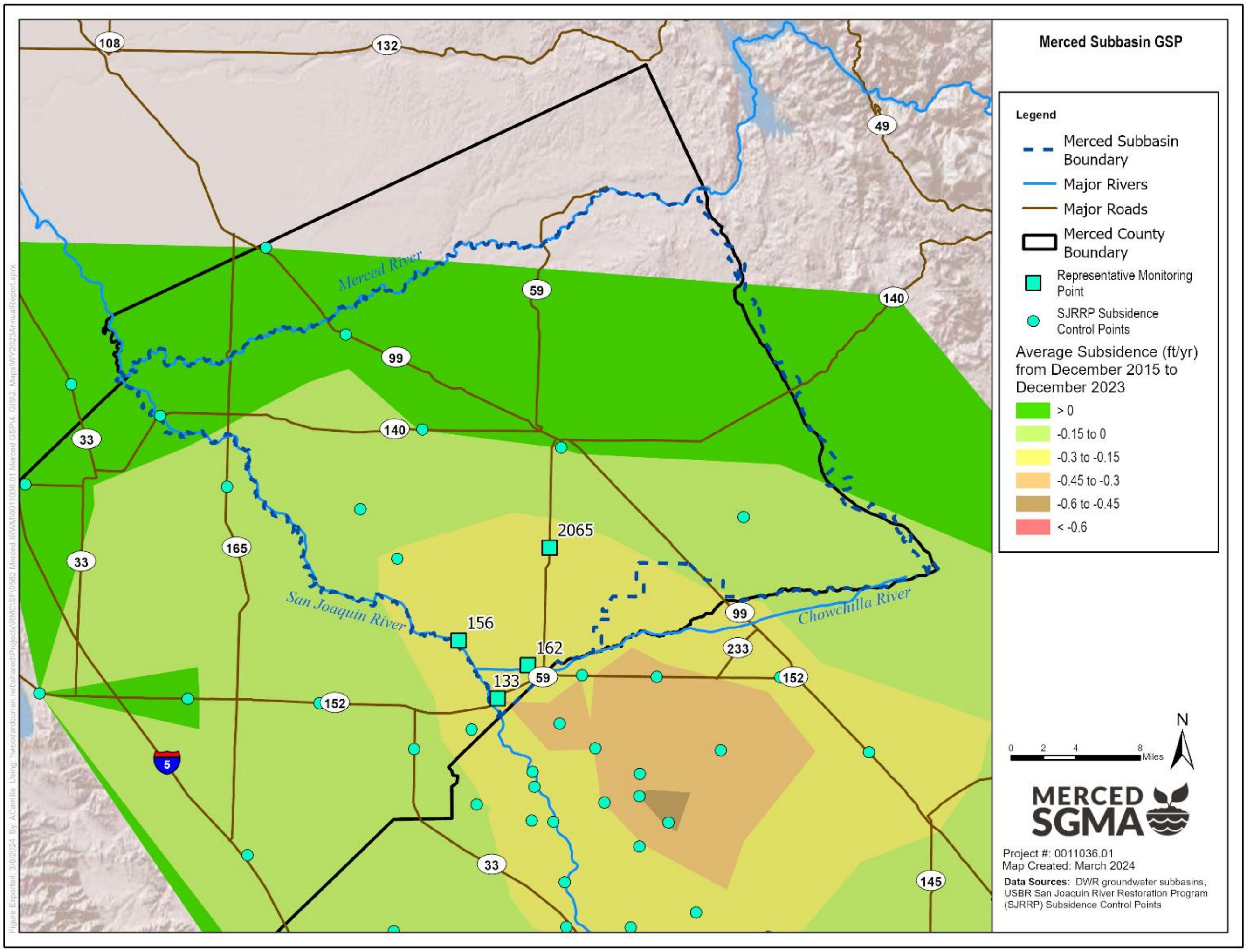


Figure 2-156: Land Subsidence December 2012 – December 2013

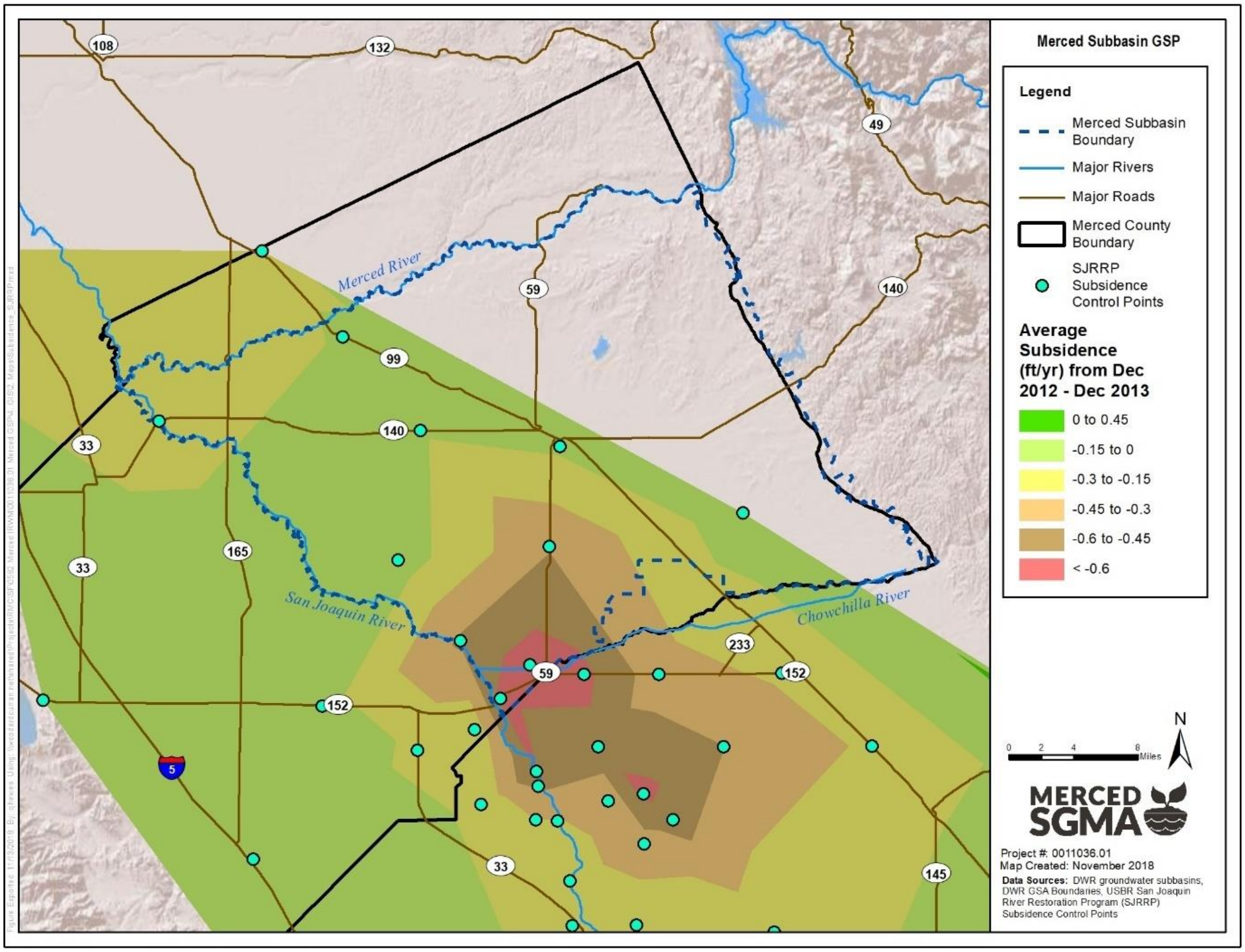
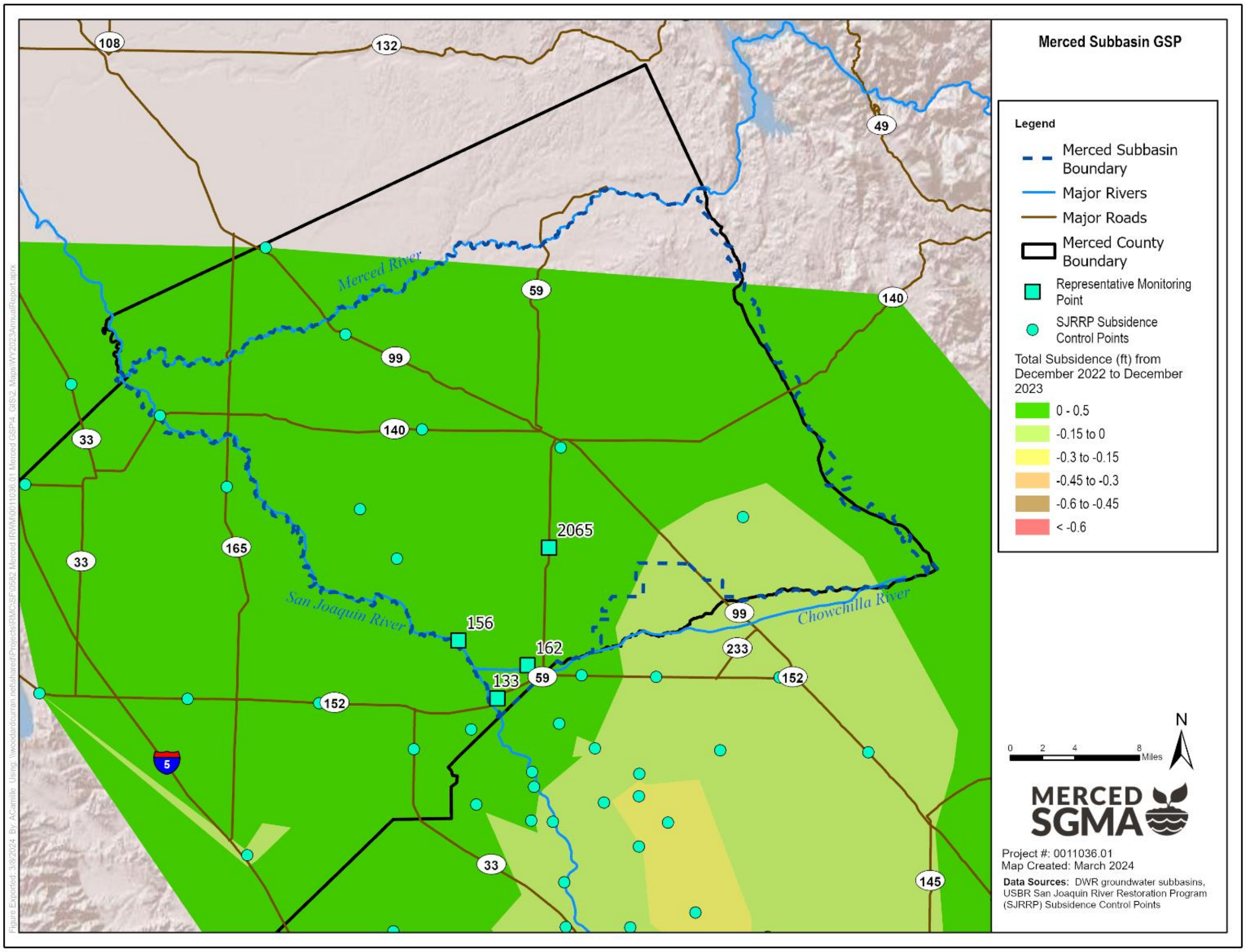


Figure 2-157: Land Subsidence December 2022 – December 2023



Subsidence in the southern corner of the Subbasin was compared against groundwater levels measured in the Below Corcoran Clay principal aquifer. Subsidence locations and historical land surface elevations measurements were obtained from two control points in the San Joaquin River Restoration Program. Historical groundwater elevations were obtained from two wells in the GSP monitoring network. Figure 2-158 shows a map of the four locations.

Figure 2-159 shows that at SJRRP point 156, subsidence has continued at a relatively steady pace from December 2011 until December 2016 where the decline in land surface elevation, on average, leveled out between December 2016 and December 2020 before declining further from December 2020 through December 2023. At station ID 13120, groundwater elevation increased during two periods of time where subsidence halted. In this case, rising groundwater levels appear to have stabilized land subsidence.

Figure 2-160 shows that at SJRRP point 2065, subsidence has continued at a relatively steady pace from December 2011 through December 2022, before leveling off between December 2022 and December 2023. At Station ID 13120, groundwater elevation decreased from December 2011 through late 2016, with a more level trend (as a long-term average (from late 2015 through early 2022). In this case, rising groundwater levels do not appear to have an impact on land subsidence, though groundwater levels fluctuated (i.e., was not a steady increase) during this time.

There are no additional available wells located in the Below Corcoran Clay Principal Aquifer with historical groundwater elevation data for further comparisons against SJRRP land subsidence data.

Figure 2-158: Map of Subsidence and Groundwater Well Comparison Points

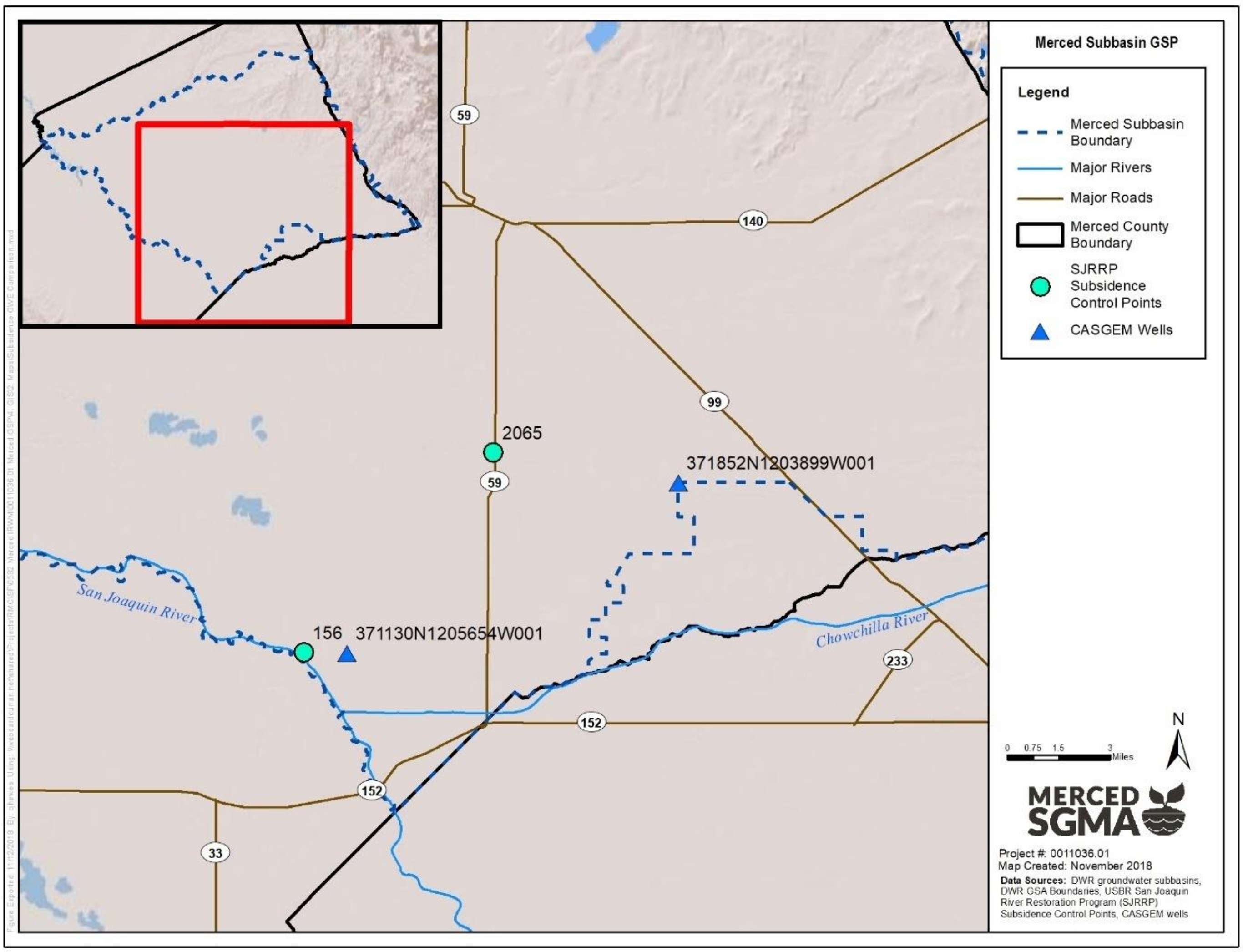


Figure 2-159: Subsidence vs Groundwater Elevation Comparison #1

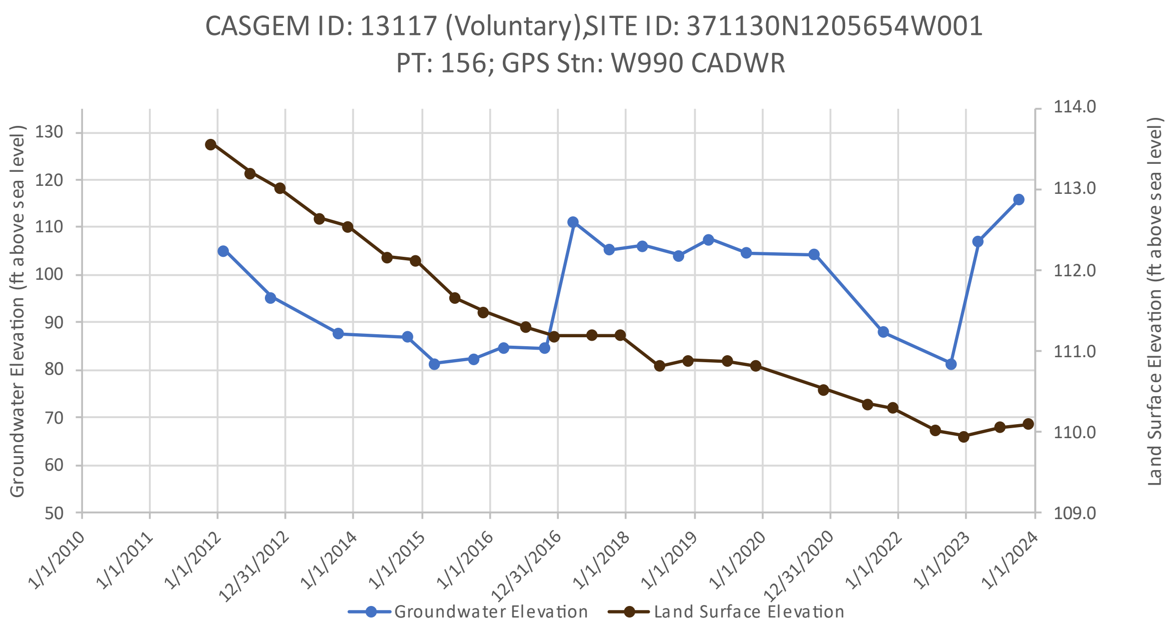
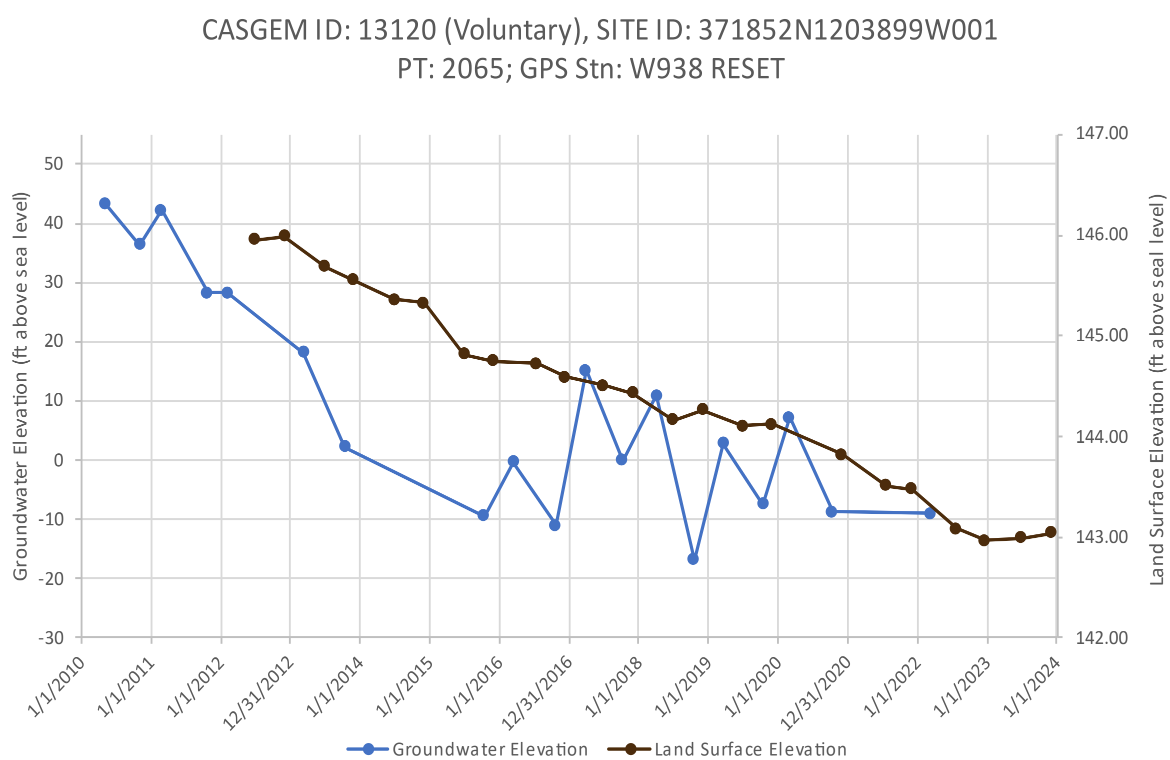


Figure 2-160: Subsidence vs Groundwater Elevation Comparison #2



2.2.6 Interconnected Surface Water Systems

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

See Section 2.1.3.5 - Groundwater Recharge and Discharge Areas for identification of Interconnected/Disconnected streams (Figure 2-10) and Gaining/Losing streams (Figure 2-9).

2.2.7 Depletions of Interconnected Surface Water

Pumping of groundwater when interconnected surface waters are present results in an increase in losses from interconnected surface waters, a decrease in gains to interconnected surface waters, or both. This results in a reduction in flow or volume of surface water and is termed depletions. Quantification of depletions provides important background on how current and historical pumping impact surface water systems in the Merced Subbasin and assists in managing depletions moving forward.

Depletion is perhaps the most complicated portion of SGMA compliance, and a full description of depletions and the mechanics of depletions is beyond the scope of this document. Additional resources are available in *Depletions of Interconnected Surface Water: An Introduction* (DWR, 2024), the first technical paper on depletions released by DWR, with two additional planned technical papers to follow along with a guidance document.

Depletions were quantified through a modeling exercise to isolate the impacts of pumping on interconnected surface waters. The historical conditions simulation of the MercedWRM was used together with a newly developed simulation that removed pumping from the Merced Subbasin. This allows for a comparison between historical conditions and a no-pumping simulation that could inform the impact of pumping on surface water bodies. Stream depletion was calculated by obtaining the difference in the stream-groundwater flow with and without groundwater pumping. The no-pumping simulation had the following assumptions:

- All pumping for urban and agricultural use within the Merced Subbasin were set to zero.
- Agricultural and urban land use remain unchanged. Groundwater supply became zero, but associated land use properties, such as runoff characteristics, remain unchanged.
- Areas within the model domain outside the Merced Subbasin were also set to zero-pumping. However, the boundary conditions were kept equal to the historical simulation, with specific head boundary conditions that represent historical groundwater elevations. This assumption implicitly states that areas outside the model boundary continue to operate groundwater pumping at historical levels.

Note that the response of stream depletions to groundwater pumping is gradual and the time scale could involve decades or centuries. In the case of the Merced Subbasin, MercedWRM simulates the scenarios with pumping and without pumping over a 30-year time period, from WYs 1994 to 2023. The depletions are estimated as the difference in stream gains and losses between the two scenarios. As such, at the end of the simulation period, in WY 2023, MercedWRM estimates the impact of pumping from WYs 1994 through 2023 as seen in changes in stream gains and losses in 2023. Because of this the values presented in this section are based on the last six years of simulation, a period representative of current and recent historical condition which accounts for the highest percentage of depletions that can be quantified by MercedWRM.

The time response in which the effects of pumping are seen in the stream depletions depend on many factors, including geologic structure, hydraulic properties of the groundwater system and the streambed, location of pumping, and location of surface water bodies amongst other factors. In the case of the Merced Subbasin, an estimate from MercedWRM indicates that about 50% of the pumped volume results in depletions or changes in out-of-basin subsurface flows in the 10 years following pumping, and about 70% happen within the 30-year simulation period. As not all pumping results in depletions (some pumping returns to the aquifer through deep percolation), the 70% value likely includes a substantial majority of depletions that will occur. As such, most of the impact of pumping from WYs 1994 through 2023 occurring as depletions in the latter years of the simulation period are captured in this analysis. Information presented in this section is based on WYs 2018 to 2023 to avoid earlier simulation years that may not quantify depletions occurring due to pre-1994 groundwater pumping.

The estimate of the time response of pumping in stream depletions in MercedWRM was obtained by looking at the impact of a single year of pumping at WY 1994, the beginning of the simulation period, and estimating the cumulative stream depletion and changes in out-of-basin subsurface flows over the volume of pumping change through the simulation period.

Based on an average of WYs 2018 to 2023 conditions, the model estimated 504,400 AFY of depletions and 141,800 AFY of increase in subsurface groundwater inflow (eventually out-of-subbasin depletions) conditions. It is important to consider that this analysis was developed for the Merced Subbasin and since the Merced, San Joaquin and Chowchilla Rivers are part of the boundary of the subbasin, the estimates for depletion of this rivers would increase if the depletions on neighboring subbasins are evaluated.

Location of Depletions

The location of depletions is dependent on the distance (vertical and horizontal) between groundwater pumping and surface water systems as well as the characteristics of the subsurface in between. Within the Merced Subbasin, over half of the depletions are focused on three reaches: Merced River, with 120,000 AFY of depletions, Eastside Bypass with 91,000 AFY of depletions and San Joaquin River with 72,000 AFY of depletions. The average annual depletion by each river reach in the MercedWRM is shown in Table 2-11.

Table 2-11: Average Annual Depletion by River Reach

River Reach	Average Depletion (AFY)	Average Depletion per River Mile (AFY/mi)
Merced River	120,000	2,500
Eastside Bypass	91,100	2,400
San Joaquin River	72,200	1,500
Bear Creek	51,800	1,300
Owens Creek	42,300	1,500
Black Rascal Creek	41,200	2,000
Duck Slough	36,300	1,100
Deadman Creek	23,600	700
Chowchilla River	14,500	700
Mariposa Bypass	6,400	1,300
Miles Creek	3,100	200
Dutchman Creek	1,900	100
Total	*504,400*	*1,400*

In addition to the depletions noted in Table 2-11, pumping results in a change in subsurface groundwater flow from neighboring subbasins. This change in subsurface groundwater flow shows the impacts due to pumping in the Merced Subbasin occurring in neighboring subbasins. These impacts will eventually result in depletions, but because they occur outside of the Merced Subbasin they are accounted separately. Change in subsurface groundwater flow due to pumping is an increased inflow or decreased outflow of 141,800 AFY, on average, based on simulated WYs 2018 to 2023 conditions. A breakdown of the change in subsurface flow due to pumping is shown in Table 2-12.

Table 2-12: Change in Subsurface Flow Due to Pumping

Neighboring Subbasin	Average Change in Subsurface Flow due to Pumping (AFY)	Average Change in Subsurface Flow due to Pumping per Boundary Mile (AFY/mi)
Turlock	50,300	1,000
Chowchilla	69,500	1,800
Delta-Mendota	21,900	500
Total	141,800	1,100

Timing of Depletions

The timing of depletions includes the monthly distribution of depletions and the distribution of depletions among different year types. Based on MercedWRM results for WYs 2018 to 2023 conditions, there is not a clear trend in depletions in the monthly distribution. It appears to have relatively similar conditions across the months, but with higher depletions in January and July, and lower depletions during April and November. On the other hand, the change in subsurface flow shows higher values during irrigation season and lowest in the winter and early spring. A breakdown of the monthly distribution for depletions and change in subsurface flow is shown in Table 2-13.

Table 2-13: Monthly Distribution of Depletions and Change in Subsurface Flow

Month	Average Depletion (AF/month)	Average Change in Subsurface Flow due to Pumping (AF/month)
Oct	37,800 (7%)	11,900 (8%)
Nov	36,900 (7%)	10,700 (8%)
Dec	41,900 (8%)	10,100 (7%)
Jan	45,800 (9%)	9,700 (7%)
Feb	42,100 (8%)	9,500 (7%)
Mar	45,200 (9%)	9,900 (7%)
Apr	38,100 (8%)	11,200 (8%)
May	40,800 (8%)	12,400 (9%)
Jun	43,500 (9%)	12,900 (9%)
Jul	46,300 (9%)	14,700 (10%)
Aug	45,300 (9%)	14,900 (11%)
Sep	40,600 (8%)	13,900 (10%)

Analysis of the six-year period shows that depletions and change in subsurface flow appear to be dependent on the water year type. Lowest depletions and changes in subsurface flows are seen in WYs 2021 and 2022, which are critically dry years according to the San Joaquin River Water Year Index, and the highest values were seen in WYs 2019 and 2023, which are wet years. The breakdown of annual depletions and change in subsurface flows are shown in Table 2-14.

Table 2-14: Monthly Distribution of Depletions and Change in Subsurface Flow

Water Year	Year Type	Depletions (AFY)	Change in Subsurface Flow due to Pumping (AFY)
2018	Below Normal	467,800	138,100
2019	Wet	547,900	153,400
2020	Dry	468,500	140,700
2021	Critically Dry	459,300	136,300
2022	Critically Dry	461,900	130,000
2023	Wet	621,000	152,000

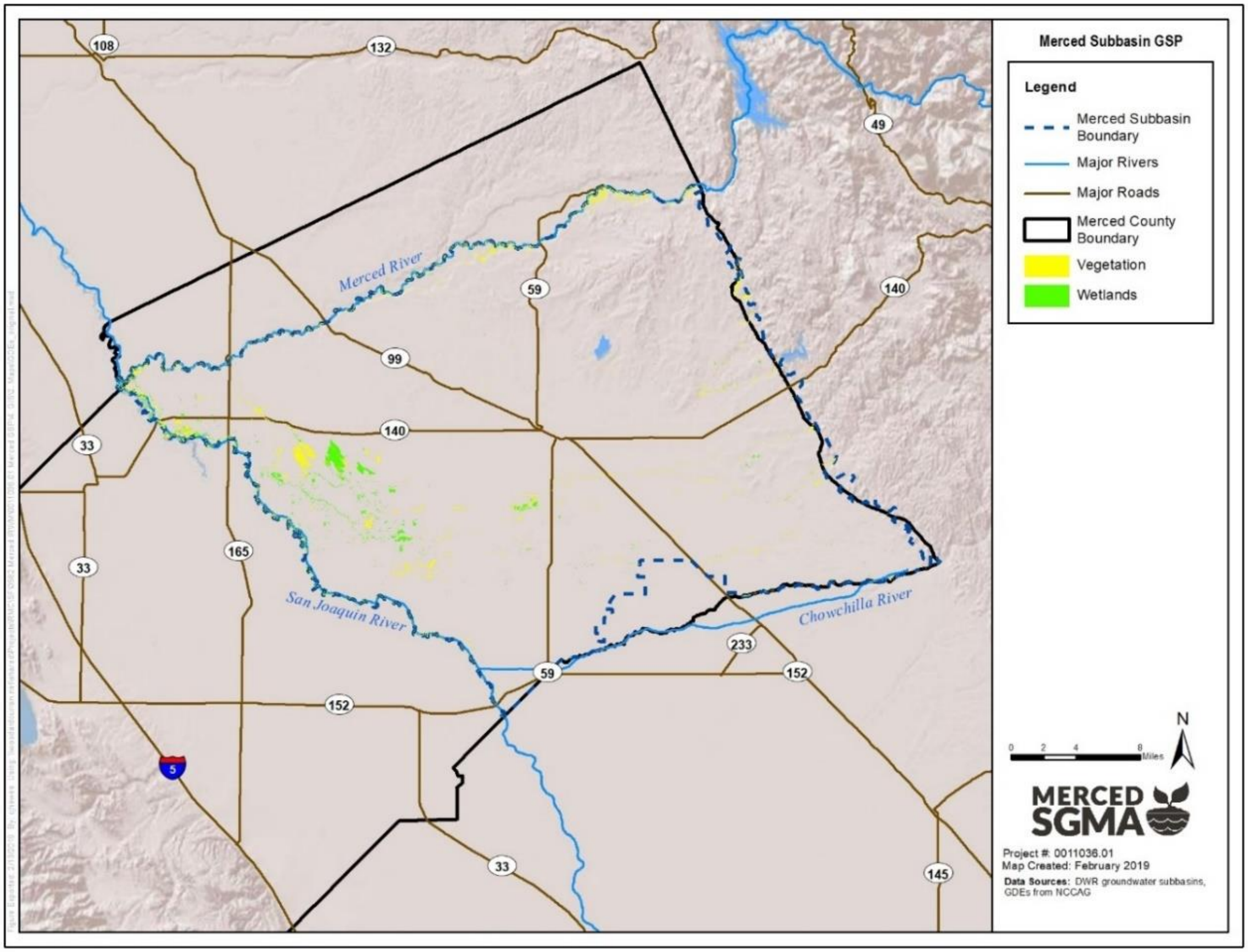
2.2.8 Groundwater-Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined in the SGMA regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface". GDEs exist within the Merced Subbasin largely where vegetation accesses shallow groundwater for survival; without the access to shallow groundwater, these plants would die. GDEs were identified within the Merced Subbasin as areas dependent on groundwater.

Certain species of plants are commonly associated with groundwater use. However, the presence of these plants does not necessarily indicate that these are also GDEs. The identification of GDEs was performed by first identifying the types of plants that are often associated with accessing groundwater, then by identifying if those plants are dependent on groundwater, or if they can access alternate water supplies.

The Natural Communities Commonly Associated with Groundwater (NCCAG) database was used to identify plants commonly associated with groundwater use. The NCCAG database was developed by a working group comprised of DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) by reviewing publicly available state and federal agency datasets that mapped California vegetation, wetlands, springs, and seeps and by conducting a screening process to retain types and locations commonly associated with groundwater. The results were compiled into the NCCAG database with two habitat classes defined. The first class includes wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions. The second class includes vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes). Figure 2-161 shows the locations identified by the NCCAG database within the Merced Subbasin.

Figure 2-161: Natural Communities Commonly Associated with Groundwater (NCCAG)



The next step in identifying GDEs was to analyze each GDE for groundwater dependence. This was performed by identifying NCCAG locations that are likely to have access to alternate water supplies. In the Merced Subbasin, areas with alternate water supplies are substantial, partly due to the fact that groundwater levels are already deep in most portions of the Subbasin, but also due to the availability of other water supplies that ecosystems are often able to access. Figure 2-162 shows the locations of NCCAG identified as not likely to be GDEs due to the presence of alternate water supplies and thus a lack of dependence on groundwater.

Noting that no land use protections are conveyed on GDEs or NCCAG through this document or other documents, the distinction between GDEs and NCCAG that are not GDEs is important from a management perspective. While NCCAG may have ecological value, management of groundwater may not be the most appropriate way to allow those communities to thrive. Instead, management of NCCAG may require more focus on changing land use or irrigation efficiencies more so than groundwater management. The rigorous analysis to identify GDEs was developed to focus groundwater management activities on the most appropriate areas.

The analysis was conducted by thorough review of aerial photographs from several sources across multiple years for all GDE areas as well as comparison against external databases, such as vernal pool complexes published by the California Department of Fish and Game. While many NCCAG areas were identified as not being GDEs, several GDEs not captured in the NCCAG database were digitized where a likely GDE was observed through this additional analysis.

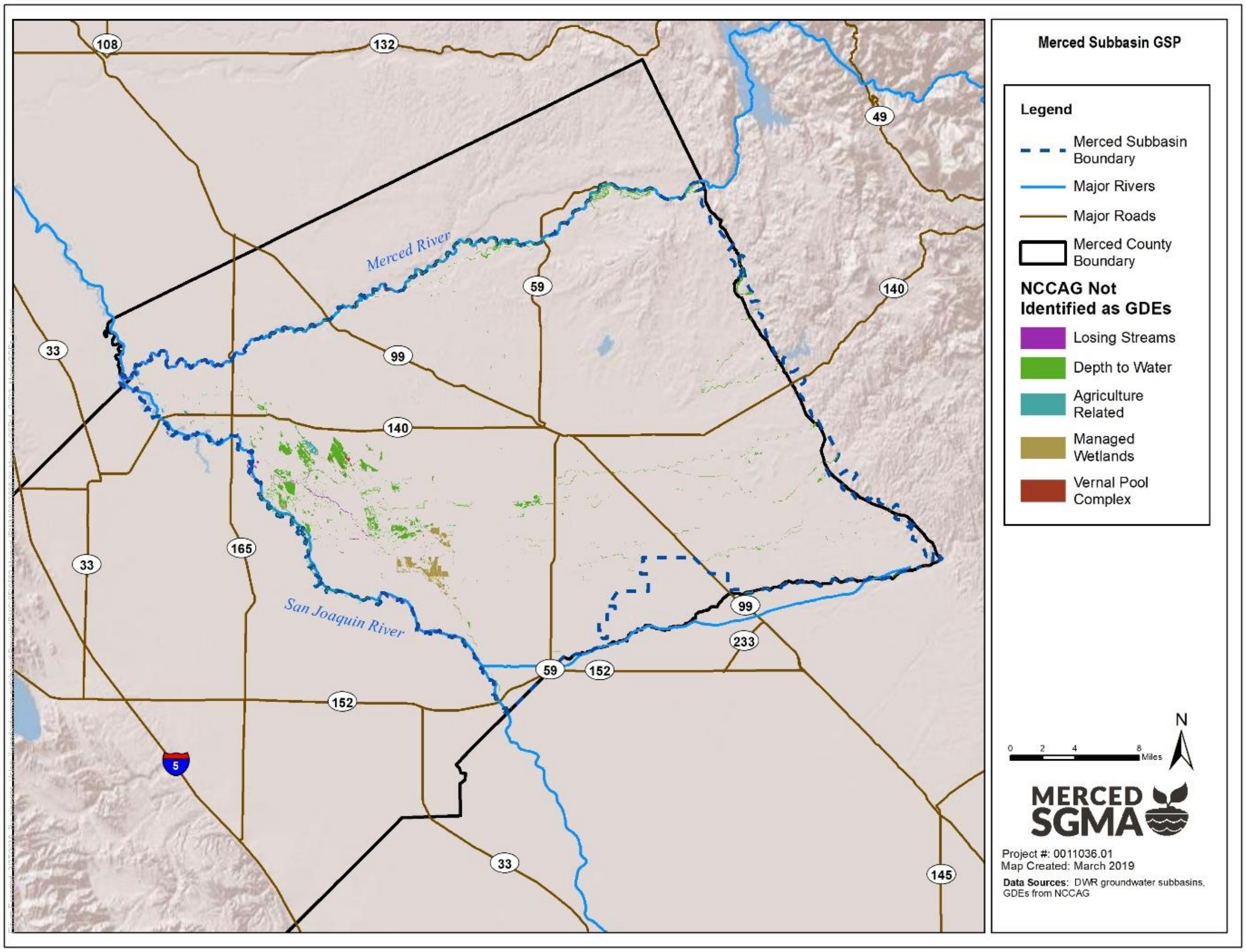
NCCAG areas not identified as GDEs can be categorized as follows. The locations are shown in Figure 2-162 to support improved understanding of ecosystems in the Merced Subbasin.

1. **Areas with a depth to groundwater greater than 30 feet in Spring 2015** – Oak trees are considered the deepest-rooted plant in the region with a root zone of roughly 25 feet, and zones where the depth to water was deeper than 30 feet were excluded because they are unlikely to support vegetative growth. The 30-foot value is considered conservative, as this depth is unlikely to support recruitment of new oak seedlings. These areas are assumed to be accessing other water sources rather than groundwater that is inaccessibly deep. Thus, they are not identified as GDEs; these areas are represented as "Depth to Water" in Figure 2-162.
2. **Habitat areas with supplemental water** – Managed wetlands were identified and reviewed with local water managers to verify supplemental water deliveries. These areas are assumed to be accessing supplemental water deliveries and not reliant on groundwater. Thus, they are not identified as GDEs; these areas are represented as "Managed Wetlands" in Figure 2-162. A substantial portion of this area overlaps with the Merced National Wildlife Refuge which receives an average 11,000 AFY of surface water (2009-2013), with reduced deliveries during drought (100 to 4,000 AFY during 2014-2016).
3. **Areas adjacent to irrigated fields** – Agricultural lands are dependent on reliable water supplies to ensure a successful harvest and substantial surface water or deeper groundwater is used to irrigate crops in the Merced Subbasin. Such irrigation benefits not only the crops, but also surrounding vegetation. These areas are assumed to be accessing irrigation water. Thus, they are not identified as GDEs. Aerial photography was used to examine and determine if vegetated areas were adjacent to irrigated fields or drainage canals. These areas are identified as "Agriculture Related" in Figure 2-162**.**
4. **Areas depending on adjacent losing surface water bodies** – Losing streams are streams that recharge the groundwater system. This requires groundwater levels that are lower than stage in the stream and that are progressively lower away from the stream. These areas are assumed to be accessing water flowing out of the stream. Areas with losing streams were identified using the MercedWRM (see Section 2.1.3.5 - Groundwater Recharge and Discharge Areas); NCCAG within 300 feet of losing stream areas were

assumed to not be GDEs. Areas depending on adjacent losing surface water are represented as "Losing Streams" in Figure 2-162.

5. **Areas of vernal pool complexes** – Vernal pools are shallow, intermittently flooded wetlands. They typically appear in winter due to rainfall and evaporate completely by summer and fall. Vernal Pool Complexes were identified based on the "Vernal Pool Complexes – Central Valley, 1989-1998" dataset published by the California Department of Fish and Game. Vernal pools are dependent on rainfall-fed, extremely shallow groundwater conditions not directly connected with the deeper aquifer system, thus these areas are not dependent on groundwater and are not identified as GDEs. These areas are represented as "Vernal Pool Complexes" in Figure 2-162.

Figure 2-162: NCCAG Not Identified as GDEs



Based on the analysis, areas were identified as likely GDEs. These areas are shown "Likely GDEs – NCCAG Vegetation" and "Likely GDEs - NCCAG Wetland" in two regions within the Subbasin. Figure 2-163 shows likely GDEs at the confluence of the Merced and San Joaquin Rivers while Figure 2-164 shows likely GDEs in the region of the southern portion of the San Joaquin River within the Merced Subbasin.

Figure 2-163: Likely GDEs – Confluence of Merced and San Joaquin Rivers

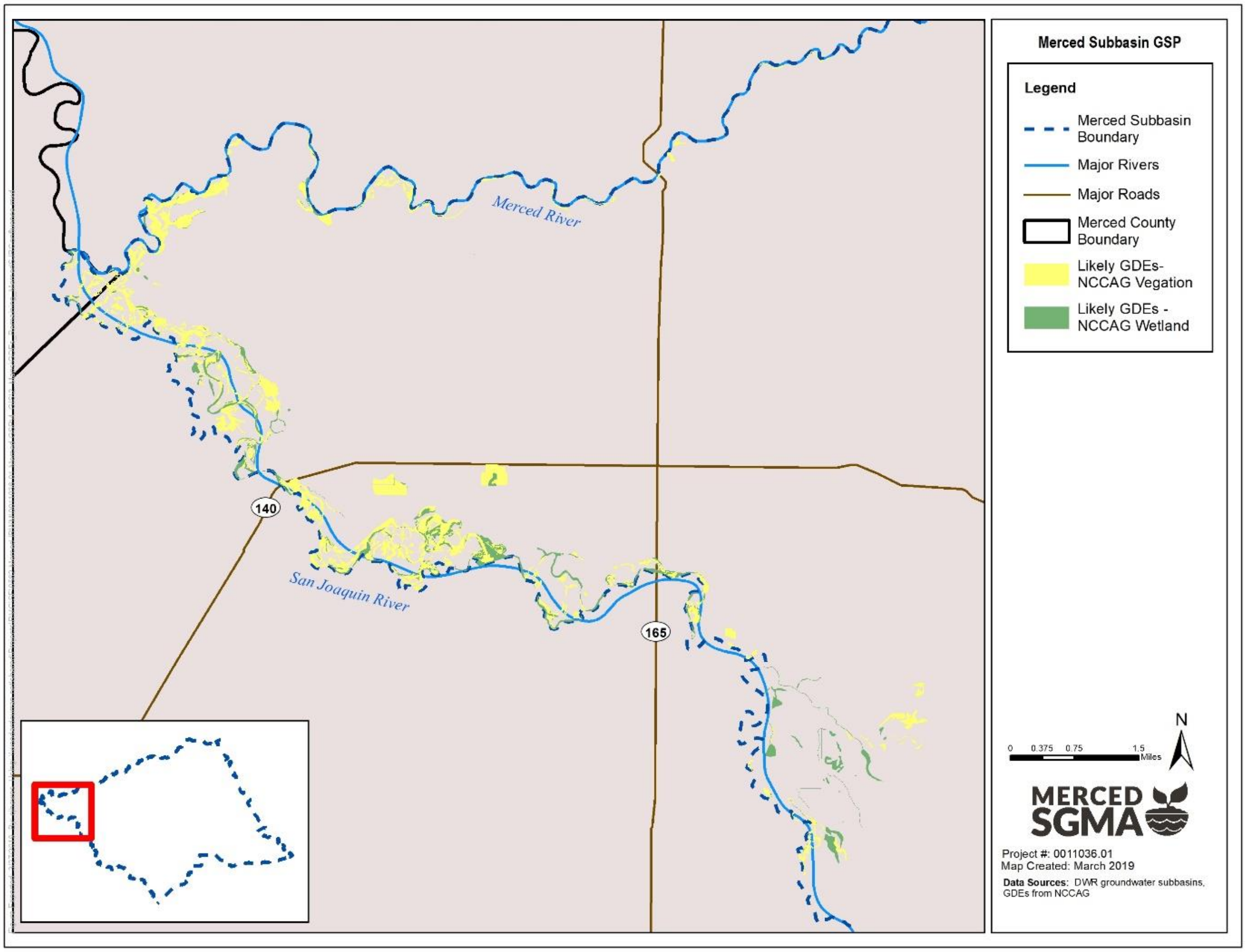
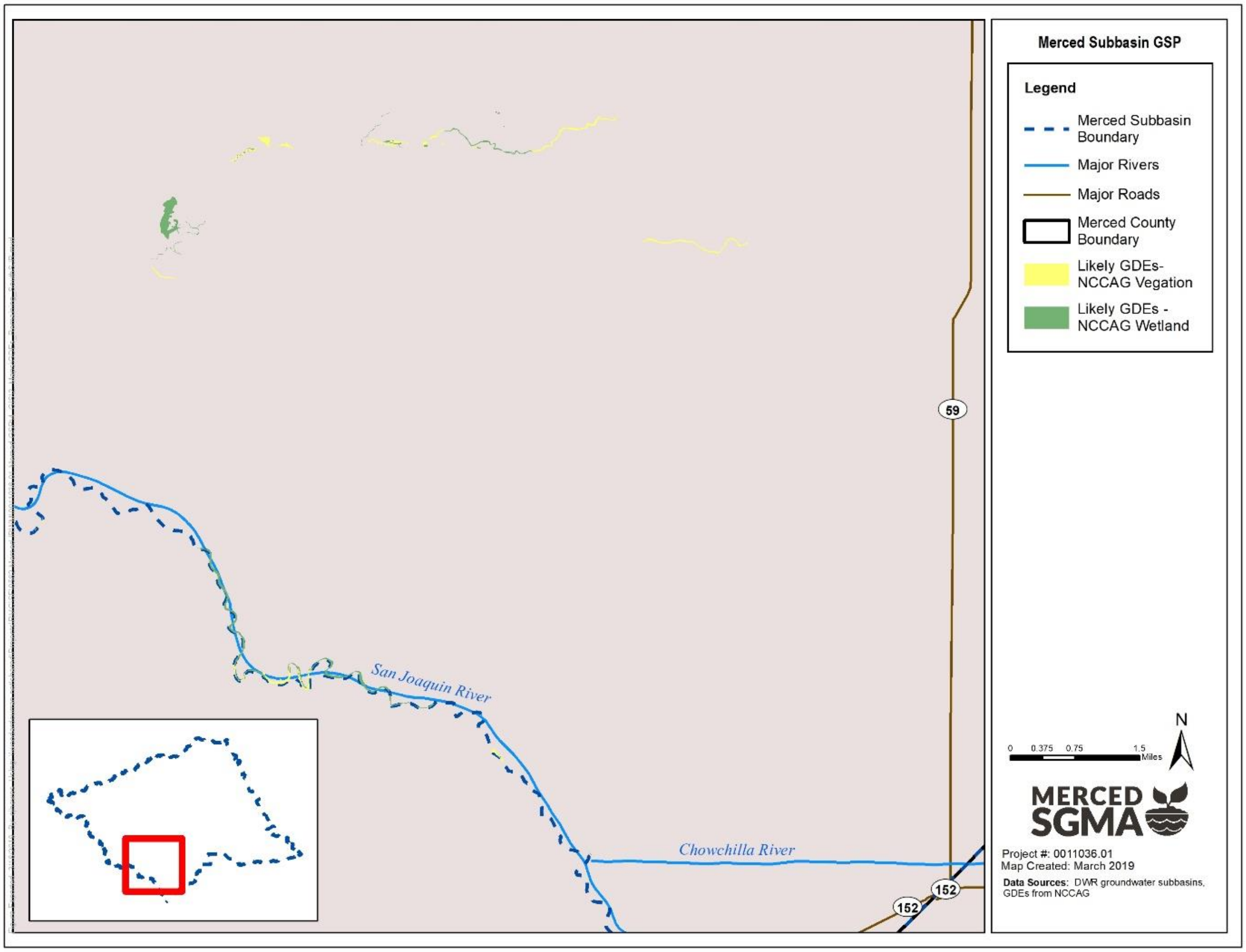


Figure 2-164: Likely GDEs – South Region of San Joaquin River

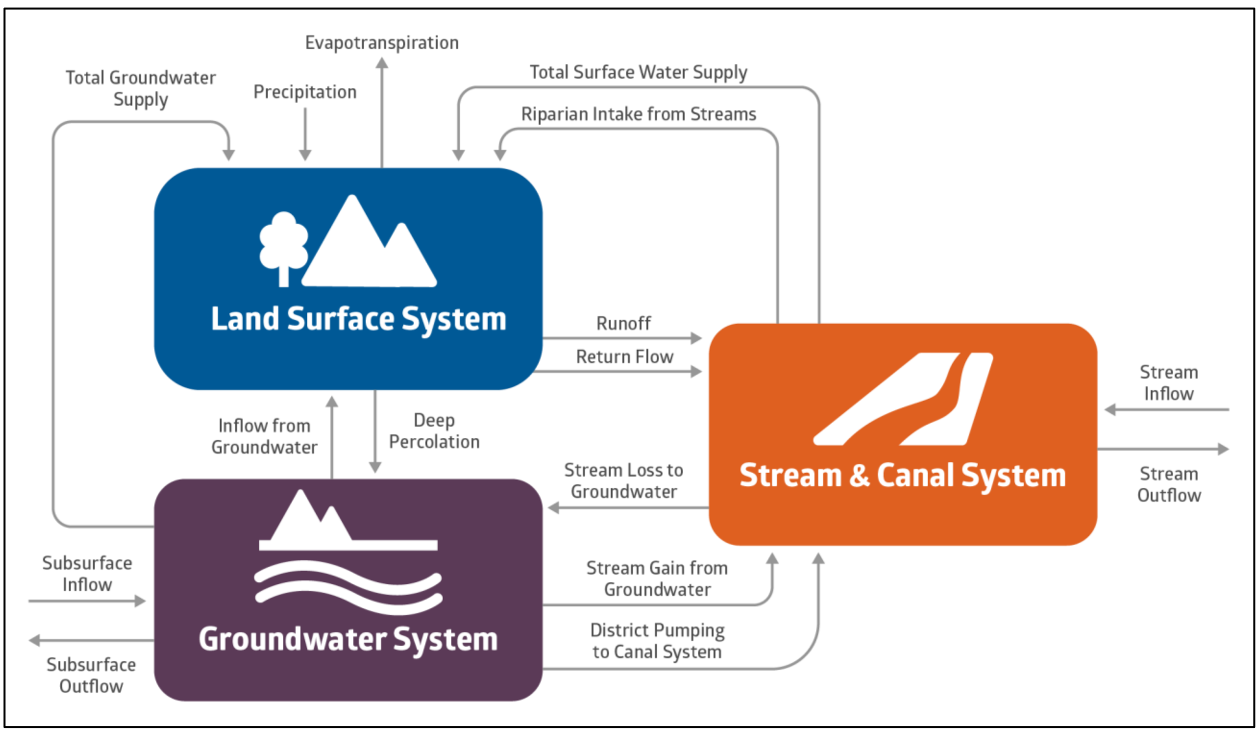


2.3 WATER BUDGET INFORMATION

Water budgets were developed to provide a quantitative account of water entering and leaving the Merced Subbasin. Water entering the Subbasin includes water entering at the surface and through the subsurface. Similarly, water leaving the Subbasin leaves at the surface and through the subsurface. Water enters and leaves naturally, such as precipitation and streamflow, and through human activities, such as pumping and recharge from irrigation. Figure 2-165 highlights the interconnectivity of stream, surface, and groundwater components of the natural and human related hydrologic system used in this analysis.

The values presented in the water budget provide information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate change, sea level rise (not applicable in the Merced Subbasin), groundwater and surface water interaction, and subsurface groundwater flow. This information can assist in management of the Subbasin by identifying the scale of different uses, highlighting potential risks, and identifying potential opportunities to improve water supply conditions, among others.

Figure 2-165: Generalized Water Budget Diagram



Water budgets can be developed on different scales. In agricultural use, water budgets may be limited to the root zone, 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 pure groundwater study, water budgets may be limited to water flow within the subsurface, aiding in understanding how water flows beneath the surface. Global climate models simulate water budgets that incorporate atmospheric water, allowing for simulation of climate change conditions. In this document, consistent with the Regulations (California Code of Regulations), the water budgets investigate the combined land surface, stream, and groundwater systems, specifically for the Merced Subbasin.

Water budgets can also be developed at different 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 document, consistent with the Regulations, water budgets are represented based on water year (WY), with some consideration to monthly variability.

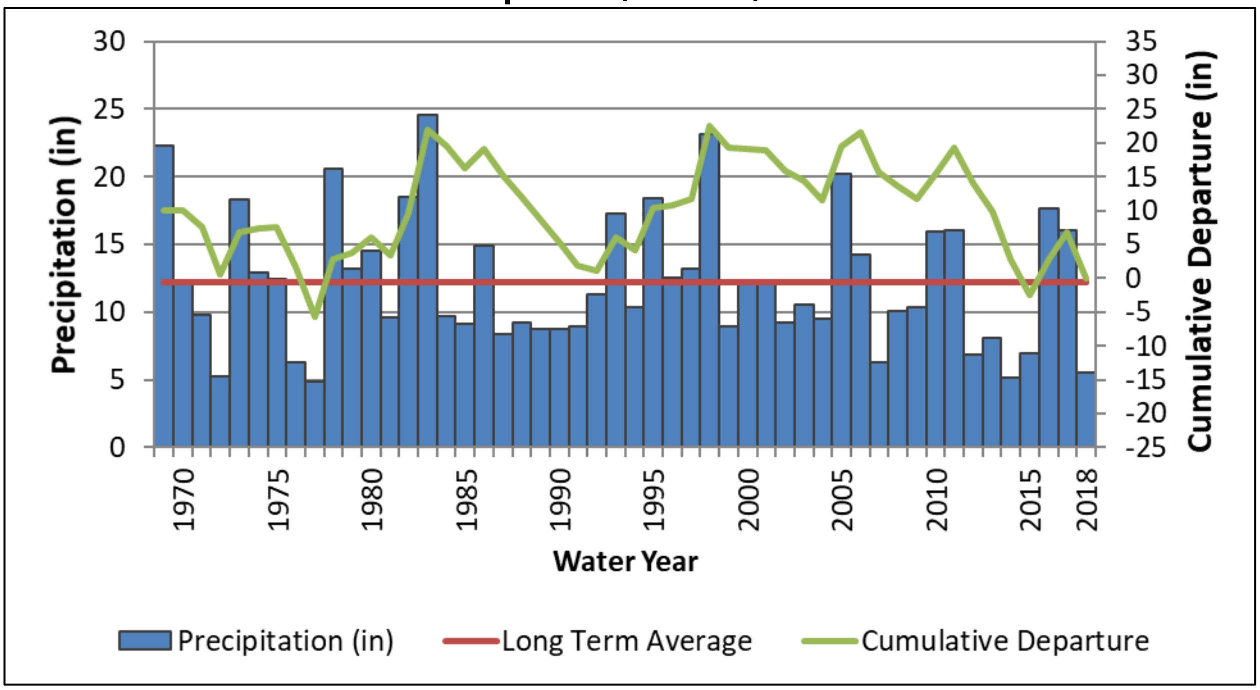
The Regulations require the annual water budgets be based on three different levels of development: historical, current, and projected conditions. Budgets are developed to capture typical conditions during these time periods. Typical conditions are developed through averaging hydrologic conditions that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions within the budgets, analysis of the system under certain hydrologic conditions, such as drought, can be performed along with analysis of long-term averages. Information is provided in the following subsections on the hydrology dataset used to identify time periods for budget analysis, the usage of the MercedWRM and associated data in water budget development, and on the budget estimates.

2.3.1 Identification of Hydrologic Periods

Hydrologic periods were selected to meet the needs of developing historical, current, and projected water budgets. The Regulations require that the projected water budget incorporate a 50-year hydrologic period, in order to reflect long-term average hydrologic conditions. Precipitation for the Merced Subbasin was used to identify hydrologic periods that would provide a representation of wet and dry periods and long-term average conditions needed for water budget analyses.

Rainfall data for the Subbasin is derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset at node locations from DWR’s California Simulation of Evapotranspiration of Applied Water (CALSIMETAW) model. Identification of periods with a balance of wet and dry periods was performed by evaluating the cumulative departure from mean precipitation. Under this method, the long-term average precipitation is subtracted from annual precipitation within each water year to develop the departure from mean precipitation for each water year. Wet years have a positive departure and dry years have a negative departure; a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, the departures are added cumulatively for each year. So, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (5 plus -2) for Year 2. A chart is used to graphically illustrate the cumulative departure from mean precipitation within the Merced Subbasin (Figure 2-166). The chart includes bars displaying annual precipitation for each water year from 1969 through 2018 and a horizontal line representing the mean precipitation of 12.3 inches which varies only slightly from the full period of record (1922-2018) average of 12.0 inches. The cumulative departure from mean precipitation is displayed as a line that starts at zero and highlights wet periods with upward slopes and dry periods with downward slopes. More severe events are shown by steeper slopes and greater changes. Thus, the period from 1976 to 1977 illustrates a short period with dramatically dry conditions (13-inch decline in cumulative departure over 2 years).

Figure 2-166: 50-Year Historical Precipitation and Cumulative Departure from Mean Precipitation, Merced, California



2.3.2 Usage of the MercedWRM and Associated Data in Water Budget Development

Water budgets were developed utilizing the MercedWRM, a fully integrated surface and groundwater flow model covering approximately 1,500 square miles of the Merced Groundwater Region (Region), which fully encompasses the Merced Subbasin plus the Dry Creek watershed North of the Merced River and the section of Chowchilla Water District north of the Chowchilla River. The MercedWRM, a quasi-three-dimensional finite element model, was developed using the Integrated Water Flow Model (IWFM) 2015 software package to simulate the relevant hydrologic processes prevailing in the Region. The MercedWRM integrates the groundwater aquifer with the surface hydrologic system and land surface processes and operations. Using data from federal, state, and local resources, the MercedWRM was calibrated for the hydrologic period of October 1995 to September 2015 by comparing simulated evapotranspiration, groundwater levels, and streamflow records with historical observed records. Development of the model involved the study and analyses of hydrogeologic conditions, agricultural and urban water demands, agricultural and urban water supplies, and an evaluation of regional water quality conditions (Woodard & Curran, 2019). Additional information on the data used to develop the MercedWRM are included as Appendix D.

All groundwater models contain assumptions and some level of uncertainty. They are decision support tools used to better understand complex interactive systems. Sources of model uncertainty include heterogeneity in hydrogeologic properties and stratigraphy, quality of historical data, projections of future land use, hydrology, and climate. The MercedWRM model has been calibrated and validated. Inputs for GSP-related modeling runs used the best available data and science. Projections of future land use and water demands were based on the most recent planning documents prepared by agencies in the Subbasin. The model in its current form represents the best available representation of the basin. As additional information is collected during GSP implementation, the model will be updated to reflect the newly available data. Efforts to address basin data gaps will improve information available for the model.

With the MercedWRM as the underlying framework, model simulations were developed to allow for the estimation of water budgets. Several model simulations were used to develop the water budgets for historical, current, and multiple projected conditions, which are discussed in detail below:

- The **historical water budget** is based on a simulation of historical conditions in the Merced Subbasin.
- The **current water budget** is based on a simulation of current (2015) land and water use over historical hydrologic conditions, assuming no other changes in population, water demands, land use, or other conditions.
- The **projected water budget** is based on a simulation of future land and water use over the historical hydrologic conditions.

- The **projects and management actions water budget** is similar to the projected water budget, but incorporates impacts of projects and management actions that involve recharge and demand reduction.
- The **sustainable yield water budget** is similar to the projects and management actions water budget, but incorporates additional demand reductions to avoid projected undesirable results.

Significant refinements to the MercedWRM were made for the 2025 GSP Update, focusing on the Land Surface and Groundwater Systems:

- Land Surface System – Land Use

  Land Use Data was updated for the entire time period using DWR's Statewide Crop Mapping from 2014 through 2022. Data prior to 2014 was obtained from decadal County Land Use Surveys and interpolated between existing datasets.

- Land Surface System – Evapotranspiration

  Actual evapotranspiration data was obtained from OpenET in a raster format with a resolution of 30m x 30m. The data was processed by aggregating them by Land Use categories of MercedWRM and validated by the local California Irrigation Management Information System (CIMIS) station near Merced to obtain each crop potential evapotranspiration (ETc). At the time of the model update, OpenET had data available from 2016 through 2022, so data before 2016 was obtained by averaging evapotranspiration information by month and water year type and establishing a correlation with the historical reference evapotranspiration (Eto) from the CIMIS station.

- Land Surface System – Soil Parameters

  Each element of the MercedWRM was mapped against the Soil Survey Geographic Database (SSURGO) to obtain a soil classification for each element based on the major soil texture classifications defined by the USDA. Using the soil classification for each element, the soil parameters needed in the MercedWRM (wilting point, field capacity, total porosity, pore size distribution index, and saturated hydraulic conductivity) were estimated using referenced ranges from published literature (Saxton & Rawls, 2006) and calibrated using the 2020 Merced Irrigation District Agricultural Water Management Plan.

  Additionally, using the soil classification and land use, the curve number for each element was estimated using the Technical Releasee 55 (TR-55) from the USDA which provides a range of curve number values based on cover type and hydrologic soil group.

- Groundwater System – Model Layering

The lithological and stratigraphic information of the model was refined based on the latest Aerial Electromagnetic (AEM) survey from DWR, including shallow alluvial aquifer layer, to enable the model for assessment of Groundwater Dependent Ecosystems (GDEs), and facilitate future work that could model shallow recharge conditions within the model.

The AEM survey was compared and validated with regional geologic maps and large-scale quadrangles, and complemented with well-specific elogs and local lithology information (see more details in Section 2.1.4.3).

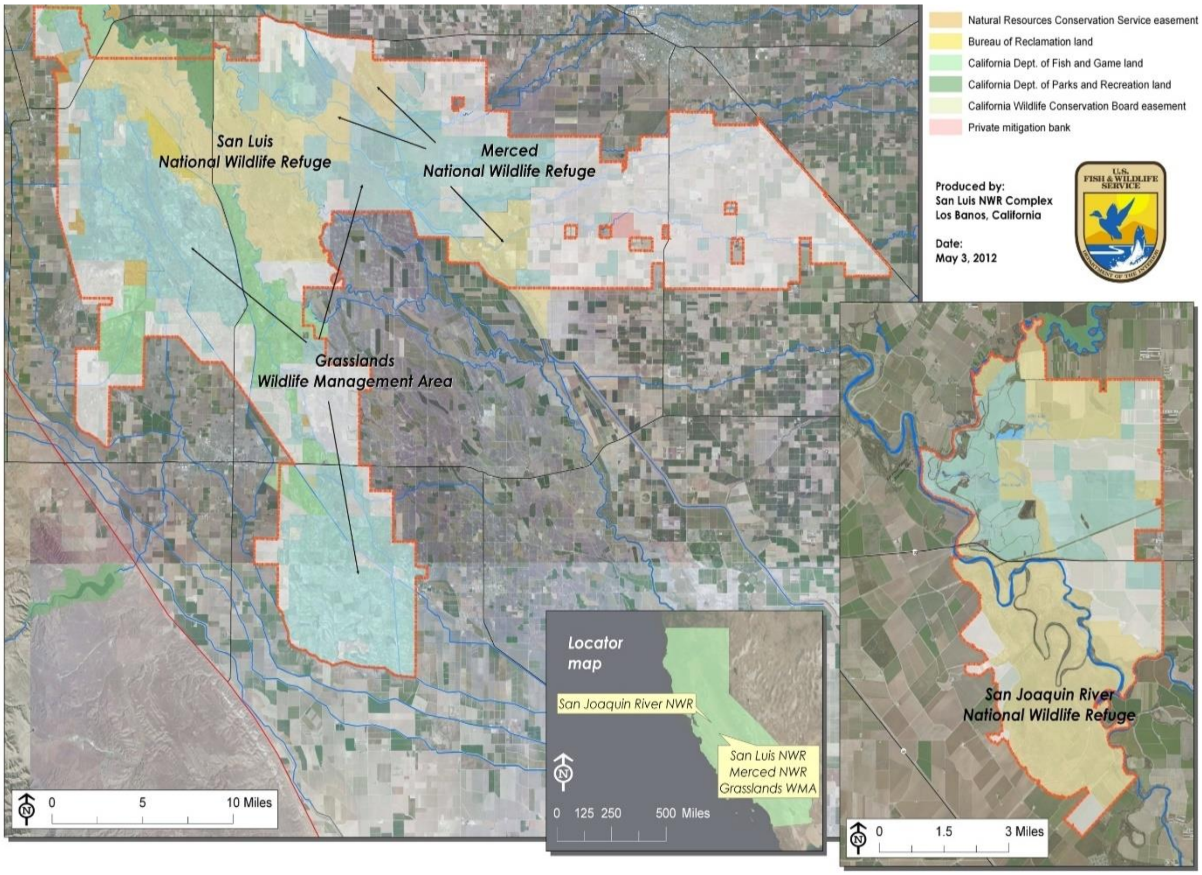
- Groundwater System – Aquifer Parameters

  New aquifer parameters were estimated by using the Texture data provided by the latest AEM survey and calibrated against groundwater level and streamflow observations between 1994 and 2023.

Managed wetlands and habitat areas have unique water use characteristics, often relying on both surface water deliveries and groundwater pumping. The GSAs collaborated with Audubon California to gather surface water and groundwater supply data for the San Luis NWR Complex (see Section 1.2.2.1.4) which includes managed wetlands. Figure 2-167 shows the San Luis NWR Complex, covering 45,000 acres of wetlands, grasslands, and riparian habitats, along with 90,000 acres of private conservation easements across the Merced and Delta-Mendota Subbasins. While these data are valuable, a data gap exists for monthly surface and groundwater delivery deliveries by sub-area within the San Luis NWR Complex.

The lack of higher resolution data combined with limitations of the Integrated Water Flow Model (IWFM), which forms the foundation of the MercedWRM, results in an inability to incorporate surface water and groundwater use at the San Luis NWR Complex into the model. An exception is Merced NWR, which has less intermixing of agriculture and habitat uses and which has detailed annual data sharing, allowing it to be included more directly in the model. While a noted data gap, the impact of not including these values in modeling is limited due to the relatively small volume of applied groundwater over a large area and due to the mixed use of surface water and groundwater.

Figure 2-167: San Luis NWR Fee Title & Conservation Easements



2.3.3 Water Budget Definitions and Assumptions

Definitions and assumptions for the historical, current, and projected water budgets are provided below.

2.3.3.1 Historical Water Budget

The historical 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 historical calibration of the MercedWRM was last updated to reflect the historical conditions in the Merced Subbasin through WY 2015. The hydrologic period of WY 2006 through 2022 is selected for the GSP historical water budget because it provides a period of representative hydrology, while capturing recent Subbasin operations, particularly the 2005 consolidation of El Nido Irrigation District into the MID service area. The period WY 2006 through 2022 has an average annual precipitation of approximately 12.5 inches, compared to the long-term 1969-2018 average of 12.3 inches and includes the recent 2012-2015 and 2018-2020 droughts, the wetter years of 2010-2011, and periods of normal precipitation.

Additional details of the data used in the development of the historical calibration model are included in Appendix D.

2.3.3.2 Current Water Budget

The Current Conditions Baseline water budget has not been updated since the GSP was originally published in 2020.

While a budget indicative of current conditions could be developed using the most recent historical conditions, like the historical water budget (1996-2015), such an analysis would be difficult to interpret due to the drought conditions of the 2012-15 and its effect on local agricultural operations. Instead, in order to analyze the long-term effects of current land and water use on groundwater conditions and to accurately estimate current inflows and outflows for the basin, a Current Conditions Baseline scenario is developed using the MercedWRM. This baseline applies current land and water use conditions to historical hydrology over a 50-year period of 1969-2018.

The Current Conditions Baseline includes the following conditions:

- Hydrologic period:
  - WY 1969-2018 (50-year hydrology)
- River flow is based on:
  - Merced River: MercedSIM releases from New Exchequer under the 2018 Federal Energy Regulatory Commission (FERC) Requirements
  - San Joaquin River and Local Tributaries: historical records from USGS, CDEC, MID stream gauges, and the simulation of small-stream watersheds
- Land use is based on:
  - 2013 USDA CropScape Cropland Data Layer (CDL), which reflects the pre-drought conditions
  - Local ground truthing and refinement
- Urban water demand is based on:
  - 2015 demands as reported in the 2015 Urban Water Management Plans (UWMPs)
    - For regions outside of the UWMP boundaries, population (by US Census tract) was multiplied by the average 2015 per-capita demands across all UWMP regions. For example, the average gallons per capita per day (GPCD) for Merced (276 GPCD), Atwater (300 GPCD), and Livingston (467 GPCD) were averaged to 348 GPCD for non-city regions.
  - Municipal pumping records

- Agricultural water demand is based on:
    - The IWFM Demand Calculator (IDC) in conjunction with historical remote sensing technology, Mapping Evapotranspiration at High Resolution and Internalized Calibration (METRIC)
- Surface water deliveries are based on data from:
    - Merced Irrigation District (MID)
    - Stevinson Water District (SWD)
    - Merquin County Water District (MCWD)
    - Turner Island Water District (TIWD)
    - Lone Tree Mutual Water Company (LTMWC)

2.3.3.3 Projected Water Budget

The projected water budget is intended to assess the conditions of the Subbasin under estimates of projected water supply, agricultural demand and urban demand, including quantification of uncertainties in the projected water budget components. The Projected Conditions Baseline applies future land and water use conditions to the 50-year hydrologic period of WY 1969-2018. The first twenty years of the Projected Conditions Baseline is assumed to be the early implementation period of the GSP, and is represented using current conditions; years 2040 and beyond are represented using projected population (General Plans), land use (General Plans), and water demand and supply projections (AWMP/UWMPs).

The Projected Conditions Baseline includes the following conditions:

- Hydrologic period:
    - WY 1969-2018 (50-year hydrology)
- River flow is based on:
    - Merced River: MercedSIM releases from New Exchequer under FERC Final Environmental Impact Statement (FEIS) Requirements
    - San Joaquin River and Local Tributaries: historical records from USGS, CDEC, MID stream gauges, and the simulation of small-stream watersheds
- Land use is based on:
    - 2022 DWR Statewide Crop Mapping
    - Direct communication on future projections with local agencies and farmers
- Urban water demand is based on:
    - Decadal population projections from 2020 Urban Water Management Plans (UWMPs)

        - For regions outside of the UWMP boundaries, population (by US Census tract) was increased at an average of the rate of growth projected for the UWMP regions, and then multiplied by the average projected per-capita demands across all UWMP regions.
    - Projected gallons per capita per day (GPCD) calculated from historical pumping records with conservation reductions according to the state's 20% mandated conservation reduction by 2020 (Senate Bill SB X7-7).
        - For regions outside of the UWMP boundaries, population was multiplied by the average projected per-capita demands across all UWMP regions.
- Agricultural water demand is based on:
    - The IDC in conjunction with historical remote sensing technology, OpenET, together with validation from CIMIS stations.
- Surface water deliveries are based on data from:
    - 2040 estimates provided by Merced Irrigation District (MID)
    - 2040 estimates provided by Stevinson Water District (SWD)
    - 2040 estimates provided by Merquin County Water District (MCWD)
    - 2040 estimates provided by Turner Island Water District (TIWD)
    - 2040 estimates provided by Lone Tree Mutual Water Company (LTMWC)

Table 2-15: Summary of Groundwater Budget Assumptions

Water Budget Type	Historical	Current	Projected
Tool	MercedWRM	MercedWRM	MercedWRM
Scenario	Historical Simulation	Current Conditions Baseline	Projected Conditions Baseline
Hydrologic Years	WY 2006-2022	WY 1969-2018	WY 1969-2018
Level of Development	Historical	Current	General Plan buildout
Agricultural Demand	Historical Records	Current Conditions	Projected based on local AWMP data
Urban Demand	Historical Records	Current Conditions	Projected based on local UWMP data
Water Supplies	Historical Records	Current Conditions	Projected based on local reservoir operations model

2.3.4 Water Budget Estimates

The primary components of the stream and canal system are:

- Inflows:
  - Stream inflows
  - Stream gain from the groundwater system
  - Surface runoff to the stream system
  - Return flow to stream system
  - Groundwater pumping to canal systems
- Outflows:
  - San Joaquin River outflows
  - Stream losses to groundwater
  - Surface water deliveries
  - Groundwater delivery via canal system
  - Riparian uptake from streams

The primary components of the land surface system are:

- Inflows:
  - Precipitation

- Surface water supplies
- Groundwater supplies
- Riparian uptake from streams
- Inflow from the groundwater system

- Outflows:
  - Evaporation
  - Surface runoff to the stream system
  - Return flow to the stream system
  - Deep percolation (of applied surface water and groundwater, and precipitation)

The primary components of the groundwater system are:

- Inflows:
  - Deep percolation (of applied surface water and groundwater, and precipitation)
  - Stream losses to the groundwater system
  - Subsurface inflow
- Outflows:
  - Stream gain from the groundwater system
  - Groundwater production (pumping)
  - Subsurface outflow
- Change in groundwater storage

The estimated water budgets are provided below in Table 2-16 through Table 2-18 for the historical, current, projected, sustainable yield, and climate change water budgets. Background on the sustainable yield water budget analysis and assumptions is provided in Section 2.3.4.4 and for climate change water budget in Section 2.4.

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Table 2-16: Average Annual Water Budget – Stream and Canal Systems, Merced Subbasin (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget[4]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
Inflows					
Stream Inflows	2,075,000	2,480,000	2,480,000	2,480,000	2,480,000
Merced River	1,001,000	981,000	981,000	981,000	981,000
Eastside Bypass	599,000	773,000	773,000	773,000	773,000
San Joaquin River	331,000	581,000	581,000	581,000	581,000
Chowchilla River	72,000	72,000	72,000	72,000	72,000
Local Tributaries[1]	72,000	74,000	74,000	74,000	74,000
Stream Gain from Groundwater	50,000	51,000	39,000	61,000	56,000
Merced Subbasin	27,000	31,000	22,000	35,000	37,000
Merced River	8,000	10,000	6,000	9,000	9,000
Eastside Bypass	1,000	1,000	0	3,000	8,000
San Joaquin River	10,000	7,000	8,000	12,000	4,000
Chowchilla River	1,000	2,000	1,000	1,000	2,000
Local Tributaries[1]	6,000	11,000	7,000	11,000	13,000
Other Subbasins[2]	24,000	21,000	18,000	26,000	19,000
Merced River	9,000	11,000	7,000	10,000	10,000
San Joaquin River	9,000	6,000	7,000	10,000	4,000
Chowchilla River	6,000	3,000	4,000	5,000	6,000
Runoff to the Stream System	213,000	355,000	262,000	250,000	248,000
Merced Subbasin	90,000	204,000	145,000	133,000	131,000
Other Subbasins[2]	123,000	151,000	117,000	117,000	117,000
Return Flow to Stream System	59,000	126,000	67,000	68,000	68,000
Merced Subbasin	46,000	63,000	56,000	57,000	57,000
Other Subbasins[2]	12,000	62,000	11,000	11,000	11,000
Groundwater Pumping to Canals	53,000	45,000	42,000	44,000	44,000
Other[3]	-28,000	-33,000	-36,000	-88,000	-34,000
Total Inflow	**2,478,000**	**3,090,000**	**2,927,000**	**2,991,000**	**2,931,000**
Outflows					

Component	Historical Condition Water Budget	Current Condition Water Budget[4]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
San Joaquin River Outflows	1,704,000	2,341,000	2,090,000	2,216,000	2,225,000
Stream Losses to Groundwater	446,000	389,000	483,000	406,000	337,000
Merced Subbasin	352,000	312,000	367,000	323,000	318,000
Merced River	53,000	37,000	70,000	54,000	9,000
Eastside Bypass	33,000	39,000	48,000	25,000	8,000
San Joaquin River	32,000	34,000	40,000	25,000	4,000
Chowchilla River	7,000	2,000	1,000	1,000	2,000
Local Tributaries[1]	90,000	50,000	68,000	58,000	135,000
Canal Recharge	136,000	149,000	140,000	160,000	160,000
Other Subbasins[2]	94,000	77,000	116,000	83,000	19,000
Merced River	54,000	37,000	72,000	56,000	10,000
San Joaquin River	35,000	38,000	44,000	27,000	4,000
Chowchilla River	6,000	2,000	0	0	6,000
Surface Water Deliveries	250,000	290,000	287,000	300,000	300,000
Groundwater Delivery via Canals	53,000	45,000	42,000	44,000	44,000
Riparian Uptake from Streams	25,000	25,000	25,000	25,000	25,000
Merced Subbasin	8,000	15,000	7,000	7,000	7,000
Other Subbasins	16,000	10,000	17,000	17,000	17,000
Total Outflow	**2,478,000**	**3,090,000**	**2,927,000**	**2,991,000**	**2,931,000**

1 Local Tributaries include Bear Creek, Black Rascal Creek, Deadman Creek, Duck Slough, Dutchman Creek, Mariposa Creek, Miles Creek, and Owens Creek. Additional smaller creeks exist but were not modeled due to minimal natural flows.

2 Other Subbasins include the Turlock, Chowchilla, and Delta-Mendota Subbasins. As supporting data was not available, modeling inputs such as curve number and return flow fractions were assumed to be similar to those used in the Merced Subbasin.

3 Other flows is a closure term that captures the stream and canal system including gains and losses not directly measured or simulated within IWFM. Some of these features include but may not be limited to direct precipitation, evaporation, unmeasured riparian diversions and return flow, temporary storage in local lakes and regulating reservoirs, and inflow discrepancies resulting from simulating impaired flows.

4 The Current Condition water budget has not been updated since the GSP was originally published in 2020.

Table 2-17: Average Annual Water Budget – Land Surface System, Merced Subbasin (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget[3]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
Inflows					
Precipitation	437,000	506,000	505,000	505,000	505,000
Total Surface Water Supply	250,000	290,000	287,000	300,000	300,000
Surface Water - Local	205,000	244,000	241,000	244,000	244,000
Surface Water - Riparian	45,000	46,000	46,000	46,000	46,000
Total Groundwater Supply	735,000	598,000	704,000	519,000	499,000
Agricultural - Agency	53,000	45,000	42,000	44,000	44,000
Agricultural - Private	628,000	490,000	590,000	400,000	380,000
Urban - Municipal	42,000	35,000	49,000	49,000	41,000
Urban - Domestic	13,000	29,000	24,000	26,000	34,000
Riparian Uptake from Streams	8,000	15,000	7,000	7,000	7,000
Inflow from Groundwater System	0	12,000	0	0	0
Total Inflow	**1,431,000**	**1,420,000**	**1,504,000**	**1,332,000**	**1,312,000**
Outflows					
Evapotranspiration	961,000	834,000	953,000	829,000	811,000
Agricultural	769,000	661,000	745,000	583,000	560,000
Municipal and Domestic	22,000	31,000	24,000	24,000	24,000
Refuge, Native, and Riparian	171,000	142,000	184,000	222,000	227,000
Runoff to the Stream System	90,000	204,000	145,000	133,000	131,000
Return Flow to the Stream System	46,000	63,000	56,000	57,000	57,000
Agricultural	14,000	25,000	12,000	12,000	12,000
Municipal and Domestic	33,000	38,000	44,000	45,000	45,000
Deep Percolation	333,000	318,000	343,000	306,000	306,000
Precipitation	87,000	81,000	91,000	96,000	97,000
Surface Water	63,000	78,000	73,000	77,000	78,000
Surface Water - Local	51,000	65,000	61,000	65,000	66,000
Surface Water - Riparian	11,000	12,000	12,000	12,000	12,000
Groundwater	184,000	160,000	179,000	134,000	130,000

Component	Historical Condition Water Budget	Current Condition Water Budget[3]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
Agricultural - Agency	13,000	12,000	11,000	11,000	11,000
Agricultural - Private	157,000	131,000	149,000	103,000	99,000
Urban - Municipal	10,000	9,000	12,000	13,000	11,000
Urban - Private	3,000	8,000	6,000	7,000	9,000
Other[2]	0	1,000	7,000	7,000	7,000
Total Outflow	**1,431,000**	**1,420,000**	**1,504,000**	**1,332,000**	**1,312,000**

[1] Managed wetlands and habitat areas are recognized as additional areas that have unique water use characteristics, often using both delivered surface water and pumped groundwater. The values for applied surface water and applied groundwater, as well as deep percolation, for private wetland/habitat areas are aggregated into larger categories (e.g., "Local" or "Riparian" or "Agricultural") due to a lack of information for demands from these private wetlands/habitat areas (see more information in Section 2.3.2). Demands were estimated based on DWR land use categorizations of native vegetation or agricultural land. Furthermore, the MercedWRM was calibrated to remote sensing of evapotranspiration data (OpenET) which is expected to result in a net accurate model result for consumptive use for these aggregated categories, even if the individual wetland components couldn't be tabulated separately. Surface water and groundwater supplied to the Merced NWR are known values and are included in the aggregated categories.

[2] Other flows is a closure term that captures the gains and losses due to land expansion and seasonal storage in the root-zone.

[3] The Current Condition water budget has not been updated since the GSP was originally published in 2020.

Table 2-18: Average Annual Water Budget – Groundwater System, Merced Subbasin (AFY)

Component	Historical Condition Water Budget	Current Condition Water Budget[3]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
Inflows					
Deep Percolation	333,000	318,000	343,000	306,000	306,000
Precipitation	87,000	81,000	91,000	96,000	97,000
Surface Water	63,000	78,000	73,000	77,000	78,000
Surface Water - Local	51,000	65,000	61,000	65,000	66,000
Surface Water - Riparian	11,000	12,000	12,000	12,000	12,000
Groundwater	184,000	160,000	179,000	134,000	130,000
Agricultural - Agency	13,000	12,000	11,000	11,000	11,000
Agricultural - Private	157,000	131,000	149,000	103,000	99,000
Urban - Municipal	10,000	9,000	12,000	13,000	11,000
Urban - Private	3,000	8,000	6,000	7,000	9,000
Stream Losses to Groundwater	352,000	312,000	367,000	323,000	318,000
Merced River	53,000	37,000	70,000	54,000	9,000
Eastside Bypass	33,000	39,000	48,000	25,000	8,000
San Joaquin River	32,000	34,000	40,000	25,000	4,000
Chowchilla River	7,000	2,000	1,000	1,000	2,000
Local Tributaries[1]	90,000	50,000	68,000	58,000	135,000
Canal Recharge	136,000	149,000	140,000	160,000	160,000
Subsurface Inflow	75,000	69,000	82,000	72,000	70,000
Total Inflow	**759,000**	**700,000**	**791,000**	**702,000**	**694,000**
Outflows					
Stream Gain from Groundwater	27,000	31,000	22,000	35,000	37,000
Merced River	8,000	10,000	6,000	9,000	9,000
Eastside Bypass	1,000	1,000	0	3,000	8,000
San Joaquin River	10,000	7,000	8,000	12,000	4,000
Chowchilla River	1,000	2,000	1,000	1,000	2,000
Local Tributaries	6,000	11,000	7,000	11,000	13,000
Groundwater Production	735,000	598,000	704,000	519,000	499,000

Component	Historical Condition Water Budget	Current Condition Water Budget[3]	Projected Condition Water Budget	Projects and Management Actions Water Budget	Sustainable Condition Water Budget
Hydrologic Period	**WY 2006 - 2022**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**	**WY 1969 - 2018**
Agricultural - Agency	53,000	45,000	42,000	44,000	44,000
Agricultural - Private	628,000	490,000	590,000	400,000	380,000
Urban - Municipal	42,000	35,000	49,000	49,000	41,000
Urban - Private	13,000	29,000	24,000	26,000	34,000
Subsurface Outflow	126,000	110,000	142,000	136,000	140,000
Outflow to Land Surface System	0	12,000	0	0	0
Other[2]	1,000	1,000	1,000	0	0
Total Outflow	**889,000**	**752,000**	**869,000**	**690,000**	**676,000**
Change in Storage	**-130,000**	**-52,000**	**-77,000**	**12,000**	**18,000**

[1] Local Tributaries include Bear Creek, Black Rascal Creek, Deadman Creek, Duck Slough, Dutchman Creek, Mariposa Creek, Miles Creek, and Owens Creek. Additional smaller creeks exist but were not modeled due to minimal natural flows.

[2] Other flows within the groundwater system including temporary storage in the vadose zone, and root water uptake from the aquifer system.

[3] The Current Condition water budget has not been updated since the GSP was originally published in 2020.

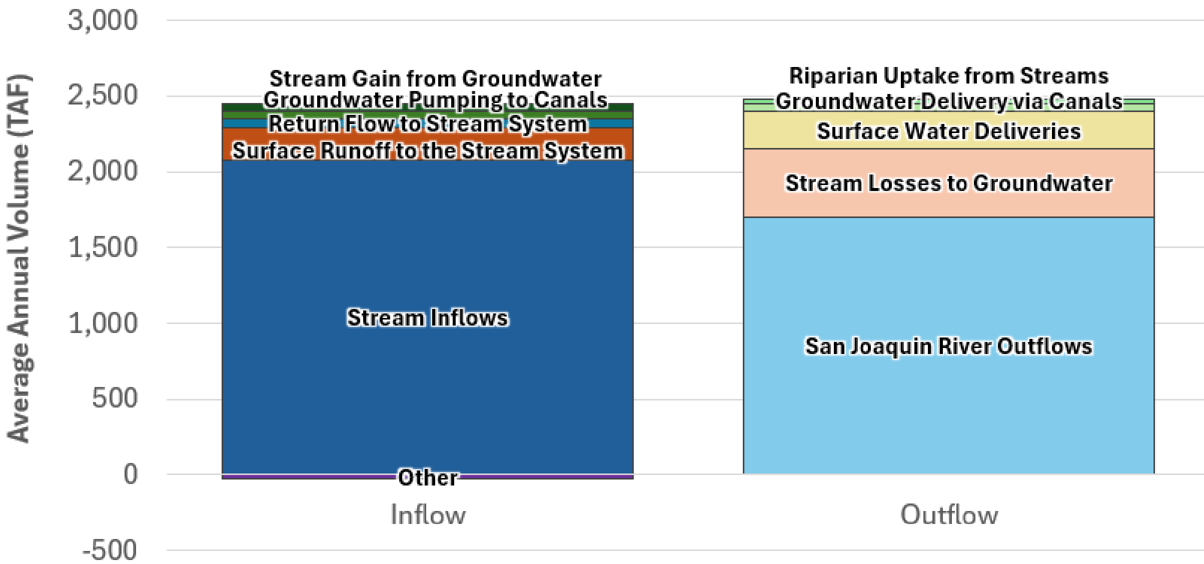
2.3.4.1 Historical Water Budget

The historical water budget is a quantitative evaluation of the historical surface and groundwater supply covering the 16-year period from WY 2006 to 2022. This period was selected as the representative hydrologic period as it reflects the most recent basin operations, particularly the annexation of the El Nido Irrigation District area into MID. The goal of the water budget analysis is to characterize the supply and demand, while summarizing the hydrologic flow within the Subbasin, including the movement of primary sources of water such as rainfall, irrigation, streamflow, and subsurface flows.

The existing stream and canal network supplies multiple water users and agencies in the Merced Groundwater Subbasin, including MID, SWD, MCWD, TIWD, and LTMWC. When analyzing the stream and canal system, it is important to note potentially significant effects resulting from the natural interactions and managed operations of adjacent groundwater subbasins. Because of this, the water budget in Table 2-15 and Figure 2-168 below attempt to not only quantify surface and canal system flows within the Merced Subbasin, but also estimate contributions from adjoining areas.

Total average annual surface water inflows of the stream and canal system are 2,478,000 AF travel through or along the Subbasin boundary. The majority of these flows enter the Subbasin through inflows from natural streams and the Eastside Bypass (2,075,000 AF) and are supplemented by surface runoff (213,000 AF), return flow (59,000 AF), natural groundwater contributions (50,000 AF), occurring through or along the Subbasin boundary, and also includes groundwater pumping into streams and canals from local water agencies (53,000 AF). Outflows of the Merced Subbasin stream and canal system total 2,478,000 AF and include downstream flow from the San Joaquin River (1,704,000 AF), stream losses to the aquifer system (446,000 AF), surface water deliveries (250,000 AF), groundwater delivered via local canal systems (53,000 AF), and riparian uptake (25,000 AF).

Figure 2-168: Historical Average Annual Water Budget – Stream and Canal Systems, Merced Subbasin



The land surface system of the Merced Subbasin, shown below in Figure 2-169, experiences 1,431,000 acre-feet of inflows each year, a combination of precipitation (437,000 AF), surface water deliveries (250,000 AF), groundwater pumping (735,000 AF), and riparian uptake from the stream system (8,000 AF). Equivalent to the inflows in magnitude, outflows from the land surface system are comprised of evapotranspiration (961,000 AF), surface runoff (90,000 AF) and return flow (46,000 AF) to the stream and canal system, and deep percolation (333,000 AF). Figure 2-170 shows the annual change in the land surface water budget through the simulation period. Note the surface water supply in this water budget is reflective of the volume available to the grower, and thus does not include operational spills, canal seepage, or canal evaporative losses.

Figure 2-169: Historical Average Annual Water Budget – Land Surface System, Merced Subbasin

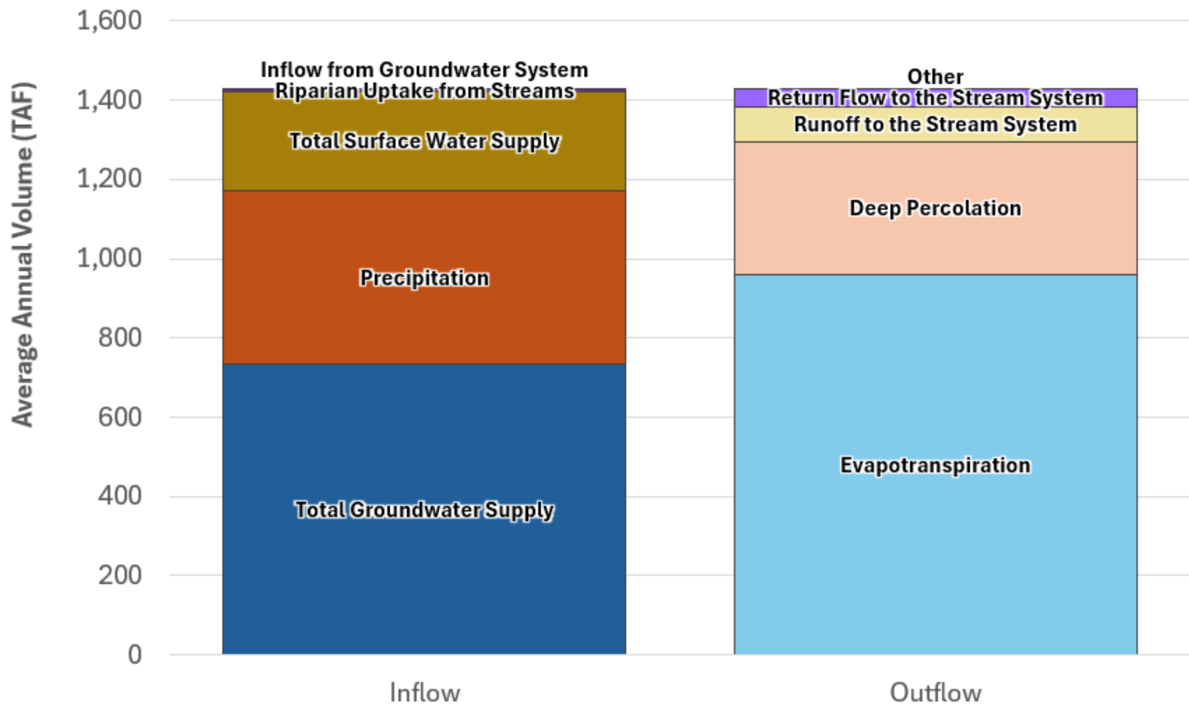
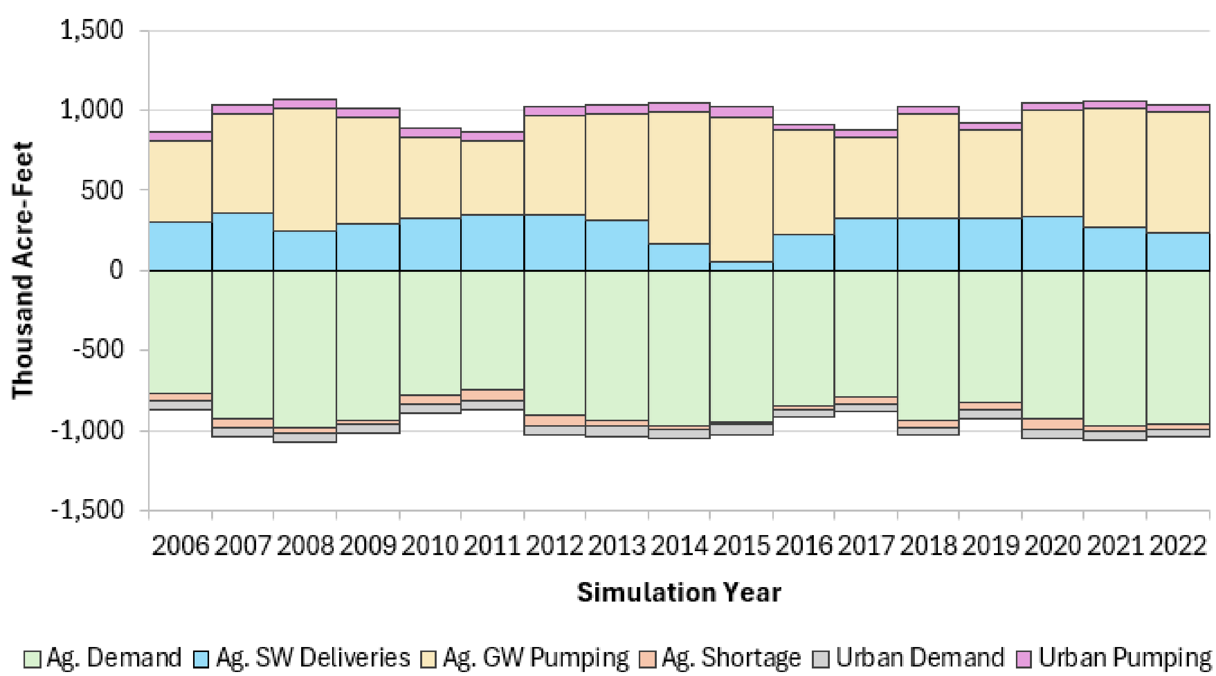


Figure 2-170: Historical Annual Water Budget – Land Surface System, Merced Subbasin



The groundwater system of the Merced Subbasin experiences over 759,000 acre-feet of inflows each year, of which 333,000 AF is surface infiltration. There is also recharge from rivers, streams, and canals (352,000 AF), and subsurface inflows (75,000 AF) from the Sierra Nevada foothills and the neighboring subbasins of Turlock, Delta-Mendota, and Chowchilla.

On average, outflows exceed inflows. The largest outflow of the groundwater system is pumping (735,000 AF), followed by subsurface flow into neighboring subbasins (126,000 AF) and losses due to local stream-groundwater interaction (27,000 AF).

The greater outflows than inflows leads to an average annual decrease in groundwater storage of 130,000 acre-feet. Figure 2-171 summarizes the average historical groundwater inflows and outflows in the Merced Subbasin. Figure 2-172 shows the annual change in the groundwater budget components, as well as cumulative storage, through the 1996 to 2023 period.

Figure 2-171: Historical Average Annual Water Budget – Groundwater System, Merced Subbasin

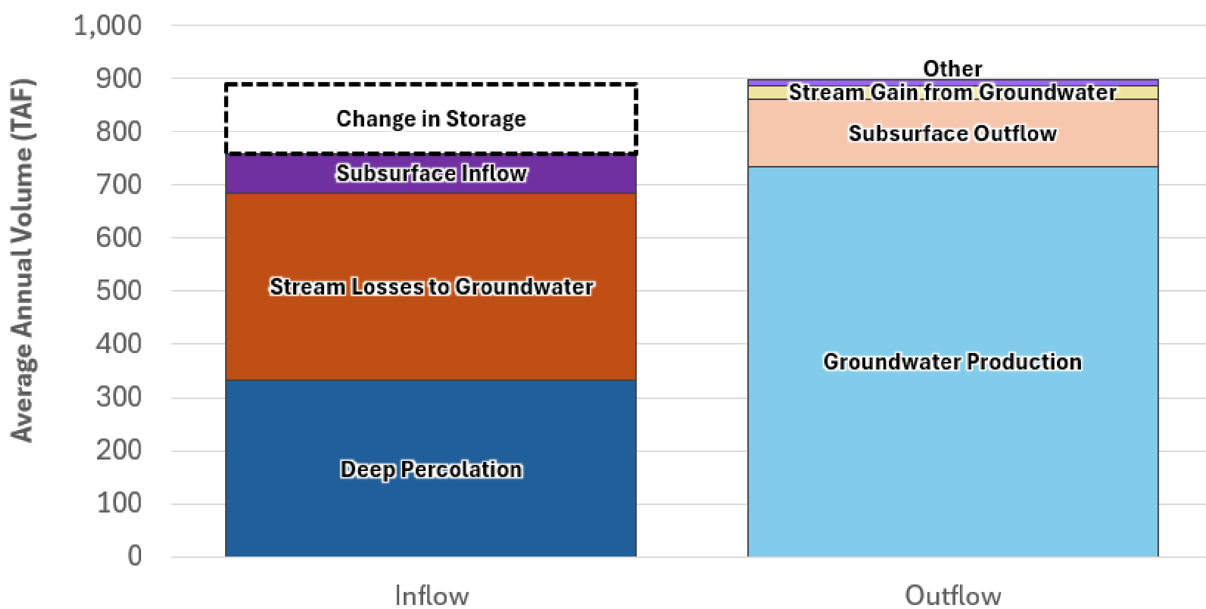
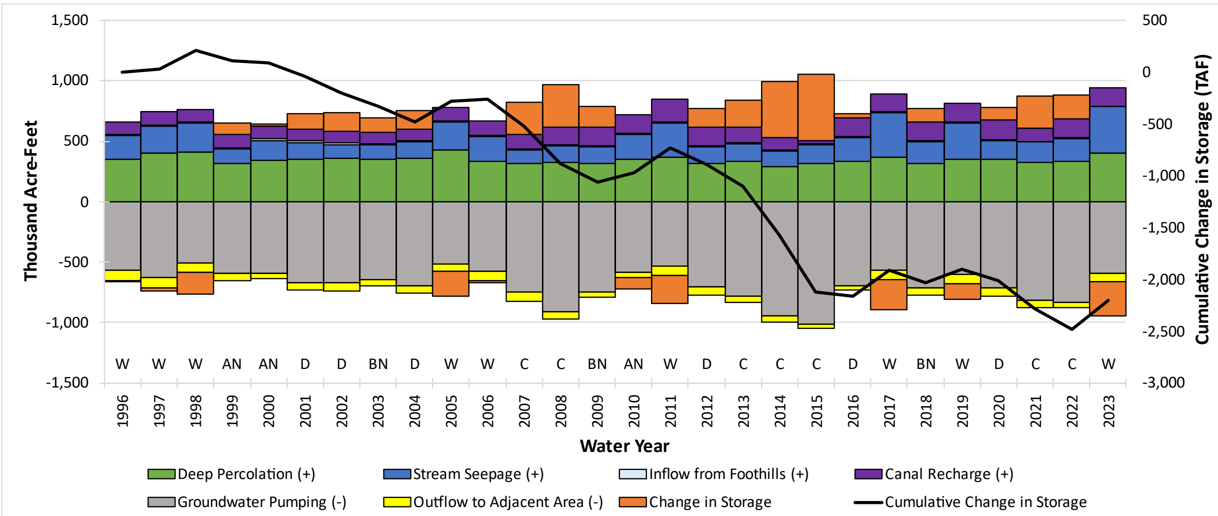


Figure 2-172: Historical Annual Water Budget – Groundwater System, Merced Subbasin



The historical inflows and outflows change by water year type. In wet years, precipitation meets more of the water demand, and greater availability of surface water reduces the need for groundwater. However, in dry years, more groundwater is pumped to meet the agricultural demand not met by surface water or precipitation. This leads to an increase in groundwater storage in wet years and a decrease in dry years. While demand of applied water increases in dry years due to lack of precipitation, surface water supply remains consistent in most non-critical years. Table 2-19 breaks down the average historical water supply and demand by water year type.

Table 2-19: Average Annual Values for Key Components of the Historical Water Budget by Year Type (AFY)

Component	Water Year Type (San Joaquin River Index)					
	Wet	Above Normal	Below Normal	Dry	Critical	Overall Average WY 2006-22
Water Demand						
Agricultural Demand	815,000	847,000	941,000	950,000	997,000	930,000
Urban Demand	55,000	59,000	55,000	55,000	57,000	56,000
Total Demand	**869,000**	**906,000**	**996,000**	**1,005,000**	**1,053,000**	**986,000**
Water Supply						
Total Surface Water Supply	313,000	320,000	291,000	314,000	178,000	255,000
Local	269,000	276,000	245,000	264,000	136,000	211,000
Riparian	45,000	44,000	46,000	49,000	42,000	44,000
Total Groundwater Supply	560,000	590,000	701,000	694,000	862,000	726,000
Agricultural - Agency	29,000	32,000	46,000	41,000	87,000	57,000
Agricultural - Private	476,000	499,000	600,000	599,000	718,000	613,000
Urban - Municipal	42,000	45,000	42,000	42,000	44,000	43,000
Urban - Domestic	13,000	14,000	13,000	13,000	13,000	13,000
Total Supply	**873,000**	**909,000**	**992,000**	**1,008,000**	**1,040,000**	**982,000**
Change in GW Storage	**151,000**	**-9,000**	**-141,000**	**-125,000**	**-336,000**	**-142,000**

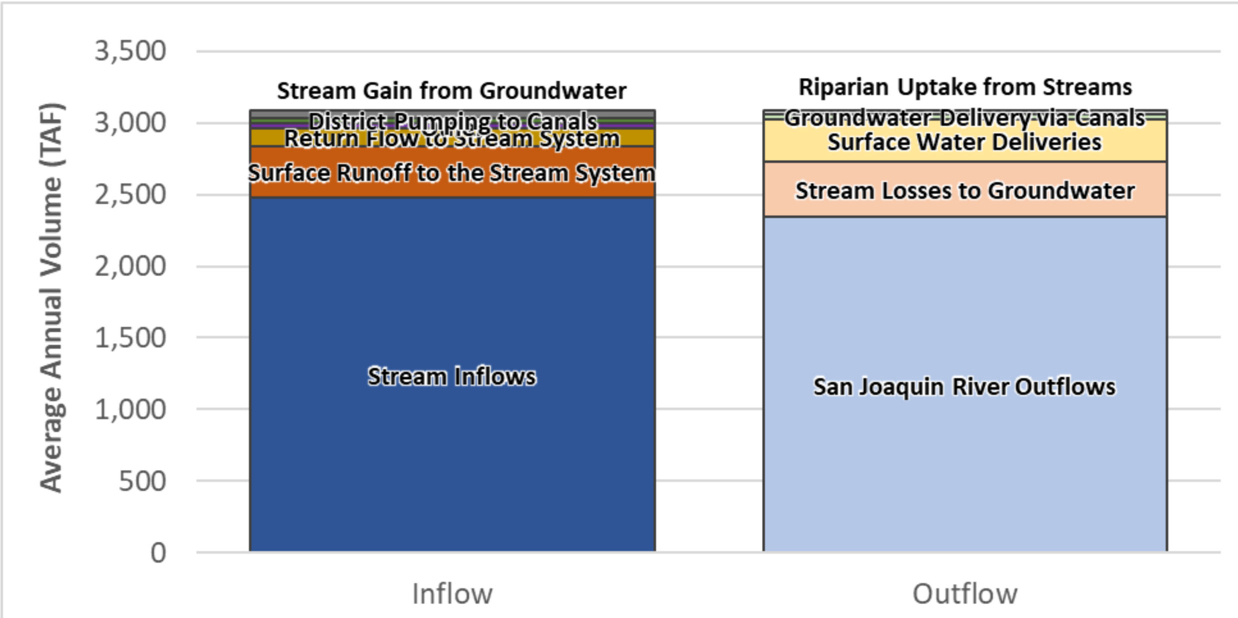
2.3.4.2 Current Water Budget

The current water budget quantifies inflows to and outflows from the basin using 50-years of hydrology in conjunction with 2015 water supply, demand, and land use information. These conditions are incorporated in the Current Conditions Baseline simulation of the MercedWRM.

The stream and canal system in the Current Conditions Baseline supplies agricultural users with an average of 290,000 AF in surface water diversions from local streams with an additional 45,000 AF of pumping by local surface water purveyors supplementing their conveyance system. In addition to these volumes, on average, 2,341,000 AFY leaves the Subbasin's surface water features as downstream flow in the San Joaquin River, 389,000 AFY is lost to the groundwater system, and 25,000 AFY is used by riparian vegetation as direct-uptake.

Inflows to the stream and canal system include 2,480,000 AFY of local stream inflow, 355,000 AFY of surface runoff, 126,000 of return flow, 51,000 AFY of groundwater contributions, 45,000 AFY of district pumping, and 33,000 AFY of uncategorized flows. Figure 2-173 summarizes the average annual inflows and outflow of the Current Conditions Baseline in the Merced Subbasin surface water network.

Figure 2-173: Current Conditions Average Annual Water Budget – Stream and Canal Systems, Merced Subbasin



Based on pre-drought cropping patterns and 2015 urban buildout, over the simulation period, the Current Conditions land surface water budget simulates annual inflows of 1,420,000 AF, including 506,000 AF of precipitation, 880,000 AF of applied water (290,000 AF of surface water and 598,000 AF of groundwater), 15,000 AF of riparian uptake from the stream system, and 12,000 AF of inflow from the groundwater system. The 1,420,000 of outflows include evapotranspiration (834,000 AF), surface runoff to the stream system (204,000 AF), return flow to the stream system (63,000 AF), deep percolation (318,000 AF), and other flows (1,000 AF). Figure 2-174 summarizes the average annual current condition inflows and outflows in the land surface budget for the Merced Subbasin. Figure 2-175 shows the annual change in the land surface water budget components through the simulation period.

Figure 2-174: Current Conditions Average Annual Water Budget – Land Surface System, Merced Subbasin

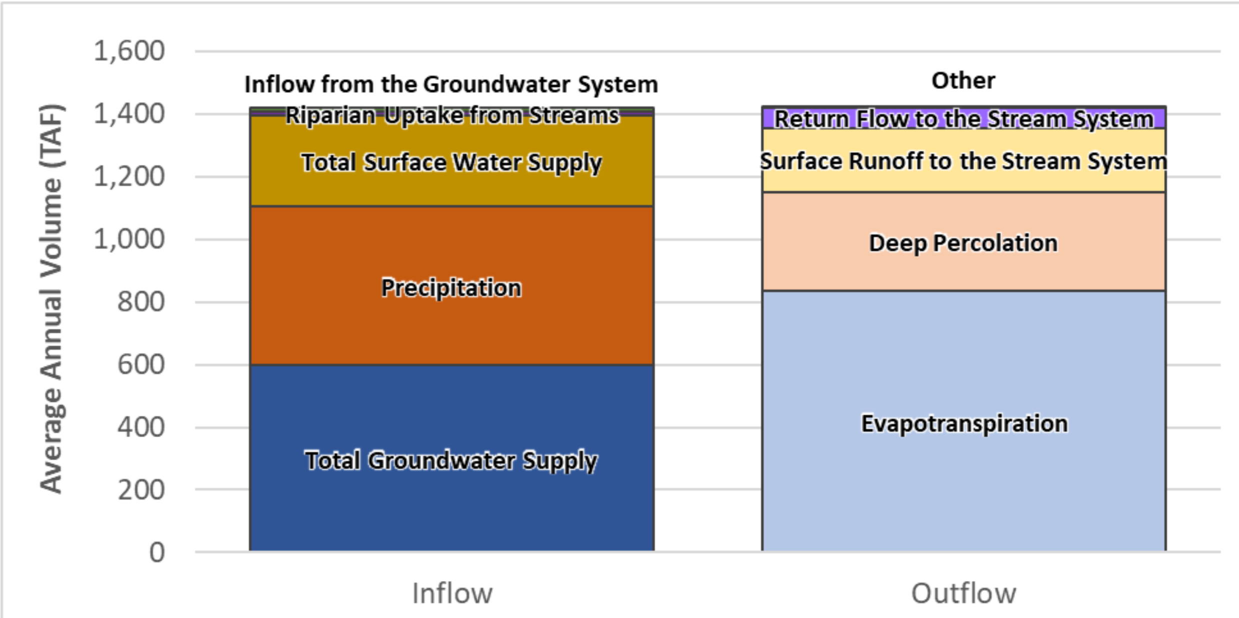
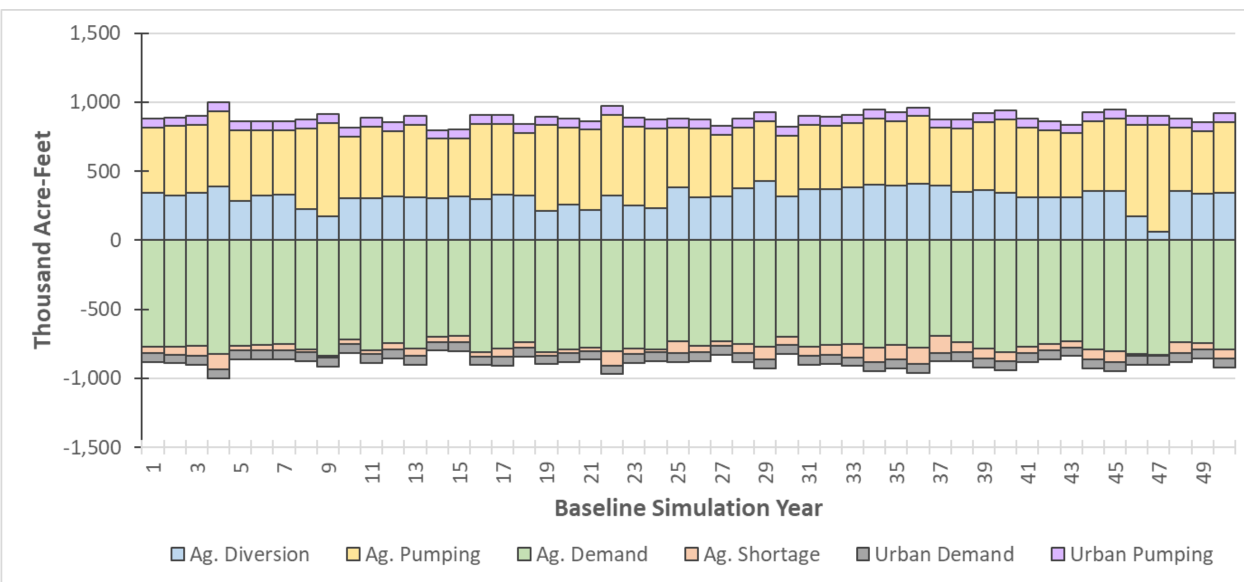


Figure 2-175: Current Conditions Annual Water Budget – Land Surface System, Merced Subbasin



The Current Conditions Baseline simulates 50 years of hydrology whose initial conditions are reflective of the start of WY 2016. Over the simulation period, the Current Conditions groundwater water budget simulates annual inflows of 700,000 AF, including 318,000 AF of deep percolation, 312,000 AF of stream and canal seepage, and subsurface inflows totaling 69,000 AF.

Similar to the historical water budget, average aquifer outflows exceed the inflows under current conditions. Groundwater production (598,000 AF) remains the largest point of aquifer discharge, with subsurface outflow (110,000 AF), losses to the local stream system (31,000 AF), and other flows (13,000 AF) bringing the total system outflows to 752,000 acre-feet annually.

The Merced Subbasin current conditions groundwater budget has greater outflows than inflows, resulting in an average annual deficit in groundwater storage of 52,000 acre-feet. Figure 2-176 summarizes the average current conditions groundwater inflows and outflows in the Merced Subbasin. Figure 2-177 shows the annual change in the groundwater budget components, as well as cumulative storage, through the 50-year simulation period.

Figure 2-176: Current Conditions Average Annual Water Budget – Groundwater System, Merced Subbasin

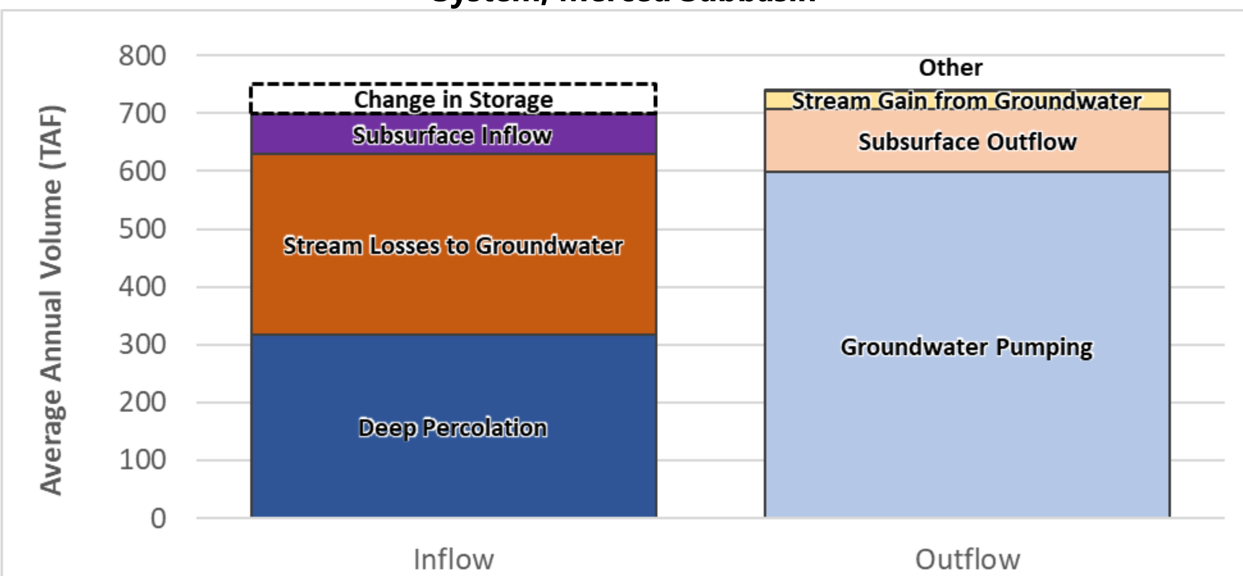
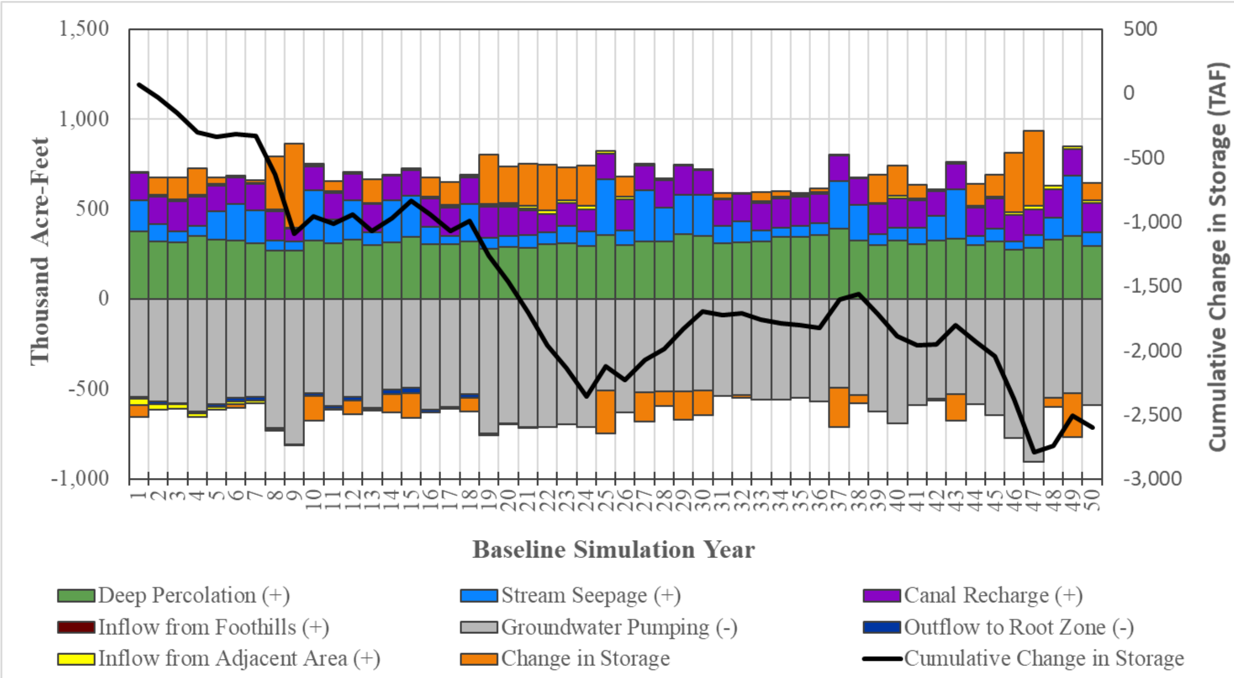


Figure 2-177: Current Conditions Annual Water Budget – Groundwater System, Merced Subbasin



2.3.4.3 Projected Water Budget

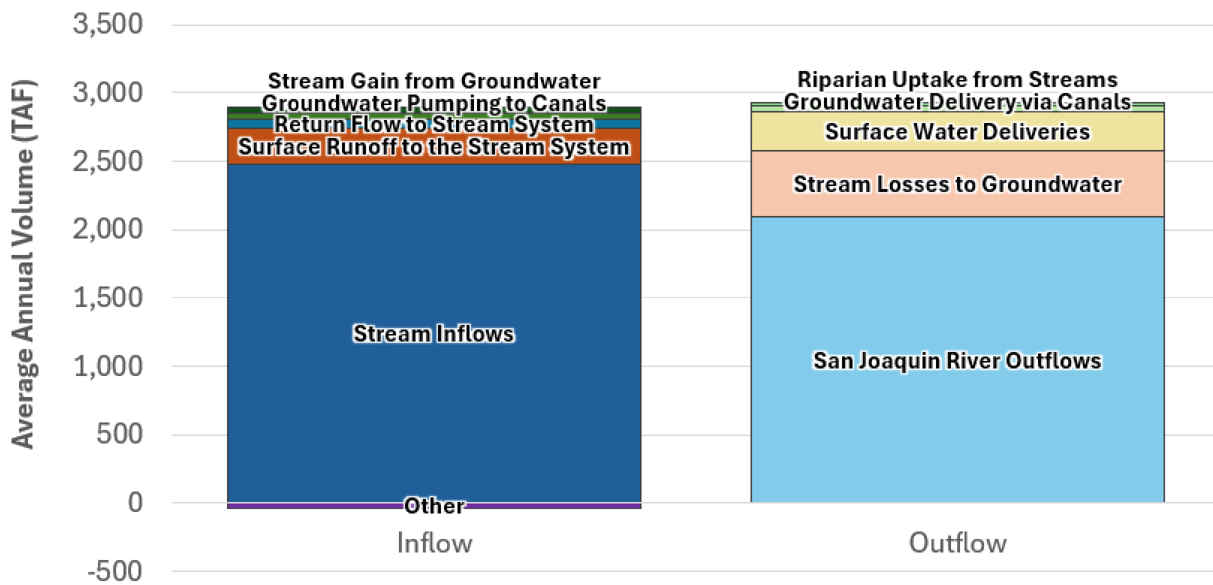
The projected water budget is used to estimate future baseline conditions of supply, demand, and aquifer response to plan implementation. The Projected Conditions Baseline simulation of the MercedWRM is used to evaluate the projected conditions of the water budget using hydrology from 1969 to 2018. As previously discussed, this represents a hydrologic period of at least 50 years and has average precipitation similar to the long-term average.

Development of the projected water demand is based on the population growth trends reported in the 2020 UWMPs, and land use, evapotranspiration, and crop coefficient information from the 2020 AWMP. This data has been adjusted based on projected growth identified in general, agricultural, and urban water management plans to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate. Similarly, projected surface water supplies were determined through analysis of MercedSIM, Merced Irrigation District's reservoir and surface water operations model, and accounts for the FERC's operations schedule under their FEIS for the 2018 licensing of the Lake McClure Reservoir.

Average annual surface water inflows to the Merced Subbasin's stream and canal system total an average of 2,927,000 AF. Under projected conditions, local water district pumping will supplement surface water supplies with 42,000 AF of groundwater production. Of these volumes, it is anticipated that 329,000 AF will be distributed to local growers to meet agricultural demand

(287,000 AF of surface water deliveries and 42,000 AF of groundwater deliveries) and the remaining amount will leave the system in the form of San Joaquin River outflow (2,090,000 AF), aquifer recharge (483,000 AF), or riparian uptake (25,000 AF). Figure 2-178 summarizes the average projected inflows and outflows in the Merced Subbasin surface water network.

Figure 2-178: Projected Conditions Average Annual Water Budget – Stream and Canal Systems, Merced Subbasin



The land surface water budget for the Projected Conditions Baseline has annual average inflows and outflows of 1,504,000 AF. Inflows comprise precipitation (505,000 AF), applied surface water (287,000 AF), applied groundwater (704,000 AF), and riparian uptake from streams (7,000 AF). The balance of this is the summation of average annual evapotranspiration (953,000 AF), surface runoff (145,000 AF) and return flow (56,000 AF) to the stream system, deep percolation (343,000 AF), and other flows (7,000 AF). A summary of these flows can be seen below in Figure 2-179. Figure 2-180 shows the annual change in the land surface water budget components through the simulation period.

Figure 2-179: Projected Conditions Average Annual Water Budget – Land Surface System, Merced Subbasin

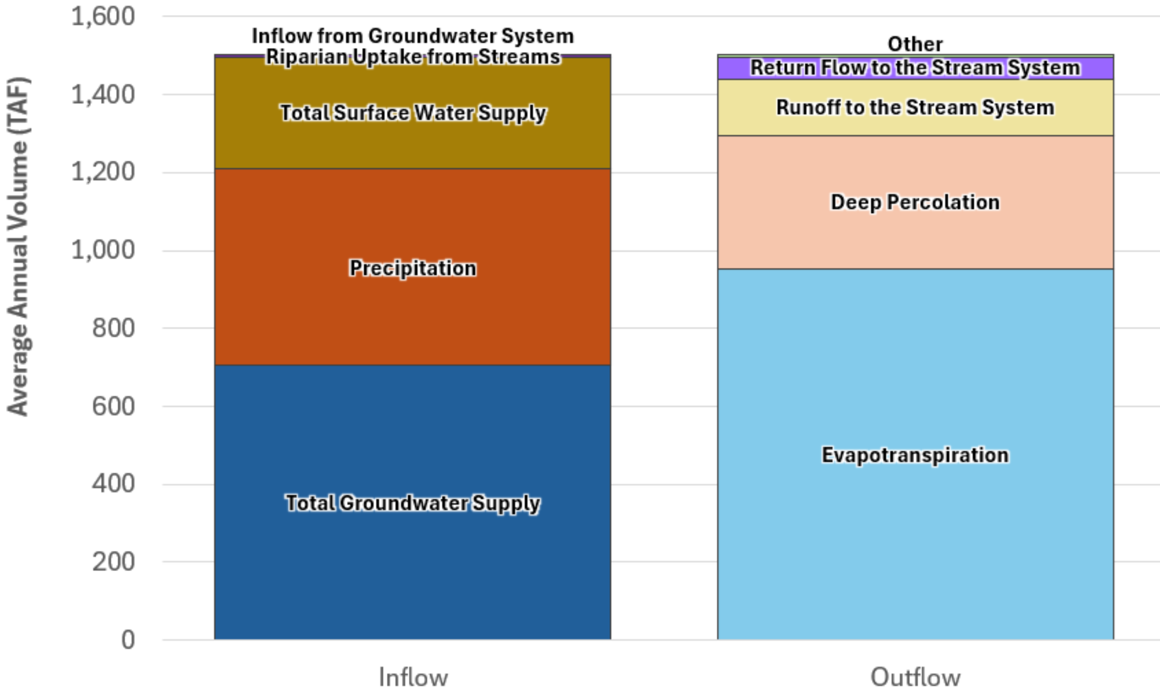


Figure 2-180: Projected Conditions Annual Water Budget – Land Surface System, Merced Subbasin

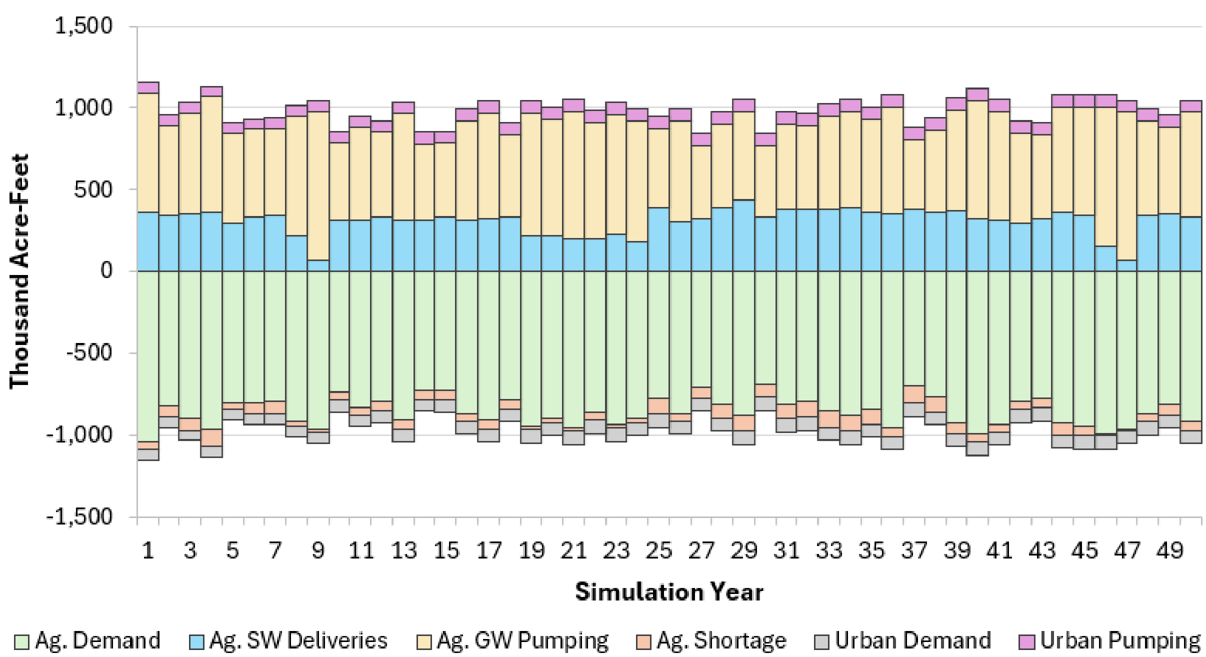


Figure 2-181 below shows how anticipated growth in the Projected Conditions Baseline is reflected in groundwater production (704,000 AF) across the Subbasin. Subsurface outflow to neighboring subbasins (142,000 AF), stream gain from groundwater (22,000 AF), and other flows (1,000 AF) bring the total Subbasin discharges to 869,000 AFY.

Under projected conditions, the groundwater system experiences an average of 791,000 AF of inflows each year, of which 343,000 AF is deep percolation. There is also recharge from rivers, streams, and canals (367,000 AF), and subsurface inflows (82,000 AF) from the Sierra Nevada foothills and the neighboring subbasins of Turlock, Delta-Mendota, and Chowchilla.

The Projected Conditions Baseline has greater outflows than inflows, resulting in an average annual deficit in groundwater storage of 77,000 AF. Figure 2-181 summarizes the average projected groundwater inflows and outflows in the Merced Subbasin. Figure 2-182 shows the annual change in the groundwater budget, as well as cumulative storage, through the simulation period.

Figure 2-181: Projected Conditions Average Annual Water Budget – Groundwater System, Merced Subbasin

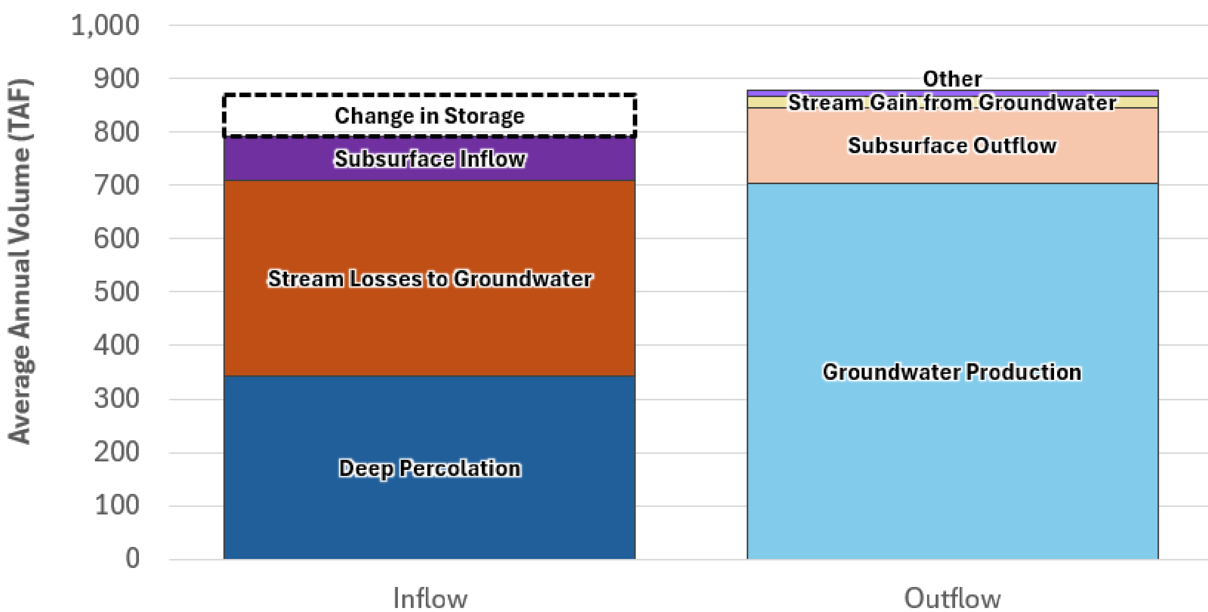
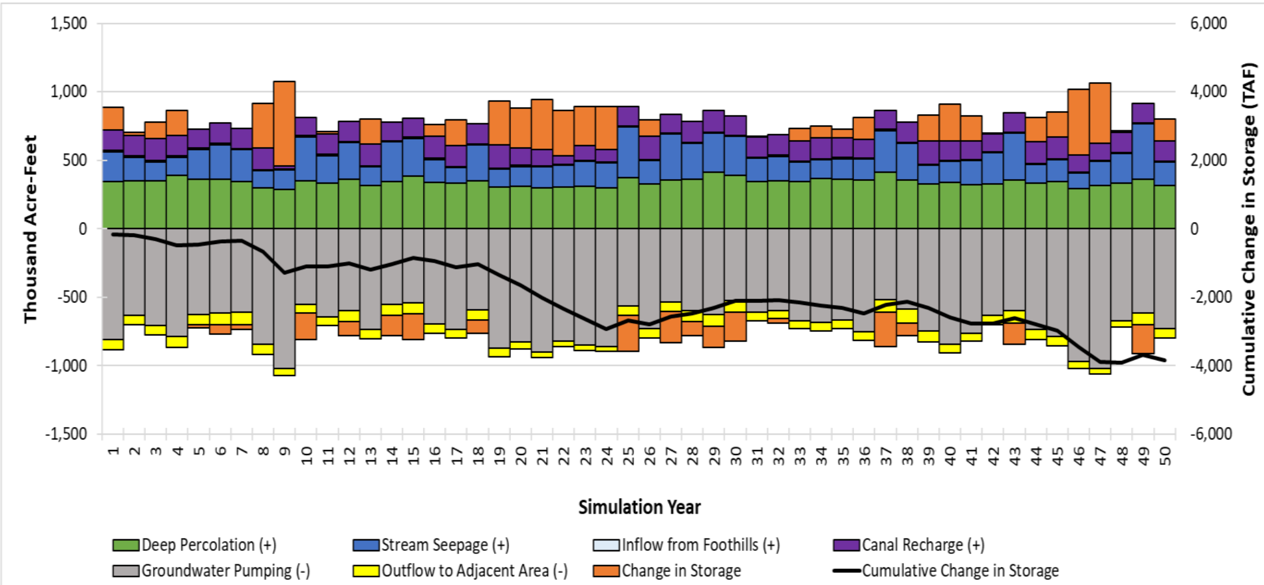


Figure 2-182: Projected Conditions Annual Water Budget – Groundwater System, Merced Subbasin



2.3.4.4 Projects & Management Actions Water Budget

The Projects and Management Actions (PMAs) water budget is a quantification of the anticipated benefits from planned actions carried out by the GSAs or member agencies that could affect groundwater sustainability. The PMAs water budget is developed by adding the PMAs to the simulation used to develop the Projected Conditions water budget.

Table 2-20 lists the modeled project benefits of the current and future projects within the Merced Subbasin aiming to enhance groundwater sustainability via in-lieu or direct recharge.

Table 2-20: Summary of Modeled Project Benefits

Project	In-Lieu Recharge	Direct Recharge	Land Reduction*	Total Yield (AFY)
MID to LTMWC	1,300	0	0	1,300
El Nido Conveyance Improvements	0	2,300	0	2,300
LeGrand-Athlone Intertie Canal	1,000	3,400	0	4,400
Vander Dussen Flood-MAR	0	2,200	0	2,200
Vander Woude Storage Reservoir	700	0	100	800
Crocker Control Structure Rehabilitation	5,800	9,900	0	15,700
TIWD Water Conservation	1,800	0	0	1,800
La Paloma Mutual Water Company Project	0	1,800	500	2,300
MID out of district	44,000	0	0	4,400
Total	**15,000**	**19,700**	**600**	**32,200**

Management Actions are described in more detail in Section 6.2. Ultimately, the Merced Subbasin GSA Demand Reduction program is the only management action that is directly modeled in the MercedWRM. While MIUGSA and TIWD GSA-1 both have programs to manage demand, based on long-term average estimates of consumptive use of groundwater made in the MercedWRM projected conditions scenario, the approach taken by these two GSAs do not suggest any associated reduction in demand.

The Merced Subbasin GSA Demand Reduction program will likely include a variety of methods to reduce demand. For the purpose of representing the demand reduction in the MercedWRM, demand reductions are solely represented by lowering groundwater production through reduced agricultural acreage. The reduction in agricultural acreage is performed separately for each of the GSA's sustainability zones. Reductions were calculated based on comparing the long-term average estimate of consumptive use of groundwater to the annual Sustainable Yield and Annual Pumping Allowance established in the GSA's demand reduction program (more details in Section 6.2.2). Demand reductions by sustainability zone are shown in Table 2-21.

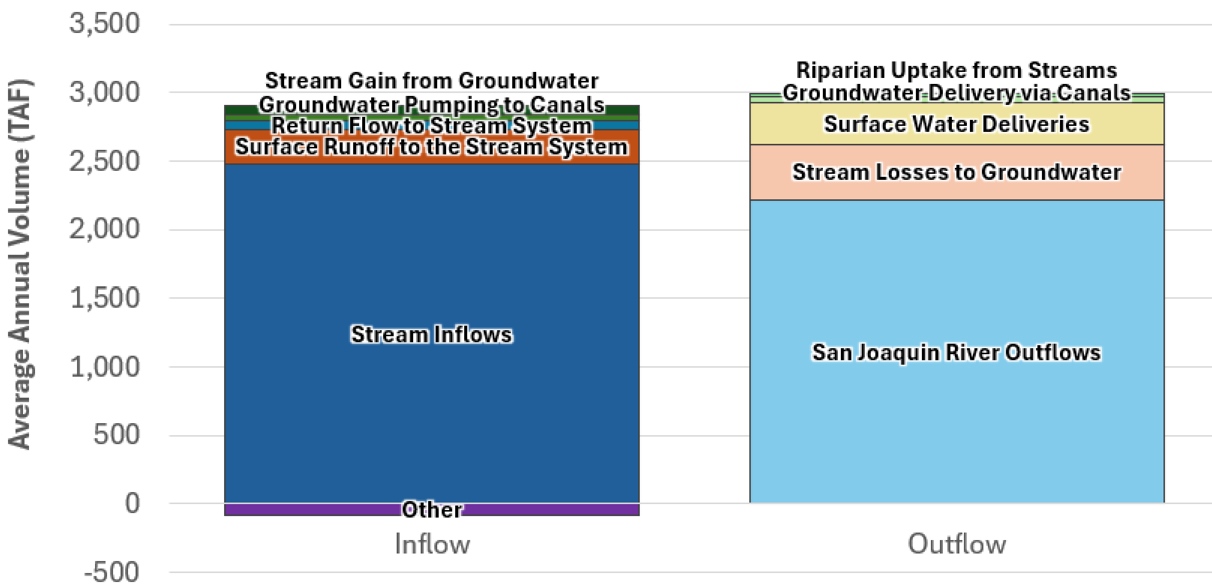
Table 2-21: MSGSA Demand Reductions by Sustainability Zone

Water Year	Allocation (inches)	Sustainability Zone							
		1	2	3	4	5	6	7	8
Base Consumptive Use of Groundwater (inches)		28.2	29.4	24.3	28.4	24.6	20.1	20.8	16.4
2024	24	15%	18%	1%	16%	2%	0%	0%	0%
2025	23	18%	22%	5%	19%	6%	0%	0%	0%
2026	22	22%	25%	9%	23%	10%	0%	0%	0%
2027	21	25%	29%	14%	26%	14%	0%	0%	0%
2028	20	29%	32%	18%	30%	19%	0%	4%	0%
2029	19	33%	35%	22%	33%	23%	5%	9%	0%
2030	18	36%	39%	26%	37%	27%	10%	14%	0%
2031	17	40%	42%	30%	40%	31%	15%	18%	0%
2032	16	43%	46%	34%	44%	35%	20%	23%	3%
2033	15	47%	49%	38%	47%	39%	25%	28%	9%
2034	14	50%	52%	42%	51%	43%	30%	33%	15%
2035 - 2073	13	54%	56%	46%	54%	47%	35%	38%	21%

Model Results

Under the PMAs budget, the stream and canal system experiences average annual surface water inflows of 2,991,000 AF, predominantly drawn from stream inflows (2,480,000 AF) and surface runoff (250,000 AF). Under the PMAs budget, surface water deliveries will account for 300,000 AF of the system's outflow and local water district pumping will continue to supplement surface water supplies with 44,000 AF of groundwater production. Most inflow will continue to exit the system via the San Joaquin River (2,216,000 AF) with additional outflows through aquifer recharge (406,000 AF) and riparian uptake (25,000 AF). Figure 2-178 summarizes the average projected inflows and outflows in the Merced Subbasin surface water network.

Figure 2-183: Project & Management Actions Average Annual Water Budget – Stream and Canal Systems, Merced Subbasin



The land surface water budget for the PMAs budget has annual average inflows and outflows of 1,332,000 AF. Land surface inflows account for precipitation (505,000 AF), applied surface water (300,000 AF), applied groundwater (519,000 AF), and riparian uptake from streams (7,000 AF). System outflows include average annual evapotranspiration (829,000 AF), surface runoff (133,000 AF) and return flow (57,000 AF) to the stream system, deep percolation (306,000 AF), and other flows (7,000 AF). A summary of these flows can be seen below in Figure 2-179. Figure 2-180 shows the annual change in the land surface water budget components through the simulation period.

Figure 2-184: Project & Management Actions Average Annual Water Budget –Land Surface System, Merced Subbasin

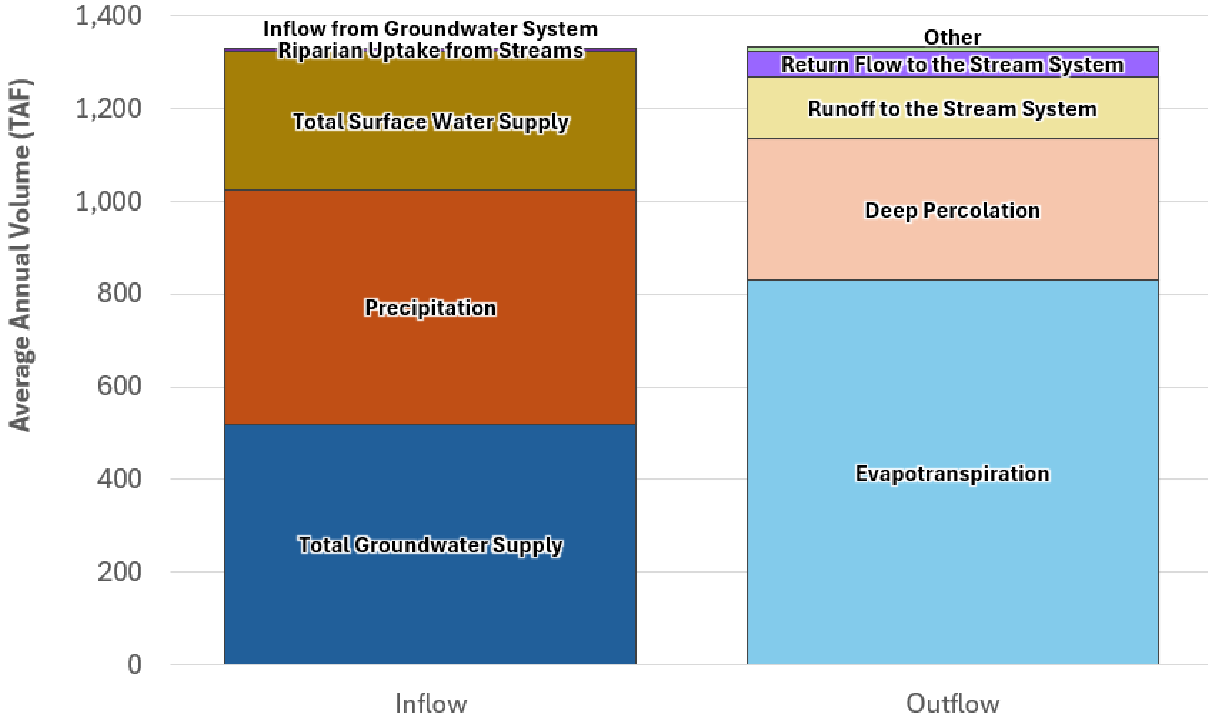
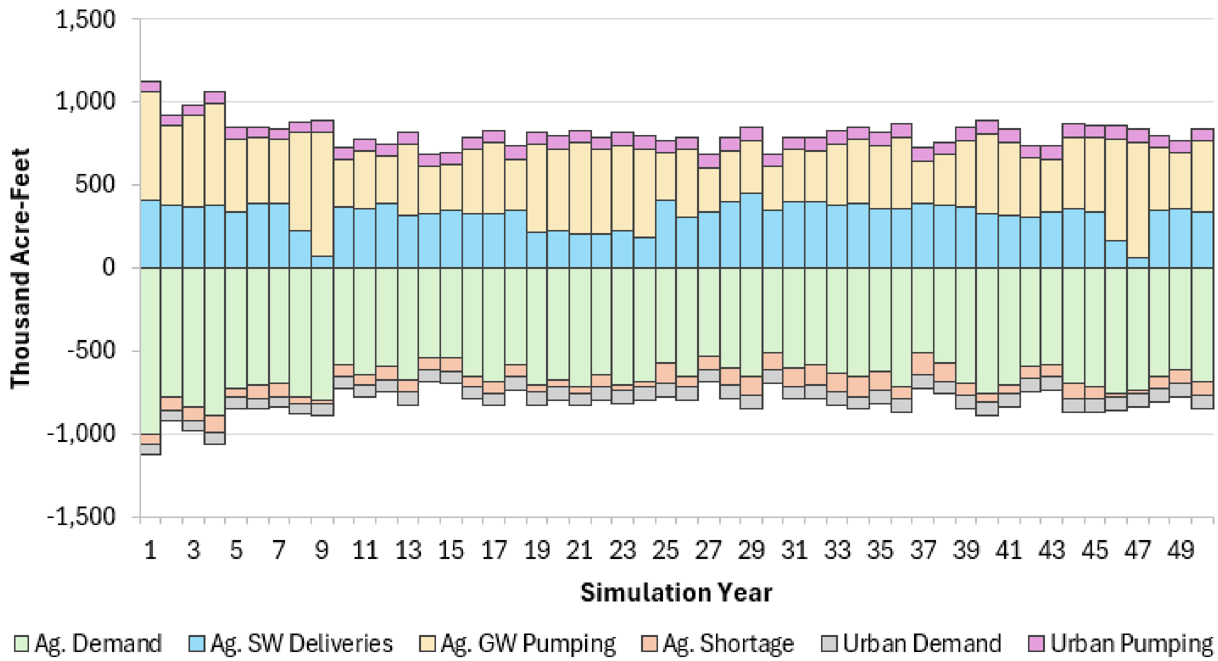


Figure 2-185: Project & Management Actions Annual Water Budget – Land Surface System, Merced Subbasin



Under the PMAs scenario, the groundwater system of the Merced Subbasin experiences an average of 702,000 AF of inflows each year, of which 306,000 AF is deep percolation. There is also recharge from rivers, streams, and canals (323,000 AF), and subsurface inflows (72,000 AF) from the Sierra Nevada foothills and the neighboring subbasins of Turlock, Delta-Mendota, and Chowchilla. Conversely, groundwater production (519,000 AF), subsurface outflow to neighboring subbasins (136,000 AF), and stream gain from groundwater (35,000 AF) bring the total Subbasin discharges to 690,000 AFY.

The PMAs budget has greater inflows than outflows, resulting in an average annual increase in groundwater storage of 12,000 AF. Figure 2-181 summarizes the average projected groundwater inflows and outflows in the Merced Subbasin. Figure 2-182 shows the annual change in the groundwater budget, as well as cumulative storage, through the simulation period.

The significant demand reductions anticipated to result from the PMAs, especially the MSGSA Groundwater Demand Reduction Management Action (allocation program), will have substantive beneficial effects throughout the Subbasin. While the PMAs scenario results in long-term stable groundwater levels and a near zero average change in storage, the MercedWRM estimates that groundwater levels at some locations are still low enough that undesirable results are projected for one year out of the 33-year "sustainable conditions" period of 2040-2073 within the 50-year simulated hydrology (e.g. there is one year in which more than 25% of representative monitoring wells experience groundwater levels below minimum thresholds for two consecutive years).

Figure 2-186: Project & Management Actions Average Annual Water Budget – Groundwater System, Merced Subbasin

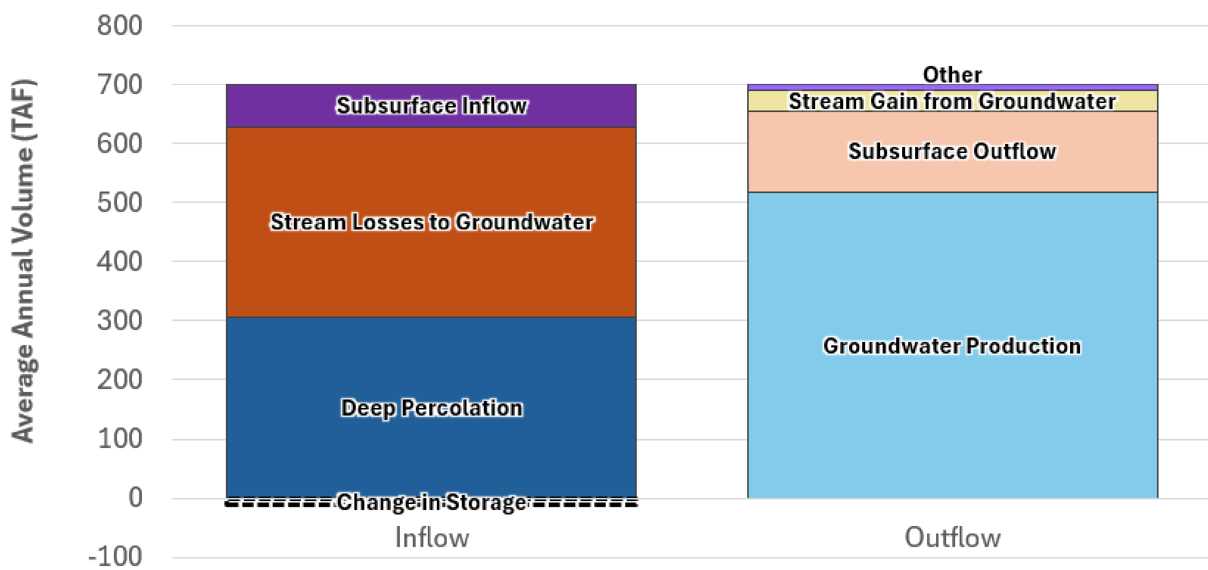
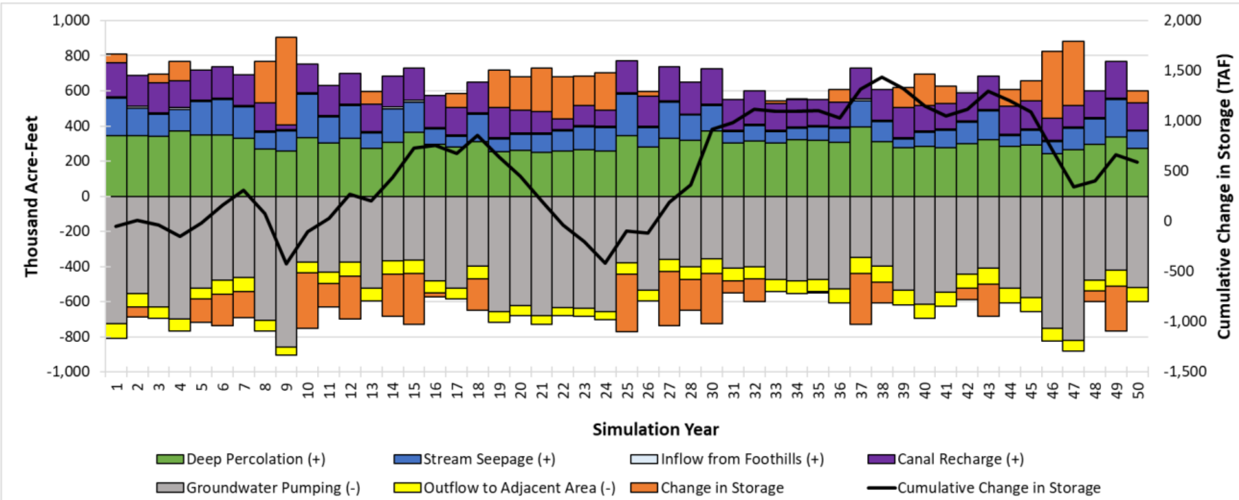


Figure 2-187: Project & Management Actions Annual Water Budget – Groundwater System, Merced Subbasin



2.3.5 Sustainable Yield Estimate

Sustainable yield is defined for SGMA purposes 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." (CWC §10721(w)). Sustainable yield for the Merced Subbasin was calculated through development of a MercedWRM scenario in which:

- The long-term (50-year) change in Subbasin storage is zero or net positive
- There are no undesirable results for the chronic lowering of groundwater levels sustainability indicator (e.g., avoids MT exceedances at 25% or more of the representative monitoring wells for two consecutive years) from 2040-2073 (the "sustainable conditions" period within the 50-year simulation running from 2023-2073).

The PMA scenario discussed in the previous section already had a net positive long-term change in Subbasin storage, but also projected undesirable results for the groundwater levels in one year out of the 33-year "sustainable conditions" period of 2040-2073 within the 50-year simulated hydrology. The Sustainable Yield estimate is based on a modified version of the PMA scenario that lowers groundwater production through reduced agricultural demand across the model domain until undesirable results are no longer observed.

Reductions in agricultural water demand are implemented through a reduction in agricultural land using a Subbasin-wide quadrant system that reduces the cropped acreage evenly throughout each quadrant starting from the beginning of the simulation period. The quadrant delineation is shown in Figure 2-188. Each quadrant has its own acreage reduction, providing flexibility based on the location of the projected undesirable results.

Modeling results showed an additional agricultural crop reduction of 1% in the North and West quadrants, and of 6% in the South and East quadrants on top of the existing reductions projected as part of the PMA scenario.

Figure 2-188: Quadrant Delination from PMAs Water Budget Scenario

The sustainable yield water budget is intended to estimate future conditions of supply, demand, and aquifer response to implementation of sustainable conditions in the Subbasin. The sustainable yield water budget is estimated using the sustainable conditions scenario for MercedWRM. The methodology for reducing basinwide pumping to estimate sustainable yield is developed solely for the purpose of estimating basinwide sustainable yield and is not intended to prescribe or describe how pumping would actually be reduced (or recharge increased) in the subbasin during GSP implementation to achieve sustainability. The implementation of pumping reductions to achieve sustainability will be done by the GSAs and will incorporate multiple considerations including water rights, beneficial uses, and human right to water. The status of plans for implementing management actions related to pumping reductions is further discussed in Chapter 6 - Projects and Management Actions to Achieve Sustainability Goal.

Model Results

Because of the reduction of agricultural demand, the sustainable groundwater management condition scenario simulates reductions in evapotranspiration (reduced to 811,000 AF) and groundwater production (reduced to 499,000 AF) across the Subbasin. Subsurface outflow to neighboring subbasins (140,000 AF) and stream discharge (37,000 AF) bring the total Subbasin discharges to 676,000 AFY.

Under sustainable groundwater management conditions, the groundwater system maintains inflows of 694,000 AFY, which is greater than the outflow volume of 676,000 AF each year, and of which 306,000 AF of inflow is deep percolation. Inflows also include recharge from rivers, streams, and canals (318,000 AF), and subsurface inflows (70,000 AF) from the Sierra Nevada foothills and the neighboring subbasins of Turlock, Delta-Mendota, and Chowchilla.

The sustainable groundwater management scenario results in groundwater outflows that are slightly less than groundwater inflows, bringing the long term (50-year) average change in groundwater storage to a positive value. Figure 2-189 summarizes the average projected groundwater inflows and outflows in the Merced Subbasin. Based on this analysis, the sustainable yield of the basin is approximately 499,000 AFY. Figure 2-190 shows the annual change in the groundwater budget components, as well as cumulative storage, through the simulation period.

The significant demand reductions anticipated to result from the PMAs, especially the MSGSA Groundwater Demand Reduction Management Action (allocation program), will have substantive beneficial effects throughout the Subbasin. While the MercedWRM is useful tool to provide direction and evaluate the effects of changes, the ability to ascertain success in meeting sustainability objectives is dependent on the configurations and assumptions of the model. Recognizing the potential limitations within the MercedWRM to reflect the Subbasin's response to significant demand reduction, the model predicts that the combined benefit of the PMAs is slightly lower than what is required for the Sustainable Yield scenario. However, these scenarios are highly dependent on the management of neighboring subbasins, assumed hydrologic variability, and the model's configuration. Thus, the difference between the PMA benefits and the Sustainable Yield estimate is considered within the range of uncertainty. The success of the PMAs will continue to be revisited as part of the periodic evaluation process. The current modeled difference between the PMA benefits and the Sustainable Yield estimate was considered too small to warrant modification to the PMAs, especially given the magnitude of planned demand reduction. Refinements of the PMAs will be revisited as GSP implementation progresses.

Figure 2-189: Groundwater Water Budget under Sustainable Groundwater Management Conditions Long-Term (50-Year) Average Annual

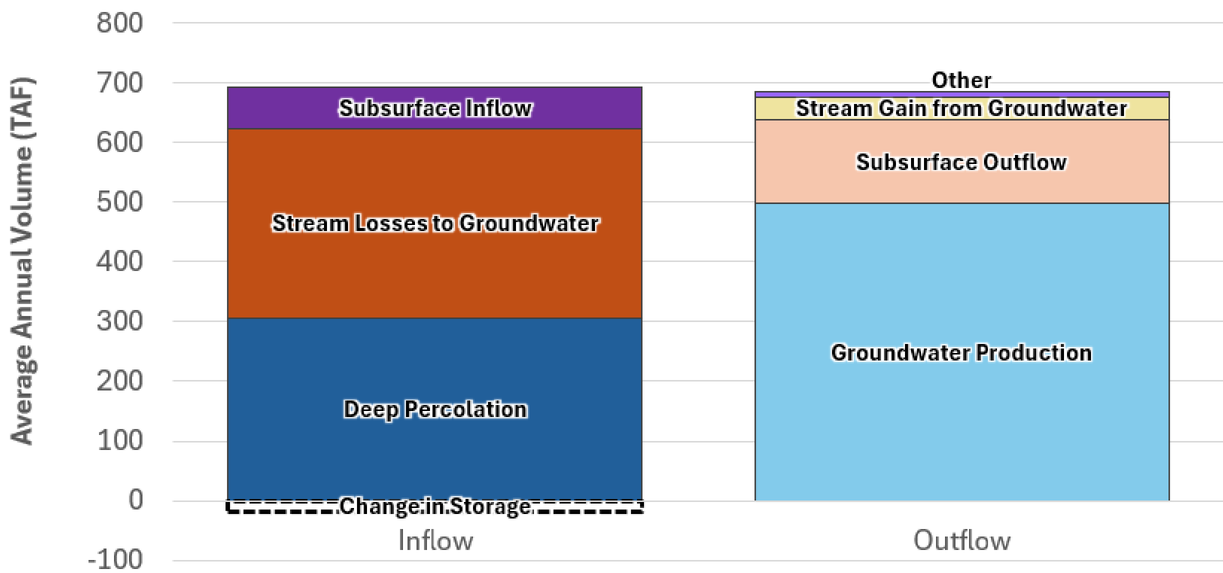
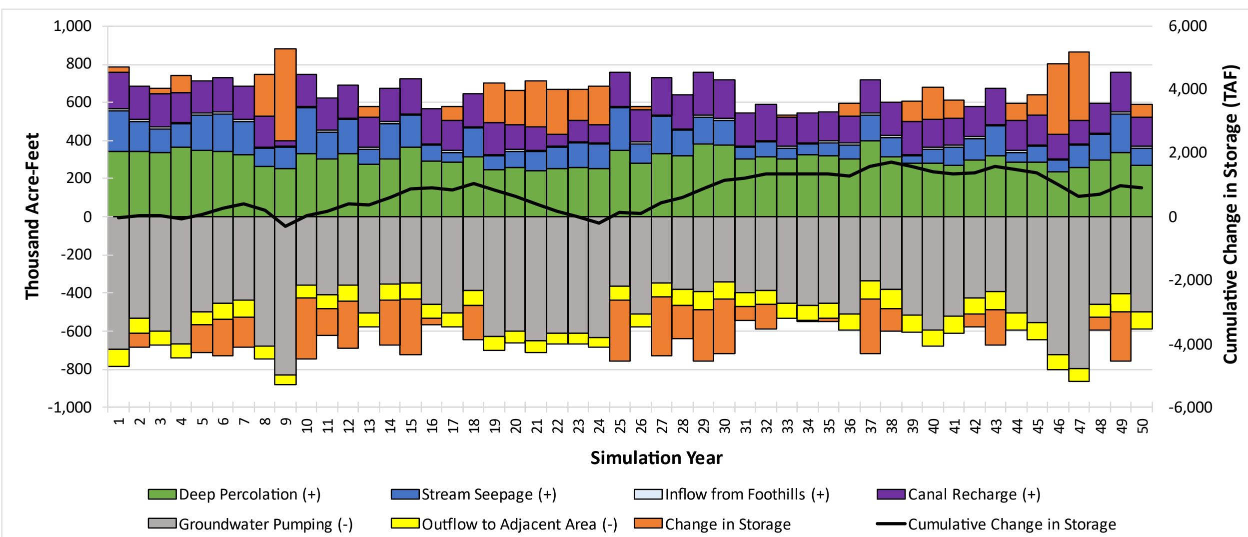


Figure 2-190: Groundwater Water Budget under Sustainable Groundwater Management Conditions Long-Term (50-Year) Annual



2.4 CLIMATE CHANGE ANALYSIS

2.4.1 Regulatory Background

SGMA requires taking into consideration uncertainties associated with climate change in the development of GSPs.

Consistent with §354.18(d)(3) and §354.18(e) of the SGMA Regulations, analyses for the Merced GSP evaluated the projected water budget with and without climate change conditions.

2.4.2 DWR Guidance

Climate change analysis is an area of continued evolution in terms of methods, tools, forecasted datasets, and the predictions of greenhouse gas concentrations in the atmosphere. The approach developed for this GSP is based on the methodology in DWR's guidance document (DWR, 2018a). Similarly, the "best available information" related to climate change in the Merced Subbasin was deemed to be the information provided by DWR combined with basin-specific modeling tools. The following resources from DWR were used in the climate change analysis:

- SGMA Data Viewer
- Guidance for Climate Change Data Use During Sustainability Plan Development and Appendices (Guidance Document)
- Water Budget BMP
- Desktop IWFM Tools

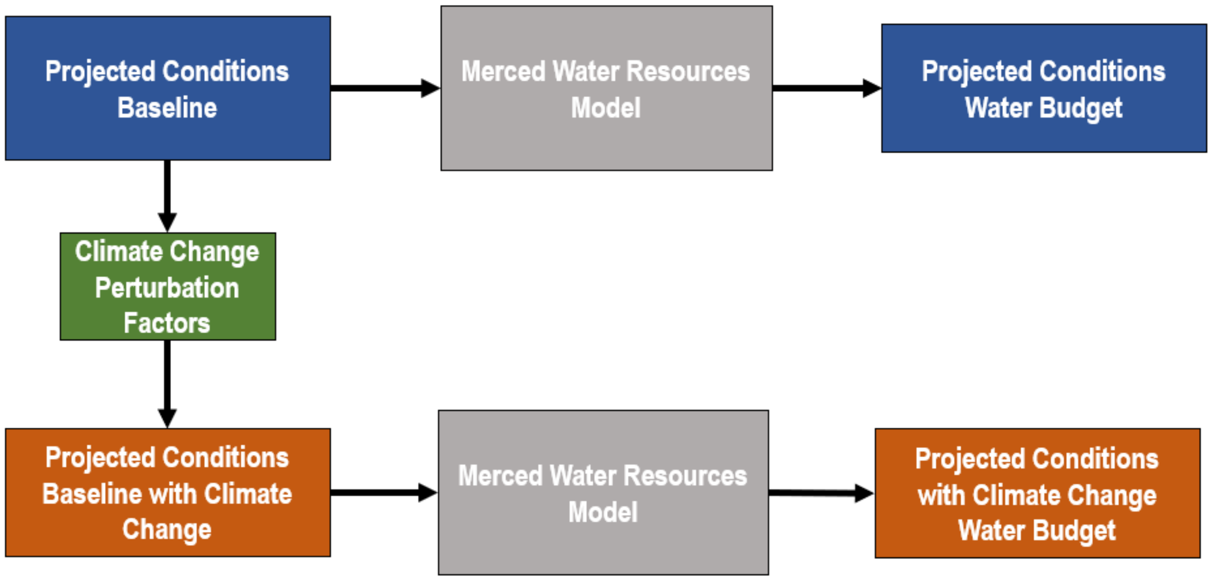
SGMA Data Viewer provides the location for which the climate change forecasts datasets[32] were downloaded for the Merced Subbasin (DWR, 2019). The guidance document details the approach, development, applications, and limitations of the datasets available from the SGMA Data Viewer (DWR, 2018a). The Water Budget BMP describes in greater detail how DWR recommends projected water budgets be computed (DWR, Best Management Practices for the Sustainable Management of Groundwater Water Budget, 2016a). The Desktop IWFM Tools are available to calculate the projected precipitation and evapotranspiration inputs under climate change conditions (DWR, 2018b).

The methods suggested by DWR in the above resources were used, with modifications where needed, to ensure the resolution would be reasonable for the Merced Subbasin and align with the assumptions of the Merced Water Resources Model (MercedWRM). Figure 2-191 shows the overall process developed for the Merced GSP consistent with the Climate Change Resource Guide

[32] In the industry, climate change impacted variable forecasts are sometimes referred to as "data" and their collections are called "datasets." Calling forecasted variable values "data" can be misleading so this document tries to be explicit about when we are referring to data (historical data) vs. forecasts or model outputs.

(DWR, 2018a) and describes workflow beginning with baseline projected conditions to perturbed 2070 conditions for the projected model run.

Figure 2-191: Merced GSP Climate Change Analysis Process



The process described in Figure 2-191 of developing a projected conditions water budget with and without climate change was discussed with DWR staff[33] and is consistent with the regulations. Further, it enables the analysis to account for variability in demand and supply separate from climate change uncertainty.

Table 2-22 below summarizes the forecasted variable datasets provided by DWR that were used to carry out the climate change analysis (DWR, 2019). The "VIC" model (Variable Infiltration Capacity) referred to in Table 2-22 is the fully mechanistic hydrologic model used by DWR to derive hydrographs under baseline and climate change conditions. "Impaired" streamflow referred to in Table 2-22 is DWR's terminology for streams whose flow is impacted by ongoing water operations, such as diversions, deliveries, and storage. Flows on these streams are simulated using the CalSim II model. Conversely, "unimpaired" streamflow refers to the natural streamflow produced by a watershed, not impacted by ongoing operations. All time series shown in Table 2-22 use a monthly timestep. Section 2.4.3 includes further description of the model and other tools and datasets.

33 Pers. Comm. 4/4/2019 meeting with DWR staff.

Table 2-22: DWR-Provided Climate Change Datasets

Input Variable	DWR Provided Dataset
Unimpaired Streamflow	Combined VIC model runoff and baseflow to generate change factors, provided by HUC 8 watershed geometry
Impaired Streamflow (Ongoing Operations)	CalSim II time series outputs in .csv format
Precipitation	VIC model-generated GIS grid with associated change factor time series for each cell
Reference ET	VIC model-generated GIS grid with associated change factor time series for each cell

2.4.3 Climate Change Methodology

For climate change impacts on groundwater, accepted methods are based on the assessment of impacts on the individual water resource system elements that directly link to groundwater. These elements include precipitation, streamflow, evapotranspiration and, for coastal aquifers, sea level rise as a boundary condition. For the Merced Subbasin, sea level is not relevant.

The method for perturbing the streamflow, precipitation, and evapotranspiration input files is described in the following sections. The late-century, 2070 central tendency climate scenario was evaluated in this analysis, consistent with DWR guidance (DWR, 2018a).

DWR combined 10 global climate models (GCMs) for two different representative climate pathways (RCPs) to generate the central tendency scenarios in the datasets used in this analysis. The "local analogs" method (LOCA) was used to downscale these 20 different climate projections to a scale usable for California (DWR, 2018a). DWR provides datasets for two future climate periods: 2030 and 2070. For 2030, there is one set of central tendency datasets available. For 2070, DWR has provided one central tendency scenario and two extreme scenarios: one that is drier with extreme warming and one that is wetter with moderate warming.

The 2070 central tendency among these projections serves to assess impacts of climate change over the long-term planning and implementation period. For this reason, it was chosen as the most appropriate scenario to assess in the Merced GSP.

2.4.3.1 Streamflow under Climate Change

Hydrological forecasts for streamflow under various climate change scenarios are available from DWR as either a flow-based timeseries or a series of perturbation factors applicable to local data. DWR simulated volumetric flow in most regional surface water bodies by utilizing The Water Resource Integrated Modeling System (WRIMS, formally named CalSim II). While river flows and surface water diversions in the Merced, Chowchilla, and San Joaquin rivers are simulated in CalSim II, there are significant variations when compared to local historical data. Due to the uncertainty in reservoir operations, flows from CalSim II provided by the state are not used directly in the Merced GSP climate change analysis. Instead, as explained later in this section, relative perturbation factors were used to derive surface water inflows and diversions for analysis with the MercedWRM.

Local tributaries and smaller streams within Merced Subbasin are not simulated in CalSim II and must be simulated using adjustment factors developed by DWR for unregulated stream systems. While not all of these local tributaries are completely unregulated, most control structures are minor in operation, do not significantly impair natural flow when simulated on a monthly timestep, and are considered unimpaired for this analysis. Resolution of these perturbation factors are available at the HUC 8 watershed scale and include Bear Creek, Owens Creek, and Mariposa Creek. The remaining streams simulated in the MercedWRM utilize the IWFM small-watershed package, whose climate change impacts are dynamically calculated using the Curve Number Method and soil moisture routing.

Table 2-23 presents which streams, modeled by the MercedWRM for the Merced GSP, are considered impaired or unimpaired in this analysis.

Table 2-23: Merced Stream Inflows

Stream	Impaired	Unimpaired
Merced River	X	
Bear Creek		x
Owens Creek		x
Mariposa Creek		x
Chowchilla River	X	
San Joaquin River	X	

2.4.3.1.1 Unimpaired Flows

Change factors for unimpaired streams were downloaded from SGMA Data Viewer and multiplied by the projected conditions baseline. Perturbed flows on Bear Creek, Owens Creek, and Mariposa Creek were calculated in this way. DWR provided change factors are available through 2011. However, the model period runs from 1969 through 2018. Flows for the remaining seven water years between 2012 and 2018 were synthesized using the change factor from the most recent water year type in the available dataset. Water year types are designated for each year based on the San Joaquin Valley Runoff WY year type index (DWR, 2024). DWR uses five WY type designations: Critical, Dry, Below Normal, Above Normal, and Wet. Table 2-24 below shows the year type designations used to synthesize the remaining years (2011-2018). A "Critical" year type represents the driest designation.

Table 2-24: DWR San Joaquin Valley Water Year Type Designations

Water Year	Year Type
2003	Below Normal
2004	Dry
2005	Wet
2006	Wet
2007	Critical
2008	Critical

2009	Below Normal
2010	Above Normal
2011	Wet
2012	Dry
2013	Critical
2014	Critical
2015	Critical
2016	Dry
2017	Wet
2018	Below Normal

Source: Water year types based on San Joaquin Valley Water Year Index (DWR, 2024)

The hydrograph in Figure 2-192 shows the perturbed time series against the model baseline time series for Bear Creek. Results for the other unimpaired streams present a similar trend where the changes in stream flows are relatively small compared to the magnitude of flows in the baseline. The x-axis represents the period of record from which the future conditions simulation is made. Figure 2-193 through Figure 2-195 present the exceedance probability curves[34] for Bear Creek, Owens Creek, and Mariposa Creek, respectively. The exceedance curves are provided because they more clearly show the differences between the baseline scenario and the climate change scenario. Generally, flows under the climate change scenario selected are only slightly higher, and almost unperceivable.

[34] Exceedance probability describes the probability that streamflow or precipitation will be greater than (or "exceed") a certain value. An exceedance probability curve shows how the probability changes over a range of streamflow or precipitation values.

Figure 2-192: Bear Creek Hydrograph

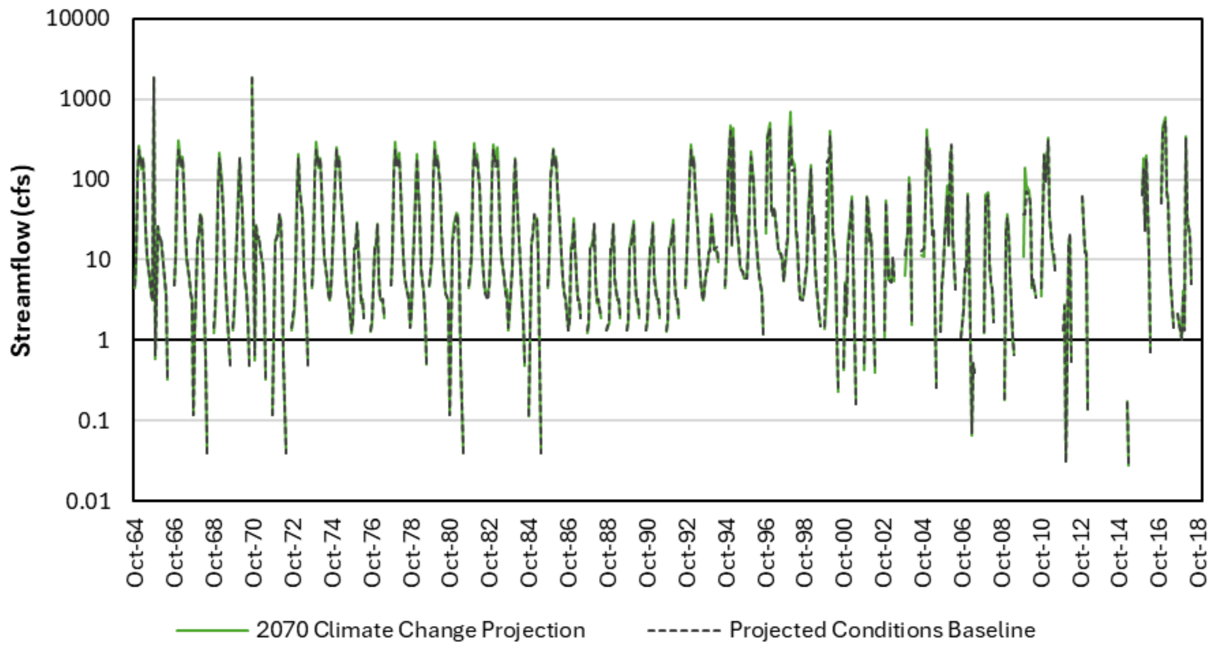


Figure 2-193: Bear Creek Exceedance Curve

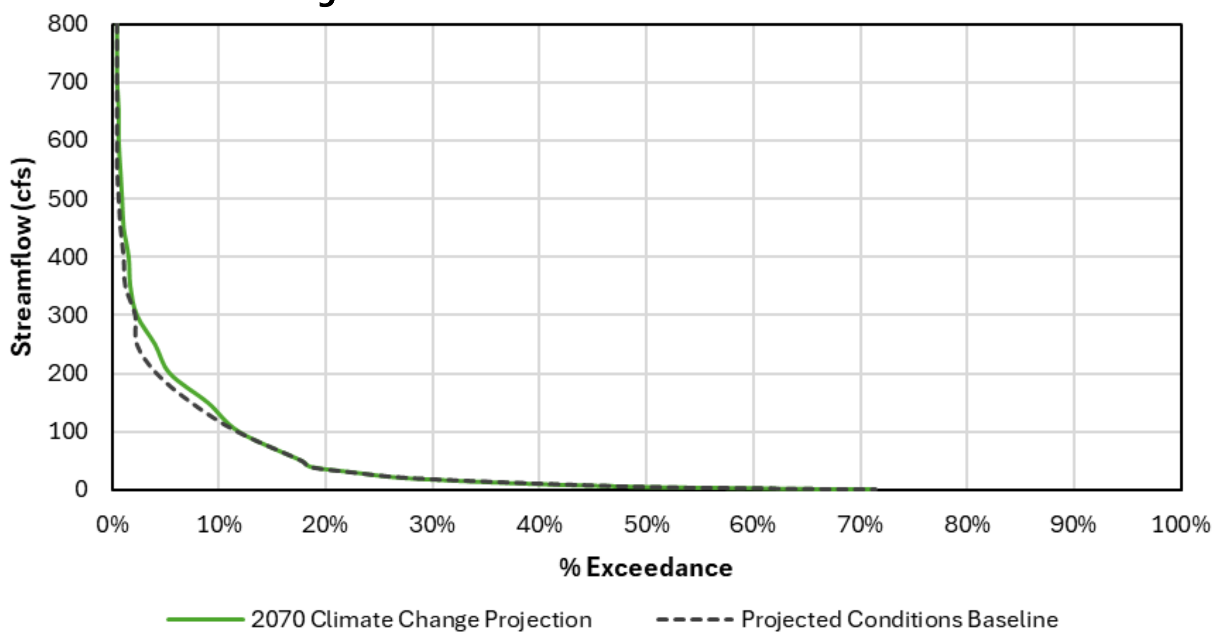


Figure 2-194: Owens Creek Exceedance Curve

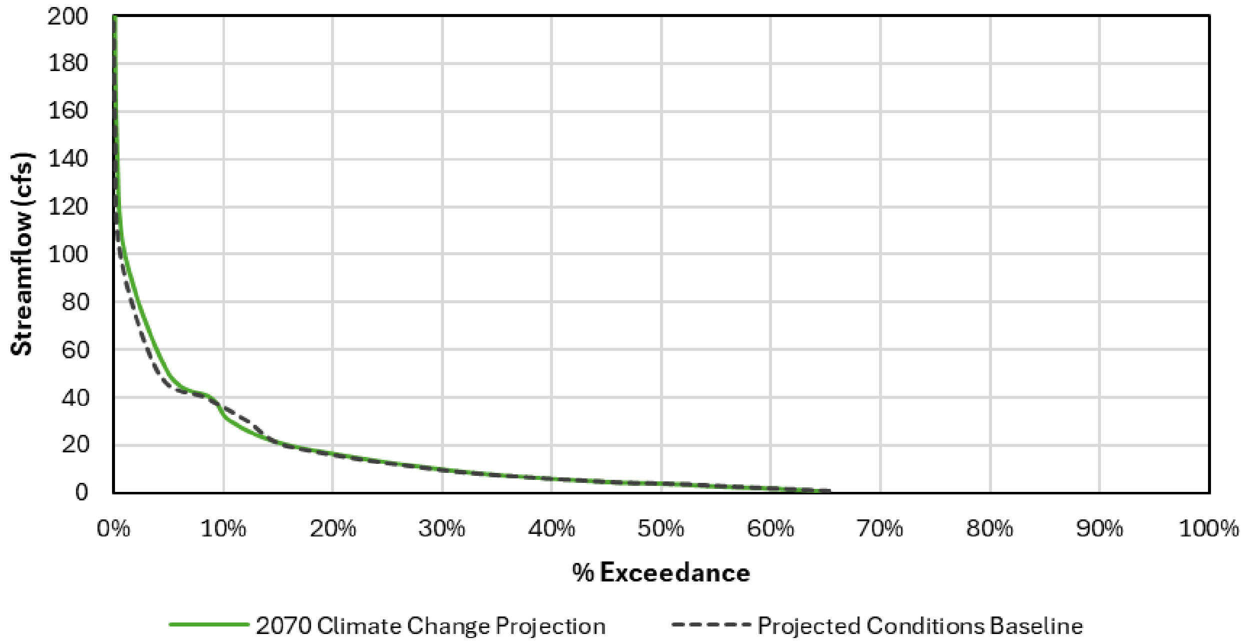
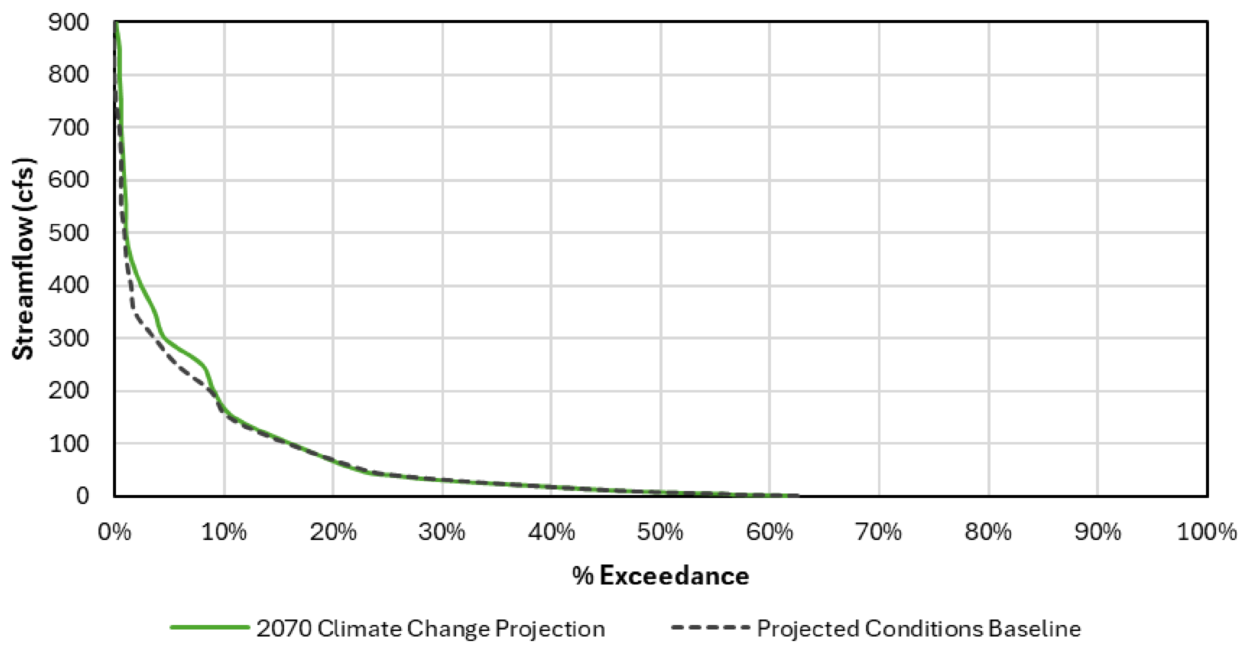


Figure 2-195: Mariposa Creek Exceedance Curve



2.4.3.1.2 Impaired Flows

CalSim II estimated flows for point locations on the Merced River, Chowchilla River, and the San Joaquin River were downloaded from DWR. The three key flows obtained from CalSim II include:

- **Merced River:** Lake McClure Outflow
- **Chowchilla River:** Eastman Lake Outflow
- **San Joaquin River:** San Joaquin River below Mendota Pool

These flows represent projected hydrology with climate change based on reservoir outflow, operational constraints, and diversions and deliveries of water for the State Water Project and the Central Valley Project. CalSim II data from WY 1965 to WY 2003 was available. For WY 2004 to WY 2018, streamflow was synthesized based on flows from WY 1965 to WY 2003 and the DWR San Joaquin Valley water year type index. Table 2-24 indicates the water year types that were used for the years with synthesized streamflow (DWR, 2024). For example, the total monthly streamflow for October 2003 would be calculated as the average of the monthly streamflow from October 1966 and October 1971 because they are the same year type.

In order to verify the relative accuracy of CalSim II simulated flows on the local scale, simulated flows were compared with those generated using the DWR-provided unimpaired perturbation factors. As expected, streamflow simulated in CalSim II and those derived using the unimpaired adjustment factors did not present similar trends, particularly in dry years. Because they are indicative of reservoir operations, CalSim II outputs are considered more appropriate for regulated streams given that downstream flow is driven by surface water demand rather than natural flow. DWR-provided unimpaired change factors do not account for variations in the operation of the reservoirs that would result from climate change conditions. The CalSim II flows, however, were also not considered completely appropriate for local conditions so a method was derived to compute change factors from CalSim II flows, as described below.

Using DWR's method of deriving the precipitation and evapotranspiration factors as a guide, the team explored a hybrid approach to improve upon the discrepancy between the CalSim II and local models while accounting for some change in reservoir operations. In this approach, change factors are generated from the difference between each simulated future climate change CalSim II scenario (i.e., 2070) and the "without climate change" baseline CalSim II run. This "without climate change" baseline run is the CalSim II 1995 Historical Detrended simulation run provided through personal communication from DWR. The generated change factors are then used to perturb the regulated river inflows simulated in the MercedWRM Projected Conditions Baseline. For the purposes of simplicity, this method is referred to throughout the rest of the document as CalSim II Generated Perturbation Factors (CGPF). The CGPF method presents limitations given that the resulting flows are not directly obtained from an operations model. The actual mass balance on the reservoirs is not tracked in the estimates of the flows and, instead, the method relies on CalSim II tracking that storage and managing the reservoir based on the appropriate rule curves.

Figure 2-196 through Figure 2-201 provide a comparison of projected conditions baseline and the CGPF method described above. Exceedance curves are included for each of the CGPF flows against the projected conditions baseline.

Figure 2-196: Merced River Hydrograph

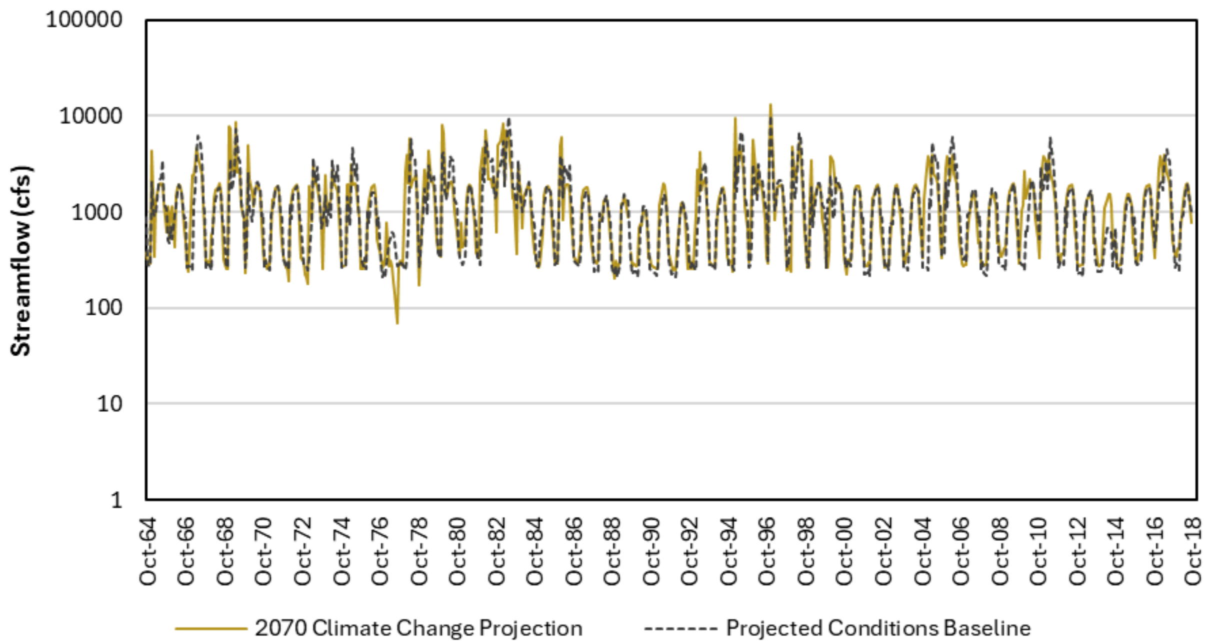


Figure 2-197: Merced River Exceedance Curve

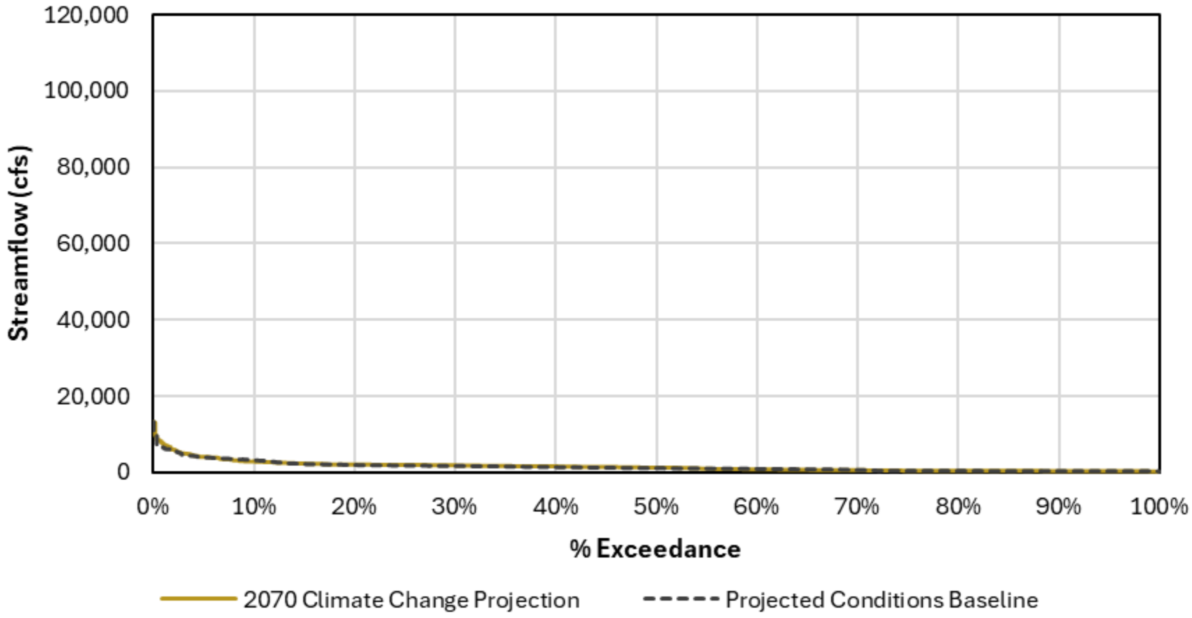


Figure 2-198: Chowchilla River Perturbed Hydrograph

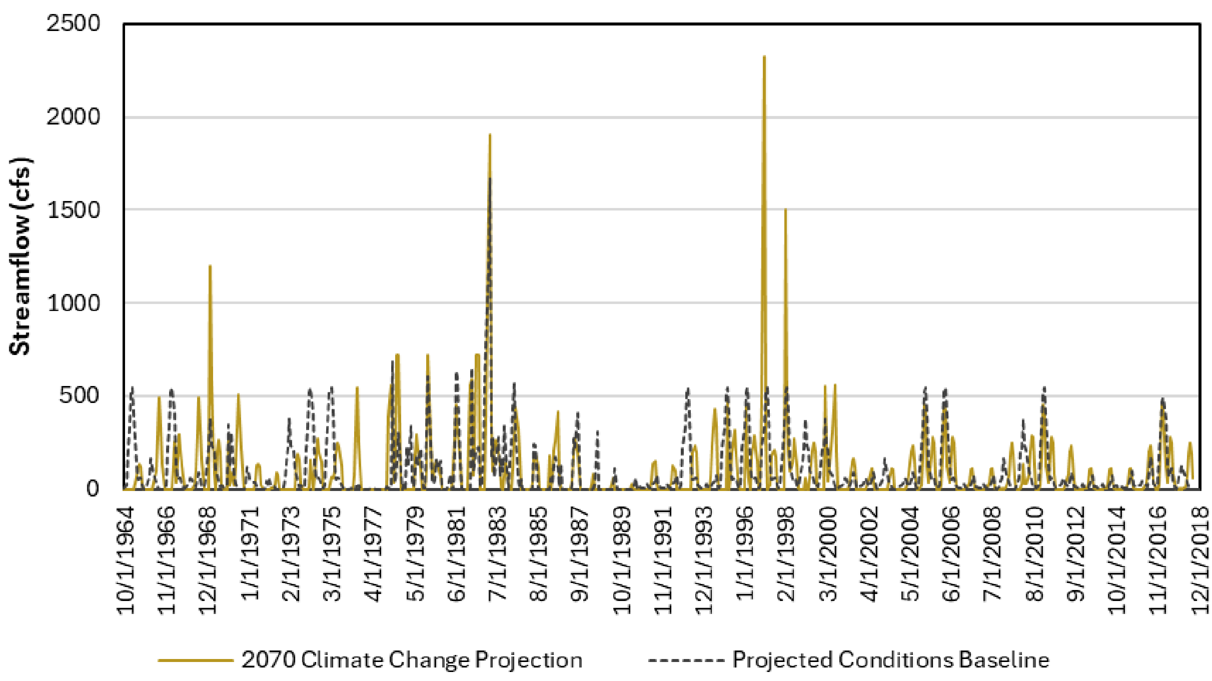


Figure 2-199: Chowchilla Exceedance Curve

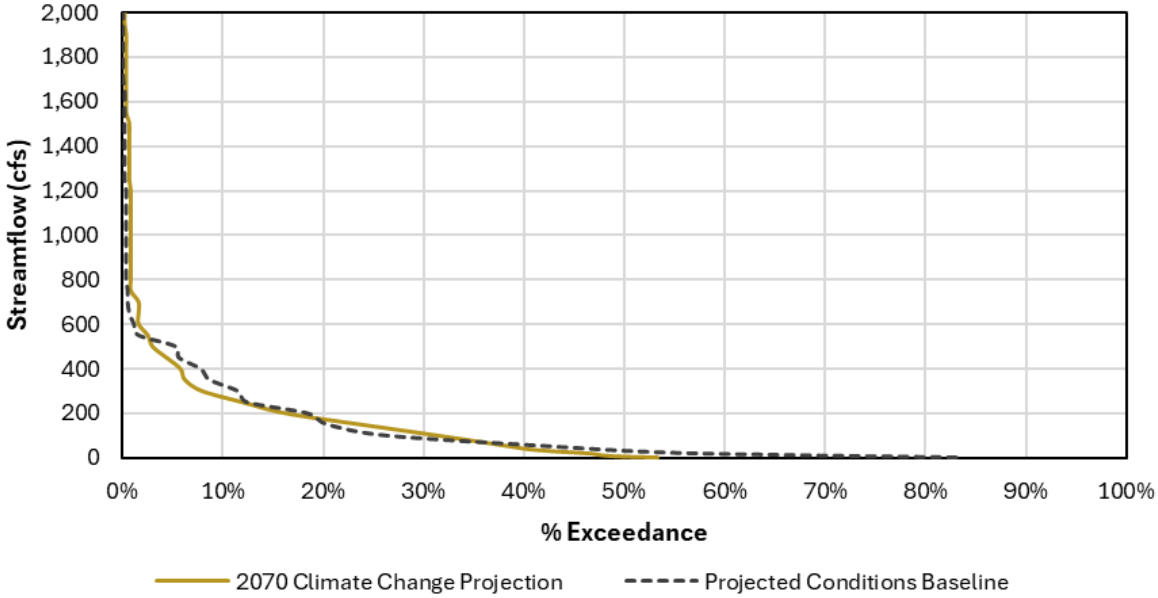


Figure 2-200: San Joaquin River Hydrograph

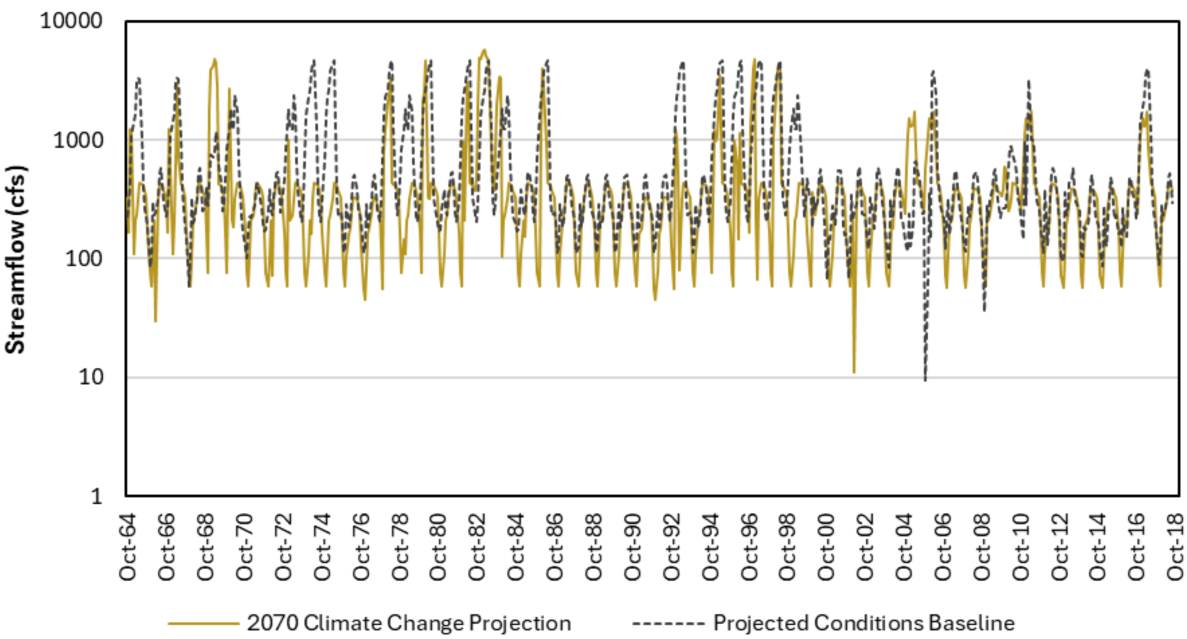
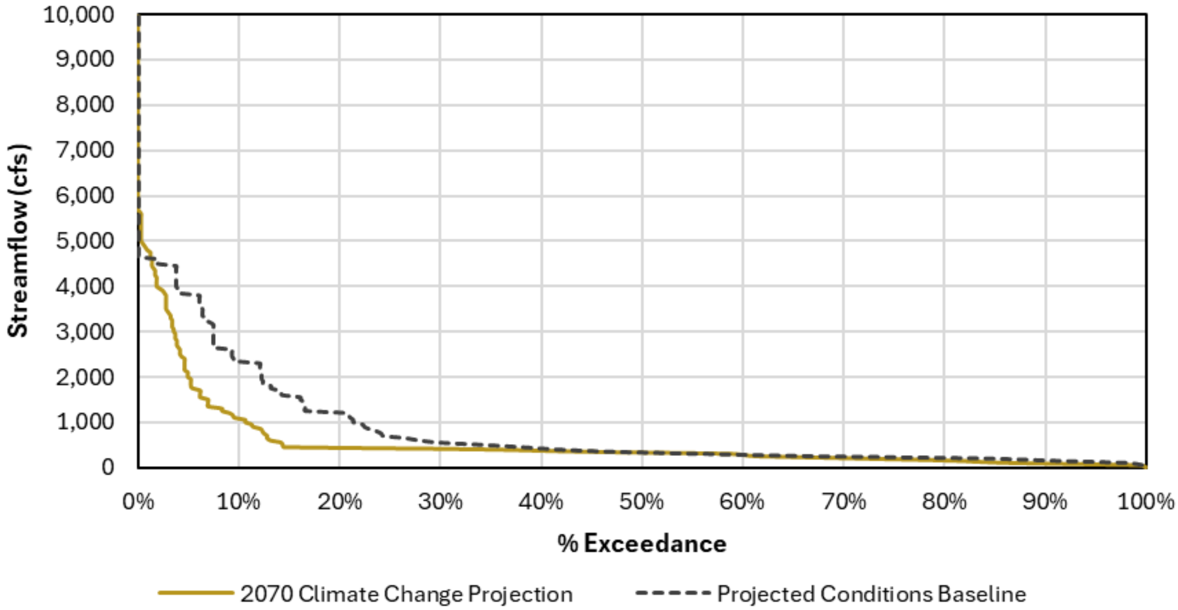


Figure 2-201: San Joaquin River Exceedance Curve



2.4.3.2 Precipitation and Evapotranspiration under Climate Change

Projected precipitation and evapotranspiration (ET) change factors provided by DWR were calculated using a climate period analysis based on historical precipitation and ET from January 1915 to December 2011 (DWR, 2018a). The Variable Infiltration Capacity (VIC) hydrologic model was used by DWR to simulate land-surface atmosphere exchanges of moisture and energy on a six-kilometer grid. Model output includes both precipitation and reference evapotranspiration whose change factors provided by DWR were calculated as a ratio of the value of a variable under a "future scenario" divided by a baseline. The baseline data is the 1995 Historical Template Detrended scenario by the VIC model through GCM downscaling. The "future scenario" corresponds to VIC outputs of the simulation of future conditions using GCM forecasted hydroclimatic variables as inputs. These change factors are thus a simple perturbation factor that corresponds to the ratio of a future with climate change divided by the past without it. Change factors are available on a monthly time step and spatially defined by the VIC model grid. Supplemental tables with the time series of perturbation factors are available by DWR for each grid cell. DWR has made accessible a Desktop GIS tool for both IWFM and MODFLOW to process these change factors (DWR, 2018b).

2.4.3.2.1 Applying Change Factors to Precipitation

DWR change factors were multiplied by projected conditions baseline precipitation to generate projected precipitation under the 2070 central tendency future scenario using the Desktop IWFM GIS tool (DWR, 2018b). The tool calculates an area weighted precipitation change factor for each model grid geometry. This model grid geometry was generated based on polygons built around the PRISM nodes that are within the model area.

However, the DWR tool only includes change factors through 2011. The remaining seven years of the time series were synthesized according to historically comparable water years. The perturbation factor from the corresponding month of the comparable year was applied to the baseline of the missing years (2012-2018) to generate projected values. Months with no precipitation in the baseline were assumed a monthly precipitation of 1 mm under climate change to account for increased precipitation that cannot be calculated from a baseline of 0 mm for these synthesized years. The comparable years that were used can be found in Table 2-25.

Table 2-25: Comparable Water Years (Precipitation)

Missing Water Year	Comparable Water Year
2012	1968
2013	2007
2014	2002
2015	1971
2016	1981
2017	1993
2018	1987

The resulting perturbed precipitation values and the baseline precipitation values for the representative historical period can be found in Figure 2-202 below. The exceedance plot for these two times series can be found in Figure 2-203.

Figure 2-202: Perturbed Precipitation Under Climate Change

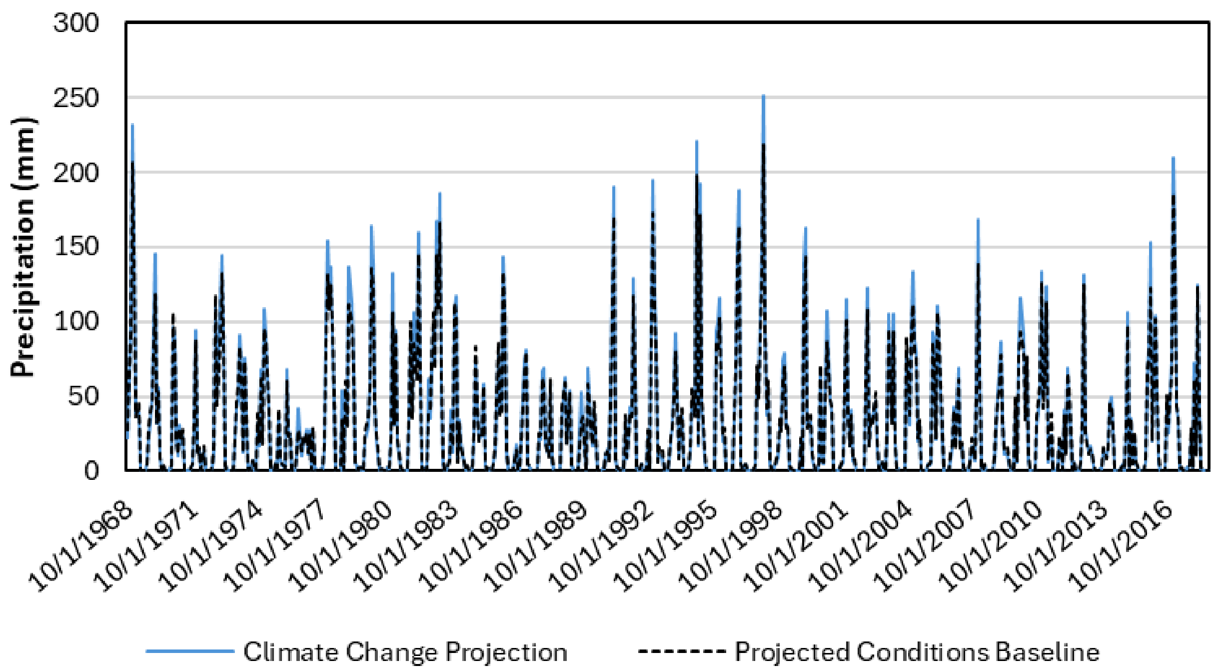


Figure 2-203: Perturbed Precipitation Exceedance Curve

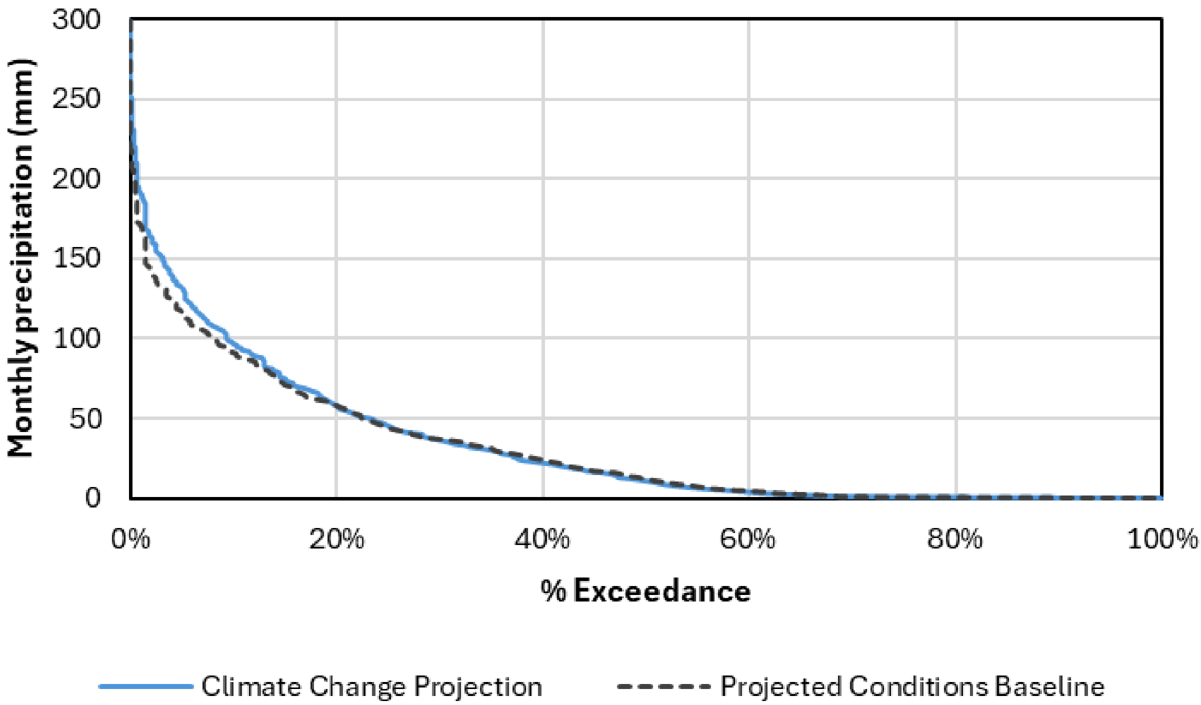
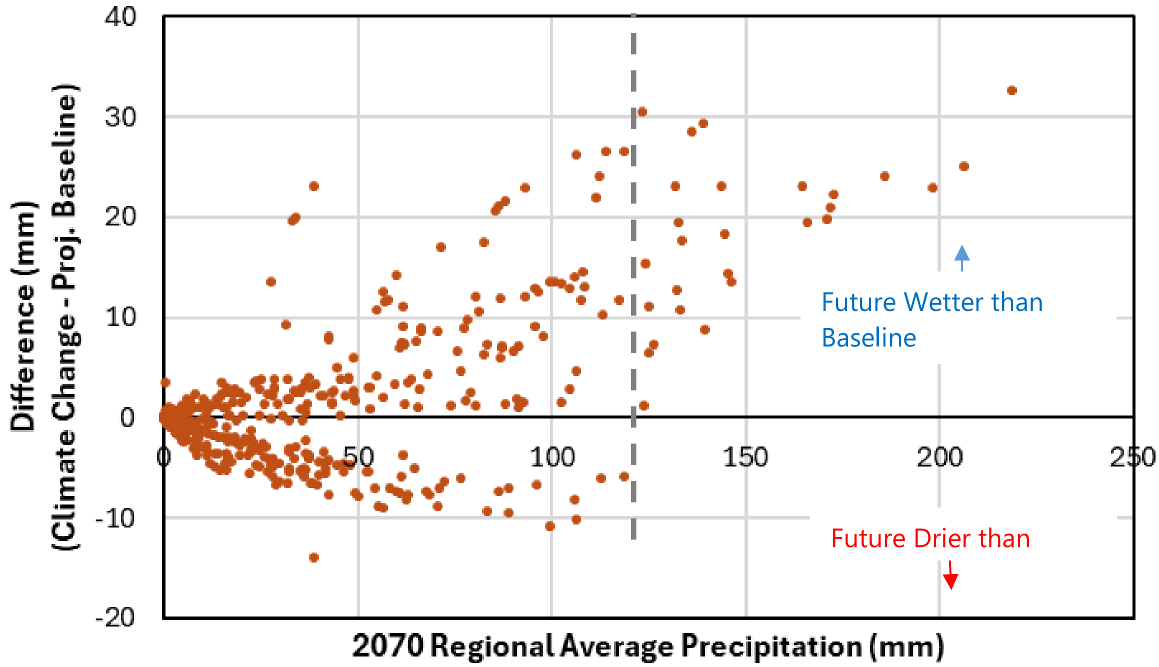


Figure 2-204 shows the difference between the regional average under 2070 climate change conditions and the regional average under projected conditions baseline plotted against different amounts of projected monthly precipitation. The average was taken across the area of the Merced Subbasin.

Figure 2-204: Variation from Baseline of Perturbed Precipitation

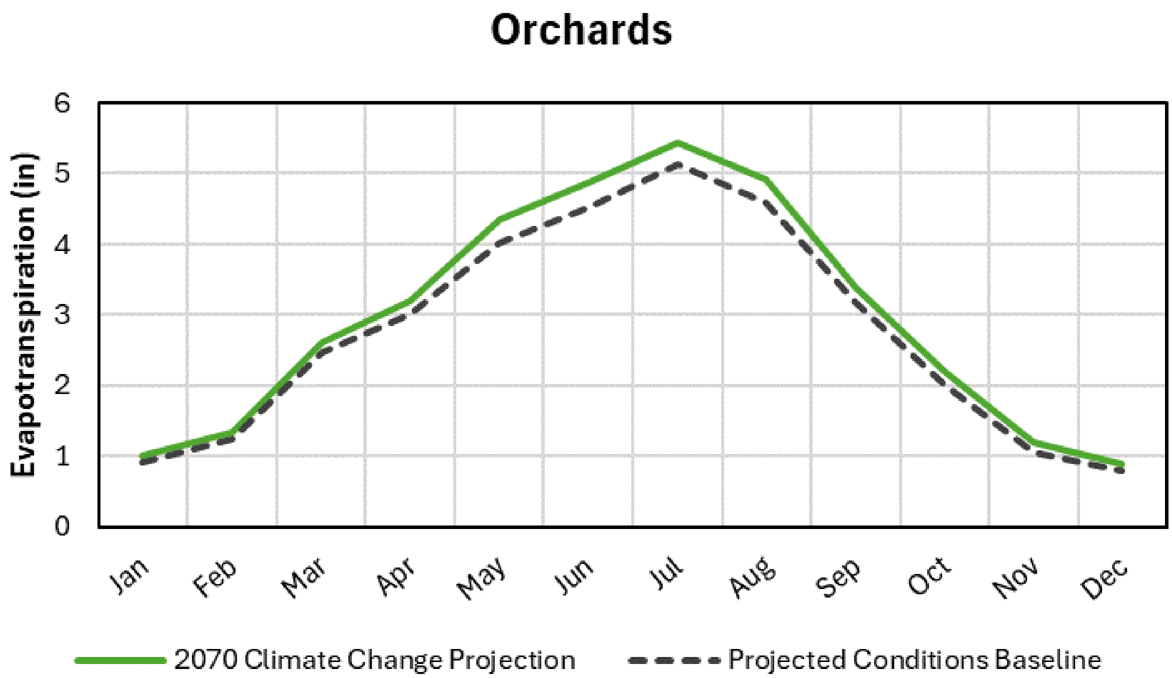


This plot (Figure 2-204) demonstrates that in 2070 with climate change added, in low precipitation months, there is approximately equal probability that the month will be wetter or drier than projected conditions baseline. However, under climate change, the 2070 conditions will be wetter in months with precipitation above approximately 150mm, indicated by the vertical gray dashed line. Therefore, under climate change conditions (in the scenario selected for the GSP), we can see that the occurrence of low precipitation months will likely not change significantly, but the higher precipitation months are predicted to be wetter overall than the projected conditions baseline.

2.4.3.2.2 Applying Change Factors to Evapotranspiration

Potential ET is in the Merced Subbasin is aggregated to one of seventeen land use categories but does not vary spatially. DWR provides change factors for ET in the same spatially distributed manner as precipitation, as described above. However, to match the level of discretization with the Merced model, an average ET change factor was calculated across all VIC grid cells within the Merced Subbasin boundary. Therefore, the tool to process ET provided by DWR was not needed or used. Change factors provided by DWR for November 1, 1964 through December 1, 2011 were averaged. This average ET change factor was then applied to the baseline ET time series for each crop type. Because the same ET change factor was applied over the entire baseline, no synthesis was required in this analysis. Refinement to the simulated evapotranspiration of orchards under 2070 climate conditions is shown in Figure 2-205 below. For 2070, the average change factor is 1.08.

Figure 2-205: Monthly ET for Sample Crops



2.4.3.3 Merced Subbasin Water Budget Under Climate Change

A climate change scenario was developed for the MercedWRM to evaluate the hydrological impacts under these conditions. The analysis was based on the projected conditions baseline with climate change perturbed inputs for streamflow, precipitation, and ET. Tabular results are presented below in Table 2-26, Table 2-27, and Table 2-28. Under the climate change scenario, the average annual volume of evapotranspiration is seven percent higher than the projected conditions baseline, increasing to 916,000 AFY from 853,000 AFY. Due to changes to local hydrology, the average annual surface water availability was projected to increase 4 percent from 274,000 AFY to 286,000 AFY.[35] The simulated increase in surface water supply is not enough to meet the increased water demands under the climate change scenario. As a result, private groundwater production is simulated to increase approximately 7 percent, from 536,000 AFY to 565,000 AFY. Under climate change conditions, depletion in aquifer storage is expected to increase by about 60 percent to an average annual rate of 130,000 AFY, from 82,000 AFY in the projected conditions baseline. A graphical representation of simulated changes to evapotranspiration, surface deliveries, and groundwater pumping are presented in Figure 2-206

[35] There are various approaches to estimating the effects of climate change on local hydrology. The 2070 Central Tendency used in this GSP according to DWR guidelines for GSP submittal may differ from local studies or certain Flood-MAR scenarios.

though Figure 2-208, below, and complete water budgets for the climate change scenario are shown in Figure 2-209 and Figure 2-210.

Figure 2-206: Simulated Changes in Evapotranspiration due to Climate Change (Scenario minus Baseline)

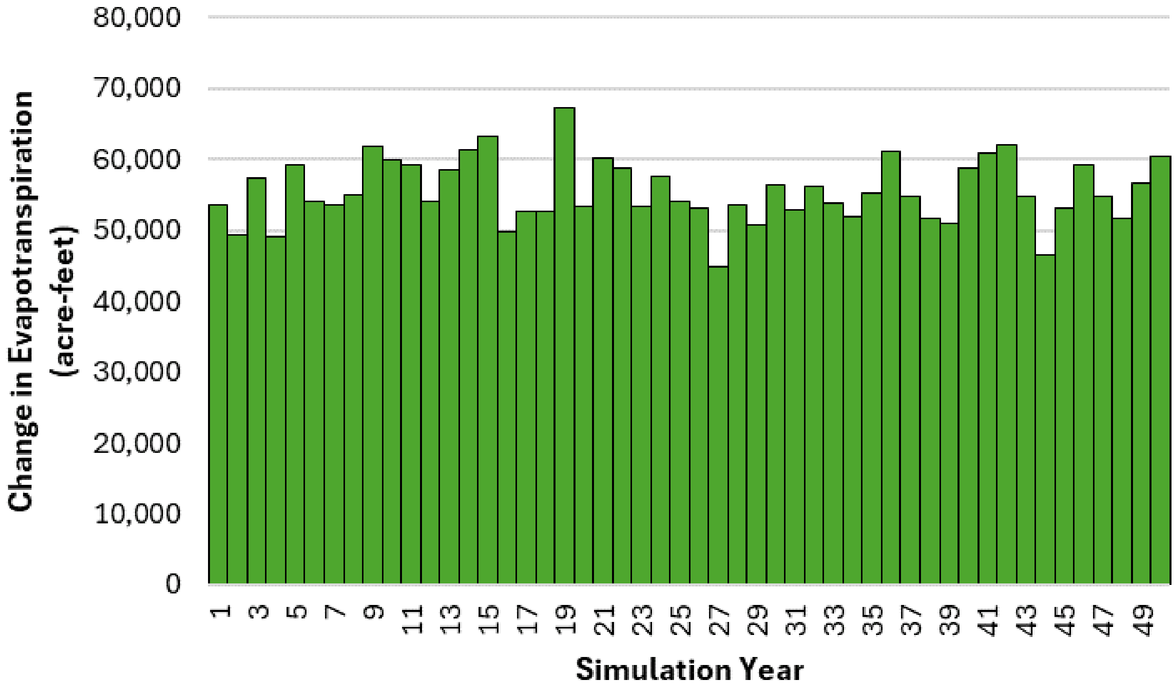


Figure 2-207: Simulated Changes in Surface Water Supplies due to Climate Change (Scenario minus Baseline)

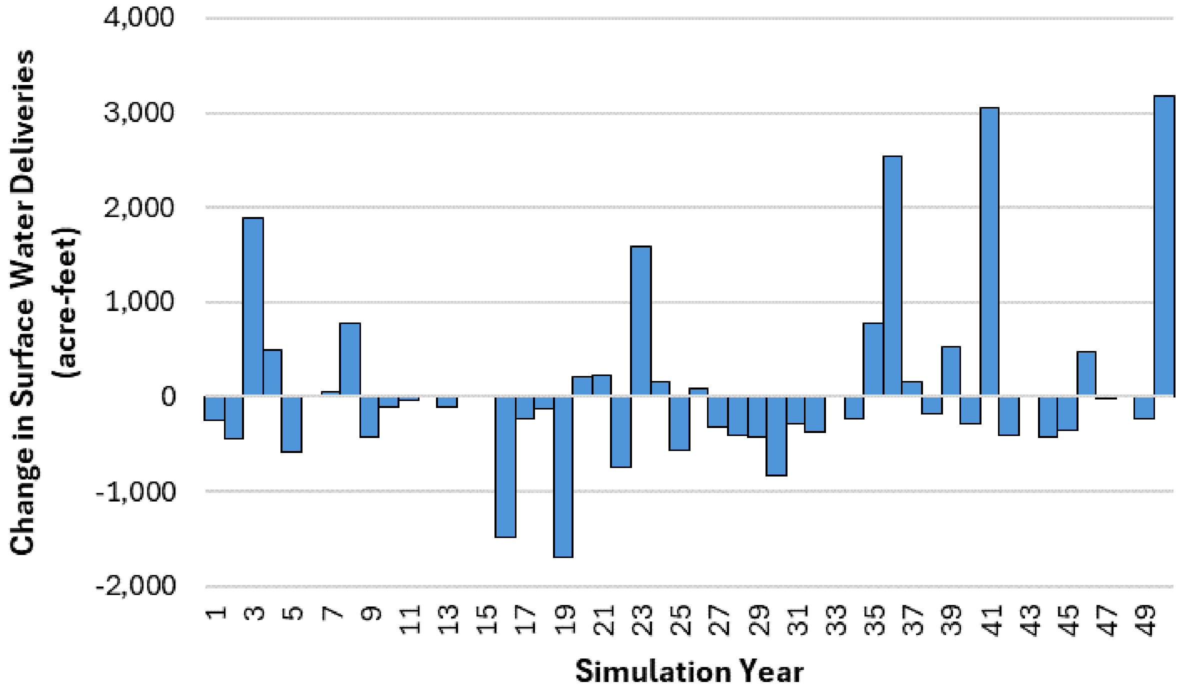


Figure 2-208: Simulated Changes in Groundwater Production due to Climate Change (Scenario minus Baseline)

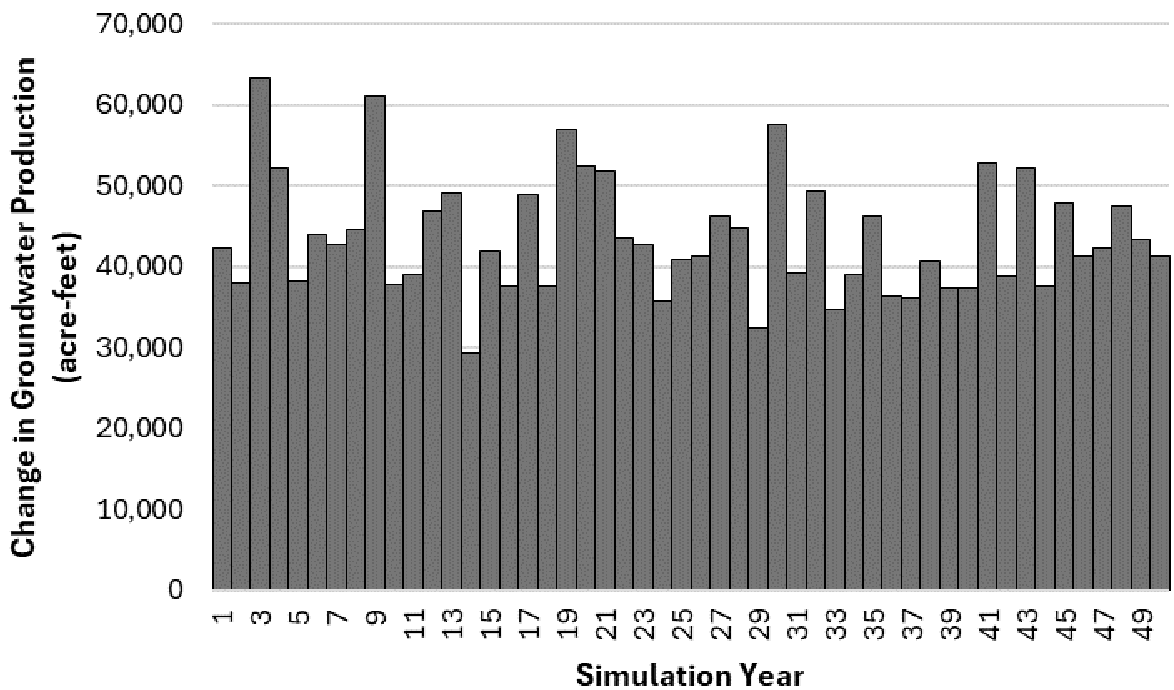


Figure 2-209: Land and Water Use Budget - MercedWRM Climate Change Scenario

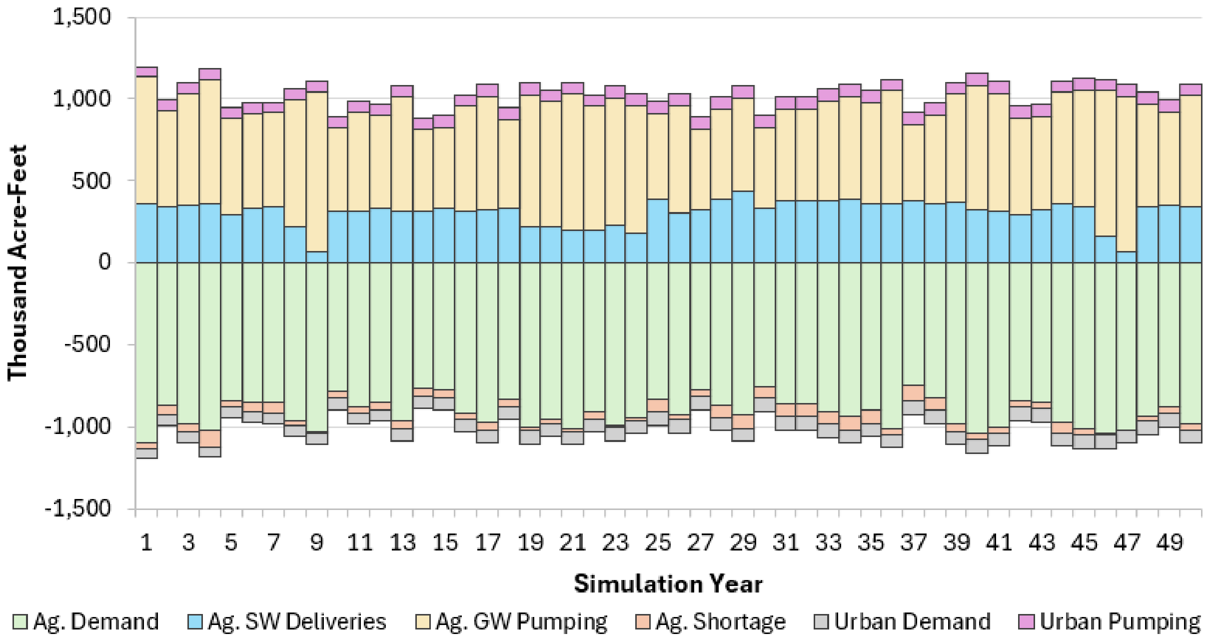


Figure 2-210: Groundwater Budget - MercedWRM Climate Change Scenario

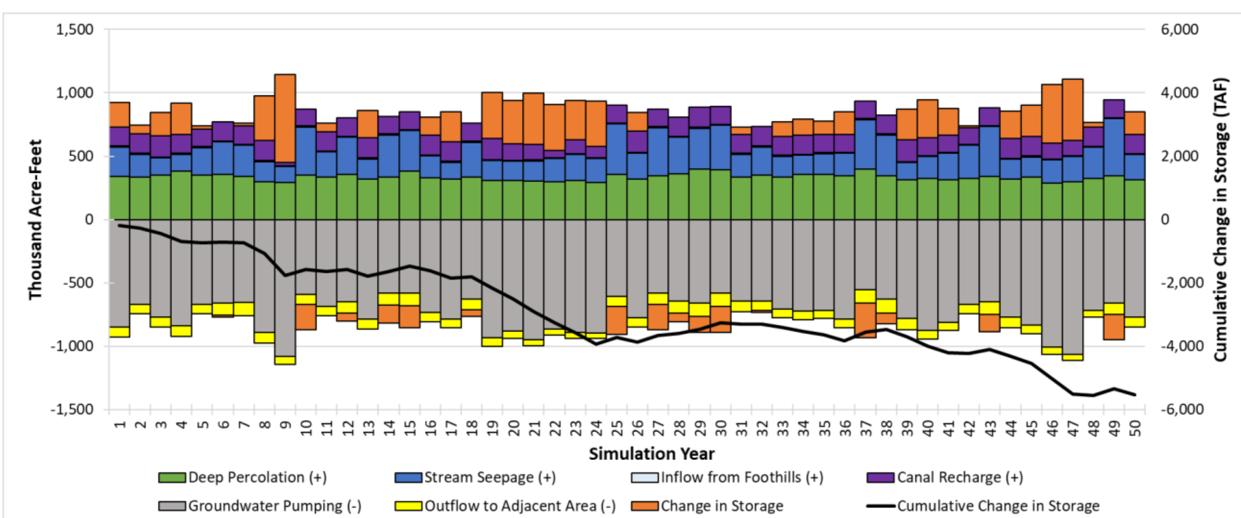


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Table 2-26: Average Annual Water Budget Under Climate Change – Stream and Canal Systems, Merced Subbasin (AFY)

Component	Projected Condition Water Budget	Climate Change Water Budget
Hydrologic Period	**WY 1969 - 2018**	**WY 1969-2018**
Inflows[1]		
Stream Inflows	2,480,000	2,333,000
Merced River	981,000	1,024,000
Eastside Bypass	773,000	773,000
San Joaquin River	581,000	385,000
Chowchilla River	72,000	71,000
Local Tributaries[1]	74,000	81,000
Stream Gain from Groundwater	39,000	32,000
Merced Subbasin	22,000	17,000
Merced River	6,000	4,000
Eastside Bypass	0	0
San Joaquin River	8,000	7,000
Chowchilla River	1,000	1,000
Local Tributaries[1]	7,000	5,000
Other Subbasins[2]	18,000	15,000
Merced River	7,000	5,000
San Joaquin River	7,000	6,000
Chowchilla River	4,000	4,000
Runoff to the Stream System	262,000	299,000
Merced Subbasin	145,000	164,000
Other Subbasins[2]	117,000	135,000
Return Flow to Stream System	67,000	67,000
Merced Subbasin	56,000	55,000
Other Subbasins[2]	11,000	11,000
Groundwater Pumping to Canals	42,000	42,000
Other[3]	-36,000	-39,000
Total Inflow	**2,927,000**	**2,812,000**
Outflows[1]		
San Joaquin River Outflows	2,360,000	1,948,000
Stream Losses to Groundwater	401,000	510,000
Merced Subbasin	318,000	388,000
Merced River	42,000	75,000
Eastside Bypass	44,000	58,000
San Joaquin River	36,000	41,000
Chowchilla River	2,000	1,000
Local Tributaries[1]	52,000	73,000
Canal Recharge	141,000	140,000
Other Subbasins[2]	83,000	122,000
Merced River	42,000	77,000
San Joaquin River	39,000	45,000
Chowchilla River	2,000	0
Surface Water Deliveries	274,000	287,000
Groundwater Delivery via Canals	45,000	42,000

Riparian Uptake from Streams	25,000	25,000
Merced Subbasin	14,000	8,000
Other Subbasins	11,000	17,000
Total Outflow	**3,105,000**	**2,812,000**

[1] Local Tributaries include Bear Creek, Black Rascal Creek, Deadman Creek, Duck Slough, Dutchman Creek, Mariposa Creek, Miles Creek, and Owens Creek. Additional smaller creeks exist but were not modeled due to minimal natural flows.

[2] Other Subbasins include the Turlock, Chowchilla, and Delta-Mendota Subbasins. As supporting data was not available, modeling inputs such as curve number and return flow fractions were assumed to be similar to those used in the Merced Subbasin.

[3] Other flows is a closure term that captures the stream and canal system including gains and losses not directly measured or simulated within IWFM. Some of these features include but may not be limited to direct precipitation, evaporation, unmeasured riparian diversions and return flow, temporary storage in local lakes and regulating reservoirs, and inflow discrepancies resulting from simulating impaired flows.

Table 2-27: Average Annual Water Budget Under Climate Change – Land Surface System, Merced Subbasin (AFY)

Component	Projected Condition Water Budget	Climate Change Water Budget
Hydrologic Period	**WY 1969 - 2018**	**WY 1969-2018**
Inflows		
Precipitation	505,000	529,000
Total Surface Water Supply	287,000	287,000
Surface Water - Local	241,000	242,000
Surface Water - Riparian	46,000	46,000
Total Groundwater Supply	704,000	747,000
Agricultural - Agency	42,000	42,000
Agricultural - Private	590,000	634,000
Urban - Municipal	49,000	49,000
Urban - Domestic	24,000	22,000
Riparian Uptake from Streams	7,000	8,000
Inflow from Groundwater System	0	0
Total Inflow	**1,504,000**	**1,571,000**
Outflows		
Evapotranspiration	953,000	1,009,000
Agricultural	745,000	797,000
Municipal and Domestic	24,000	25,000
Refuge, Native, and Riparian	184,000	187,000
Runoff to the Stream System	145,000	164,000
Return Flow to the Stream System	56,000	55,000
Agricultural	12,000	13,000
Municipal and Domestic	44,000	43,000
Deep Percolation	343,000	336,000
Precipitation	91,000	88,000
Surface Water	73,000	69,000
Surface Water - Local	61,000	58,000
Surface Water - Riparian	12,000	11,000
Groundwater	179,000	179,000
Agricultural - Agency	11,000	10,000
Agricultural - Private	149,000	152,000
Urban - Municipal	12,000	12,000
Urban - Private	6,000	5,000
Other[1]	7,000	7,000
Total Outflow	**1,504,000**	**1,571,000**

[1] Other flows is a closure term that captures the gains and losses due to land expansion and seasonal storage in the root-zone.

Table 2-28: Average Annual Water Budget Under Climate Change – Groundwater System, Merced Subbasin (AFY)

Component	Projected Condition Water Budget	Climate Change Water Budget
Hydrologic Period	WY 1969 - 2018	WY 1969-2018
Inflows		
Deep Percolation	343,000	336,000
Precipitation	91,000	88,000
Surface Water	73,000	69,000
Surface Water - Local	61,000	58,000
Surface Water - Riparian	12,000	11,000
Groundwater	179,000	179,000
Agricultural - Agency	11,000	10,000
Agricultural - Private	149,000	152,000
Urban - Municipal	12,000	12,000
Urban - Private	6,000	5,000
Stream Losses to Groundwater	367,000	388,000
Merced River	70,000	75,000
Eastside Bypass	48,000	58,000
San Joaquin River	40,000	41,000
Chowchilla River	1,000	1,000
Local Tributaries[1]	68,000	73,000
Canal Recharge	140,000	140,000
Subsurface Inflow	82,000	83,000
Total Inflow	**791,000**	**806,000**
Outflows		
Stream Gain from Groundwater	22,000	17,000
Merced River	6,000	4,000
Eastside Bypass	0	0
San Joaquin River	8,000	7,000
Chowchilla River	1,000	1,000
Local Tributaries	7,000	5,000
Groundwater Production	704,000	747,000
Agricultural - Agency	42,000	42,000
Agricultural - Private	590,000	634,000
Urban - Municipal	49,000	49,000
Urban - Private	24,000	22,000
Subsurface Outflow[2]	142,000	151,000
Outflow to Land Surface System	0	0
Other[3]	1,000	1,000
Total Outflow	**869,000**	**916,000**
Change in Storage	**-77,000**	**-110,000**

[1] Local Tributaries include Bear Creek, Black Rascal Creek, Deadman Creek, Duck Slough, Dutchman Creek, Mariposa Creek, Miles Creek, and Owens Creek. Additional smaller creeks exist but were not modeled due to minimal natural flows.

[2] The goal of projecting interbasin flows is to maintain a reasonable balance between the neighboring Subbasins. The results are within 10-12%, which is within the reasonable range, given the availability of

projected land use, population, surface water delivery, and groundwater production data from areas outside of the Merced Subbasin.

[3] Other flows within the groundwater system including temporary storage in the vadose zone, and root water uptake from the aquifer system.

2.4.3.4 Opportunities for Future Refinement

The climate change approach developed for this GSP is based on the methodology in DWR's guidance document (DWR, 2018a) and uses "best available information" related to climate change in the Merced Subbasin. There are limitations and uncertainties associated with the analysis. One important limitation is that Calsim II does not fully simulate local surface water operations. Thus, the analysis conducted for this GSP may not fully reflect how surface and groundwater basin operations would respond to the changes in water demand and availability caused by climate change. For this first GSP iteration, use of a regional model and the perturbation factor approach were deemed appropriate given the uncertainties in the climate change analysis.

A recommendation for future refinements of this analysis is utilization of the local surface water operations model, the Merced Irrigation District Hydrologic and Hydraulic Operations Model (MIDH2O). Use of this model would allow for greater resolution in the simulation of Merced River flows and surface water supply based on local management. Additionally, utilization of MIDH2O will allow for analysis of the localized climate conditions effecting snow-pack and its implications on reservoir operations and streamflow. Further monitoring and adaptive management should be considered for the next update of the GSP along with improvements in DWR's climate change data.

3 SUSTAINABLE MANAGEMENT CRITERIA

This section presents the sustainable management criteria (SMC, criteria) developed for the Merced Subbasin GSP. GSP regulations consolidate several requirements of GSPs under the heading of "Sustainable Management Criteria." These criteria include:

- Sustainability Goal
- Undesirable Results
- Minimum Thresholds
- Measurable Objectives

The development of these criteria for the Merced GSP relied upon information about the Subbasin developed in the hydrogeologic conceptual model (Section 2.1), current and historical groundwater conditions (Section 2.2), and the water budget (Section 2.3), and input from stakeholders during the GSP development process. SMC have been refined as part of the GSP update process.

This GSP considers the six sustainability indicators defined by SGMA in the development of sustainable management criteria. SGMA allows several pathways to meet the distinct local needs of each basin, including development of sustainable management criteria, usage of groundwater levels as a proxy, and identification as not being applicable to the Subbasin.

3.1 SUSTAINABILITY GOAL

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*" [CWC §10721(v)]. Each GSP is required to include a sustainability goal, defined by SGMA as "*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*" [CWC §10721(u)]. SGMA requires the GSP to define a succinct sustainability goal statement.

The Merced Subbasin sustainability goal succinctly states Subbasin objectives and desired conditions as defined by the GSAs and other beneficial users of groundwater in the Subbasin. The Merced Subbasin is heavily reliant on groundwater, and users recognize the basin has been in overdraft for a long period of time. As discussed in greater detail below, the Subbasin has experienced historical lowering of water levels, land subsidence, and wells going dry. The GSAs have adopted the following sustainability goal for the Merced Subbasin:

> **Achieve sustainable groundwater management on a long-term average basis by increasing recharge and/or reducing groundwater pumping, while avoiding undesirable results.**

Sustainable Management Criteria Definitions

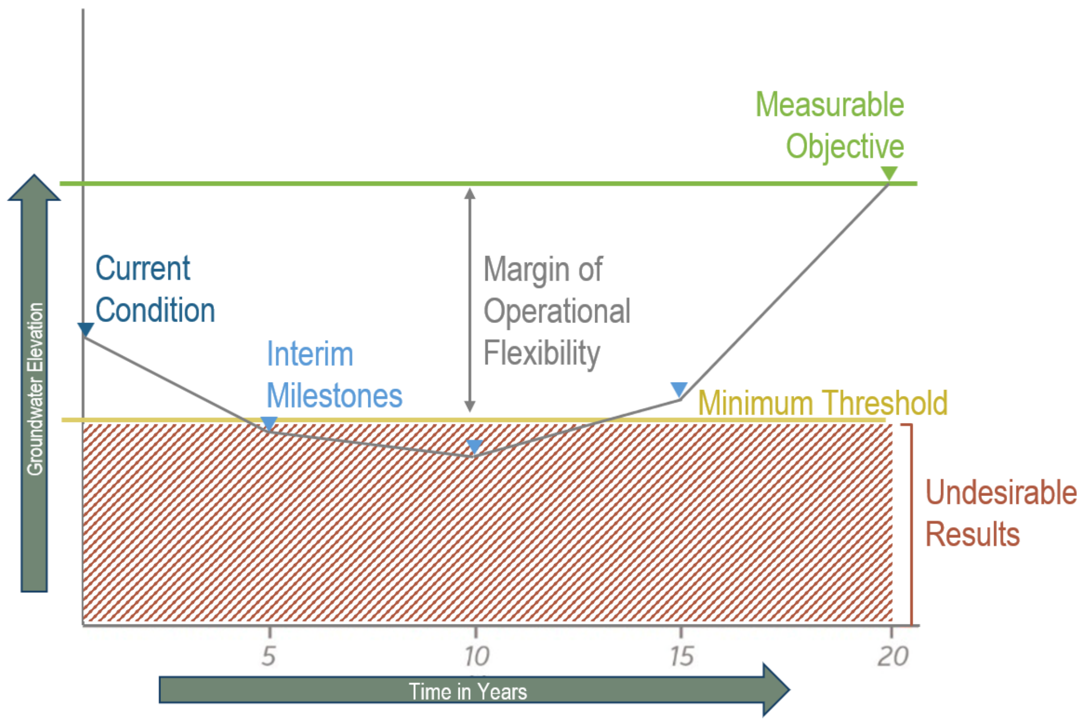
- **Undesirable Results** – Significant and unreasonable negative impacts for each sustainability indicator that are used to guide development of GSP components
- **Minimum Thresholds** – "*A numeric value for each sustainability indicator used to define undesirable results" [*CCR Title 23, Division 2, §351(t)]
- **Measurable Objectives** – Quantitative targets that establish points above the minimum thresholds that allow for a range of active management in order to achieve the sustainability goal for the basin. Defined in the CCR as "*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*" [CCR Title 23, Division 2, §351(r)]
- **Interim Milestones** – "*Target values representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan*" [CCR Title 23, Division 2, §351(q)]
- **Margin of Operational Flexibility**: The space between the measurable objective and the minimum threshold

See Figure 3-1 for a graphic that illustrates the conceptual relationship between the Sustainable Management Criteria terms.

This goal will be achieved by allocating a portion of the estimated Subbasin sustainable yield to each GSA and coordinating the implementation of programs and projects to increase both direct and in-lieu groundwater recharge, which will, in turn, increase the groundwater and / or surface water available to each GSA.

This sustainability goal is supported by the locally-defined minimum thresholds that sufficiently prevent undesirable results, presented later in this section. Achievement of the goal will be demonstrated by the avoidance of undesirable results as defined in this GSP. This will confirm that the basin is operating within its sustainable yield without experiencing undesirable results, and thus that the sustainability goal has been achieved.

Figure 3-1: Sustainable Management Criteria Conceptual Graphic (Groundwater Levels Example*)



** Note that exceeding the minimum threshold at one representative well does not necessarily trigger an undesirable result. Undesirable results are defined for each sustainability indicator in the sections below.*

3.2 MANAGEMENT AREAS

SGMA provides the option for GSAs to define management areas for portions of basins to facilitate groundwater management and monitoring. A management area is defined in SGMA as an "*area within a basin for which the [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, or other factors*" [CCR Title 23, Division 2, §351(r)].

For example, GSAs may establish management areas where they desire a higher level of monitoring or wish to set more stringent minimum thresholds relative to the rest of the basin. Per DWR Guidance:

> *Management areas may be defined by natural or jurisdictional boundaries, and may be based on differences in water use sector, water source type, geology, or aquifer characteristics. Management areas may have different minimum thresholds and measurable objectives than the basin at large and may be monitored to a different level. However, GSAs in the basin must*

provide descriptions of why those differences are appropriate for the management area, relative to the rest of the basin. (DWR, 2017a, p. 6)

Management Areas have been discussed in the Merced GSP Stakeholder Advisory and Coordination Committee Meetings, as well as GSA Board Meetings. At this time, there are no management areas established for the purposes of defining sustainability criteria for the Subbasin.

3.3 GROUNDWATER LEVELS

3.3.1 Undesirable Results

Description of Undesirable Results

The undesirable result related to groundwater levels is defined in 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. [CWC §10721(x)(1)]*

The undesirable result for chronic lowering of groundwater levels in the Merced Subbasin is sustained groundwater elevations that are too low to satisfy beneficial uses within the basin over the planning and implementation horizon of this GSP. During development of the GSP, potential undesirable results identified by stakeholders included:

- Significant and unreasonable unusable and stranded groundwater extraction infrastructure
- Significant and unreasonable reduced groundwater production
- Significant and unreasonable increased pumping costs due to greater lift and deeper installation or construction of new wells
- Significant and unreasonable number of shallow domestic wells going dry

Identification of Undesirable Results

For the Merced Subbasin, an undesirable result for declining groundwater levels is considered to occur during GSP implementation when November groundwater levels at greater than 25% of representative monitoring wells (at least 8 of 29) fall below their minimum thresholds for two consecutive years.

The GSAs recognize that water levels may continue to decline during GSP implementation and that dewatering of a single domestic well is not considered significant and unreasonable and is not considered an undesirable result. Nonetheless, the GSAs recognize the importance of access to safe drinking water for all users in the basin and are working on establishing a mitigation program for domestic wells that might be dewatered by regional declines in groundwater levels (see Section 6.2.4 – Management Action for Domestic Well Mitigation Program).

Potential Causes of Undesirable Results

The Subbasin is currently considered to be in a state of critical overdraft per the DWR Bulletin 118 2020 Update. Projections of water levels based on the GSP implementation plan do not show groundwater levels triggering undesirable results. However, the chronic lowering of groundwater levels could cause localized or basin-wide undesirable results if GSP implementation does not achieve sufficient pumping reductions. In addition, regulatory, permitting, and funding constraints may influence implementation timing for groundwater management programs and projects in the Subbasin.

Other potential causes could be external factors such as increased groundwater outflow from the Merced Subbasin to adjacent groundwater subbasins as a result of imbalances in groundwater pumping between the subbasins. Additionally, state- or federally-driven regulatory programs could dedicate surface water resources to environmental uses in the San Joaquin River or in downstream waterbodies such as the Sacramento-San Joaquin Delta, thus reducing water available to the Merced Subbasin. For example, increased flow requirements described by the Substitute Environmental Document (SED) for the Lower San Joaquin River and Southern Delta Bay-Delta Plan Update would likely cause impacts to groundwater levels.

Potential Effects of Undesirable Results

If groundwater were to reach levels that cause undesirable results, effects could include: de-watering of a subset of the existing groundwater infrastructure, starting with the shallowest wells (which are generally domestic wells) and adverse effects on groundwater dependent ecosystems. Lowering levels to this degree could necessitate drilling deeper wells for drinking water and agricultural irrigation supplies, which could cause adverse effects to property values and the regional economy. Additionally, undesirable results for groundwater levels could adversely affect current and projected municipal uses, which rely on groundwater in the Subbasin, increasing costs for potable water supplies.

3.3.2 Minimum Thresholds

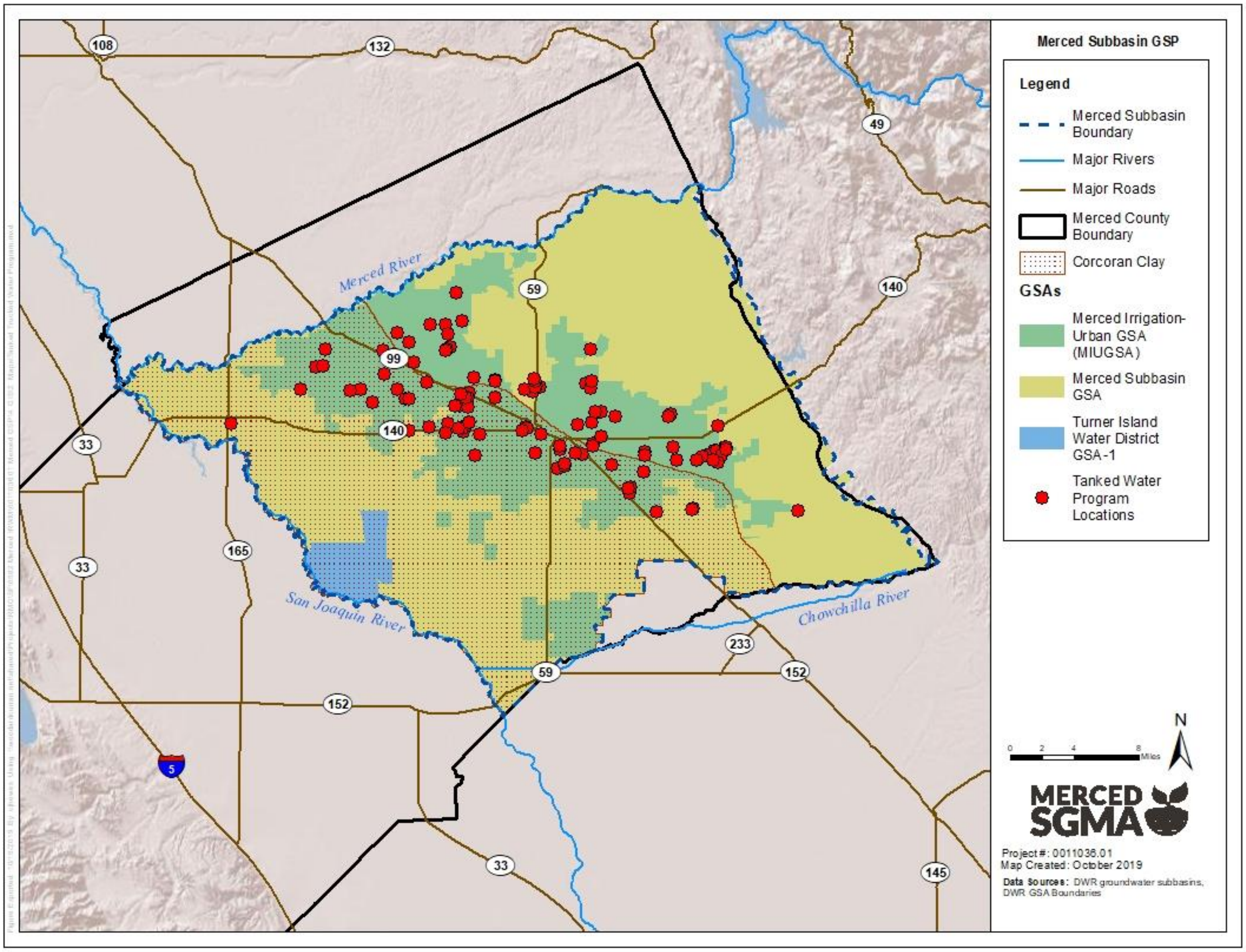
Minimum Threshold Background

The minimum threshold definition for the chronic lowering of groundwater levels was developed to represent water levels that are above conditions that could generate significant and unreasonable undesirable results in the Merced Subbasin, to the extent possible given available information. Future data may allow for refinement of this threshold.

The Subbasin, as described in the Section 2.1 – Hydrogeologic Conceptual Model, is composed of three principal aquifers: Above, Below, and Outside of the Corcoran Clay. The minimum threshold definition was applied to each of these areas by selecting monitoring wells considered representative within each principal aquifer and establishing a threshold groundwater elevation for each well.

Within the Merced Subbasin, groundwater levels have been declining for several years (see Section 2.2 – Current and Historical Groundwater Conditions). Groundwater levels during the 2012-2016 drought declined at a faster rate, especially in the region designated as the Outside Corcoran Clay Principal Aquifer which is just east of the City of Merced, causing approximately 130 domestic wells to go dry. As an emergency measure during the drought, Merced County facilitated a State of California tanked water program to make potable water available to domestic users whose wells had gone dry. Figure 3-2 shows a map with the location of the tanked water program deliveries. Of the participants in this program, those who were not removed from the program due to non-compliance with program requirements had new wells installed, with the exception of one who was connected to a city water system. Some participants sold their property; the current status of those properties is unknown.

Figure 3-2: Merced Subbasin Tanked Water Program Locations (through 2018)



Minimum Threshold Selection (for wells with measurements recorded 2011-2015)

The minimum threshold for groundwater levels is defined as the fall 2015 groundwater level measurement (November 2015, or October 2015 or December 2015 when November data are unavailable) recorded at each representative monitoring well. This threshold keeps groundwater levels generally above levels that have been experienced in the past. In this way, impacts to shallow well users and other beneficial users of groundwater will generally not exceed what has historically been experienced in the Subbasin. In some areas, groundwater levels could be lower without resulting in significant and unreasonable impacts, notably due to limited domestic wells or to generally deeper domestic wells. Further, thresholds are set at fall 2015 levels to also be consistent with the other sustainability indicators. The groundwater level minimum threshold is consistent with the avoidance of significant and unreasonable impacts to subsidence, water quality, and depletions of interconnected surface water, as described later in this Plan.

To evaluate the impact of a fall 2015 minimum threshold, Merced County's electronic well permitting database was used to determine the shallowest domestic or Public Water System well depth within five miles of each representative monitoring well (defined as a circle around the monitoring well with radius of five miles). The Merced County well permitting database includes domestic and Public Water System wells permitted by the county since the early- to mid-1990s. While DWR's Online System for Well Completion Reports (OSWCR) contains additional wells permitted before the 1990s, the Merced County well permitting database was assumed to provide a reliable current representation of active domestic wells in the Subbasin. Additionally, it provides more specific information about these wells such as detailed location from latitude/longitude coordinates, address, or APN, as well as well status as part of the county's permit approval workflow process. The Merced County well permitting database was filtered to omit known inactive wells, resulting in approximately 3,298 wells with locations that could be plotted geographically within the Subbasin and that had a total well depth reported. 3,185 of these wells (99.5%) are located within 5 miles of one of the representative monitoring wells. Additional analysis resulted in the filtering out of additional wells from the subset of 3,185, as described in the bullets below. However, it is likely that the resulting dataset still includes wells that have become inactive but are not flagged in the county's database.

- 8 wells reviewed manually and confirmed to be associated with a later well destruction record
- 8 wells that do not meet county domestic well annular seal requirements (depth of 50 feet or less)
- 18 wells flagged as other outliers[36]

Total well depths were compared to the minimum threshold. At five out of 29 representative monitoring wells, minimum threshold (fall 2015) elevation data are lower than the shallowest domestic well depth[37], indicating that these domestic well(s) may already have been dewatered and replaced. The five station IDs are 28392 (21 wells, equivalent to 41% of nearby wells), 38884 (1 well, equivalent to 2% of nearby wells), 52716 (1 well, equivalent to 5% of nearby wells), 60562

[36] Outliers that were statistically significant (much shallower than surrounding wells). Outlier Analysis: at each representative monitoring well, the interquartile range of domestic wells was calculated (75th percentile depth minus 25th percentile depth). Domestic wells were flagged as outliers and excluded from the threshold analysis if they had a depth that was shallower than: (25th percentile domestic well depth) – 1.5 * (Interquartile Range)

[37] It is acknowledged that domestic or Public Water Supply wells need additional water depth above the bottom of the well for the pump to functioning, but without information about pump settings, this was not considered in the analysis.

(3 wells, equivalent to 2% of nearby wells), 47575 (1 well, equivalent to 1% of nearby wells). Again, it is expected that these wells have likely since been deepened or abandoned and replaced given that groundwater levels have declined to this level in the past. Thus, returning to this level would not be expected to dewater these wells again. Recall that available datasets often include wells that are no longer in use for a variety of reasons.

Additional analysis was performed for domestic and PWS wells that could potentially be dewatered during the implementation period of 2020 through 2040 when groundwater levels at representative monitoring wells may temporarily decline below minimum thresholds while projects and management actions are put in place. Domestic and PWS wells were flagged where their total well depth is deeper than the MT, but shallower than the 2025 and 2030 Interim Milestones (described later in Section 3.3.3). The station IDs are 10200 (estimated 2 wells), 28392 (estimated 8 wells), 38884 (estimated 2-3 wells depending on IM), 47542 (estimated 1 well), 60562 (estimated 5 wells), and 52716 (estimated 1 well).

Minimum Threshold (& Measurable Objective) Selection (for wells without measurements 2011-2015)

During the course of GSP implementation, the GSAs have filled data gaps in the groundwater level monitoring network by installing new wells or instrumenting wells that were previously inactive or otherwise don't have recorded historical monitoring level data. A subset of the new monitoring network wells are being designated representative monitoring wells and thus need defined sustainable management criteria. The methodology described above does not apply because 2011 and 2015 groundwater level measurements are not available for the new representative monitoring network wells. For new and future representative monitoring wells, the GSAs anticipate installing new wells and collecting three or more years of monitoring data before applying a new approach to set sustainable management criteria.

For wells added during the GSP 2025 update, sustainable management criteria (minimum threshold, measurable objective, and interim milestones) were developed using a combination of recently observed and simulated groundwater levels from MercedWRM. In the absence of actual historical data, this method is meant to estimate historical conditions as closely as possible with available information. The method makes use of two primary assumptions:

1. 2021 was a dry year, associated with low groundwater levels, which can be correlated with the similarly dry conditions in 2015 (which is used to set the minimum threshold for wells with a full observation record)

2. 2023 was a wet year, associated with higher groundwater levels, which can be correlated with the similarly wet conditions in 2011 (which is used to set the measurable objective for wells with a full observation record)

The MercedWRM was used to calculate the difference in estimated groundwater elevations for each unique well for the period of ([2021] – [2015]) and ([2023] – [2011]).

Those calculated values were subtracted from the observed groundwater levels to determine sustainable management criteria:

- Minimum Threshold at new well = [Observed 2021] – [2021-2015 difference]
- Measurable Objective at new well = [Observed 2023] - [2023-2011 difference]

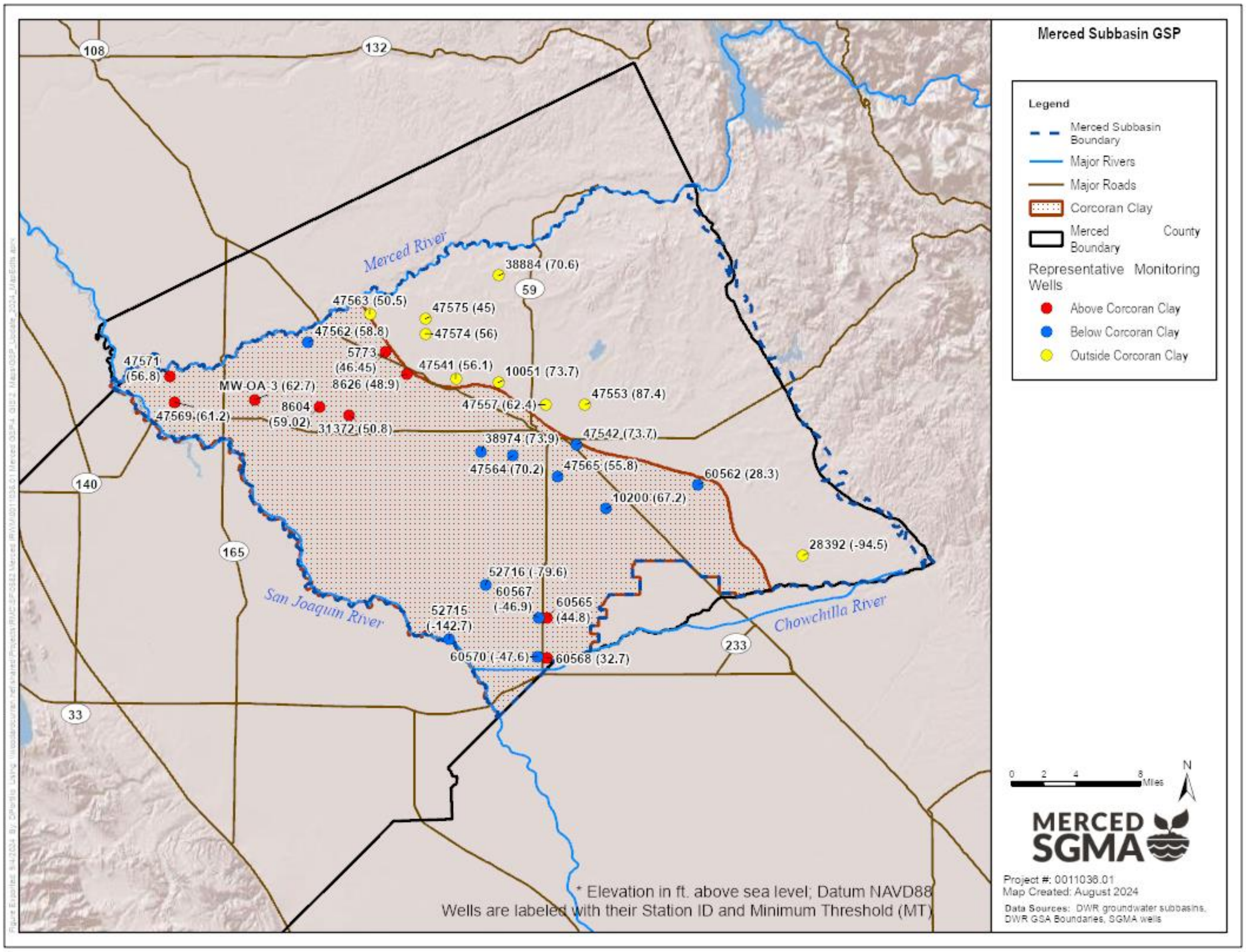
Representative Monitoring Wells for Minimum Threshold

A subset of wells originally designated for the CASGEM program serve as the representative monitoring wells, plus new wells that have been added since the original 2020 GSP was published. Minimum threshold groundwater elevations were originally developed for 21 out of 50 wells in the Subbasin that were part of the CASGEM program at the time and were considered the best representation of the Subbasin using best available information. Minimum thresholds have been developed for an additional 8 wells added since the original 2020 GSP was published. Monitoring network wells were originally selected from the CASGEM program as they are actively managed and have previously been identified as appropriate for regional monitoring activities. Not all CASGEM wells at the time were selected to be representative. For instance, only one well per unique set of multiple completion wells was considered for representative monitoring.

As additional wells are added to the monitoring network, they will be considered for inclusion as representative monitoring wells based on their ability to contribute to characterization and management of groundwater conditions in the Subbasin.

Figure 3-3 shows the minimum threshold groundwater elevations for all the representative monitoring wells. Additional information about the minimum threshold and associated groundwater elevations can be found in Table 3-1 following the discussion of measurable objectives.

Figure 3-3: Minimum Threshold Groundwater Elevations at Representative Monitoring Well Sites



Groundwater levels are also used as a proxy indicator for depletion of interconnected surface water in Section 3.8 and for reduction in groundwater storage in Section 3.4.

3.3.3 Measurable Objectives and Interim Milestones

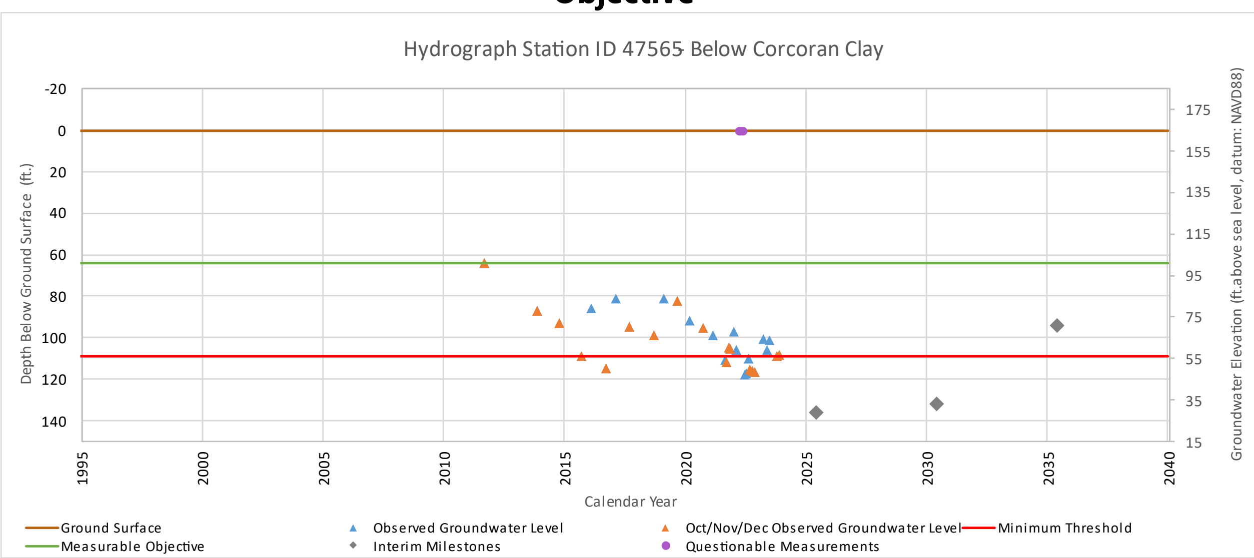
Measurable objectives are quantitative targets that establish a point above the minimum threshold that allow for a range of active management of the basin in order to achieve the sustainability goal for the basin. The condition between the measurable objective and the minimum threshold is known as the margin of operational flexibility. The margin of operational flexibility is intended to accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities.

Measurable Objective Selection (for wells with measurements recorded 2011-2015)

The measurable objective is set at the elevation of November 2011 groundwater levels for representative monitoring wells with historical measurements available. This represents relatively high groundwater levels prior to the declines seen during the 2012-2016 drought. For representative monitoring wells without available November 2011 measurements, October or December 2011 measurements were used, as available. For representative monitoring wells without November, October, or December 2011 measurements, a value has been calculated using estimates of historical groundwater levels in November 2011 from the MercedWRM historical conditions simulation. MercedWRM groundwater levels were adjusted vertically based on the average distance between observed and simulated levels before querying the November 2011 estimation.

Table 3-1 shows the measurable objective for each representative monitoring well. Figure 3-4 contains an example hydrograph, showing the relationship between historical groundwater elevations, the minimum threshold groundwater level, the measurable objective, and the interim milestones. Appendix F contains the full set of hydrographs, one for each representative monitoring well in Table 3-1.

Figure 3-4: Example Hydrograph Showing Minimum Threshold and Measurable Objective



Measurable Objective Selection (for wells without measurements 2011-2015)

See the subsection titled "Minimum Threshold (& Measurable Objective) Selection (new wells implemented since original 2020 GSP)" in prior Section 3.3.2 for a description of how the measurable objective was determined for new representative monitoring wells added since the original 2020 GSP was published.

Interim Milestones

Interim milestones (IM) have been established to facilitate the Subbasin reaching its measurable objectives for groundwater levels. Groundwater level decline is anticipated in the Subbasin prior to implementation of PMAs. Thus, the IMs for groundwater levels allow for temporary further groundwater level decline below the minimum threshold while PMAs are developed. IMs are defined in 5-year increments, for 2025, 2030, and 2035.

The IMs were developed by first calculating a range for each of the 5-year increments. The range of IMs were developed so that wet conditions were generally represented by the high value and dry conditions were generally represented by the low value. The final IM for each of the 5-year increments was then based on a percentage between the upper and lower values (as described further below).

The range of IMs were developed as follows:

- Year 5 (2025)
    - Low value: The average annual slope between the MT (based on 2015 levels) and MO (based on 2011 levels) was calculated. The calculated slope was then projected to 2025 using the average slope from the most recently recorded October or November measurement to determine the 2025 low value. All monitoring sites had a valid measurement recorded in October 2021 except for Station ID 28392.
    - High value: The average annual slope between October through December groundwater levels from 2015 through 2019 (a relatively wet period) were calculated. The calculated slope was then then projected to 2025 using the average slope from the most recently recorded October or November measurement to determine the 2025 high value. All monitoring sites, except for Station ID 28392, had a valid measurement recorded in October 2021. If the resulting value was greater than 25% of the groundwater elevation difference between the MT to the MO, then the IM high value was placed at 25% of the elevation difference between the MT to the MO.
    - For new representative wells added since the 2020 GSP update, the only difference to the methodology is that November 2023 was used as a starting point for projecting forward to 2025, rather than October/November 2021.
- Year 10 (2030):
    - Low value: The average annual slope between the MT (based on 2015 levels) and MO (based on 2011 levels) was calculated. The calculated slope was then projected to 2030 using half the average slope from the 2025 IM low value to determine the 2030 low value.

- High value: The average annual slope between October through December groundwater levels from 2015 through 2019 (a relatively wet period) was calculated. If the slope was negative, then maintained the 2025 IM high value. If the slope was positive, then projected the 2025 IM high value slope to 2030 to determine the 2030 high value. If the resulting value was greater than 50% of the groundwater elevation difference between the MT to the MO, then the IM high value was placed at 50% of the elevation difference between the MT to the MO.
  - For new representative wells added since the 2020 GSP update, the only difference to the methodology is that the slope between 2015 through 2019 was calculated using model estimates rather than using observed data.
- Year 15 (2035):
  - Low value: Set at one third of the way between the 2030 IM low value and the MO. If the resulting value is greater than the MT, then it was set at the MT.
  - High value: Set at one third of the way between the 2030 IM high value and the MO.
  - For new representative wells added since the 2020 GSP update, the same methodology was used.

The final interim milestone per representative monitoring well were developed and were calculated as follows:

- Year 5 (2025): *[2025 IM low value] + 25% * ([2025 IM high value] – [2025 IM low value])*
- Year 10 (2030): *[2030 IM low value] + 50% * ([2030 IM high value] – [2030 IM low value])*
- Year 15 (2035): *[2035 IM low value] + 75% * ([2035 IM high value] – [2035 IM low value])*

The percentage between the low value and high value increases with later years in recognition of reduced chances of predominantly dry conditions (higher potential to occur within short time periods) rather than more long-term normal conditions (higher potential to occur over longer time periods). Interim milestones are shown on Table 3-1.

Many representative monitoring wells have limited data, and many of these also show high levels of variability that make analysis difficult. Sustainable management criteria have been set using the best available data and additional information from the MercedWRM groundwater model. In several cases, there may be influences of nearby production wells that would need to be considered when setting and monitoring for sustainable management criteria; influences that are difficult to discern from the limited data. Wells that exhibit groundwater levels that are highly variable or difficult to explain, such as well ID 47541, will be a focus for the installation of pressure transducers or data-logging air bubblers to better understand the variability, to the extent feasible. Installations may be temporary or permanent.

Sustainable management criteria may be modified based on future data collection and analysis.

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Table 3-1: Groundwater Levels at Minimum Threshold, Measurable Objective, and Interim Milestones for Representative Wells

State Well ID	Well ID	Minimum Threshold[1]		Measurable Objective[1]			Interim Milestones[1]		
		Fall 2015 GW Level	Date of 2015 GWL	Fall 2011 GW Level[2]	Date of Fall 2011[2]	Measurable Objective[2]	2025	2030	2035
373496N1205890W001	47541	56.1	10/14/2015	-	-	66.4	29.9	25.6	39.5
370000N1200000W001	47574	56.0	10/1/2015	80.0	12/28/2011	80.0	40.0	36.7	56.4
373457N1205429W001	10051	73.7	10/12/2015	92.6	10/3/2011	92.6	48.1	45.8	65.7
373260N1204432W004	47553	87.4	10/8/2015	-	-	118.1	56.8	54.2	83.3
373243N1207424W001	8604	59.0	10/15/2015	67.0	10/3/2011	67.0	55.9	55.1	61.0
372904N1204207W001	47542	73.7	10/8/2015	-	-	112.6	38.3	35.6	71.6
373166N1207091W001	31372	50.8	10/15/2015	75.6	10/3/2011	75.6	33.9	34.6	55.9
373260N1204880W004	47557	62.4	10/8/2015	-	-	102.1	37.4	38.3	71.7
373532N1206432W001	8626	48.9	10/12/2015	78.0	10/3/2011	78.0	15.5	18.4	48.2
373278N1209054W002	47569	61.2	10/14/2015	68.2	10/15/2011	68.2	59.4	59.3	64.1
373510N1209113W001	47571	56.8	10/14/2015	66.3	11/15/2011	66.3	53.8	53.8	60.5
373732N1206679W001	5773	46.5	10/15/2015	-	-	73.8	26.8	30.6	54.8
372335N1204199W001	10200	67.2	10/29/2015	145.2	10/3/2011	145.2	11.5	13.9	81.8
372806N1205241W001	47564	70.2	10/12/2015	108.7	10/3/2011	108.7	53.5	55.1	84.4
370000N1200000W002	47575	45.0	10/1/2015	89.0	12/28/2011	89.0	26.1	27.8	61.3
374074N1206859W001	47563	50.5	10/15/2015	81.0	10/3/2011	81.0	33.1	35.7	60.8
373821N1207551W001	47562	58.8	10/15/2015	-	-	75.3	48.8	50.4	64.2
372838N1205602W001	38974	73.9	10/12/2015	104.4	10/3/2011	104.4	61.8	62.6	85.4
372617N1204747W001	47565	55.9	10/15/2015	100.9	10/3/2011	100.9	28.5	32.9	70.7
371902N1201985W001	28392	-94.5	10/14/2015	47.5	10/14/2011	47.5	-169.7	-159.4	-45.1

374421N1205407W001	38884[3]	70.7	N/A[3]	100.4	10/3/2011	100.4	40.4	38.1	66.7
	52715	-142.7	-	-	-	1.5	-133.7	-151.7	-73.6
	52716	-79.6	-	-	-	-15.2	-75.6	-83.6	-48.7
	60568	32.7	-	-	-	57.6	32.8	30.2	44.3
	60570	-47.6	-	-	-	4.5	-44.3	-50.8	-22.6
	60565	44.8	-	-	-	92.3	41.0	37.3	66.0
	60567	-47.0	-	-	-	17.7	-43.2	-51.2	-16.0
	60562	28.3	-	-	-	71.4	1.7	2.2	36.7
	MW-OA-3[4]	62.7	-	-	-	76.1	63.5	61.9	69.1

Table 3-1 Notes:

1. *The Minimum Threshold, Measurable Objective, and Interim Milestones are reported as groundwater elevations in feet above sea level, datum: NAVD88.*
2. *For representative monitoring wells without observed fall 2011 measurements, a value has been calculated using estimates of historical groundwater levels in November 2011 from the MercedWRM historical conditions simulation. MercedWRM groundwater levels were adjusted vertically based on the average distance between observed and simulated levels before querying the November 2011 estimation.*
3. *Well ID 38884 does not have measurements recorded for 2012-2017. A 2015 estimate was calculated based on looking at the average difference between fall 2021 and fall 2015 measurements at representative monitoring wells in the Outside Corcoran Clay in the northern half of the Subbasin (e.g., in the region of well 38884). This average factor was applied to the 2021 measurement at 38884 to estimate the 2015 value and MT.*
4. *MW-OA-3 has not yet been added to the SGMA Portal and does not yet have an official Station ID. For now, it is shown with its local name.*

3.4 REDUCTION OF GROUNDWATER STORAGE

3.4.1 Undesirable Results

Description of Undesirable Results

The undesirable result related to reduction of groundwater storage is defined in SGMA as:

Significant and unreasonable reduction of groundwater storage. [CWC §10721(x)(2)]

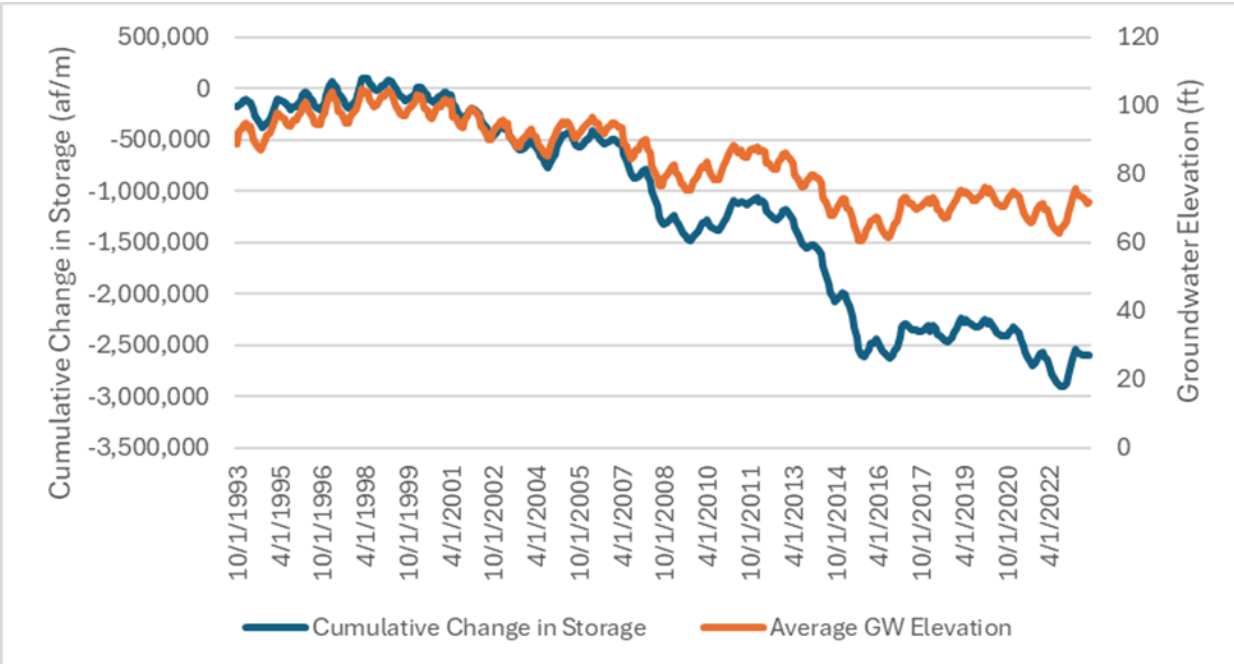
Undesirable results reduction groundwater storage would occur if groundwater storage volumes decreased to the point of not satisfying beneficial uses within the Subbasin over the planning and implementation horizon of the GSP.

An undesirable result related to reduction of groundwater storage is not currently occurring nor has occurred historically within the Merced Subbasin. The Subbasin has approximately 47 million acre-feet (MAF) of fresh (non-saline) groundwater storage as of 2023 (see Section 2.2.2 – Groundwater Storage in Current and Historical Groundwater Conditions), and analysis of groundwater storage has shown a cumulative change in storage of less than -2 MAF from 2006-2023. This cumulative change in storage, which includes both representative dry and wet years, reflects a rate of overdraft of approximately 0.2% per year. Thus, undesirable results related to reduction of groundwater in storage are unlikely to occur. However, reduction in groundwater in storage is closely correlated with chronic lowering of groundwater levels. Thus, undesirable results would be a reduction of groundwater in storage equivalent to lowering groundwater levels to undesirable results.

Identification of Undesirable Results and Justification for Groundwater Levels as a Proxy

An undesirable result occurs when groundwater storage volumes are insufficient to satisfy beneficial uses within the Subbasin. To identify undesirable results, the GSAs conducted an analysis to compare the relationship between groundwater levels and groundwater in storage. The analysis utilized cumulative storage change data from the MercedWRM historical baseline (1994-2023) and average groundwater level data throughout the Subbasin during the same period. Both datasets were plotted to evaluate the relationship between both components (Figure 3-5).

Figure 3-5: Cumulative Change in Storage-Groundwater Level Comparison



Additionally, a linear regression analysis was performed to generate a coefficient of determination (R^2) to further confirm the correlation between groundwater levels and groundwater in storage. The average R^2 during the analysis period was approximately 0.954, indicating a significant correlation between groundwater levels and groundwater in storage. As a note, R^2 values range from 0-1, 0 indicating no relationship between two components and 1 indicating a direct relationship. Following this analysis, the GSAs concluded that groundwater levels are significantly correlated to groundwater in storage. The results of the linear regression are shown in Figure 3-6 and Table 3-2 below.

Figure 3-6: Linear Regression Results between Groundwater Levels and Storage

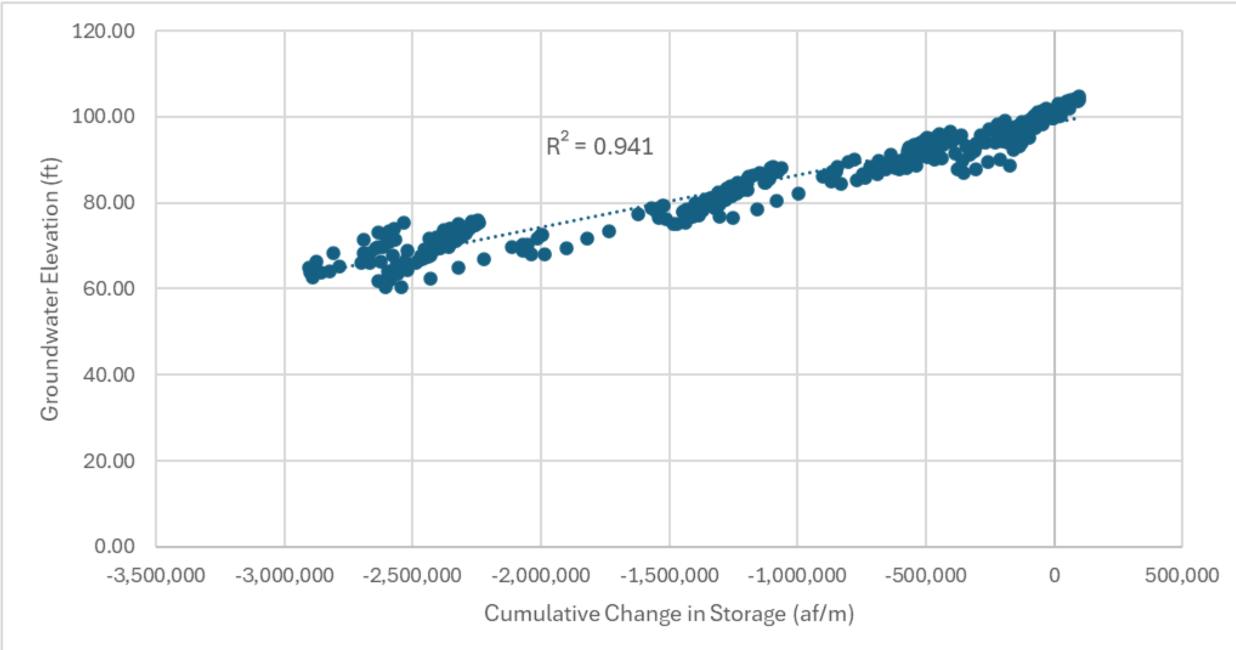


Table 3-2: Average Linear Regression Results by Month

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
R^2	0.962	0.966	0.951	0.961	0.944	0.946	0.944	0.945	0.947	0.952	0.962	0.963	0.954

As a result, the GSP utilizes groundwater levels as a proxy for defining an undesirable result for the reduction of groundwater storage sustainability indicator.

Potential Causes of Undesirable Results

Potential causes of undesirable results for the reduction in groundwater storage include:

- Increased or continued groundwater extractions in the Subbasin leading to groundwater elevation declines
- Significant reduction in groundwater recharge as a result of severe drought or other natural processes
- Reduction in surface water availability, driven by regulation or other causes

Potential Effects of Undesirable Results

The potential effects of undesirable results for groundwater storage would be equivalent to those for the chronic lowering of groundwater levels, such as de-watering of a subset of the existing groundwater infrastructure, starting with the shallowest wells (which are generally domestic wells) and adverse effects on groundwater dependent ecosystems. Lowering levels to this degree could necessitate drilling deeper wells for drinking water and agricultural irrigation supplies, which could cause adverse effects to property values and the regional economy. Additionally, undesirable results for groundwater storage could adversely affect current and projected municipal uses, which rely on groundwater in the Subbasin, increasing costs for potable water supplies. Note that these effects are all related to groundwater levels and the accessibility of groundwater in storage to beneficial users, not to the overall volume of storage, of which there is ample supply.

3.4.2 Minimum Thresholds

Section 354.28I(2) of the GSP Regulations states "The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin."

The GSP uses groundwater levels as a proxy for establishing minimum thresholds for the reduction of groundwater storage sustainability indicator. Based on modeling results (as discussed in Section 3.4.1) and hydrogeologic principles applicable to the Subbasin (Alley, Reilly, & Franke, 1999), groundwater levels are correlated to groundwater storage and sustainable management criteria for groundwater levels are established to maintain adequate groundwater supply for beneficial uses and users. Minimum thresholds for the chronic lowering of groundwater levels sustainability indicator are presented in Section 3.3.2. Groundwater levels maintained above minimum thresholds will indicate that groundwater storage is not being depleted.

3.4.3 Measurable Objectives and Interim Milestones

As 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 the same measurable objectives and interim milestones as for the chronic lowering of groundwater levels sustainability indicator as set forth in Section 3.3.3.

3.5 SEAWATER INTRUSION

Seawater intrusion is not an applicable sustainability indicator, because seawater intrusion is not present and is not likely to occur due to the distance between the Subbasin and the Pacific Ocean (and Sacramento-San Joaquin Delta).

3.6 DEGRADED WATER QUALITY

3.6.1 Undesirable Results

Description of Undesirable Results

The undesirable result related to degraded water quality is defined in SGMA as:

> *Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies. [CWC §10721(x)(4)]*

Undesirable results for degraded water quality would be impacts caused by groundwater extractions and other SGMA groundwater management activities in the Subbasin that cause significant and unreasonable reduction in the long-term viability of domestic, agricultural, municipal, or environmental uses over the planning and implementation horizon of this GSP.

In identifying undesirable results for the Subbasin, the GSAs sought input from beneficial users through multiple venues including the stakeholder advisory committee and public workshops held in locations specifically selected to provide access to disadvantaged communities. The protection of water quality for drinking and for agricultural use was identified as a priority for users in the basin. Degraded water quality is unique among the six sustainability indicators because it is already the subject of extensive federal, state, and local regulations carried out by numerous entities and SGMA does not directly address the role of GSAs relative to these other entities (Moran & Belin, 2019). The GSAs also sought input from the Merced County Division of Environmental Health as to which constituents of concern in the Subbasin could be tied to groundwater management activities and therefore managed through SGMA. While the Division of Environmental Health has identified several constituents of concern in the Subbasin (see Section 2.2.4 - Groundwater Quality in Current and Historical Groundwater Conditions), this GSP focuses on only those constituents where groundwater management activities have the potential to cause undesirable results. The GSAs and Subbasin stakeholders, in consultation with the Division of Environmental Health, determined that salinity is the only constituent of concern currently known to be directly tied to groundwater management activities and therefore appropriate to include in the GSP.

Identification of Undesirable Results

An undesirable result is considered to occur during GSP implementation when at least 25% of representative monitoring wells (11 of 44 sites) exceed the minimum threshold for degraded water quality for two consecutive years[38].

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[38] Between November 2019 when the GSP was originally published and this July 2022 update, three representative groundwater quality monitoring wells were added to the network because they were added by ESJWQC in their GQTM program specifically within the Merced Subbasin.

Potential Causes of Undesirable Results

Groundwater in the Merced Subbasin contains both anthropogenic and naturally-occurring constituents. While groundwater quality is typically sufficient to meet beneficial uses, some of these constituents either currently impact groundwater use within the Subbasin or have the potential to impact it in the future. Depending on the water quality constituent, the issue may be widespread or more of a localized concern. The focus of this GSP is on constituents that are exacerbated or ameliorated due to groundwater management activities.

Salinity was identified by the GSAs based on stakeholder input and the recommendation of the Merced County Division of Environmental Health as the only constituent with sustainability management criteria to monitor in the GSP because the causal nexus between salinity concentrations and groundwater management activities has been established (see Section 3.6.2 - Minimum Thresholds). Relatively high salinity groundwater in the basin has been shown to migrate due to groundwater extraction activities. These areas of relatively high salinity groundwater are primarily located along the west side of the Subbasin, adjacent to the San Joaquin River and in urban use areas such as the cities of Livingston and Atwater. High salinity groundwater is principally the result of the migration of a deep saline water body which originates in regionally-deposited marine sedimentary rocks that underlie the San Joaquin Valley. Groundwater pumping can cause the upwelling of saline brines originating from naturally-occurring marine sedimentary rocks. Though the Corcoran Clay naturally impedes high TDS groundwater, high permeability pathways through the clay from the Below Corcoran Principal Aquifer to the Above Corcoran Principal Aquifer may be created by perforated wells. In addition, this poorer-quality water can migrate across the Subbasin from the west to the east (AMEC, 2008). Better quality groundwater (less than 1,000 mg/L) in these western and southwestern areas is generally found at shallower depths (AMEC, 2008), generally in the Below Corcoran Principal Aquifer.

Note that accumulation of salts due to agricultural activities, urban wastewater, or other land use activities do not have an established causal nexus with groundwater management activities.

Potential Effects of Undesirable Results

If groundwater quality were degraded to levels causing undesirable results, the effect could potentially cause a reduction in usable supply to groundwater users, with domestic wells being most vulnerable as treatment or access to alternate supplies may be unavailable or at a high cost for small users. Water quality degradation could cause potential changes in irrigation practices, crops grown, crop productivity, adverse effects to property values, and other economic effects. Degraded water quality could have impacts on native vegetation or managed wetlands. Additionally, reaching undesirable results levels for groundwater quality could adversely affect current and projected municipal uses, and users could have to install wellhead treatment systems or seek alternate supplies.

3.6.2 Minimum Thresholds

Minimum Threshold Applicability

Degraded water quality is unique among the six sustainability indicators because it is already the subject of extensive federal, state, and local regulations carried out by numerous entities, and SGMA does not directly address the role of GSAs relative to these other entities (Moran & Belin, 2019). SGMA does not specify water quality constituents that must have minimum thresholds. Groundwater management (e.g., via controls on pumping and/or recharge) is the mechanism available to GSAs to implement SGMA. Establishing minimum thresholds for constituents that cannot be managed by increasing or decreasing pumping was deemed inappropriate by the GSAs and basin stakeholders during initial GSP development. Other water quality concerns are being addressed through various water quality programs (e.g., CV-SALTS and ILRP) and agencies (e.g., RWQCB, EPA) that have the authority and responsibility to address them. The GSAs will abide by any future local restrictions that may be implemented by the agencies or coalitions managing these programs. These water quality issues without a causal nexus in the Merced Subbasin include:

- **Naturally occurring constituents such as arsenic, uranium, iron, and manganese:** the GSAs do not have control over the presence of these constituents in aquifer materials. Thresholds are not set for these constituents as there is no demonstrated local correlation between fluctuations in groundwater elevations and/or flow direction and concentrations of these constituents at wells.
- **Constituents from human activities that are not managed under SGMA:** pesticides, herbicides, and fertilizers may be present from agricultural and, to a lesser degree, urban uses. Existing programs, including CV-SALTS, ILRP, and regulation by the California Department of Pesticide Regulation, are designed to address these concerns. Thresholds are not set for these constituents as the GSAs have no authority to limit the loading of nutrients or agrochemicals. However, as mentioned above, the GSAs will abide by any future local restrictions that may be implemented by agencies managing such programs.
- **Constituents from human activities at contaminated sites managed under other regulatory authority:** constituents at the former Castle Air Force Base and other smaller contaminated sites are under cleanup orders set by state or federal agencies. The potentially responsible parties are required to contain contaminants and remediate the groundwater. Data collected as part of GSP monitoring will be provided to regulators upon request. Thresholds are not set for these constituents as the GSAs are not responsible and do not have authority for containment or cleanup of these sites.

The major water quality issue being addressed by sustainable groundwater management is the migration of relatively higher salinity water into the freshwater principal aquifers. The nexus between water quality and water supply management exists for the pumping-induced movement of low-quality water from the west and northwest to the east.

The GSAs sought input from the Merced County Division of Environmental Health (Division) during the development of water quality minimum thresholds. The Division agreed that salinity is an appropriate indicator for water quality issues and trends that are related to Subbasin groundwater management activities. In addition, the Division recommended that the GSAs make use of resources like GeoTracker and EnviroStor and closely coordinate with agencies that already monitor contamination plumes.

While the approved GSP did not set sustainable management criteria for the types of constituents described above, current conditions in the Subbasin are summarized in Section 2.2.4 (Groundwater Quality), monitoring of these constituents is included in ongoing monitoring efforts, and results are summarized below and in the 2025 Periodic Evaluation.

Per DWR's recommendation, the GSAs evaluated the relationship between groundwater elevation changes and water quality constituent concentrations to determine if changes in groundwater elevations have an impacted on the concentration of constituents. This was accomplished via a Mann-Kendall Trend Test which is a statistical method used to assess if there is the presence of a positive or negative trend over time. The data used in the analysis were sourced and processed as described below:

- All groundwater quality data were compiled from GAMA (see Section 1.2.2.2.1.3) from wells throughout the Subbasin.
- Data were excluded at wells representing localized contamination sites under federal, state, and local regulatory oversight.
- Non-detect concentrations were considered a valid measurement with a value at the detection limit.
- Individual wells with less than eight measurements of the particular constituent to be analyzed were excluded. While the Mann-Mendall Trend Test requires a minimum of four samples per well, a more commonly used range for greater confidence in the results is 8-10 samples per well.

The analysis was conducted for water quality concentrations measured in two separate time periods:

1. Period where groundwaters levels were consistently declining (2012-2016)
2. Period where more stable groundwater levels were observed (2016-2020)

As an example, nitrate concentrations were analyzed in 35 wells between 2012 and 2016 (a dry period with declining groundwater levels). The results for this analysis showed approximately 3% of wells with an increasing trend and 3% of wells with a decreasing trend, while the vast majority (94%) indicated no trend. Data collected from 40 wells between 2016 and 2020 (a wetter period with more stable groundwater levels) only one monitoring well with an increasing trend, while the remainder (98%) of wells did not demonstrate any trend. No wells showed a decreasing trend.

Arsenic was also analyzed for 13 wells. The results show no trend in arsenic concentrations in either time period.

The results of the Mann-Kendall Trend Test are presented in Table 3-3 below for nitrate, arsenic, and other common water quality constituents in the Subbasin. Overall, the results from the analysis suggest that groundwater elevation decline does not have a statistically significant observable impact on trends in water quality concentrations. Thus, the GSAs will continue with salinity as the indicator for degradation of groundwater quality.

Table 3-3: Mann-Kendall Trend Test Results for Groundwater Quality

Constituent	Declining Groundwater Levels (2012-2016)				Stable Groundwater Levels (2016-2020)			
	Increasing WQ Trend	Decreasing WQ Trend	No Trend	Count of Wells	Increasing WQ Trend	Decreasing WQ Trend	No Trend	Count of Wells
Nitrate	3%	3%	94%	35	3%	0%	98%	40
Total Dissolved Solids				0				0
Chlorine				0				0
Arsenic	0%	0%	100%	13	0%	0%	100%	13
Iron				0	0%	0%	100%	1
Manganese	0%	0%	100%	1	0%	0%	100%	2
Chromium-6				0				0
Benzene	0%	0%	100%	12	0%	0%	100%	11
123 TCP	8%	15%[1]	77%	13	0%	2%	98%	50
DBCP	0%	0%	100%	10	0%	7%	93%	14
MTBE	0%	0%	100%	12	0%	0%	100%	12
111 TCA	0%	0%	100%	12	0%	0%	100%	11
PCE	8%	0%	92%	12	0%	0%	100%	11
TCE	0%	0%	100%	12	0%	0%	100%	11
Boron				0				0
Sodium				0				0
Specific Conductivity	100%	0%	0%	1				0
EDB	0%	0%	100%	2	0%	0%	100%	3

1. *Trend is likely not indicative of true conditions; influenced by reduction in the detection limit (e.g., better lab technology through time).*

The GSAs will continue to conduct the following ongoing water quality coordination activities:

- Annual review of data submitted to the Department of Pesticide Regulation (DPR), Division of Drinking Water (DDW), Department of Toxic Substances Control (EnviroStor), and GeoTracker as part of the Groundwater Ambient Monitoring and Assessment (GAMA) database.
- Annual check-ins with existing monitoring programs, such as CV-SALTS and ESJWQC GQTM.
- Annual review of annual monitoring reports prepared by other programs (such as CV-SALTS and ILRP)
- GSAs will invite representative(s) from the Regional Water Quality Control Board, Merced County Division of Environmental Health, and ESJWQC to attend an annual meeting of the GSAs to discuss constituent trends and concerns in the Subbasin in relation to groundwater pumping.
- GSAs will consider potential beneficial and adverse effects on groundwater quality in siting groundwater recharge projects and other management actions.

The purpose of these reviews will be to monitor and summarize the status of constituent concentrations throughout the Subbasin with respect to typical indicators such as applicable MCLs or SMCLs. The Merced Subbasin GSP Annual Report and Periodic Evaluation will include a summary of the coordination and associated analyses of conditions. The GSP Periodic Evaluation may include analyses of whether sustainable management criteria for additional constituents are needed.

The GSAs have selected a minimum threshold for groundwater levels that corresponds with 2015 elevations. One potential concern with water quality is that declines in groundwater levels can dewater additional portions of the aquifer impacting the migration of low-quality groundwater, resulting in low-quality groundwater entering from dewatering clays or other aquifer zones, or resulting in changes in aquifer chemistry. While the interim milestones for groundwater levels allow for temporary further groundwater level decline below 2015 elevations, it is expected that groundwater levels will be above 2015 elevations by 2040. As a result of the short-term nature of potential limited declines below 2015 elevations and the desire to operate at the measurable objective rather than the minimum threshold, groundwater quality degradation due to groundwater level declines below 2015 elevations is not expected in the long-term. In the meantime, the groundwater quality minimum threshold for salinity and other groundwater quality monitoring coordination activities described above will function to monitor for groundwater quality impacts.

Minimum Threshold Selection

Salinity is a measure of the amount of dissolved particles and ions in water. Salinity can include several different ions, but the most common are chloride, sodium, nitrate, calcium, magnesium, bicarbonate, and sulfate. While there are several different ways to measure salinity, the two most frequently used are Total Dissolved Solids (TDS) and Electrical Conductivity (EC). TDS is a measure of all dissolved substances that can pass through a very small filter (typically with 2-micrometer pores) and is typically reported in milligrams per liter (mg/L). EC measures the ability of an electric current to pass through water because conductivity is proportional to the amount of dissolved salts in the water. It is generally reported in microSiemens/cm. Salinity throughout this GSP is reported in terms of TDS.

The minimum threshold for salinity is defined based on the potential impact of salinity on drinking water and agricultural beneficial uses, as aligned with state and federal regulations. The recommended drinking water secondary MCL for TDS is 500 mg/L with an upper limit of 1,000 mg/L and a short-term limit[39] of 1,500 mg/L (SWRCB, 2006). The secondary MCL was established by the USEPA and then adopted by the SWRCB. The secondary MCL is a secondary drinking water standard established for aesthetic reasons such as taste, odor, and color and contaminant concentrations at the secondary MCL do not present a risk to human health.

For agricultural uses, salt tolerance varies by crop, with common crops in the Merced Subbasin (alfalfa, almonds, corn, grapes, sweet potatoes, and tomatoes (Merced County Department of Agriculture, 2017)) tolerant of irrigated water with TDS below about 1,500 mg/L at a 90% crop yield potential (Ayers & Westcot, 1985). [40] Salinity tolerances of major Subbasin crops are presented in Table 3-4.

Table 3-4: Salinity Tolerances of Major Subbasin Crops

Crop Type	Salinity Tolerance (mg/L as TDS)
Alfalfa	1,400
Almonds	900
Corn	1,100
Grapes	1,100
Sweet Potatoes	1,000
Tomatoes	1,500

Salinity levels within the Merced Subbasin have historically ranged from less than 90 mg/L to greater than 3,000 mg/L as TDS. Generally, similar to other basins in the eastern San Joaquin Valley, TDS tends to increase from the foothills to the trough of the Valley. TDS in the eastern two-

[39] Short-term limits are acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources (California Code of Regulations Title 22 § 64449).

[40] An average value of 1.8 dS/m was converted using University of California Agriculture and Natural Resources salinity unit conversion formula of TDS (mg/L) = Electrical Conductivity (dS/m) * 640 (applicable for electrical conductivity ranging 0.1 to 5 dS/m).

thirds of the Subbasin is generally less than 400 mg/L. TDS increases westward and southwestward towards the San Joaquin River and southward towards the Chowchilla River. In these areas, high TDS water is found in wells deeper than 350 feet (AMEC, 2008). TDS is slightly elevated in certain urban portions of the northern Subbasin, such as beneath the Atwater and Winton areas (AMEC, 2008).

2000-2016 TDS concentrations in the Merced Subbasin, as analyzed by the CV-SALTS program, ranged widely from 90 mg/L to 2,005 mg/L. In the northwest area of the Above Corcoran Clay, average TDS is greater than 751 mg/L. Average TDS concentration in the Below Corcoran Clay is lowest in the North (less than 501 mg/L) and increases in the Southwest to over 1,000 mg/L (Luhdorff and Scalmanini Consulting Engineers, 2016). In pockets of the Subbasin with elevated TDS (greater than 1,000 mg/L), water use behaviors have already shifted to accommodate these concentrations. For example, agriculture has focused on more salt-tolerant crops, and more saline water supplies are blended with less saline water supplies. As a result, TDS concentrations in excess of 1,000 mg/L where currently experienced are not considered to be undesirable. There is, however, a desire on the part of Subbasin stakeholders to limit increases in salinity in parts of the Subbasin where TDS is below 1,000 mg/L to prevent undesirable results such as requirements to change cropping, blending supplies, etc.

Given these conditions, the minimum threshold for salinity was defined as 1,000 mg/L as TDS to be protective against undesirable results related to elevated salinity.

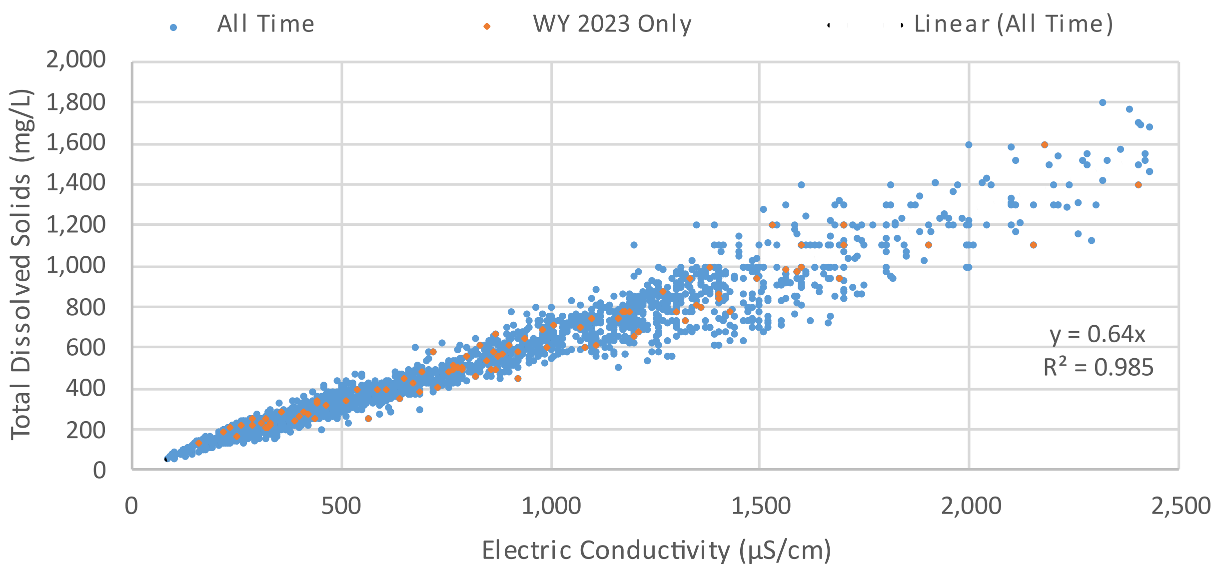
Representative Monitoring Wells for Minimum Threshold

The East San Joaquin Water Quality Coalition (ESJWQC) is a group of agricultural interests and growers formed to represent dischargers who own or operate irrigated lands east of the San Joaquin River within Madera, Merced, Stanislaus, Tuolumne, and Mariposa Counties, as well as portions of Calaveras County. The ESJWQC has developed a Groundwater Quality Trend Monitoring workplan (GQTM) as part of the Irrigated Lands Regulatory Program (ILRP), which includes a targeted set of domestic wells (denoted as principal wells) supplemented by public water system wells (denoted as complementary wells) (ESJWQC, 2018). All ESJWQC GQTM program principal and complementary monitoring wells in the Merced Subbasin are used as representative monitoring wells for this GSP. Additional information about minimum thresholds can be found in Table 3-5 following the discussion of measurable objectives. More information about these representative monitoring wells and plans to fill data gaps are included in Section 4.8 - Groundwater Quality Monitoring Network.

ESJWQC monitors EC, pH, dissolved oxygen, temperature, and nitrate as nitrogen (as N) annually. TDS and other constituents are monitored every five years. The GSAs will convert EC measurements into estimates of TDS for purpose of annual reporting if TDS samples were not measured directly during the reporting period.

There is a relationship between EC and TDS (SWRCB, 2004), with a typical acceptable ratio of TDS to EC ranging from 0.55 to 0.7 (American Public Health Association, American Water Works Association, and Water Environment Foundation, 1999). The ratio used for conversion is 0.64 (where TDS [mg/L] ≈ EC [µS/cm] * 0.64). This is based on an analysis of paired EC and TDS measurements recorded in Merced County, as shown in Figure 3-7. Each paired EC/TDS measurement was recorded on the same day at the same site. The line of best fit has a slope of 0.64 (the ratio), with a strong level of correlation based on the coefficient of determination (R^2) value of 0.985 out of 1.

Figure 3-7: Relationship Between Electrical Conductivity & Total Dissolved Solids



a. *This graph is based on 2,771 measurements of EC and TDS recorded on the same day at monitoring sites throughout Merced County from 1925-2023.*

b. *Outliers were identified by calculating the interquartile (IQR) range of EC measurements (75th percentile value minus 25th percentile value). Measurement pairs (EC with TDS) were flagged as outliers and excluded from the analysis if they had an EC measurement that was higher than: (75th percentile EC value) + 1.5 * IQR, or 2,485 µS/cm. A second-step outlier analysis using the same methodology was performed on a small handful of remaining measurement pairs where the ratio between TDS and EC was outside of the range 0.43 – 0.93 ([25th percentile ratio – 1.5 IQR] to [75th percentile ratio + 1.5 IQR]). Overall, 217 outliers were excluded out of 2,988 measurement pairs.*

3.6.3 Measurable Objectives and Interim Milestones

The measurable objective is a TDS concentration of 500 mg/L, which aligns with the recommended Secondary MCL for TDS. The margin of operational flexibility is 500 mg/L TDS, the difference between the measurable objective of 500 mg/L and the minimum threshold of 1,000 mg/L.

In the case of degraded water quality, specifically for salts, there is a natural tendency for salt concentrations to increase over time due to agricultural and urban uses of water, which add salts either directly or increases concentrations through evapotranspiration. As previously noted, such increases are not due to a causal nexus with groundwater management activities and would not constitute an undesirable result under this GSP. Continued monitoring data will be analyzed for trends, and future increasing trends will be analyzed for evidence of the sources of the trends, such as upward migration of relatively higher salinity water due to overpumping or due to continued agricultural and urban uses. If caused by upward migration, GSAs will respond accordingly due to the causal nexus with groundwater pumping.

Table 3-5 shows the measurable objective for each representative monitoring well. Interim milestones are set at the same concentrations as the measurable objectives.

Table 3-5: Groundwater Quality Minimum Threshold & Measurable Objective Concentrations

ESJWQC GQTM Well ID	Complementary or Principal?[1]	Principal Aquifer	TDS Concentration at Minimum Threshold (mg/L)	TDS Concentration at Measurable Objective (mg/L)
P06	Principal	Outside	1,000	500
P07	Principal	Below	1,000	500
P08	Principal	Outside	1,000	500
P09	Principal	Below	1,000	500
P10	Principal	Below	1,000	500
ESJQC00019	Principal	Below	1,000	500
ESJQC00022	Principal	Above	1,000	500
ESJQC00030	Principal	Below	1,000	500
ESJQC00043	Principal	Outside	1,000	500
C35	Complementary	Above	1,000	500
C41	Complementary	Above	1,000	500
C45	Complementary	Above	1,000	500
C38	Complementary	Below	1,000	500
C44	Complementary	Below	1,000	500
C40	Complementary	Outside	1,000	500
C42	Complementary	Outside	1,000	500
C43	Complementary	Outside	1,000	500
C46	Complementary	Outside	1,000	500
C47	Complementary	Outside	1,000	500
C39	Complementary	Outside	1,000	500
C48	Complementary	Outside	1,000	500
C49	Complementary	Unknown	1,000	500

C50	Complementary	Unknown	1,000	500
CA2400134_003	Complementary	Unknown	1,000	500
CA2400172_002	Complementary	Above	1,000	500
CA2410004_008	Complementary	Below	1,000	500
CA2410004_009	Complementary	Below	1,000	500
CA2410004_012	Complementary	Below	1,000	500
CA2410004_013	Complementary	Below	1,000	500
CA2410004_025	Complementary	Below	1,000	500
CA2410004_028	Complementary	Unknown	1,000	500
CA2410007_001	Complementary	Outside	1,000	500
CA2410007_004	Complementary	Below	1,000	500
CA2410007_006	Complementary	Outside	1,000	500
CA2410007_007	Complementary	Outside	1,000	500
CA2410007_014	Complementary	Outside	1,000	500
CA2410008_004	Complementary	Unknown	1,000	500
CA2410008_005	Complementary	Below	1,000	500
CA2410008_010	Complementary	Unknown	1,000	500
CA2410009_057	Complementary	Unknown	1,000	500
CA2410010_014	Complementary	Outside	1,000	500
CA2410010_019	Complementary	Outside	1,000	500

1. *Complementary and Principal wells are defined in Section 4.8.1 - Monitoring Wells Selected for Monitoring Network.*

3.7 LAND SUBSIDENCE

3.7.1 Undesirable Results

Description of Undesirable Results

The undesirable result related to land subsidence is defined in SGMA as:

> *Significant and unreasonable land subsidence that substantially interferes with surface land uses. [CWC §10721(x)(5)]*

An undesirable result for land subsidence would be significant and unreasonable reduction in the viability of the use of infrastructure over the planning and implementation horizon of this GSP. Land subsidence that substantially interferes with surface land uses causes damage to public and private infrastructure (e.g., roads and highways, flood control, canals, pipelines, utilities, public buildings, residential and commercial structures).

The largest conveyance facility that has the potential to be damaged or have reduced flood conveyance capacity due to subsidence is the Eastside Bypass, located in the southwest corner of the Merced Subbasin. Additionally, because most subsidence in the Subbasin has occurred in the vicinity of El Nido (see Figure 2-155), community infrastructure in El Nido has the potential to be damaged by subsidence.

Identification of Undesirable Results

Exceedances of minimum threshold rates of land subsidence at three or more monitoring sites out of four for two consecutive years will quantitatively indicate that the Subbasin has reached undesirable results for land subsidence.

Potential Causes of Undesirable Results

Land subsidence can be the direct result of over extraction of groundwater in the Subbasin. Subsidence has been observed in the southwestern portion of the Subbasin and encompasses areas included in all three GSAs. Subsidence in the Subbasin is thought to be caused by groundwater extraction below the Corcoran Clay and compaction of clays below the Corcoran Clay (DWR, 2017b). The transition from pasture or fallowed land to row and permanent crops adjacent to the San Joaquin River is thought to have created an increased groundwater pumping demand in an area that is not, at this time, provided with significant alternate surface water supplies (Reclamation, 2016).

Potential Effects of Undesirable Results

Compaction of subsurface materials can lead to land subsidence, which changes the ground surface and potentially impacts existing infrastructure and land use. Changes in land surface gradients due to land subsidence could impact the integrity of conveyance structures, which are typically gravity-driven. Subsidence could result in the need for higher dams or pumps to move surface water. Similarly, the capacity of flood conveyance systems can be reduced due to subsidence, resulting in a need for higher levees or other flood control infrastructure. As a result, negative impacts of land subsidence could include potential increases in the conveyance costs of irrigation water and in a decrease in ability to convey floodwater.

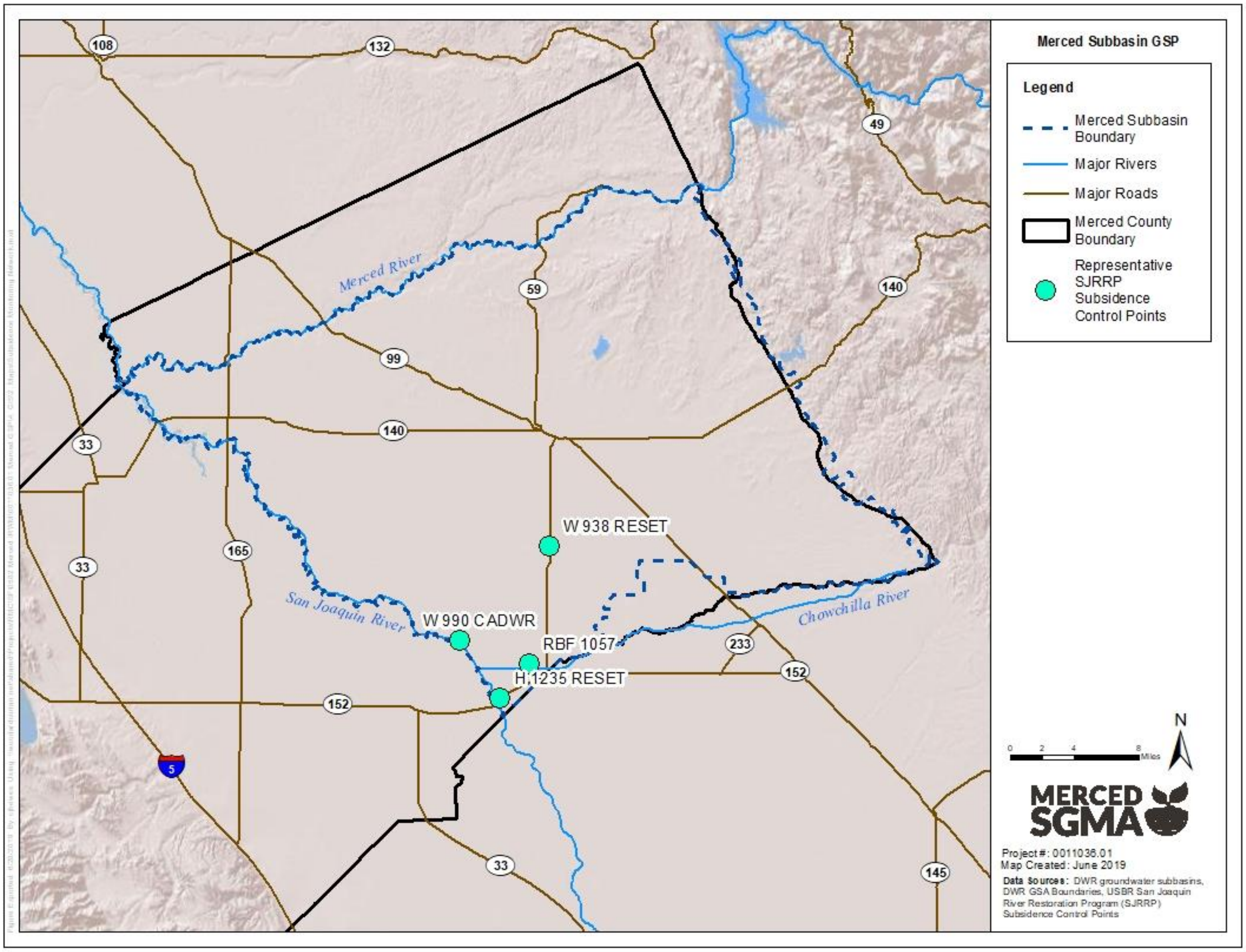
3.7.2 Minimum Threshold

The minimum threshold for land subsidence was selected to prevent undesirable results. While the sensitivity of local infrastructure to land subsidence is not well understood, the ability to convey water supplies and flood water, including the ability to maintain levees, are currently observed to be the most sensitive to land subsidence.

The minimum threshold is applied at four locations within the area of subsidence risk which are monitored for land subsidence by the US Bureau of Reclamation (USBR) on a semi-annual basis since 2011 as part of its San Joaquin River Restoration Program. These locations, and their maximum single year (December-to-December) subsidence rates recorded during USBR's monitoring period of 2011 to 2018, are listed below. A map of the locations is shown in Figure 3-8.

- W 990 CADWR: maximum recent subsidence of -0.65 ft/year (December 2014 – December 2015)
- RBF 1057: maximum recent subsidence of -0.67 ft/year (December 2012 – December 2013)
- H 1235 Reset: maximum recent subsidence of -0.61 ft/year (December 2012 – December 2013)
- W 938 Reset: maximum recent subsidence of -0.58 ft/year (December 2014 – December 2015)

Figure 3-8: Minimum Threshold Subsidence Locations



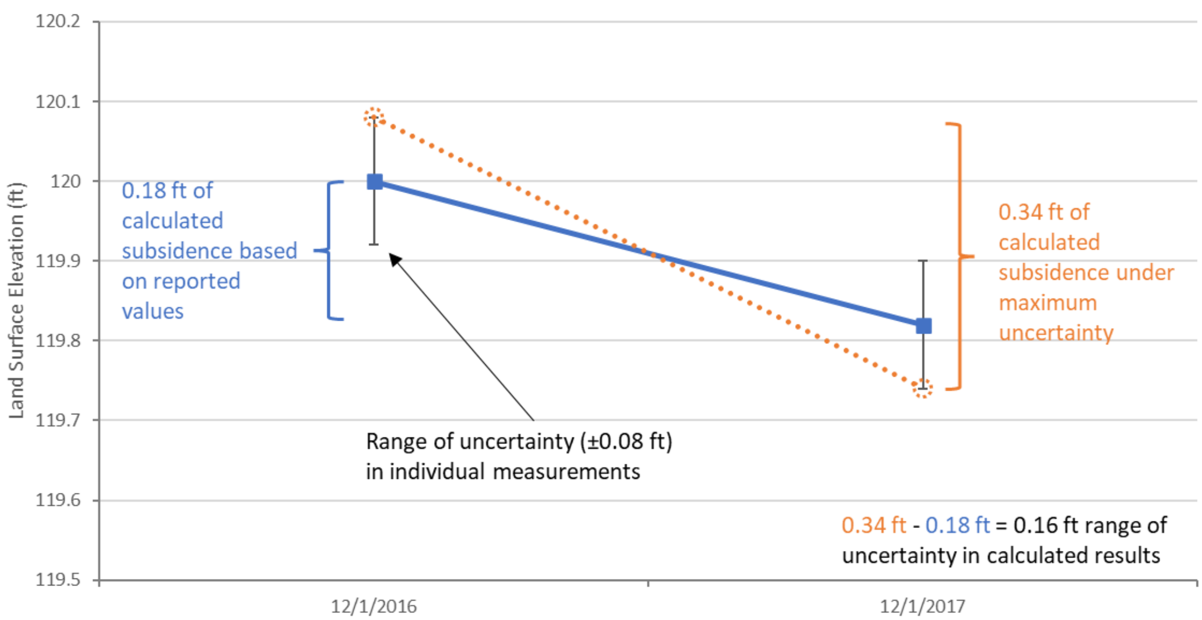
Within the Merced Subbasin, while subsidence has been recognized by the GSAs as an area of concern, it is not considered to have caused a significant and unreasonable reduction in the viability of the use of infrastructure. However, it is noted that subsidence has caused a reduction in freeboard of the Middle Eastside Bypass over the last 50 years and has caused problems in neighboring subbasins, highlighting the need for ongoing monitoring and management in the Merced Subbasin.

Despite wetter conditions, subsidence in the Merced Subbasin between December 2017 and December 2018 was approximately -0.17 ft/yr and -0.32 ft/year, depending on the location. Subsidence is a gradual process that takes time to develop and time to halt, particularly with thick, fine-grained sediments. Depending on the thickness and the hydraulic properties of a thick clay unit, inelastic compaction (and thus subsidence) can require decades or centuries to approach completion (Sneed, Brandt, & Solt, 2018) (Lees, Knight, & Smith, 2022). As a result, some level of future subsidence, potentially at rates similar to those currently experienced, is likely to be underway already and will not be able to be fully prevented, although recovery of groundwater levels may reduce the rate of subsidence.

Given the lack of historical undesirable results experienced in the Subbasin, combined with the expectation that some level of future subsidence is already underway due to continued compaction of historically dewatered subsurface materials, interim milestones are set to manage subsidence during GSP implementation. These interim milestones are described in the next section.

The land subsidence minimum threshold is set at a rate of 0 ft/year. However, compliance with this threshold will take into consideration the level of uncertainty in the measurements. The survey measurements have a vertical accuracy of +/-2.5 centimeters (Reclamation, 2011). With two measurements (before and after), the total uncertainty in the subsidence value is 5 centimeters, or approximately -0.16 ft/year. See Figure 3-9 for example calculation of uncertainty. Subsidence of less than -0.16 ft/year (values that are less negative) are within the uncertainty of the measurement and would be considered compliant with the minimum threshold of 0 ft/year. The intent of this component of the SMC is to acknowledge and account for inherent uncertainty in subsidence measurements. The GSAs do not anticipate allowing for consistent negative subsidence every year. As such, the minimum threshold will also be compared to subsidence over a five-year period.

Figure 3-9: Demonstration of Subsidence Uncertainty Calculation



This minimum threshold is set recognizing the interconnectedness of the Merced Subbasin with surrounding subbasins, and the ability to meet this objective is dependent on the successful management of all nearby subbasins. This minimum threshold is also consistent with the sustainable management criteria for groundwater levels which seeks to keep levels above 2015 conditions. Keeping groundwater levels at or above 2015 conditions is consistent with limited or no subsidence. In addition to the minimum threshold, the Above Corcoran Sustainable Management Criteria Adjustment Consideration Management Action, described in Section 6.2.5, is developed to avoid declines in storage below historical levels. This further reduces the risk of subsidence.

This threshold may require modification in the future if residual subsidence continues to be seen approaching the 20-year GSP implementation period. Further, the minimum threshold subsidence rate may be reconsidered if additional information becomes available on the sensitivity of existing infrastructure on subsidence and for consistency with neighboring subbasins.

The Merced GSP will continue to coordinate efforts with surrounding subbasins to develop regional and local solutions to subsidence occurring in the Merced, Chowchilla, and Delta-Mendota Subbasins (described further in Section 4.9.8 - Plan to Fill Data Gaps, Subsidence Monitoring Network). The County of Merced is funded a project to study the potential impacts of moving pumping from below the Corcoran Clay to above the Corcoran Clay. This analysis has helped to facilitate relocating pumping to above the Corcoran Clay layer while meeting the requirements of Merced County's Groundwater Ordinance and is described further in the GSAs' Projects tracking system. The Projects and Management Actions section also discusses installation of monitoring stations to better characterize subsidence and the relationship of subsidence to groundwater pumping activities.

3.7.3 Measurable Objectives and Interim Milestones

The measurable objective for subsidence is based on the long-term avoidance of land subsidence: 0 ft/year, on a long-term average. This measurable objective is set recognizing the interconnectedness of the Merced Subbasin with surrounding subbasins, and the ability to meet this objective is dependent on the successful management of all nearby subbasins.

Interim milestones are set in 5-year increments in recognition of the likely continuing compaction of aquifer materials from historical dewatering and to provide adequate time for the GSAs to address an issue that is technically complex, not well understood, and that has the potential to result in negative socioeconomic impacts depending on the ultimate solution. The interim milestones are defined as:

- 2025: -0.75 ft/year
- 2030: -0.5 ft/year
- 2035: -0.25 ft/year

The land subsidence interim milestone for 2025 was at a rate of -0.75 ft/year. This rate is slightly higher than actual subsidence rates experienced between 2011 and 2018. The subsequent interim milestones have reduced subsidence values as PMAs are implemented to address groundwater levels and subsidence. These interim milestones are set recognizing the interconnectedness of the Merced Subbasin with surrounding subbasins, and the ability to meet this objective is dependent on the successful management of all nearby subbasins.

3.8 DEPLETIONS OF INTERCONNECTED SURFACE WATER

Depletions of interconnected surface water are a reduction in flow or levels of surface water caused by groundwater use. This reduction in flow or levels, at certain magnitudes or timing, may have adverse impacts on beneficial uses of the surface water and may lead to undesirable results. Quantification of depletions is relatively challenging and requires significant data on both groundwater levels near streams and stage information supported by groundwater modeling.

3.8.1 Undesirable Results

Description of Undesirable Results

Undesirable results related to depletions of interconnected surface water are defined in SGMA as:

> *Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. [CWC §10721(x)(6)]*

Undesirable results for depletions of interconnected surface water in the Merced Subbasin could include depletions that result in reductions in flow or levels of major rivers and streams that are hydrologically connected to the basin such that the reduced surface water flow or levels have a significant and unreasonable adverse impact on beneficial uses of the surface water within the Subbasin over the planning and implementation horizon of this GSP.

Major rivers and streams that potentially have a hydraulic connection to the groundwater system in certain reaches are the Merced and San Joaquin Rivers. Many of the smaller creeks and streams are used for conveyance of irrigation water and generally surface water depletions (of irrigation water) would not impact natural flows in these systems; thus, these systems have not been considered in the analysis of depletions. However, future GSP updates may include considerations of these systems in the analysis of depletions. Hydraulic connection may occasionally be associated with perched water tables which are discussed further in Section 2.1.3.5 (Groundwater Recharge and Discharge Areas) in the Hydrogeologic Conceptual Model.

Identification of Undesirable Results

As chronic lowering of groundwater levels is used as a proxy for depletions of interconnected surface water, the identification of undesirable results for the depletion of interconnected surface water sustainability indicator is performed through the identification of undesirable results for the chronic lowering of groundwater levels sustainability indicator (see Section 3.3.1).

Potential Causes of Undesirable Results

As chronic lowering of groundwater levels is used as a proxy for depletions of interconnected surface water, the potential causes of undesirable results are the same as those for groundwater levels, e.g. groundwater pumping that lowers groundwater levels in areas where rivers and streams are hydrologically connected (see Section 3.3.1).

Potential Effects of Undesirable Results

If depletions of interconnected surface water were to reach levels causing undesirable results, effects could include reduced flow and stage within rivers and streams in the Subbasin to the extent that insufficient surface water would be available to support diversions for agricultural uses or to support regulatory environmental requirements. This could result in increased groundwater pumping, changes in irrigation practices and crops grown, and could cause adverse effects to property values and the regional economy. Reduced flows and stage, along with potential associated changes in water temperature, could also negatively impact aquatic species in the rivers and streams. Such impacts are tied to the inability to meet minimum flow requirements, which are defined for both the Merced River, and San Joaquin River, which, in turn, are managed through operations at New Exchequer Dam and other reservoirs.

Justification of Groundwater Levels as a Proxy

Because of the challenges associated with directly measuring streamflow depletions and because of the significant correlation between groundwater levels and depletions, this GSP uses groundwater levels as a proxy for the depletion of interconnected surface water sustainability indicator. Additionally, since the Merced Subbasin shares riverine borders with multiple other subbasins, additional complex inter-basin coordination will be involved in understanding and monitoring stream depletions directly. As such, the minimum thresholds for the interconnected surface water sustainability indicator are consistent with the minimum thresholds for the chronic lowering of groundwater levels sustainability indicator.

GSP regulations §354.36 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. The following approach from DWR is used to justify the proxy metric:

> *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, 2017a)

To use the minimum thresholds for chronic lowering of groundwater levels as a proxy for depletions of interconnected surface water, the depletions that would occur when undesirable results for groundwater levels are reached must not be significant and unreasonable. In this way, the groundwater level minimum thresholds are sufficiently protective to ensure significant and unreasonable occurrences of depletions will be prevented. The analysis was performed by first considering historical depletions and then considering potential increases in depletions under conditions that are estimated to cause undesirable results for groundwater levels.

Historical depletions of interconnected surface water in the Subbasin are not considered significant and unreasonable. Therefore, the depletions in MercedWRM's historical simulation are assumed to have no associated undesirable results. If groundwater levels were to decline to the minimum threshold levels, a corresponding increase in surface water depletions would occur, above those seen historically.

Groundwater modeling results were analyzed as part of development of the original 2020 GSP to estimate the volume of depletions associated with groundwater levels that would constitute an undesirable result (wet, below normal, or above normal year pairings where 25% or more representative wells fall below the groundwater level minimum threshold). A hypothetical scenario was simulated to select groundwater levels that would constitute an undesirable result based on the groundwater level minimum threshold (described above in Section 3.3.2). To do this, the model simulated an 8% increase in evapotranspiration as compared to the existing conditions baseline. The additional stream losses (or decreased gains) that occurred under this scenario compared to the historical simulation are estimates of depletions, as they can be linked largely to simulated increases from existing groundwater pumping.

Model results estimate an additional 16,000 AFY of depletions on the Merced River, 10,000 AFY on the San Joaquin River, and 12,000 AFY on the combined system of canals and smaller streams. The additional depletions under this hypothetical scenario (38,000 AFY measured at the San Joaquin River) are about 1.6% of average annual surface water outflow from the Subbasin. A small percentage increase in stream depletions above historical depletion levels is not considered a significant and unreasonable amount of stream depletions. Depletions greater than this level would only occur under a condition which would create undesirable results for the groundwater level sustainability indicator. As a result, the groundwater level minimum threshold is expected to be protective against undesirable results for depletions of interconnected surface water.

The "combined system of canals and smaller streams" described above is primarily used for conveyance of irrigation water. There is an increased level of uncertainty in values calculated for this system due to many estimated model input values for certain unknown characteristics, such as bank material properties or streambed geometry. These input values are known with more certainty for the Merced River and San Joaquin River.

3.8.2 Minimum Thresholds and Measurable Objectives

As chronic lowering of groundwater levels is used as a proxy for depletions of interconnected surface water, the measurable objective and interim milestones for the depletion of interconnected surface water sustainability indicator are the measurable objective and interim milestones for the chronic lowering of groundwater levels sustainability indicator.

3.9 COORDINATION WITH ADJACENT BASINS

Adjacent subbasins are Turlock, Chowchilla, and Delta-Mendota.

A formal Memorandum of Understanding (MOU) has been finalized between the Merced and Chowchilla Subbasin GSAs (see Appendix G). Inter-subbasin modeling coordination with Chowchilla was performed to provide the basis for consistency in the way minimum thresholds are determined; however, future coordination must continue to confirm consistency. In addition, the technical approach for the sustainability analysis and its relationship to inter-basin coordination is intended to result in minimum thresholds that do not negatively impact adjacent basins.

A memorandum of intent to coordinate (MOI) has been finalized between each of the GSAs in the Turlock and Merced Subbasins (see Appendix H). The MOI outlines the intention to share data and coordinate GSPs in the Merced and Turlock Subbasins without adversely impacting the adjacent basin. The MOI also recognizes that the Turlock Subbasin is on a different timeline and will not have a GSP complete until 2022; thus, the GSAs intend to work together to develop and refine common knowledge and understanding over time.

Coordination meetings with Delta-Mendota continue and an MOU was also under development at the time of preparation of this document.

4 MONITORING NETWORKS

This section discusses the monitoring networks identified to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan. Monitoring networks are established for each sustainability indicator relevant to monitoring in the Merced Subbasin: groundwater levels, groundwater storage, groundwater quality, subsidence, and depletions of interconnected surface waters. While undesirable results related to groundwater storage are not present and are not likely to occur in the Subbasin, a monitoring network based on groundwater levels is still developed to support development of groundwater budgets, including an estimate of the change in annual groundwater in storage, and to support overall characterization of the Subbasin. Similarly, while groundwater levels are used as a proxy for the sustainable management criteria for depletions of interconnected surface water, a monitoring network is still developed to allow for continued characterization of the system. Of the six sustainability indicators under SGMA, only seawater intrusion is not covered by a monitoring network in this plan, as undesirable results related to seawater intrusion are not present and are not likely to occur in the Subbasin (see Section 3.4.1 - Undesirable Results).

This section includes the monitoring network objectives, the existing monitoring networks, the rationale for monitoring, details on representative monitoring, and a description of a monitoring network for each applicable sustainability indicator. Data gaps and a plan to fill them are provided for each monitoring network.

4.1 MONITORING NETWORK OBJECTIVES

The primary objective of these monitoring networks is to allow for evaluation of the effects and effectiveness of Plan implementation, including detection of undesirable results using the minimum thresholds described in Chapter 3 of this Groundwater Sustainability Plan (GSP). Other related objectives of the monitoring network as defined in the Sustainable Groundwater Management Act (SGMA) regulations include:

- Demonstrating progress toward achieving measurable objectives
- Monitoring impacts to the beneficial uses or users of groundwater
- Monitoring changes in groundwater conditions relative to measurable objectives and minimum thresholds
- Quantifying annual changes in water budget components

4.2 EXISTING SUBBASIN MONITORING

The monitoring networks described in this section were designed by first evaluating available data and existing monitoring in the Subbasin, to leverage the substantial historical and ongoing monitoring activities. Existing monitoring programs were previously described in Section 1.2.2 - Water Resources Monitoring and Management Programs.

4.3 MONITORING RATIONALES

The Merced Subbasin GSP monitoring networks were developed to meet the objectives described above. This will allow for the detection of changes in Subbasin conditions so the GSAs can adaptively manage the Subbasin to meet sustainability goals.

Monitoring networks were developed from existing wells, or other facilities, that were selected specifically to provide an adequate amount of temporal frequency and spatial density to detect short-term, seasonal, and long-term trends in groundwater conditions. This data is necessary to evaluate the effectiveness of PMAs undertaken by the GSAs.

Data gaps, where additional monitoring information is necessary, were also identified. Plans or projects to install additional monitoring sites to fill these data gaps are included as a management action or project in the Implementation Section of the GSP.

Additional details on the monitoring rationales are described within each monitoring network.

4.4 REPRESENTATIVE MONITORING

Representative monitoring sites are a subset of the Subbasin's total monitoring network specifically selected to represent groundwater conditions in the Subbasin and track sustainability. Minimum thresholds and measurable objectives are defined only at representative monitoring locations. Representative monitoring locations are selected by evidence that the site reflects typical conditions in the area, can provide monitoring data that are representative of that area, and has access suitable for long-term monitoring. By selecting specific monitoring locations that reflect the Subbasin's typical conditions and monitoring established parameters, the GSAs can monitor the sustainability indicators and collect targeted data.

Additional monitoring facilities are included in the monitoring network to characterize conditions at a more detailed level across the Subbasin and to verify that the representative monitoring locations continue to be representative of typical conditions. This information can be used to inform the 5-year GSP updates and can support other groundwater management needs, such updates and refinements to the groundwater model. Note that, in some cases, these monitoring facilities are not designated as representative because they do not meet minimum criteria, such as known construction information or adequate historical data to develop minimum thresholds and measurable objectives.

Should additional monitoring sites be added to a particular monitoring network in the future, each may be evaluated against the criteria or methodology used to develop existing minimum thresholds to determine if the additional site is applicable as a representative monitoring site in addition to providing value to the monitoring network as a whole.

4.5 GROUNDWATER LEVEL MONITORING NETWORK

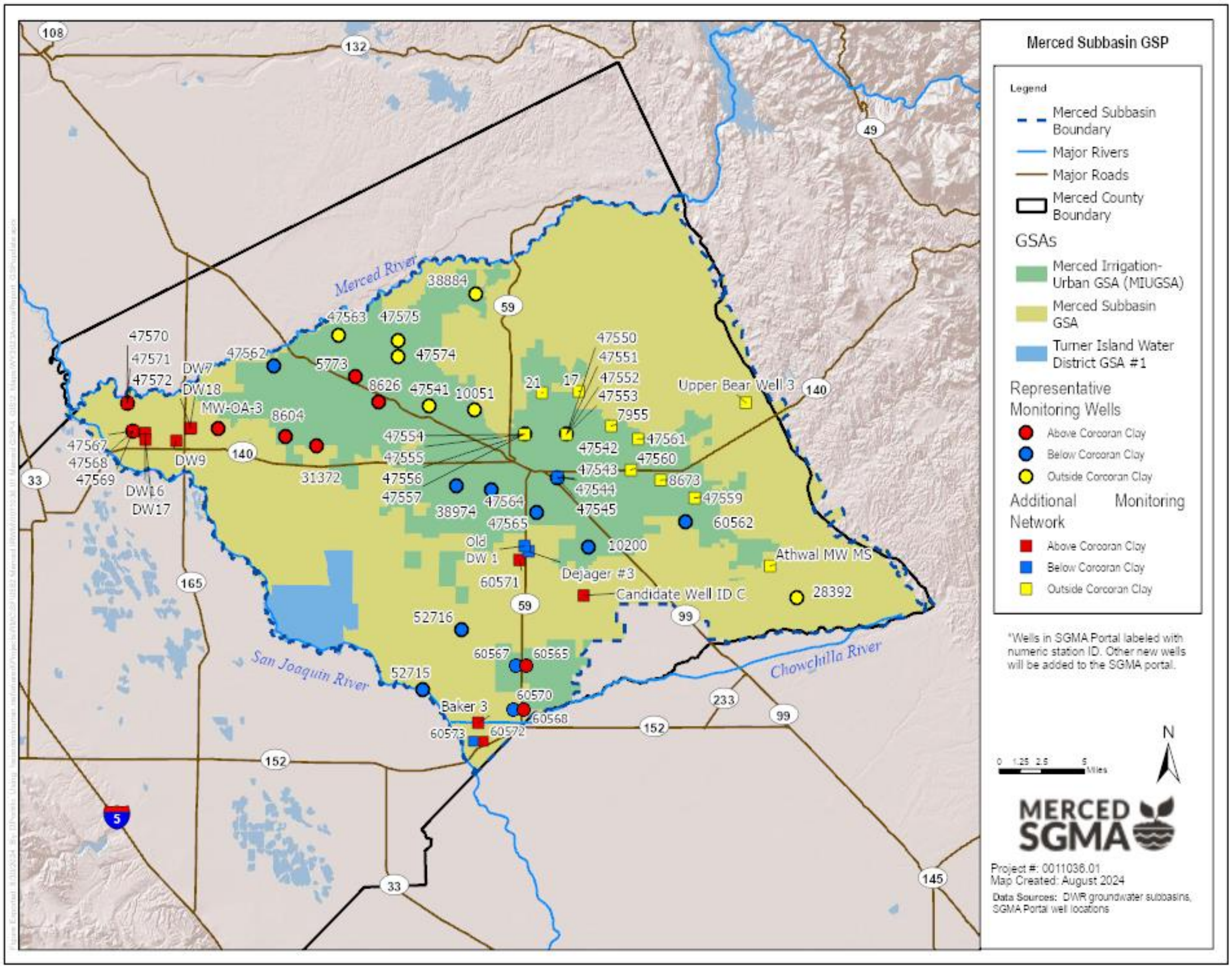
Groundwater level monitoring is conducted through a groundwater well monitoring network. The network allows for demonstration of groundwater occurrence, general flow directions, and hydraulic gradients between the principal aquifers and surface water features. Further, the network allows for characterization of the groundwater table or potentiometric surface of each of the three principal aquifers.

4.5.1 Monitoring Wells Selected for Monitoring Network

Wells for the monitoring network were selected as the entirety of the California Statewide Groundwater Elevation Monitoring (CASGEM) network within the Subbasin at the time of publishing the original 2020 GSP. CASGEM was established by the State of California and implemented locally to develop a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins. With regards to groundwater level monitoring, CASGEM has many similarities with the requirements of SGMA. While there are gaps in the overall coverage for the CASGEM network, it is appropriate for the existing CASGEM monitoring network in the Merced Subbasin to be the nucleus of a comprehensive network for this GSP. Additional wells have since been added to the GSP's groundwater level monitoring network (see more details in Section 4.5.7).

The Merced Subbasin GSP groundwater level monitoring network totals 63 wells. This includes 22 wells in the Above Corcoran Clay Principal Aquifer, 17 wells in the Below Corcoran, and 24 wells in the Outside Corcoran. Figure 4-1 shows the well locations.

Figure 4-1: Merced Subbasin GSP Groundwater Level Monitoring Network Wells



Note: Wells without SGMA Station IDs assigned have been added to the monitoring network in a provisional status. The GSAs intend to collect and review data for two full years before officially adding each well to the network which will be noted in an Annual Report.

4.5.2 Monitoring Frequency

The monitoring frequency is selected to allow the monitoring network to adequately interpret short and long-term groundwater level trends and conditions. These fluctuations may be the result of seasonality, pumping, or climatic variations such as storm events and drought. According to SGMA regulations, monitoring frequency must occur, at a minimum, at the Subbasin's seasonal high and low. In the Merced Subbasin these seasonal peaks generally occur during March and October.

DWR's *Monitoring Networks and Identification of Data Gaps BMP* provides non-regulatory guidance for monitoring frequency based on based on aquifer properties and degree of use, as shown in Table 4-1.

Table 4-1: Summary of DWR Guidance on Monitoring Frequency

Aquifer Type	Nearby Long-Term Aquifer Withdrawals		
	Small Withdrawals	*Moderate Withdrawals*	*Large Withdrawals*
Unconfined Aquifer			
"low" recharge (<5 inches/year)	Quarterly	Quarterly	Monthly
"high" recharge (>5 inches/year)	Quarterly	Monthly	Daily
Confined Aquifer			
"low" hydraulic conductivity (<200 feet/day)	Quarterly	Quarterly	Monthly
"high" hydraulic conductivity (>200 feet/day)	Quarterly	Monthly	Daily

Source: (DWR, 2016c)

According to Table 4-1, the three Merced Subbasin Principal Aquifers fall under two categories:

- **Above Corcoran Clay Principal Aquifer:** unconfined, low recharge where unirrigated, high recharge where irrigated, moderate to large withdrawals.
- **Below Corcoran Clay Principal Aquifer**: confined, low hydraulic conductivity, moderate to large withdrawals.
- **Outside Corcoran Clay Principal Aquifer**: unconfined, low recharge where unirrigated, high recharge where irrigated, moderate to large withdrawals.

While previous CASGEM monitoring currently records groundwater levels biannually at the seasonal peaks (typically March and October) as well as December, DWR's best management practice (BMP) suggests all three principal aquifers should be monitored at least quarterly, potentially monthly, and daily in some situations.

Monitoring will occur on or near the second week of each month for all monitoring network wells not equipped with continuous pressure transducers, with re-assessment of the frequency at the 5-year periodic evaluation, or sooner, if needed. At that time, the frequency may be changed, particularly if quarterly sampling can be shown to adequately capture the variability or if irrigation-season measurements are shown to be too impacted by nearby groundwater pumping to be useful.

4.5.3 Spatial Density

A sufficient density of monitoring wells is necessary to characterize the groundwater table or potentiometric surface for each principal aquifer. DWR's *Monitoring Networks and Identification of*

Data Gaps BMP (DWR, 2016b) provides multiple sources to guide monitoring network well density, as shown in Table 4-2.

Table 4-2: Monitoring Well Density Considerations

Reference	Monitoring Well Density (wells per 100 miles^2)
Heath (1976)	0.2-10
Sophocleous (1983)	6.3
Hopkins (1994)	
Basins pumping more than 10,000 AFY per 100 square miles	4.0
Basins pumping between 1,000 and 10,000 AFY per 100 square miles	2.0
Basins pumping between 250 and 1,000 AFY per 100 square miles	1.0
Basins pumping between 100 and 250 AFY per 100 square miles	0.7

Source: (DWR, 2016b)

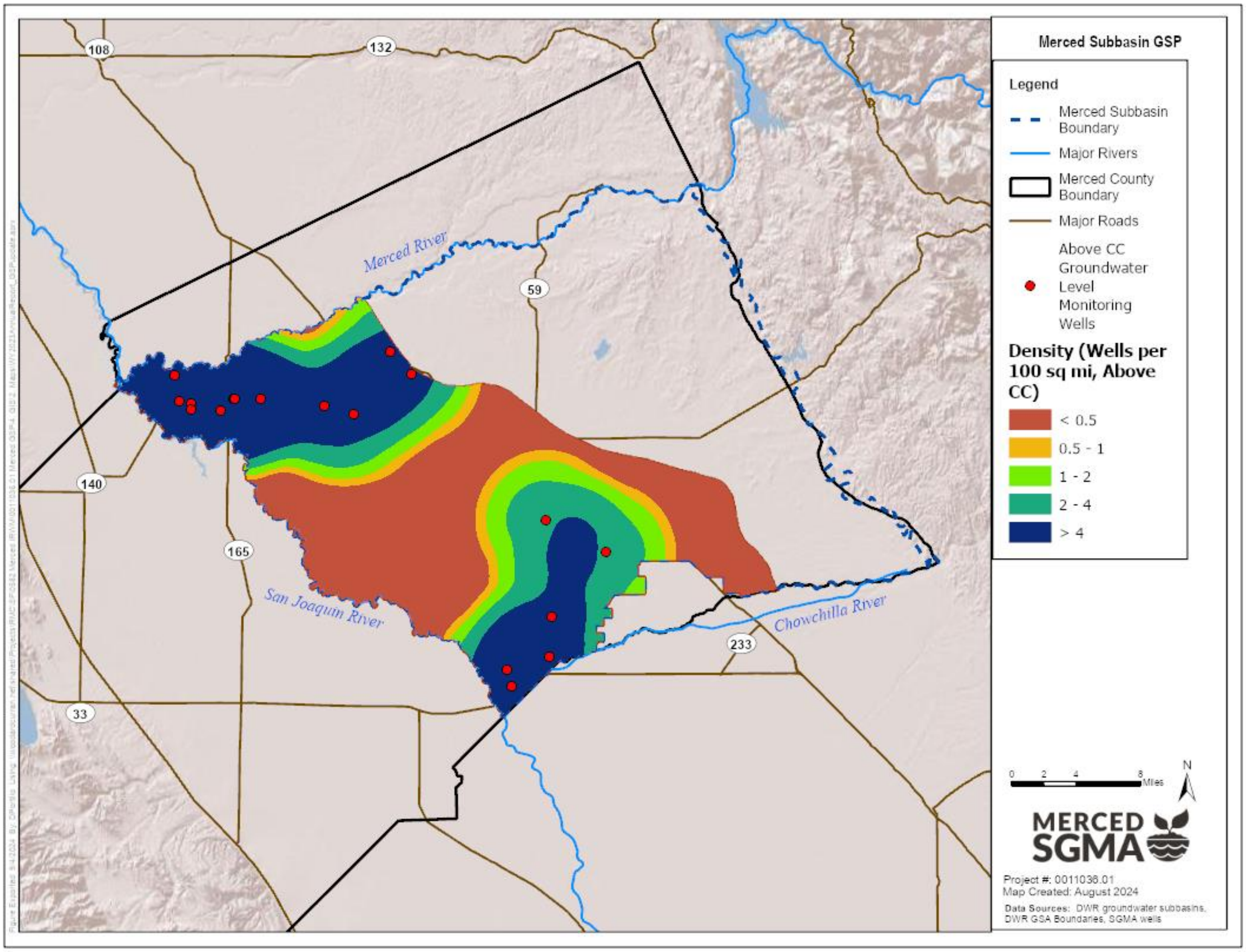
According to the Historical Conditions Water Budget (WYs 2006-2015), the Subbasin pumps approximately 723,000 AF annually. The Subbasin has an area of 801 square miles of area which leads to approximately 90,000 AF pumped per 100 square miles. Based on Hopkins (1994) well density estimate guidelines, the Subbasin should have 4 monitoring wells per 100 square miles. Based on Sophocleous (1983) well density estimate guidelines, the Subbasin should have 6.3 monitoring wells per 100 square miles. Based on Heath (1976), the Subbasin should have between 0.2 and 10 monitoring wells per 100 square miles.

The well density is within the ranges presented in DWR's guidance. Table 4-3 shows the density of wells by principal aquifer, with three following figures showing the variability in well density across the Subbasin: Figure 4-2 for the Above Corcoran Clay Principal Aquifer, Figure 4-3 for the Below Corcoran Clay Principal Aquifer and Figure 4-4 for the Outside Corcoran Clay Principal Aquifer. The density of wells in the Above Corcoran Clay Principal Aquifer (4.1 wells/100 mi^2) and Below Corcoran Clay (3.2 wells/100 mi^2) are somewhat lower than the density of wells in the Outside Corcoran Clay (4.9 wells/100 mi^2). These densities are lower than what is recommended by Sophocleous (1983) but are within the ranges of Heath (1976) and exceed (for Above and Outside Corcoran Clay Principal Aquifers) Hopkins (1994). Overall, the densities are considered sufficient to characterize conditions in most of the Subbasin. Spatial data gaps are acknowledged and described further in Section 4.5.6.

Table 4-3: Density of Groundwater Level Monitoring Wells by Principal Aquifer

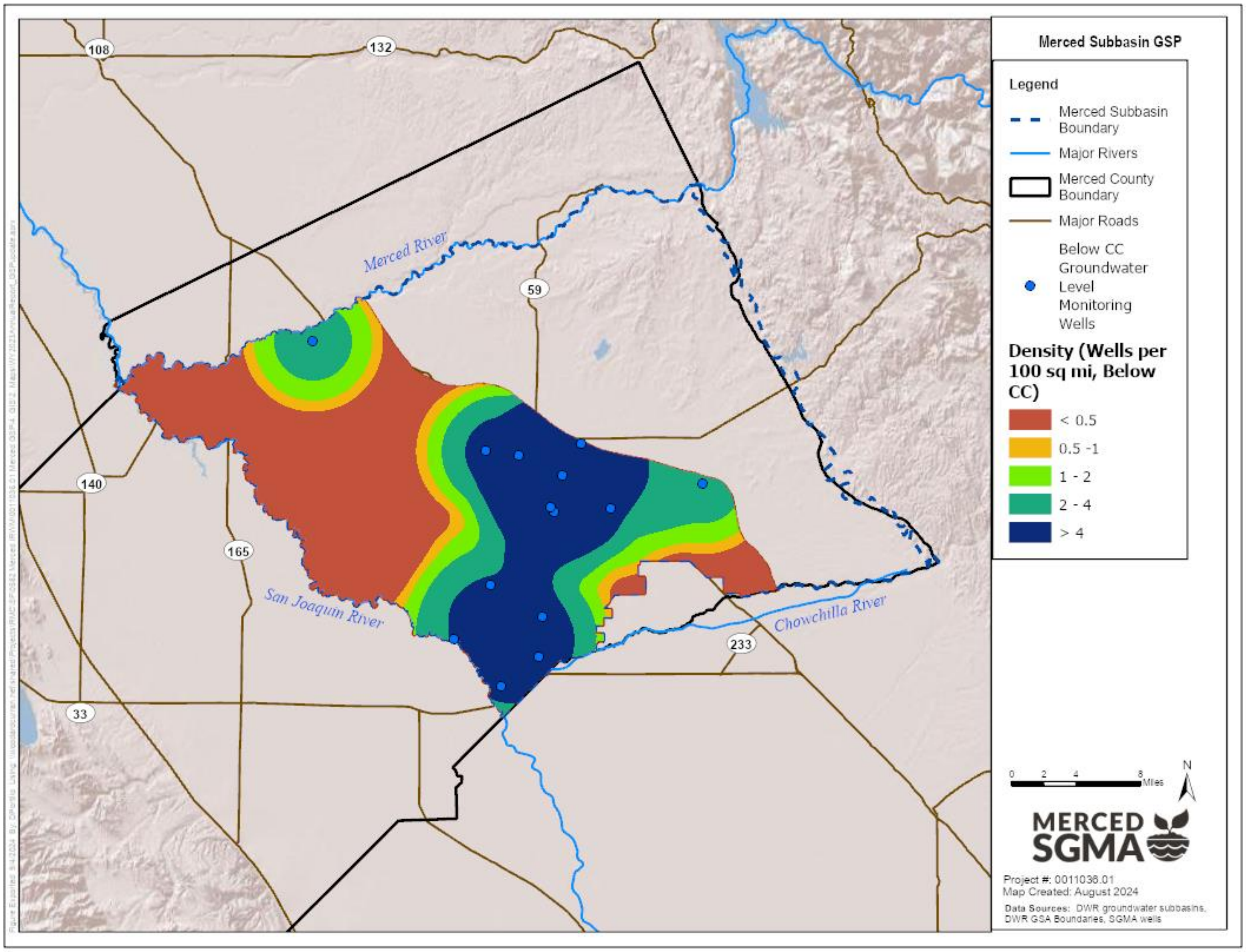
	Principal Aquifer			Total
	Above Corcoran Clay (Figure 4-2)	Below Corcoran Clay (Figure 4-3)	Outside Corcoran Clay (Figure 4-4)	
Total Number of Unique Well IDs	22	17	24	63
Subset of Total That Are Multiple Completion Wells	9	8	8	22
Total Number of Geographically Unique Well Locations	18	14	18	50
Area of Principal Aquifer (mi^2)	437	437	364	801
Density (number of wells per 100 mi^2)	4.1	3.2	4.9	6.2

Figure 4-2: Density of Groundwater Level Monitoring Network – Above Corcoran Clay Principal Aquifer



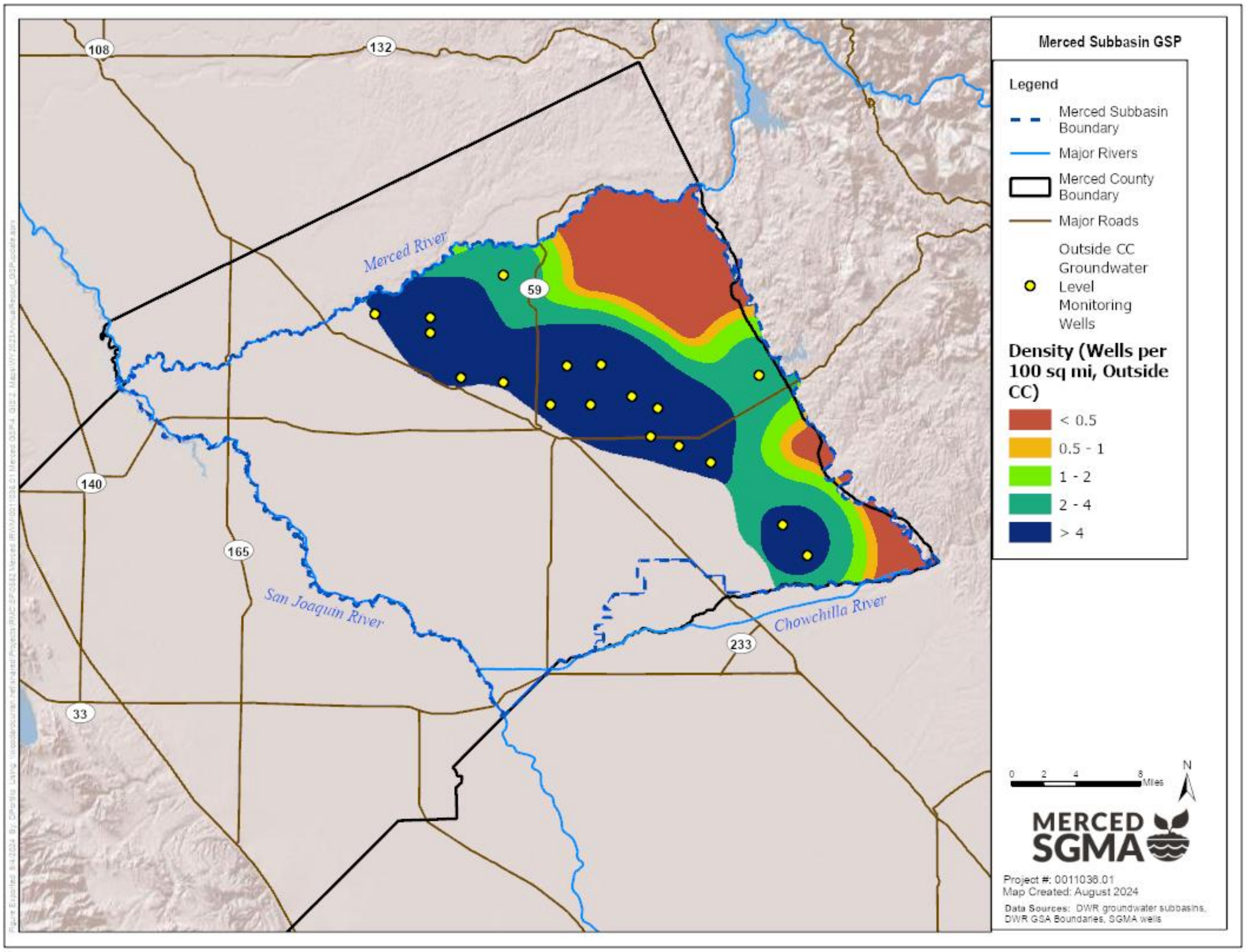
Note – voluntary wells without construction information (e.g., not sorted into a Principal Aquifer) are not shown.

Figure 4-3: Density of Groundwater Level Monitoring Network – Below Corcoran Clay Principal Aquifer



Note – voluntary wells without construction information (e.g., not sorted into a Principal Aquifer) are not shown.

Figure 4-4: Density of Groundwater Level Monitoring Network – Outside Corcoran Clay Principal Aquifer



4.5.4 Representative Monitoring

The Merced Subbasin GSP groundwater levels monitoring network totals 63 wells, 29 of which are designated as representative wells. Representative monitoring wells were selected specifically in conjunction with the minimum threshold selection methodology described in Section 3.3.2. Wells included are screened within the portion of the principal aquifer typically accessed for groundwater production and that are reflective of typical aquifer conditions, based on information from the Merced Water Resources Model (MercedWRM).

Figure 4-1 shows the locations of the groundwater level monitoring network monitoring and representative wells.

Table 4-4 details the groundwater level monitoring network monitoring and representative wells, with Table 4-5 showing locations in a tabular format. Representative wells are identified with an asterisk (*) next to their State Well Number.

Following the adoption of the 2022 GSP, three monitoring wells were removed from the monitoring network. Well 47558, located east of the City of Livingston, and completed within the Outside Corcoran Clay Principal Aquifer, has not been successfully measured since 2013. Fortunately, it is located in close proximity to other network wells that do have regular, successful measurements such as wells 47574, 47575, and 47563. Wells 53315 and 53316, located in the southern end of the Outside Corcoran Clay Principal Aquifer have not been measured since 2019 due to various site challenges and were also removed.

Table 4-4: Merced Subbasin GSP Groundwater Level Monitoring Network Well Details

State Well Number	SGMA Station ID	Principal Aquifer	Well Depth (ft bgs)	Top of Screen Interval (ft bgs)	Bottom of Screen Interval (ft bgs)	First Measure-ment Date	Last Measure-ment Date	Measure-ment Period (Years)	Measure-ment Count[1]
08S16E34J001M*	28392	Outside	639	180	639	12/11/1961	3/4/2024	62	79
08S14E15R002M*	10200	Below	265	230	265	11/1/1974	3/11/2024	49	65
08S14E06G001M*	47565	Below	225	148	225	10/3/2011	10/7/2022	11	17
07S15E32A001M	8673	Outside	650	52	650	1/2/1958	3/4/2024	66	82
07S15E30D001M	47560	Outside	642	80	642	10/3/2011	3/29/2023	11	19
07S15E18G001M	47561	Outside	550	84	550	10/3/2011	3/4/2024	12	23
07S15E15N001M	47559	Outside	510	165	510	10/15/2015	3/4/2024	8	17
07S14E35E004M	47545	Below	690	520	690	2/15/2012	3/6/2024	12	21
07S14E35E003M	47544	Below	500	300	500	2/15/2012	3/6/2024	12	21
07S14E35E002M	47543	Below	260	190	260	5/15/2012	3/6/2024	12	21
07S14E35E001M*	47542	Below	170	89	170	2/15/2012	3/6/2024	12	21
07S14E16F004M*	47553	Outside	605	550	605	2/15/2012	3/5/2024	12	22
07S14E16F003M	47552	Outside	505	400	505	2/15/2012	3/5/2024	12	22
07S14E16F002M	47551	Outside	385	330	385	2/15/2012	3/5/2024	12	22
07S14E16F001M	47550	Outside	235	180	235	2/15/2012	3/5/2024	12	22
07S14E12N001M	7955	Outside	341	196	341	11/1/1974	3/4/2024	49	63
07S13E34G001M*	47564	Below	394	230	394	10/3/2011	3/4/2024	12	22
07S13E32H001M*	38974	Below	412	132	412	11/1/1974	3/1/2024	49	50
07S13E13H004M*	47557	Outside	580	434	580	2/15/2012	3/8/2024	12	21
07S13E13H003M	47556	Outside	424	350	424	2/15/2012	3/8/2024	12	21
07S13E13H002M	47555	Outside	340	194	340	2/15/2012	3/8/2024	12	21
07S13E13H001M	47554	Outside	184	88	184	2/15/2012	3/8/2024	12	21
07S13E09A001M*	10051	Outside	139	128	136	11/1/1974	10/30/2023	49	55
07S12E07C001M*	47541	Outside	450	425	440	3/4/2015	10/10/2023	9	18
07S12E03F001M*	8626	Above	183	60	95	11/1/1974	3/1/2024	49	66
07S11E24A001M*	31372	Above	87	0.01	60	11/1/1974	3/1/2024	49	53
07S11E15H001M*	8604	Above	105	1	105	11/1/1974	3/1/2024	49	63

State Well Number	SGMA Station ID	Principal Aquifer	Well Depth (ft bgs)	Top of Screen Interval (ft bgs)	Bottom of Screen Interval (ft bgs)	First Measure-ment Date	Last Measure-ment Date	Measure-ment Period (Years)	Measure-ment Count[1]
07S10E17D003M*	47569	Above	85	70	80	10/15/2011	3/1/2024	12	20
07S10E17D002M	47568	Above	50	40	50	10/15/2011	3/1/2024	12	20
07S10E17D001M	47567	Above	30	20	30	10/15/2011	3/1/2024	12	20
07S10E11A001M	47570	Above	22	12	22	10/15/2011	3/1/2024	12	19
07S10E06K003M	47572	Above	155	140	150	10/15/2011	3/1/2024	12	20
07S10E06K002M*	47571	Above	53	38	48	11/15/2011	3/1/2024	12	20
06S13E04H001M*	38884	Outside	574	-	-	11/1/1974	3/1/2024	49	40
06S12E33D001M*	5773	Above	200	85	190	11/1/1974	3/1/2024	49	65
06S12E23P001M*	47574	Outside	368	220	270	12/28/2011	3/19/2024	12	21
06S12E23C001M*	47575	Outside	930	660	920	12/28/2011	3/8/2023	11	18
06S12E17M001M*	47563	Outside	202	192	202	10/3/2011	3/1/2024	12	13
06S11E27F001M*	47562	Below	127	108	127	10/16/2014	3/8/2022	7	11
-*	60568	Above	140	125	140	3/5/2024	3/5/2024	-	1
-*	60565	Above	125	110	125	3/6/2024	3/6/2024	-	1
-*	MW-OA-3†	Above	55	40	50	11/1/2018	12/1/2023	5	62
-*	52715	Below	812	484	806	10/23/2018	3/5/2024	5	10
-*	52716	Below	500	220	480	10/24/2018	3/6/2024	5	11
-*	60567	Below	345	320	340	3/6/2024	3/6/2024	-	1
-*	60570	Below	312	287	307	3/5/2024	3/5/2024	-	1
-*	60562	Below	250	240	250	3/4/2024	3/4/2024	-	1
-	60571	Above	104	94	104	-	-	-	-
-	60572	Above	184	164	174	3/5/2024	3/5/2024	-	1
-	Candidate Well ID C†	Above	100	-	-	-	-	-	-
-	DW7†	Above	172	30	160	-	-	-	-
-	Baker 3†	Above	77	-	-	-	-	-	-
-	DW9†	Above	158	30	150	-	-	-	-
-	DW16†	Above	205	60	200	-	-	-	-
-	DW17†	Above	127	20	120	-	-	-	-

State Well Number	SGMA Station ID	Principal Aquifer	Well Depth (ft bgs)	Top of Screen Interval (ft bgs)	Bottom of Screen Interval (ft bgs)	First Measure-ment Date	Last Measure-ment Date	Measure-ment Period (Years)	Measure-ment Count[1]
-	DW18†	Above	190	80	165	-	-	-	-
-	60573	Below	386	366	376	3/5/2024	3/5/2024	-	1
-	Dejager #3†	Below	202	190	210	-	-	-	-
-	Old DW 1†	Below	219	-	-	-	-	-	-
-	17†	Outside	500	-	-	-	-	-	-
-	21†	Outside	640	-	-	-	-	-	-
-	Upper Bear Well 3†	Outside	331	51	401	-	-	-	-
-	Athwal MW MS†	Outside	400	178	304	-	-	-	-

1. Count of measurements excludes any measurements with a data quality flag.

* indicates representative monitoring well

† Indicates a well that has not yet been assigned a SGMA Station ID. Wells without SGMA Station IDs assigned have been added to the monitoring network in a provisional status. The GSAs intend to collect and review data for two full years before officially adding each well to the network which will be noted in an Annual Report.

ft bgs: feet below ground surface

Table 4-5: Merced Subbasin GSP Groundwater Level Monitoring Network Locations

State Well Number	SGMA Station ID	Latitude	Longitude
08S16E34J001M*	28392	37.1902	-120.1985
08S14E15R002M*	10200	37.23238	-120.42003
08S14E06G001M*	47565	37.26173	-120.47461
07S15E32A001M	8673	37.288	-120.3432
07S15E30D001M	47560	37.29644	-120.37487
07S15E18G001M	47561	37.32199	-120.36716
07S15E15N001M	47559	37.27332	-120.30705
07S14E35E004M	47545	37.29038	-120.45288
07S14E35E003M	47544	37.29038	-120.45288
07S14E35E002M	47543	37.29038	-120.45288
07S14E35E001M*	47542	37.29038	-120.45288
07S14E16F004M*	47553	37.32603	-120.44316
07S14E16F003M	47552	37.32603	-120.44316
07S14E16F002M	47551	37.32603	-120.44316
07S14E16F001M	47550	37.32603	-120.44316
07S14E12N001M	7955	37.33278	-120.39574
07S13E34G001M*	47564	37.2806	-120.52411
07S13E32H001M*	38974	37.2839	-120.56008
07S13E13H004M*	47557	37.32603	-120.48801
07S13E13H003M	47556	37.32603	-120.48801
07S13E13H002M	47555	37.32603	-120.48801
07S13E13H001M	47554	37.32603	-120.48801
07S13E09A001M*	10051	37.34607	-120.54089
07S12E07C001M*	47541	37.34955	-120.58897
07S12E03F001M*	8626	37.3531	-120.64383
07S11E24A001M*	31372	37.3167	-120.70898
07S11E15H001M*	8604	37.32412	-120.74238
07S10E17D003M*	47569	37.32776	-120.90538
07S10E17D002M	47568	37.32772	-120.90538
07S10E17D001M	47567	37.32781	-120.90538
07S10E11A001M	47570	37.35101	-120.91138
07S10E06K003M	47572	37.35103	-120.91128
07S10E06K002M*	47571	37.35102	-120.91133
06S13E04H001M*	38884	37.44218	-120.54066
06S12E33D001M*	5773	37.37326	-120.66816
06S12E23P001M*	47574	37.38973	-120.62316
06S12E23C001M*	47575	37.40341	-120.62281
06S12E17M001M*	47563	37.40736	-120.68591
06S11E27F001M*	47562	37.38207	-120.7551
-*	60568	37.09855	-120.48948
-*	60565	37.13473	-120.49286
-*	MW-OA-3†	37.33028	-120.81444
-*	52715	37.11533	-120.59578
-*	52716	37.16396	-120.55557

-*	60567	37.13471	-120.49283
-*	60570	37.09856	-120.48953
-*	60562	37.25385	-120.31603
-	60571	37.22215	-120.49352
-	60572	37.07218	-120.54256
-	Candidate Well ID C†	37.1927	-120.4252
-	DW7†	37.3304	-120.8447
-	Baker 3†	37.0874	-120.5372
-	DW9†	37.32023	-120.85914
-	DW16†	37.32627	-120.89207
-	DW17†	37.3208	-120.8919
-	DW18†	37.33065	-120.84336
-	60573	37.07218	-120.54256
-	Dejager #3†	37.2292	-120.4837
-	Old DW 1†	37.2337	-120.4882
-	17†	37.36141	-120.43016
-	21†	37.36033	-120.46956
-	Upper Bear Well 3†	37.3518	-120.2522
-	Athwal MW MS†	37.2169	-120.2269

* indicates representative monitoring well

† Indicates a well that has not yet been assigned a SGMA Station ID

4.5.5 Groundwater Level Monitoring Protocols

Groundwater monitoring protocols are essential to producing quality data measurements and protecting the water quality of monitoring wells. Existing protocol resources include DWR's *Groundwater Elevation Monitoring Guidelines* (DWR, 2010) and United States Geological Survey's (USGS's) *National Field Manual* (Wilde, 2015). Protocols are established to improve consistency in data and ensure comparable methodologies.

Typical groundwater level measurement equipment used by agencies include electric sounders, data loggers, steel tapes, and air gauges. Regardless of the instrumentation used in the field, each groundwater level data measurement must include: well identification number, measurement date, reference point and land surface elevation, depth to water, method of measuring water depth, and measurement quality codes.

DWR released a BMP for monitoring protocols in the Best Management Practices for the Sustainable Management of Groundwater - Monitoring Protocols, Standards, and Sites, included as Appendix I. The monitoring protocols described in DWR's BMP recommend that groundwater level measurements are taken in a manner to ensure data are:

- Taken from the correct location, well ID, and screen interval depth
- Accurate and reproducible

- Representative of conditions that inform appropriate basin management data quality objectives
- Recorded with all salient information to correct, if necessary, and compare data
- Handled in a way that ensures data integrity.
- Taken using a CASGEM-approved water-level measurement methods to ensure consistency across measurements. Methods include:
  - Establishing a reference point
  - Using one of four approved methods (steel tape, electric sounding tape, sonic water-level meter, or pressure transducer) to measure groundwater levels

Additionally, if monitoring wells are also production wells, monitoring should occur after at least 48 hours of no extraction activities.

Existing wells, monitored under the CASGEM program, already use these procedures in the collection of groundwater level data. The protocols included in Appendix I will also be used for monitoring under this GSP.

4.5.6 Data Gaps

Data gaps can be the result of poor spatial (horizontal and/or vertical) distribution of the monitoring wells or a lack of well construction information needed for accurate monitoring data collection.

Data gap areas are described below separately for each aquifer, as shown in **Figure 4-5** based on areas with a relatively low density of monitoring wells per principal aquifer (<0.5 wells per 100 square miles). While progress has been made on filling these data gaps, additional work remains.

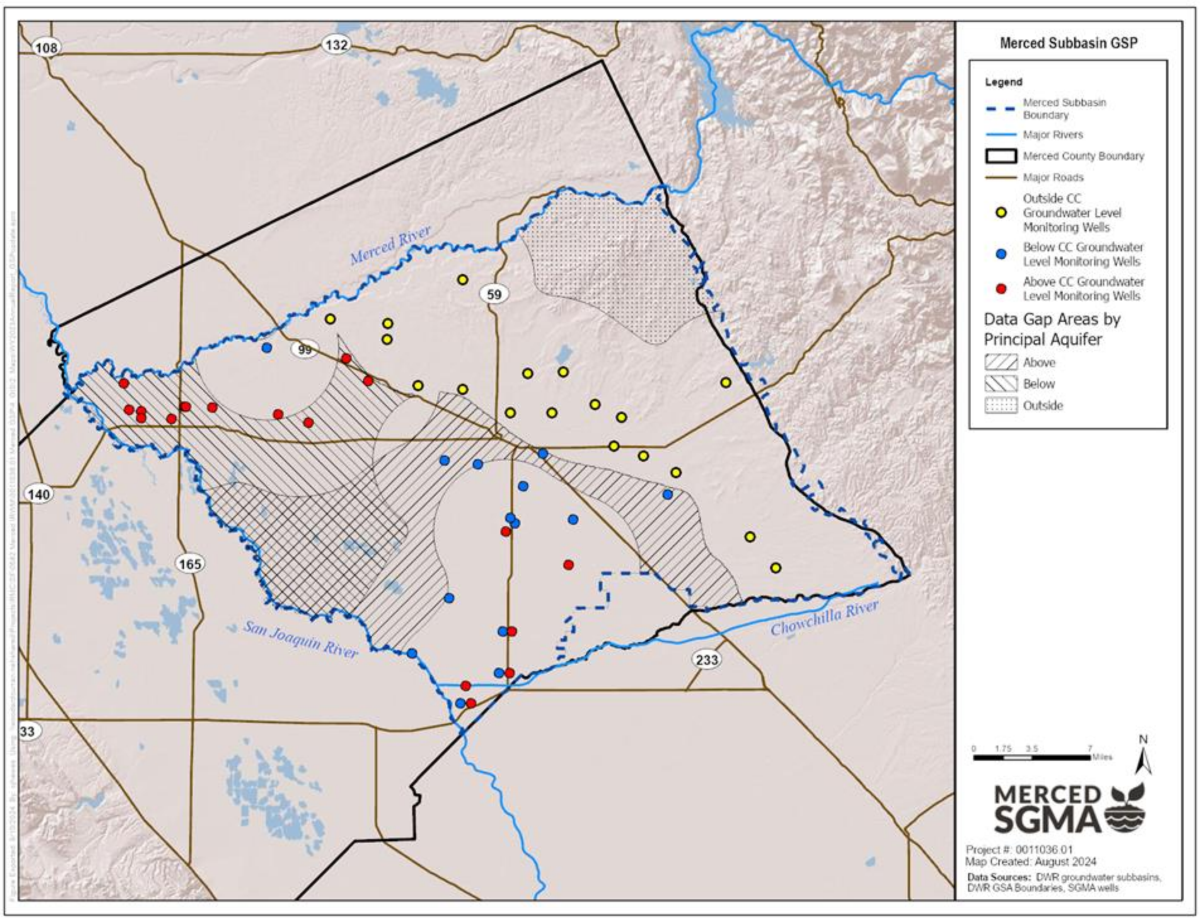
1. **Outside Corcoran Clay Principal Aquifer:** Located in the northern corner of the Subbasin, though with a lower priority due to relatively limited beneficial uses of groundwater in this region.
2. **Above Corcoran Clay Principal Aquifer:** Located primarily in the center of the aquifer.
3. **Below Corcoran Clay Principal Aquifer:** Located in the northwestern and central portion of the aquifer.

Overall, there is a data gap of monitoring wells for groundwater levels along the western edge of the Subbasin (see spatial density maps in Figure 4-2 and Figure 4-3). In addition to providing valuable groundwater elevation data, wells along this area would help improve the understanding of subsurface groundwater flow between adjacent subbasins, depletions of interconnected surface waters, subsidence, and connection between principal aquifers. The GSAs have made progress in addressing these data as discussed in Section 4.5.6 below.

Note that data gaps associated with depth-discrete groundwater elevation data near rivers, streams, and Natural Communities Commonly Associated with Groundwater (NCCAGs) are discussed in Section 4.10.6.

Finally, many representative monitoring wells have limited data, and many of these also show high levels of variability that make analysis difficult. Sustainable Management Criteria have been set using that best available data, including in some cases additional information from the MercedWRM groundwater model. In several cases, there may be influences of nearby production wells that would need to be considered when setting and monitoring for sustainable management criteria; influences that are difficult to discern from the limited data. Wells that exhibit groundwater levels that are highly variable or difficult to explain will be a focus for the installation of pressure transducers to better understand the variability, to the extent feasible. One such well is 47541. Installations may be temporary or permanent. Sustainable management criteria may be modified based on future data collection and analysis.

Figure 4-5: Merced Subbasin GSP Groundwater Level Monitoring Network Data Gaps



4.5.7 Progress on Filling Data Gaps

A Data Gaps Plan was prepared by the GSAs in 2021 and has been used to guide the strategy of filling data gaps since then (Woodard & Curran, 2021). The objectives of the Plan included identifying data gaps in the Subbasin's monitoring network, prioritizing data gaps for certain sustainability indicators, and planning for implementation activities designed to fill these prioritized gaps. The Plan developed a tool to determine optimal locations for siting new monitoring wells to enhance the network's ability to collect data. As described above, three areas were prioritized in installing additional groundwater monitoring wells due to their potential to address multiple data gaps, particularly groundwater levels. As a result, the following wells were installed and added to the monitoring network:

- Well "Michael Road", located near Highway 59, south of the City of Merced, and completed within the Above Corcoran Clay Principal Aquifer.
- Wells HR1-S (Harmon Rd Shallow) and HR1-D (Harmon Rd Deep), located on Harmon Rd, southwest of El Nido, with dual completions in both the Above Corcoran Clay and Below Corcoran Clay Principal Aquifers.
- Wells "El Nido Firehouse – Shallow", "El Nido Firehouse – Above Corcoran Deep", and "El Nido Firehouse – Deep", located within the El Nido area in the southern portion of the Subbasin. Both the "Shallow" and "Above Corcoran Clay Deep" wells were installed in the Above Corcoran Clay Aquifer and the "Deep" well was situated in the Below Corcoran Clay Aquifer. This well was funded using SDAC funding.
- Wells "Jefferson Shallow Nested" and "Jefferson Road", located southwest or El Nido and northeast of Harmon Road with dual completions in both the Above Corcoran Clay and Below Corcoran Clay Principal Aquifers. The "Jefferson Shallow Nested" is listed in the SGMA data viewer as monitoring sites "Jefferson Road – Above Corcoran Shallow" "Jefferson Road – Above Corcoran Deep" with separate screen intervals.
- Well "Nested MW" located southeast of Planada. This is a nested monitoring well with three monitoring sites screened at different intervals: "Cardwell Ranch – Shallow", "Cardwell Ranch – Intermediate", and "Cardwell Ranch – Deep". The nested well is located within the Outside Corcoran Clay Aquifer. This well was funded using SDAC funding.
- Seven additional wells located within MSGSA's boundary. Each were existing wells that were identified as potential candidates for becoming a monitoring well. Pressure transducers have been installed to begin monitoring groundwater levels. Three are located in the Above Corcoran Clay Aquifer, while two are Below and two are Outside. These have been added to the monitoring network in a provisional status. The GSAs intend to collect and review data for two full years before officially adding each well to the network which will be noted in an Annual Report.

- Four additional wells located within the Stevinson/Merquin area in the northwest corner of the Subbasin, all completed within the Above Corcoran Clay Aquifer, have been added to the monitoring network in a provisional status.
- Two additional wells (local names 21 and 17) installed by the City of Merced and located within the Outside Corcoran Clay Principal Aquifer have been added to the network in a provisional status.

Figure 4-1 shows the locations of the additional wells added to address data gaps. The addition of new monitoring wells allows the GSAs to better monitor groundwater level changes relative to the established sustainable management criteria, impacts to beneficial uses and users, and better track annual changes in water budget (Woodard & Curran, 2021). Note that groundwater level SMC were established for eight of the newly added monitoring network wells, as described in Section 3.3.

The three wells listed below are located within TIWD GSA-1. The GSA is still in the process of confirming the addition of these wells to the monitoring network. Monitoring data has been collected and used to update groundwater contour maps since at least 2016 and continues to be collected.

- Well "R", located in the northern portion of TIWD GSA-1 and completed within the Below Corcoran Clay Principal Aquifer.
- Well "I", located along the southern edge of TIWD GSA-1 and completed within the Below Corcoran Clay Principal Aquifer.
- Well "L", located along the southern edge of TIWD GSA-1 and completed within the Above Corcoran Clay Principal Aquifer.

4.5.8 Plan to Fill Data Gaps

The GSAs are continuing to implement the Data Gaps Plan (see Section 4.5.7). At the time of publishing, the GSAs have funding remaining from grant applications specific to monitoring networks and will continue implementation to fill additional data gaps. This includes identifying and evaluating existing wells that could be incorporated into the monitoring network. The GSAs are also beginning implementation of the "Filling Data Gaps Identified in the Data Gaps Plan" project funded by "Sustainable Groundwater Management Implementation Grant Round 1" grant. This work is anticipated to be complete in early 2025.

4.6 GROUNDWATER STORAGE MONITORING NETWORK

As groundwater levels are used a proxy for the reduction of groundwater in storage sustainability indicator, the monitoring network is the same as that developed for groundwater levels. The monitoring network was developed to support development of groundwater budgets, including an estimate of the change in annual groundwater in storage, and to support overall characterization of the Subbasin.

4.7 SEAWATER INTRUSION MONITORING NETWORK

The Merced Subbasin is geographically and geologically isolated from the Pacific Ocean and any other large source of seawater. Thus, the Subbasin is not at risk for seawater intrusion and does not require an associated monitoring network.

4.8 GROUNDWATER QUALITY MONITORING NETWORK

Groundwater quality monitoring is conducted through a groundwater well monitoring network. While the sustainable management criteria established in Section 3.6 (Degraded Water Quality) focuses on salinity (by total dissolved solids [TDS]), the water quality monitoring network is established for a broader spectrum of constituents to characterize water quality conditions throughout the basin, regardless of relevance to management under this GSP. This broader focus allows for documentation of issues which could then be resolved through the appropriate program, such as this GSP, Irrigated Lands Regulatory Program (ILRP), Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), Regional Water Quality Control Board (RWQCB), or others (see Section 1.2.2.2 - Groundwater Quality Monitoring). Within that broad focus is monitoring for salinity (by TDS) to determine trends and provide representative information about groundwater conditions as necessary to evaluate GSP implementation.

4.8.1 Monitoring Wells Selected for Monitoring Network

The Merced Subbasin GSP groundwater quality monitoring network totals 287 wells, with 8 wells from the East San Joaquin Water Quality Coalition (ESJWQC) Groundwater Quality Trend Monitoring (GQTM) program and 279 wells sourced from Public Water System (PWS) wells that report data to the State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW).

Groundwater quality monitoring network wells are opportunistically selected, in that they both meet the needs of GSP monitoring for the Subbasin and are being actively monitored for other purposes. The selected wells (e.g., wells from which data are collected in the future for reporting) are not necessarily the specific wells listed in the following subsections, but rather the wells that continue to be monitored under the ESJWQC and DDW programs. Thus, monitoring would not continue if wells were removed from the ESJWQC program or if wells were not sampled for DDW compliance. Additionally, wells added to the ESJWQC program or wells newly sampled for DDW compliance would be added to the monitoring network.

Each group is described in the subsection below.

4.8.1.1 ESJWQC GQTM Principal Wells

ESJWQC was formed in response to the adoption of the ILRP by the Central Valley RWQCB in 2003. The ILRP was initiated to regulate discharges from irrigated agriculture to surface waters and groundwater. To comply with this new regulation, owners or operators of irrigated cropland in the Central Valley could either obtain an individual permit for each farming operation or join a group that represents farmers across a specific geographic region. ESJWQC was formed to give growers an option for complying with ILRP. The ESJWQC encompasses the lower Stanislaus, Tuolumne, and Merced River watersheds and includes the irrigated farmland in Stanislaus and Merced counties. Through this designation the ESJWQC monitors the Merced Subbasin along with the Turlock and Chowchilla Subbasins (ESJWQC, 2018).

ESJWQC's GQTM Phase III workplan is the final part of a multi-phase approach to establish a network of wells to use for the GQTM program. ESJWQC initially selected five principal wells within the Merced Subbasin which meet the requirements of the waste discharge requirements (WDRs) and can be accessed for annual sampling. These are all domestic wells owned by ESJWQC members that have been vetted for construction details, accessibility, and condition. An additional four principal wells have been added within the Merced Subbasin in subsequent ESJWQC GQTM annual reports.

4.8.1.2 PWS Wells That Report to DDW

The SWRCB DDW requires monitoring of PWS wells for Title 22 requirements (such as organic and inorganic compounds, metals, microbial, and radiological analytes). Data is available for active and inactive drinking water sources for water systems that serve the public: defined as serving 15 or more connections or more than 25 people per day. Wells are monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate.

There are 279 PWS wells within the Merced Subbasin that report water quality data to DDW. Out of these 279, 14 are classified as complementary wells in the ESJWQC's GQTM Phase III workplan. These 14 wells are expected to add substantial value to the GQTM program due to availability of historical data, but they may not satisfy the criteria for principal wells (ESJWQC, 2018).

The remaining 265 PWS wells also report water quality data to DDW but are not included in the group of complementary wells selected by the ESJWQC GQTM program.

4.8.1.3 Overall Monitoring Network

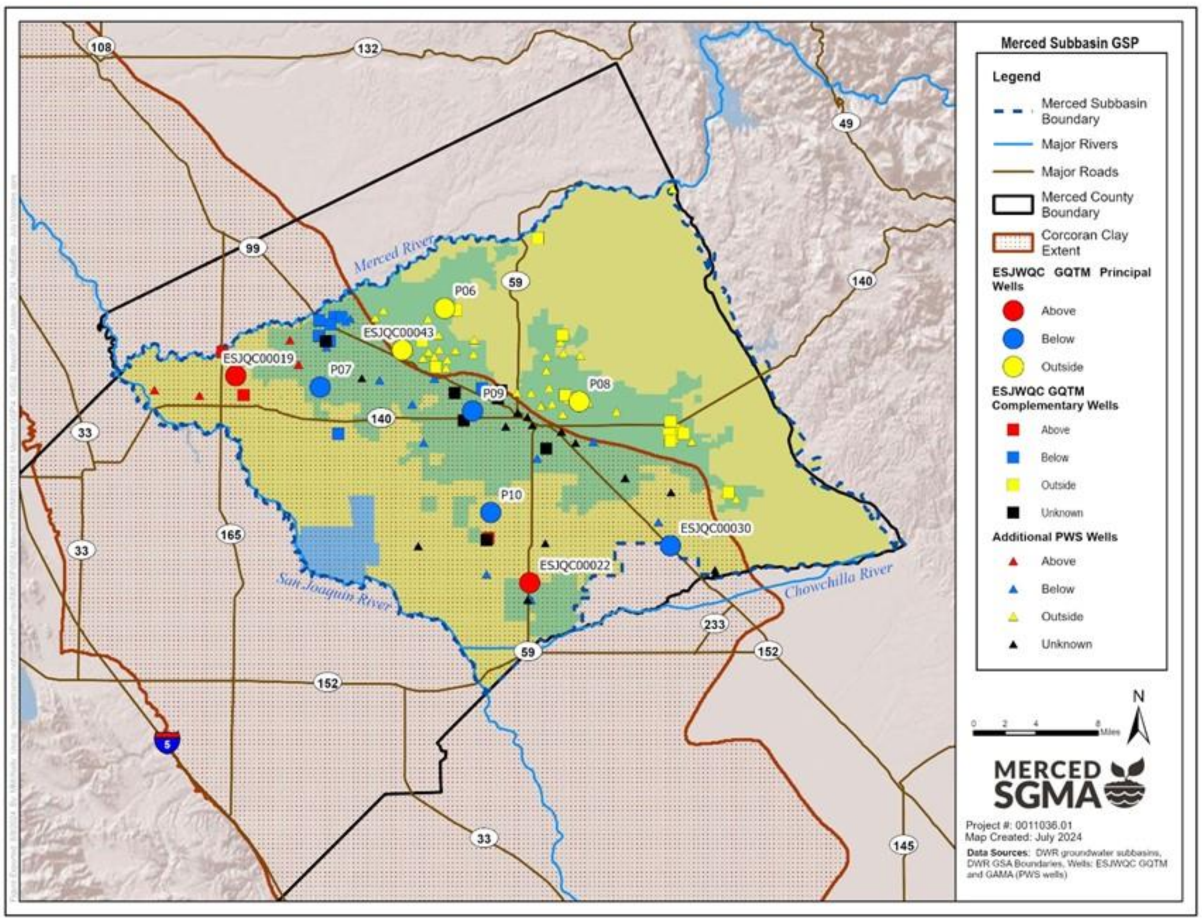
Table 4-6 lists the monitoring sites selected for the groundwater quality monitoring network by category and principal aquifer. The monitoring network is composed of 4 wells located within the Above Corcoran Clay Principal Aquifer, 7 wells within the Below Corcoran Clay Principal Aquifer, 131 wells within the Outside Corcoran Clay Principal Aquifer, and 145 wells in an unknown principal aquifer (either Above Corcoran Clay or Below Corcoran Clay, unknown due to lack of depth information).

Figure 4-6 shows the Merced Subbasin GSP Groundwater Quality Monitoring Network.

Table 4-6: Merced GSP Groundwater Quality Monitoring Well Selection by Principal Aquifer

Category	Principal Aquifer				Total Wells
	Above Corcoran Clay	Below Corcoran Clay	Outside Corcoran Clay	Unknown	
ESJWQC GQTM Principal Wells	2	4	3	0	9
ESJWQC GQTM Complementary Wells	4	8	15	7	34
Other PWS Wells	8	29	56	19	112
Total	**14**	**41**	**74**	**26**	**155**

Figure 4-6: Merced Subbasin GSP Groundwater Quality Monitoring Network Wells



4.8.2 Monitoring Frequency

Sampling of GQTM principal wells will be conducted by ESJWQC at approximately the same time each year, per the WDRs, and will occur in the fall (ESJWQC, 2018). The GSAs will coordinate with ESJWQC to obtain the necessary TDS (or EC when TDS is not available, see Section 3.6.2) results for GSP reporting.

PWS wells are sampled according to DDW requirements which will vary by well and by constituent.

4.8.3 Spatial Density

DWR's *Monitoring Networks and Identification of Data Gaps BMP* states "The spatial distribution [of the groundwater quality monitoring network] must be adequate to map or supplement mapping of known contaminants" (DWR, 2016b). The selected groundwater quality monitoring network wells provide adequate coverage of the Outside Corcoran Clay Principal Aquifer for purposes of mapping salinity. The lack of depth information for many wells located in the Above and Below Corcoran Clay Principal Aquifers is a significant data gap described further in Section 4.8.7.

Various spatial considerations were considered in designing the GQTM network (ESJWQC, 2015). These considerations focused on where and how to representatively monitor groundwater quality trends relative to agricultural activities. Spatial factors relating to the GQTM design include:

- **Prioritization of high vulnerability areas.** High vulnerability areas are monitoring areas where physical conditions make groundwater more vulnerable to impacts from overlying land use activities
- **Well characteristics (pumping rate and depth) and the aquifer properties in the area.** Larger-capacity (higher pumping rates) wells such as irrigation wells and public water supply wells provide a better representation of regional groundwater conditions because these wells have relatively larger groundwater captures zones drawing groundwater from a greater contributing area and minimizing the degree to which a well reflects highly localized groundwater conditions.
- Well construction characteristics (e.g., well completion reports), the accessibility of wells and willing cooperation of well owners for inclusion in the monitoring program, and the desired spatial distribution and adequacy to provide the information needed to fulfill the objectives of the GQTM.

PWS wells that report to DDW are located throughout the Subbasin but are concentrated in urban areas where water suppliers have wells for municipal uses.

4.8.4 Representative Monitoring

The Merced Subbasin GSP groundwater quality monitoring network totals 155 wells, nine of which are designated as representative wells. The nine GQTM principal wells are the nine wells where minimum thresholds have been established, and they are committed to annual sampling and reporting. The remaining GQTM complementary wells and other PWS wells all report to DDW on a variety of schedules and serve as general trend monitoring wells for the GSP.

Figure 4-6 shows the locations of the groundwater quality monitoring network monitoring and representative wells. Table 4-7 details additional information about the 43 GQTM program wells that are part of the groundwater quality monitoring network. The nine representative wells (GQTM principal wells) are identified with an asterisk (*) next to the ESJWQC ID. The additional 112 PWS wells are shown in Table 4-8.

Table 4-7: Merced Subbasin GSP Groundwater Quality Monitoring Network GQTM Well Details

Principal or Complementary? [1]	ESJWQC ID	Owner	Principal Aquifer	Well Depth (ft)	Depth to Top of Screen Interval (ft)	Depth to Bottom of Screen Interval (ft)	Latitude	Longitude
Principal	P06*	(domestic)	Outside	185	215	235	37.40480	-120.58900
Principal	P07*	(domestic)	Below	195	220	230	37.33080	-120.73500
Principal	P08*	(domestic)	Outside	150	170	180	37.31780	-120.43200
Principal	P09*	(domestic)	Below	150	170	180	37.30920	-120.55600
Principal	P10*	(domestic)	Below	Unknown	Unknown	180	37.21440	-120.53500
Principal	ESJQC00019*	(domestic)	Above	162	142	162	37.34129	-120.833
Principal	ESJQC00022*	(domestic)	Above	124	112	122	37.14877	-120.489
Principal	ESJQC00030*	(observation)	Below	290	105	280	37.18317	-120.325
Principal	ESJQC00043*		Outside				37.36574	-120.63842
Complementary	C35	Sandy Mush Detention Center d.b.a. John	Above	140	100	140	37.19042	-120.53781
Complementary	C41	Stevinson Ranch Golf Club	Above	115	95	115	37.32350	-120.82392
Complementary	C45	Hagaman County Park (MCDPW)	Above	138	113	138	37.36339	-120.84869
Complementary	C38	City of Livingston	Below	233	160	233	37.39336	-120.73563
Complementary	C44	Foster Farms Fertilizer Plant	Below	268	248	268	37.28760	-120.71300
Complementary	C40	City of Atwater	Outside	146	86	146	37.35009	-120.59938
Complementary	C42	Black Rascal Water Company	Outside	154	124	154	37.32372	-120.44803
Complementary	C43	Planada CSD	Outside	180	130	180	37.29125	-120.32081
Complementary	C46	Planada CSD	Outside	Unknown	140	170	37.28806	-120.30972

Complementary	C47	Oasis Ranch (closed)	Outside	230	115	135	37.28104	-120.32534
Complementary	C39	Merced Golf & Country Club	Outside	Unknown	Unknown	Unknown	37.37980	-120.45101
Complementary	C48	Le Grand Community Services District	Outside	304	234	304	37.23290	-120.25738
Complementary	C49	Sandy Mush Detention Center d.b.a. John	Unknown	Unknown	Unknown	Unknown	37.18858	-120.53975
Complementary	C50	McSwain Elementary School	Unknown	Unknown	Unknown	Unknown	37.30021	-120.56643
Complementary	2400134-003		Unknown	Unknown	Unknown	Unknown	37.32571	-120.57710
Complementary	2400172-002		Above	Unknown	110	145	37.19044	-120.53785
Complementary	2410004-008		Below	Unknown	165	242	37.39660	-120.71777
Complementary	2410004-009		Below	Unknown	167	238	37.38945	-120.72261
Complementary	2410004-012		Below	Unknown	165	267	37.37392	-120.72326
Complementary	2410004-013		Below	Unknown	162	264	37.37885	-120.73622
Complementary	2410004-025		Below	Unknown	236	326	37.39663	-120.70962
Complementary	2410004-028		Unknown	Unknown	Unknown	Unknown	37.37376	-120.72826
Complementary	2410007-001		Outside	Unknown	0	10	37.28917	-120.32419
Complementary	2410007-004		Outside	Unknown	0	50	37.28981	-120.31499
Complementary	2410007-006		Outside	Unknown	0	70	37.28436	-120.32268
Complementary	2410007-007		Outside	Unknown	0	46	37.28722	-120.32641
Complementary	2410007-014		Outside	Unknown	240	300	37.29917	-120.32503
Complementary	2410008-004		Unknown	Unknown	0	101	37.32815	-120.52263
Complementary	2410008-005		Below	Unknown	275	338	37.33003	-120.54522
Complementary	2410008-010		Unknown	Unknown	Unknown	Unknown	37.32097	-120.52658
Complementary	2410009-057		Unknown	Unknown	Unknown	Unknown	37.27389	-120.47028
Complementary	2410010-014		Outside	Unknown	525	650	37.40323	-120.57577

Complementary	2410010-019		Outside	Unknown	243	374	37.37464	-120.61543
Complementary	5000433-008		Outside	Unknown	Unknown	Unknown	37.47022	-120.48009
Complementary	T10000004224-071415							

1. Principal and Complementary wells in the ESJWQC GQTM Program are defined in Section 4.8.1 - Monitoring Wells Selected for Monitoring Network.

Table 4-8: PWS Wells Not Part of GQTM Program

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602410010	2410010-007	Outside	37.38333	-120.63333
W0602410010	2410010-006	Outside	37.38333	-120.61667
W0602410001	2410001-013	Outside	37.36458	-120.60758
W0602410001	2410001-017	Outside	37.36007	-120.60114
W0602410001	2410001-003	Outside	37.35000	-120.60000
W0602400084	2400084-001	Outside	37.38017	-120.59571
W0602410001	2410001-019	Outside	37.36693	-120.59526
W0602400010	2400010-002	Outside	37.36000	-120.57000
W0602410009	2410009-048	Outside	37.32665	-120.50420
W0602410009	2410009-049	Outside	37.31611	-120.46333
W0602410009	2410009-022	Outside	37.32476	-120.44327
W0602400114	2400114-003	Outside	37.37618	-120.42206
W0602400315	2400315-001	Outside	37.29604	-120.40428
W0602410011	2410011-004	Outside	37.22722	-120.24833
W0602400128	2400128-001	Outside	37.41087	-120.68957
W0602400011	2400011-001	Outside	37.36605	-120.63034
W0602400069	2400069-001	Outside	37.38000	-120.61000
W0602410001	2410001-011	Outside	37.35000	-120.58333
W0602400182	2400182-011	Outside	37.43971	-120.58267
W0602410700	2410700-010	Outside	37.36603	-120.57631
W0602400344	2400344-001	Unknown	37.29762	-120.44728
W0602400151	2400151-001	Outside	37.51000	-120.44000
W0602400047	2400047-001	Outside	37.51000	-120.43000
W0602400230	2400230-001	Outside	37.33156	-120.41886
W0602410007	2410007-003	Outside	37.30000	-120.31667
W0602400067	2400067-001	Outside	37.22000	-120.25000
W0602400013	2400013-003	Outside	37.39166	-120.66542
W0602410010	2410010-003	Outside	37.38333	-120.61667
W0602400143	2400143-001	Outside	37.37193	-120.59045
W0602410001	2410001-016	Outside	37.35758	-120.58588
W0602400117	2400117-001	Outside	37.34350	-120.57929
W0602400136	2400136-001	Outside	37.35000	-120.47000
W0602410009	2410009-019	Outside	37.33110	-120.46667
W0602410009	2410009-009	Outside	37.30000	-120.46667
W0602410009	2410009-054	Outside	37.30639	-120.45083
W0602410009	2410009-014	Outside	37.32456	-120.44398
W0602400114	2400114-002	Outside	37.37236	-120.42708
W0602410007	2410007-007	Outside	37.28722	-120.32641
W0602400013	2400013-002	Outside	37.39009	-120.66547
W0602400011	2400011-012	Outside	37.36605	-120.63112
W0602400011	2400011-011	Outside	37.35713	-120.62988
W0602410010	2410010-012	Outside	37.39006	-120.62322
W0602410010	2410010-015	Outside	37.40367	-120.62256

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602410010	2410010-005	Outside	37.38333	-120.61667
W0602410010	2410010-008	Outside	37.38333	-120.61667
W0602410001	2410001-014	Outside	37.35865	-120.61438
W0602410001	2410001-004	Outside	37.35000	-120.60000
W0602410010	2410010-010	Outside	37.38333	-120.60000
W0602410001	2410001-012	Outside	37.35000	-120.58333
W0602410001	2410001-021	Outside	37.37593	-120.55440
W0602410009	2410009-016	Outside	37.32610	-120.48792
W0605000433	5000433-008	Outside	37.47022	-120.48009
W0602400046	2400046-001	Outside	37.32025	-120.44492
W0602400176	2400176-001	Outside	37.31196	-120.44300
W0602410009	2410009-017	Outside	37.28972	-120.41861
W0602410007	2410007-001	Outside	37.28917	-120.32419
W0602410007	2410007-004	Outside	37.28981	-120.31499
W0602410011	2410011-003	Outside	37.23151	-120.25492
W0602410011	2410011-002	Outside	37.22723	-120.24856
W0602410010	2410010-019	Outside	37.37464	-120.61543
W0602400234	2400234-001	Outside	37.36803	-120.61289
W0602400061	2400061-001	Outside	37.36000	-120.61000
W0602410010	2410010-001	Outside	37.38333	-120.60000
W0602410001	2410001-009	Outside	37.34418	-120.59608
W0602400149	2400149-001	Outside	37.39728	-120.59471
W0602410001	2410001-018	Outside	37.34958	-120.58724
W0602410700	2410700-002	Outside	37.36333	-120.57222
W0602410700	2410700-004	Outside	37.36278	-120.57111
W0602410700	2410700-003	Outside	37.36278	-120.57056
W0602410700	2410700-006	Outside	37.37472	-120.55972
W0602410009	2410009-013	Outside	37.32448	-120.44418
W0602400112	2400112-011	Outside	37.28000	-120.32000
W0602400152	2400152-001	Outside	37.30000	-120.32000
W0602400013	2400013-004	Outside	37.39022	-120.66602
W0602400011	2400011-013	Outside	37.36605	-120.63032
W0602410001	2410001-002	Outside	37.35000	-120.61667
W0602410001	2410001-001	Outside	37.35000	-120.61667
W0602410010	2410010-013	Outside	37.39580	-120.60839
W0602410010	2410010-002	Outside	37.38333	-120.60000
W0602400203	2400203-001	Outside	37.36000	-120.59000
W0602400117	2400117-014	Outside	37.34403	-120.58270
W0602410700	2410700-007	Outside	37.35944	-120.57639
W0602410700	2410700-005	Outside	37.37528	-120.55861
W0602400130	2400130-001	Outside	37.33000	-120.52000
W0602410009	2410009-001	Outside	37.31445	-120.47598
W0602410009	2410009-002	Outside	37.31429	-120.47572
W0602400114	2400114-014	Outside	37.36856	-120.43252
W0602400031	2400031-001	Outside	37.29000	-120.40000

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602400240	2400240-002	Outside	37.29697	-120.35523
W0602400112	2400112-001	Outside	37.28000	-120.32000
W0602400162	2400162-001	Outside	37.41087	-120.68957
W0602400307	2400307-001	Outside	37.41960	-120.66652
W0602410001	2410001-007	Outside	37.35000	-120.61667
W0602410010	2410010-009	Outside	37.38333	-120.61667
W0602410010	2410010-004	Outside	37.38333	-120.61667
W0602410010	2410010-011	Outside	37.38472	-120.61222
W0602400159	2400159-001	Outside	37.37000	-120.61000
W0602410001	2410001-008	Outside	37.35000	-120.60000
W0602410001	2410001-010	Outside	37.35000	-120.60000
W0602400059	2400059-001	Outside	37.36000	-120.58000
W0602410010	2410010-014	Outside	37.40323	-120.57577
W0602400010	2400010-003	Outside	37.36000	-120.57000
W0602400111	2400111-001	Outside	37.33000	-120.51000
W0602400148	2400148-001	Outside	37.31779	-120.44311
W0602400219	2400219-001	Outside	37.29641	-120.44126
W0602410009	2410009-043	Outside	37.36144	-120.43006
W0602400114	2400114-004	Outside	37.37926	-120.42189
W0602400212	2400212-001	Outside	37.36000	-120.42000
W0602400340	2400340-001	Outside	37.29461	-120.32531
W0602410007	2410007-014	Outside	37.29917	-120.32503
W0602410007	2410007-006	Outside	37.28436	-120.32268
W0602410001	2410001-005	Outside	37.35000	-120.60000
W0602400021	2400021-001	Outside	37.38000	-120.59000
W0602400009	2400009-001	Outside	37.36097	-120.58305
W0602400010	2400010-001	Outside	37.36000	-120.57000
W0602400071	2400071-001	Outside	37.43944	-120.56431
W0602410700	2410700-012	Outside	37.36245	-120.55520
W0602410009	2410009-003	Outside	37.31411	-120.47622
W0602410009	2410009-042	Outside	37.34703	-120.46995
W0602400327	2400327-001	Outside	37.30675	-120.44400
W0602410009	2410009-018	Outside	37.28944	-120.42438
W0602410011	2410011-001	Outside	37.23333	-120.25000
-	2400046-002	Outside	37.32372	-120.44803
-	2410007-005	Outside	37.29125	-120.32081
W0602400169	2400169-022	Unknown	37.38656	-120.79612
W0602400190	2400190-001	Unknown	37.30000	-120.77000
W0602400331	2400331-001	Unknown	37.36471	-120.74270
W0602410004	2410004-013	Below	37.37885	-120.73622
W0602410004	2410004-009	Below	37.38945	-120.72261
W0602400097	2400097-001	Below	37.35219	-120.71900
W0602410004	2410004-006	Unknown	37.38333	-120.71667
W0602410004	2410004-004	Unknown	37.38333	-120.71667
W0602400206	2400206-002	Unknown	37.28791	-120.67396

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602400104	2400104-002	Unknown	37.34000	-120.63000
W0602400052	2400052-002	Unknown	37.33816	-120.61802
W0602400138	2400138-003	Unknown	37.34000	-120.60000
W0602400034	2400034-011	Below	37.33047	-120.57905
W0602400134	2400134-001	Below	37.32569	-120.57706
W0602400003	2400003-001	Unknown	37.33000	-120.57000
W0602410008	2410008-005	Below	37.33003	-120.54522
W0602410008	2410008-001	Unknown	37.32097	-120.52637
W0602400007	2400007-002	Unknown	37.31597	-120.52411
W0602400007	2400007-012	Unknown	37.31594	-120.52383
W0602410008	2410008-004	Unknown	37.32815	-120.52263
W0602400053	2400053-002	Unknown	37.13261	-120.49133
W0602400103	2400103-001	Unknown	37.28000	-120.49000
W0602410009	2410009-010	Unknown	37.30000	-120.48333
W0602400248	2400248-001	Unknown	37.18627	-120.47135
W0602410009	2410009-007	Unknown	37.28333	-120.46667
W0602410009	2410009-023	Unknown	37.28997	-120.45246
W0602400065	2400065-001	Unknown	37.23358	-120.32453
W0602410004	2410004-003	Unknown	37.38333	-120.71667
W0602400027	2400027-001	Unknown	37.36000	-120.66000
W0602400052	2400052-001	Unknown	37.33840	-120.61816
W0602400138	2400138-002	Unknown	37.34000	-120.60000
W0602400135	2400135-001	Unknown	37.33000	-120.58000
W0602400005	2400005-001	Unknown	37.33548	-120.57731
W0602400015	2400015-001	Unknown	37.33000	-120.57000
W0602400172	2400172-013	Unknown	37.19044	-120.53694
W0602400153	2400153-001	Below	37.31282	-120.51708
W0602400140	2400140-001	Below	37.31282	-120.51708
W0602400053	2400053-001	Unknown	37.13278	-120.49028
W0602400186	2400186-001	Unknown	37.24699	-120.37804
W0602400065	2400065-002	Unknown	37.23333	-120.32500
W0602410004	2410004-015	Below	37.38822	-120.73409
W0602410004	2410004-010	Unknown	37.37838	-120.72994
W0602410004	2410004-012	Below	37.37392	-120.72326
W0602410004	2410004-001	Unknown	37.38333	-120.71667
W0602400024	2400024-001	Unknown	37.36000	-120.67000
W0602400110	2400110-001	Unknown	37.36108	-120.65328
W0602400104	2400104-001	Unknown	37.34000	-120.63000
W0602410001	2410001-015	Below	37.33970	-120.60093
W0602400227	2400227-002	Unknown	37.29760	-120.55214
W0602410008	2410008-003	Unknown	37.32989	-120.54517
W0602400033	2400033-001	Unknown	37.29391	-120.47374
W0602400139	2400139-001	Unknown	37.26850	-120.43750
W0602410009	2410009-020	Unknown	37.28002	-120.43593
W0602400300	2400300-001	Unknown	37.22893	-120.32553

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602400064	2400064-001	Above	37.32861	-120.85781
W0602400215	2400215-001	Unknown	37.32350	-120.82392
W0602400169	2400169-016	Unknown	37.38517	-120.78578
W0602410004	2410004-028	Unknown	37.37376	-120.72826
W0602400249	2400249-002	Unknown	37.36151	-120.72452
W0602400333	2400333-001	Unknown	37.36995	-120.72289
W0602400113	2400113-014	Unknown	37.38650	-120.68466
W0602400138	2400138-004	Unknown	37.34000	-120.60000
W0602400036	2400036-001	Unknown	37.32000	-120.57000
W0602400160	2400160-001	Unknown	37.13120	-120.56470
W0602400075	2400075-002	Unknown	37.13325	-120.48805
W0602410009	2410009-008	Unknown	37.29638	-120.48643
W0602410009	2410009-006	Unknown	37.28333	-120.46667
W0602400139	2400139-011	Unknown	37.26560	-120.43607
W0602400101	2400101-001	Unknown	37.28000	-120.43000
W0602400250	2400250-001	Unknown	37.15592	-120.26774
W0602400082	2400082-001	Unknown	37.32715	-120.85080
W0602400169	2400169-017	Unknown	37.38626	-120.80024
W0602400169	2400169-004	Unknown	37.37840	-120.78717
W0602400122	2400122-001	Below	37.35221	-120.71902
W0602410004	2410004-002	Unknown	37.36667	-120.71667
W0602410004	2410004-007	Unknown	37.37389	-120.71389
W0602400336	2400336-001	Unknown	37.36715	-120.71305
W0602400255	2400255-002	Unknown	37.35321	-120.70358
W0602400174	2400174-011	Unknown	37.15000	-120.69254
W0602410001	2410001-020	Below	37.33831	-120.58296
W0602400156	2400156-001	Unknown	37.33000	-120.57000
W0602400079	2400079-012	Unknown	37.30203	-120.56837
W0602410009	2410009-021	Unknown	37.29529	-120.51748
W0602410009	2410009-015	Unknown	37.30801	-120.50360
W0602410009	2410009-011	Unknown	37.30417	-120.49220
W0602400053	2400053-013	Unknown	37.13318	-120.49173
W0602400102	2400102-001	Unknown	37.28000	-120.47000
W0602400223	2400223-001	Unknown	37.16147	-120.27222
W0602400326	2400326-001	Unknown	37.36130	-120.74053
W0602400127	2400127-001	Unknown	37.36000	-120.74000
W0602400025	2400025-001	Unknown	37.37000	-120.73000
W0602410004	2410004-008	Below	37.39660	-120.71777
W0602410004	2410004-005	Unknown	37.38333	-120.71667
W0602400328	2400328-001	Unknown	37.36099	-120.70770
W0602400113	2400113-013	Unknown	37.38669	-120.68462
W0602400232	2400232-002	Unknown	37.34237	-120.68359
W0602400334	2400334-001	Outside	37.36722	-120.67821
W0602400206	2400206-001	Unknown	37.28484	-120.67785
W0602400206	2400206-004	Unknown	37.27421	-120.67524

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
W0602700592	2700592-001	Unknown	37.13120	-120.56470
W0602410008	2410008-010	Unknown	37.32097	-120.52658
W0602400053	2400053-014	Unknown	37.13365	-120.49200
W0602400211	2400211-012	Unknown	37.27799	-120.48603
W0602400030	2400030-001	Unknown	37.28000	-120.46000
W0602410009	2410009-004	Unknown	37.29035	-120.45244
W0602410009	2410009-005	Unknown	37.29048	-120.45244
W0602410009	2410009-041	Below	37.28081	-120.41505
W0602400077	2400077-001	Unknown	37.32947	-120.85127
W0602400169	2400169-002	Unknown	37.37933	-120.78710
W0602400191	2400191-001	Unknown	37.30000	-120.77000
W0602400118	2400118-001	Unknown	37.39000	-120.73000
W0602400081	2400081-001	Unknown	37.39000	-120.73000
W0602410004	2410004-025	Below	37.39663	-120.70962
W0602410004	2410004-014	Below	37.39278	-120.70467
W0602400129	2400129-001	Unknown	37.37056	-120.67444
W0602400206	2400206-003	Unknown	37.28430	-120.67212
W0602400114	2400114-001	Unknown	37.36108	-120.65328
W0602400138	2400138-001	Unknown	37.34000	-120.60000
W0602400001	2400001-001	Unknown	37.34000	-120.58000
W0602400320	2400320-001	Unknown	37.33750	-120.57646
W0602400222	2400222-001	Unknown	37.16147	-120.53686
W0602400007	2400007-001	Unknown	37.31592	-120.52344
W0602400116	2400116-001	Unknown	37.28000	-120.48000
W0602400099	2400099-001	Below	37.36339	-120.84869
W0602400215	2400215-011	Unknown	37.32426	-120.83073
W0602400169	2400169-018	Unknown	37.38661	-120.79704
W0602400169	2400169-014	Unknown	37.37522	-120.77818
W0602400337	2400337-001	Unknown	37.33155	-120.75172
W0602400331	2400331-002	Unknown	37.36601	-120.74422
W0602400323	2400323-001	Unknown	37.32783	-120.74053
W0602400232	2400232-003	Unknown	37.34514	-120.68349
W0602400146	2400146-001	Unknown	37.35000	-120.63000
W0602400117	2400117-011	Unknown	37.33958	-120.58188
W0602400001	2400001-002	Unknown	37.34000	-120.58000
W0602400079	2400079-002	Unknown	37.29995	-120.56646
W0602400175	2400175-001	Unknown	37.19042	-120.53781
W0602410008	2410008-002	Unknown	37.32804	-120.52938
W0602400318	2400318-001	Unknown	37.13659	-120.49135
W0602410009	2410009-012	Unknown	37.28794	-120.48125
W0602400054	2400054-001	Unknown	37.29000	-120.48000
W0602410009	2410009-057	Unknown	37.27389	-120.47028
W0602400144	2400144-001	Unknown	37.27000	-120.45000
W0602400075	2400075-001	Below	37.23358	-120.32453
-	2400134-003	Unknown	37.32571	-120.57710

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
-	2400172-002	Unknown	37.19045	-120.53650
-	240172-012	Unknown	37.18858	-120.53975
-	2400223-002	Unknown	37.16113	-120.27341
-	2400223-003	Unknown	37.15794	-120.27290
-	2400232-004	Unknown	37.34004	-120.68570
-	2400172-002	Above	37.19044	-120.53785
-	2410004-011	Below	37.39336	-120.68570
-	USGS-370800120291701	Below	37.13325	-120.48803
-	USGS-370804120292401	Below	37.13439	-120.49008
-	USGS-370926120322401	Below	37.15731	-120.53986
-	USGS-371100120370001	Below	37.18347	-120.61953
-	USGS-371221120202201	Below	37.20585	-120.33930
-	USGS-371300120150001	Outside	37.23294	-120.25739
-	USGS-371357120154001	Outside	37.23247	-120.26100
-	USGS-371449120224101	Below	37.24700	-120.37803
-	USGS-371555120285101	Below	37.26531	-120.48075
-	USGS-371648120364901	Below	37.27994	-120.61350
-	USGS-371651120180001	Outside	37.28081	-120.30014
-	USGS-371722120192401	Outside	37.28939	-120.32435
-	USGS-371829120300801	Below	37.30808	-120.50358
-	USGS-371832120231201	Outside	37.30885	-120.38811
-	USGS-371835120331801	Below	37.30917	-120.55611
-	USGS-371856120373601	Below	37.31569	-120.62669
-	USGS-371902120251501	Outside	37.31708	-120.42078
-	USGS-371908120254001	Outside	37.31929	-120.42769
-	USGS-371924120523101	Above	37.32328	-120.87536
-	USGS-371942120554101	Above	37.32842	-120.92814
-	USGS-372017120395401	Below	37.33808	-120.66497

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
-	USGS-372100120340001	Outside	37.36611	-120.57636
-	USGS-372110120453101	Above	37.35253	-120.75969
-	USGS-372149120280101	Outside	37.36353	-120.45012
-	USGS-372205120381701	Outside	37.36809	-120.63964
-	USGS-372209120433801	Below	37.36911	-120.72731
-	USGS-372227120271201	Outside	37.37411	-120.45347
-	USGS-372231120461201	Above	37.37528	-120.77000
-	USGS-372344120415801	Below	37.39564	-120.69956
-	USGS-372346120401201	Outside	37.39603	-120.67008
-	USGS-372412120393401	Outside	37.40327	-120.66048
-	USGS-373100120191901	Outside	37.51661	-120.32192
-	MADCHOW-12R	Below	37.13325	-120.48803
-	MER-06	Outside	37.28939	-120.32435
-	MER-10	Below	37.30808	-120.50359
-	MER-11	Outside	37.23294	-120.25739
-	MER-12	Unknown	37.18347	-120.61953
-	MER-14	Outside	37.36611	-120.57636
-	S12-ME01	Outside	37.37411	-120.45348
-	S12-ME02-U	Outside	37.31708	-120.42078
-	S12-ME03	Outside	37.36809	-120.63964
-	S12-ME04	Outside	37.39603	-120.67008
-	S12-ME05-U	Below	37.39564	-120.69955
-	S12-ME06	Above	37.37528	-120.77000
-	S12-ME07	Below	37.30917	-120.55611
-	S12-ME08-U	Below	37.36911	-120.72730
-	S12-ME09	Above	37.35253	-120.75970
-	S12-ME10	Above	37.32328	-120.87536
-	S12-ME11-U	Above	37.32841	-120.92814
-	S12-ME12	Below	37.27995	-120.61350
-	S12-ME13	Unknown	37.24700	-120.37803
-	S12-ME14	Below	37.33809	-120.66497
-	S12-ME15	Outside	37.40327	-120.66048
-	S12-ME16	Outside	37.30885	-120.38811
-	S12-ME17	Outside	37.28080	-120.30014
-	S12-ME18	Below	37.26530	-120.48075
-	S12-ME19	Below	37.20585	-120.33929

Global ID	Well ID	Principal Aquifer	Latitude	Longitude
-	S12-ME20	Outside	37.23247	-120.26100
-	S12-ME21	Outside	37.31929	-120.42770
-	S12-ME22-U	Below	37.15731	-120.53986
-	S12-ME23-U	Below	37.31569	-120.62669
-	S12-ME24	Below	37.13439	-120.49008
-	S12-UP01	Outside	37.36353	-120.45012
-	S12-UP06	Outside	37.51661	-120.32191

4.8.6 Groundwater Quality Monitoring Protocols

Sampling protocols for the ESJWQC GQTM principal wells will follow the guidelines presented in the ESJWQC GQTM Phase I Workplan, consistent with requirements specified in the WDRs and detailed in the Quality Assurance Protection Plan which is still pending review by the RWQCB and State Board QA Officer (MLJ Environmental, 2019) (see Appendix J which includes both the draft Central Valley Groundwater Monitoring Collaborative Quality Assurance Program Plan and the draft Quality Assurance Project Plan specific to the ESJWQC GQTM Program).

GQTM data will be compiled in a database. Data will be compiled and used to develop five-year update reports, beginning January 2019 (ESJWQC, 2018). GQTM workplans Phase I (ESJWQC, 2015) and Phase II (ESJWQC, 2016) describe the annual reporting, data analysis, and presentations that will be submitted annually and on five-year intervals.

Water quality monitoring performed for PWS wells that report to DDW will be performed to DDW protocols which are specific based on the contaminant being sampled.

4.8.7 Data Gaps

Two significant data gaps exist:

- There are relatively few monitoring wells closer to the San Joaquin River and closer to Mariposa County.
- Many wells used for monitoring do not have construction information, which notably limits the ability to distinguish whether wells are below or above the Corcoran Clay.

4.8.8 Progress on Filling Data Gaps

A Data Gaps Plan was prepared by the GSAs in 2021 and describes the ongoing efforts by ESJWQC to expand and improve the GQTM (Woodard & Curran, 2021), of which the GSAs have continued to monitor and report on through the GSP Annual Reports through the inclusion of several new principal and complementary wells that have been incorporated to the monitoring network. Recommendations coming out of the Data Gaps Plan for water quality included:

- Increase monitoring frequency - Coordinate with the existing efforts by ESJWQC in the GQTM due an overlap of goals and objectives. Activities may include working with ESJWQC to fund additional testing of TDS concentrations during annual sampling of primary monitoring wells rather than every 5 years.
- Increase monitoring frequency – Work with PWS to coordinate increased frequency of TDS sampling at complementary wells identified in the GQTM.
- Identify additional wells - Analyze potential wells completed within the Below Corcoran Principal Aquifer and potentially rural or deep areas of the Outside Corcoran Clay Principal

Aquifer for inclusion in the GSP groundwater quality monitoring network. ESJWQC has conducted extensive efforts to identify monitoring wells for inclusion in the Upper Zone which covers the Above Corcoran Clay Principal Aquifer and shallower portions of the Outside Corcoran Clay Principal Aquifer. ESJWQC already plans to continue expanding monitoring in these areas.

- Incorporate data from adjacent subbasins - Coordinate with the neighboring Turlock and Chowchilla Subbasins on collection of water quality information along their respective edges that are adjacent to the Merced Subbasin.

4.8.9 Plan to Fill Data Gaps

The ESJWQC GQTM plan already includes a plan to add additional principal wells, stating that "[t]he spatial representation and statistical validity of the GQTM well network will be evaluated on an annual basis with respect to the objectives of the program" (ESJWQC, 2018). The Phase III Workplan design approach recognizes the importance for the monitoring program to adapt based on consideration of data derived through continuous evaluation of program implementation. Some additional goals discussed in the GQTM plan's network refinement section include:

- Verification of construction information for complementary wells.
- Locating wells in the Chowchilla region where domestic and public supply wells are less common or most often deeper than expected for Upper Zone wells (this region overlaps with the very southern corner of the Merced Subbasin).
- Identification of network wells in "lower vulnerability agricultural areas, especially in the more eastern portions of the Coalition region" (ESJWQC, 2018) through focused outreach efforts to Coalition members, which includes the eastern portion of the Merced Subbasin.

The GSAs plan to obtain additional construction information for at least 20 PWS wells located throughout the Subbasin to determine the completion information for these wells so they can be assigned to Above or Below Corcoran Clay for the purpose of analyzing salinity. Additionally, the GSAs will work with the ESJWQC to identify monitoring opportunities and associated funding opportunities in the data gap areas.

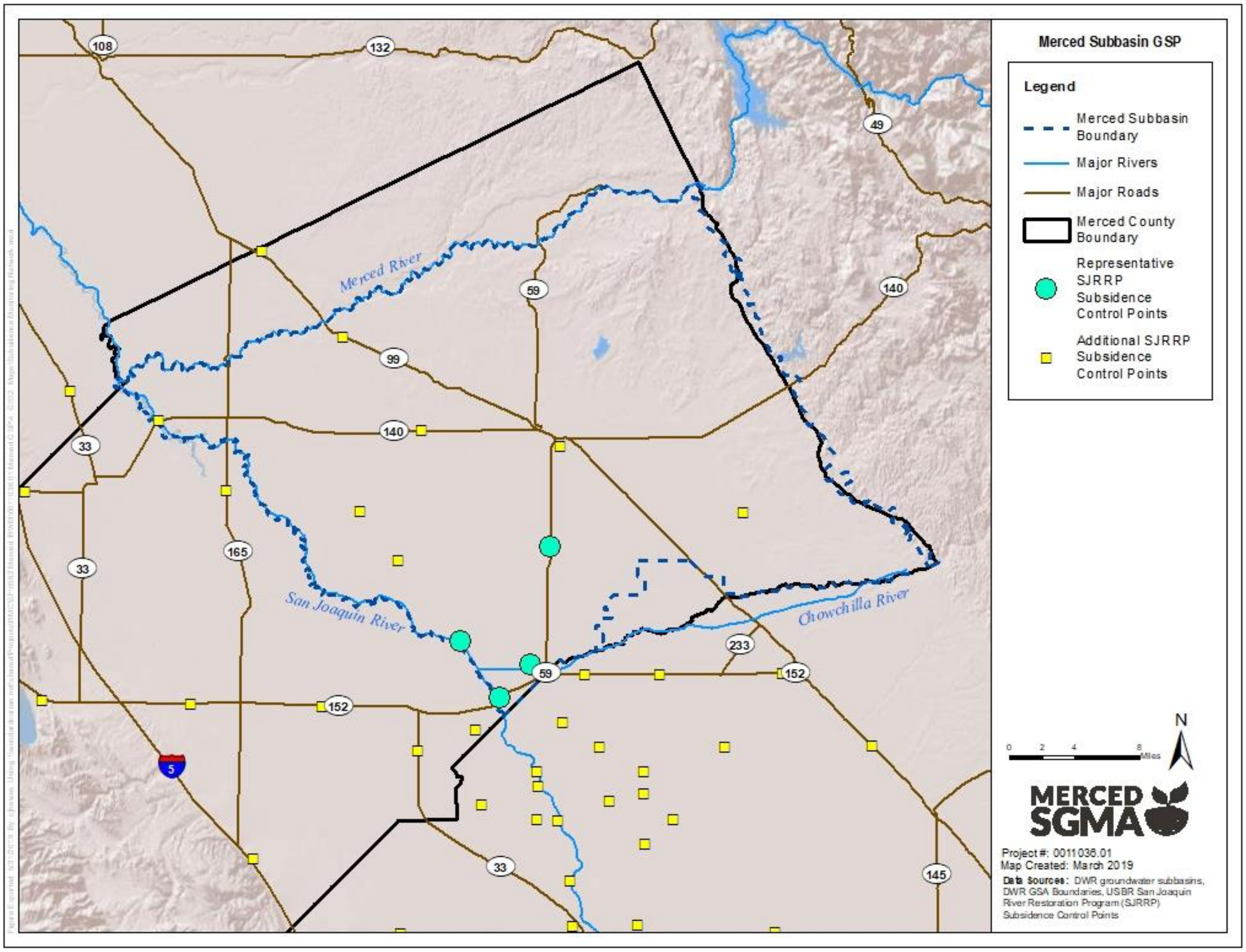
4.9 SUBSIDENCE MONITORING NETWORK

4.9.1 Monitoring Sites Selected for Monitoring Network

The Merced Subbasin GSP subsidence monitoring network includes all 71 subsidence control points monitored by the United States Bureau of Reclamation (USBR) as part of the SJRRP, noting that many of these are outside of the Subbasin, but provide regional context. The control points outside the Subbasin are opportunistically selected, in that they both meet the needs of GSP monitoring for the Subbasin and are being actively monitored for other purposes. The selected sites are not necessarily the specific sites shown and listed below, but rather the sites that continue to be monitored under SJRRP monitoring program. Thus, monitoring would not continue if sites were removed from the program. Additionally, sites added to the program would be added to the monitoring network.

Figure 4-7 shows the Merced Subbasin GSP Subsidence Monitoring Network sites.

Figure 4-7: Merced Subbasin GSP Subsidence Monitoring Network Sites



4.9.2 Monitoring Frequency

USBR conducts subsidence measurements on a semiannual basis. Measurements are recorded in the middle of July and the middle of December as part of the SJRRP.

4.9.3 Spatial Density

DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific spatial density guidelines for subsidence monitoring networks and thus relies on professional judgment on site identification. The subsidence monitoring network stations provide an adequate spatial coverage of the Subbasin, being specifically developed to characterize regional subsidence in support of the SJRRP. However, the locations provide only information on the elevation of the land surface and do not provide information on the depths at which compaction is occurring. Depth of compaction is an important consideration when managing groundwater elevations to avoid dewatering of sensitive clays. Extensometers are needed within the basin and in the nearby portions of neighboring subbasins to provide this information.

4.9.4 Representative Monitoring

The Merced Subbasin GSP subsidence monitoring network includes four representative monitoring sites at which minimum thresholds and measurable objectives were defined. Representative monitoring sites were selected for the subsidence monitoring network because of their proximity to the region of known subsidence in the southern corner of the Subbasin. Other subsidence control points within and outside of the Merced Subbasin will be used to construct maps of regional subsidence rates for ongoing monitoring, tracking, and analysis.

Figure 4-7 (above) shows the locations of the land subsidence monitoring network monitoring and representative sites in the vicinity of the Merced Subbasin. Additional SJRRP subsidence control points are located as far south as Fresno County.

Table 4-9 details the land subsidence monitoring network sites. Representative sites are identified with an asterisk (*) next to the SJRRP ID and Local ID.

Table 4-9: Merced Subbasin GSP Subsidence Monitoring Network and Representative Site Details

SJRRP ID	Local ID	Elevation (ft above MSL)	Latitude	Longitude
119	109.28	111.03	37.46356	-120.81269
121	375 USE	127.64	36.98302	-120.50087
170	4S3	97.9	37.22997	-120.70143
HS2494	57.95 USBR	183.31	37.24608	-121.07802
120	604.164	606.63	36.99646	-119.70152
122	ALEX 5	167.37	36.77005	-120.39230
2160	BLYTHE	232.29	36.53247	-119.87233
2147	BURNSIDE	195.1	36.48785	-120.15206
124	D 158 RESET	146.55	37.08372	-120.44936
125	DWIGHT	183.51	36.82226	-120.50180
2362	DWR 154.33	146.69	37.01822	-120.43325
126	E1420	167.16	37.28817	-120.47662
2076	F 158 RESET 1967	178.59	37.08358	-120.36555

SJRRP ID	Local ID	Elevation (ft above MSL)	Latitude	Longitude
128	F 928	619.26	36.62403	-120.65904
129	FIREPORT	145.42	36.85731	-120.46284
130	FREMONT	73.14	37.31065	-120.92791
131	G 706 RESET	242.93	37.22833	-120.27055
132	G 990	124.4	36.99616	-120.50295
133*	H 1235 RESET*	119.82	37.06187	-120.54345
2348	HARMON	112.54	37.01497	-120.63602
2562	HETFIELD	131.82	36.95189	-120.47907
62	HPGN 06 06	288.74	36.69844	-119.75773
63	HPGN 06 07	328.99	36.50107	-120.35386
135	HPGN CA 06 03	234.65	37.08448	-120.22755
137	HPGN CA 10 01	100.37	37.05472	-120.74308
138	HPGN CA 10 04	238.97	37.46425	-121.17791
139	HPGN D CA 06 NF	185.65	36.59009	-120.06086
141	HPGN D CA 06 RF	284.97	36.88701	-119.98165
142	HPGN D CA 06 RG	430.37	36.97544	-119.79378
143	HPGN D CA 06 SG	1107.13	37.09489	-119.75237
144	HPGN D CA 10 BK	314.06	36.91701	-120.82034
AA4259	HPGN D CA 10 FP	1289.23	37.42909	-120.10257
GU0278	J 1074	704.59	36.78119	-120.81158
145	J 1233	494.09	36.86675	-119.56149
146	K 361	285.34	37.05889	-121.05689
GT1871	KAKTUS	506.69	36.71553	-119.35207
147	KELLIE	123.28	36.96627	-120.56499
GU0492	L 928	1103.55	36.53750	-120.56144
104	LIFESON	179.59	36.77410	-120.28436
148	LIVINGSTON RESET	134.13	37.38675	-120.72109
2107	MARTIN 2008	174.89	36.58926	-120.16264
DH6665	MATTHEW	189.6	36.85084	-120.65533
2378	MELISSA	179.76	37.01834	-120.29259
2149	MURIETTA	164.61	36.63206	-120.31785
150	NEWMAN NW BASE	97.26	37.33715	-121.02848
29	NOTARB	277.64	37.01818	-120.12660
DH6671	PEYTON	233.37	36.70719	-120.45965
1108	R940 RESET	123.59	37.30241	-120.63321
1007R	RBF 1007 RESET	145.34	36.93077	-120.38222
1009	RBF 1009	127.84	36.95265	-120.50342
159	RBF 1027	150.99	36.82490	-120.37284
160R	RBF 1047 RESET	215.34	36.82212	-120.14185
1053R	RBF 1053 RESET	151.35	36.97609	-120.38301
1054R	RBF 1054 RESET	149.15	36.99620	-120.38328
1055R	RBF 1055 RESET	124.96	37.04002	-120.47373
162*	RBF 1057*	119.54	37.09215	-120.51025
158	RBF1026	149.65	36.85772	-120.39088
152	SALT RM1	84.04	37.19244	-120.83978
153	SHAWN	154.1	36.81757	-120.43339
154	SPEAK AZ MK	229.61	36.72608	-120.02468
108	SSH	78.63	37.24767	-120.85146

SJRRP ID	Local ID	Elevation (ft above MSL)	Latitude	Longitude
155	T 987 CADWR	109.39	37.18612	-120.65872
127	USHER	181.93	36.85100	-120.23693
2448	V513	197.46	36.48511	-120.00531
2065*	W 938 RESET*	144.43	37.19818	-120.48807
156*	W 990 CADWR*	111.2	37.11342	-120.58833
123	WES	159.71	36.95263	-120.35004
157	WILLIAM 3	113.61	37.03363	-120.57226
101	X 989	140.54	36.89757	-120.46509
AC5729	X1235	137.94	37.05653	-120.89083
2062	Y 549	139.42	36.96987	-120.42216

* indicates representative monitoring site

Source: San Joaquin River Restoration Program subsidence control points.

4.9.5 Monitoring Protocols

Subsidence monitoring will continue to be performed by USBR in accordance with agency protocols (Appendix K).

4.9.6 Data Gaps

As noted in Section 4.9.3, data gaps exist regarding an understanding of the depth at which subsidence is occurring. It is recommended that one or more extensometers be installed to collect this type of data in or near the Merced Subbasin.

4.9.7 Progress on Filling Data Gaps

A Data Gaps Plan was prepared by the GSAs in 2021 and includes the recommendations to identify funding and locations for installation of extensometer(s) (Woodard & Curran, 2021). To date, no funding has been secured to do so. In the meantime, the AEM survey data (see Section 2.1.4.3) has proven useful in providing additional information on subsurface clays, which has been incorporated into the MercedWRM.

4.9.8 Plan to Fill Data Gaps

The GSAs recognize the importance of managing pumping volumes below the Corcoran Clay, as this is the depth range believed to be causing subsidence. The Projects and Management Actions section includes a project designed to study the potential impacts of moving pumping from below the Corcoran Clay to above the Corcoran Clay. This analysis is intended to facilitate moving pumping within the requirements of Merced County's Groundwater Ordinance. To help inform this study, the Projects and Management Actions section also discusses installation of additional subsidence monitoring that may include installation of extensometers or other measurement methods to help characterize the magnitude, extent, and depth of subsidence and the relationship of subsidence to groundwater pumping activities.

The number and location of extensometers or other measurement methods will be developed in coordination with the SJRRP, the USGS, and other entities associated with subsidence studies, such as the State Water Project, Central Valley Project, California High Speed Rail Authority, and the Central Valley Flood Protection Board. Interbasin coordination will include efforts to coordinate on subsidence monitoring in the Chowchilla and Delta-Mendota Subbasins to better understand trends and any potential correlation to groundwater levels in the different principal aquifers across all subbasins. Subsidence monitoring located nearby but outside of the Subbasin may still fill the existing data gap.

Given the expense of extensometers and some other measurement methods, they may be installed in a phased manner, as funding is available. Funding of a collective effort will be a major component in proceeding with these installations.

4.10 DEPLETIONS OF INTERCONNECTED SURFACE WATER MONITORING NETWORK

Sustainable management criteria for depletions of interconnected surface waters are monitored by proxy through the measurement of groundwater levels (see Section 3.8 for rationale), and the same monitoring network is used to support overall characterization of the Subbasin. The monitoring network is intended to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions.

The monitoring network is developed to characterize the following:

- Flow conditions including surface water discharge, surface water head, and baseflow contribution.
- Temporal change in depletions due to variations in stream discharge and regional groundwater extraction.
- Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

Based on current understanding, ephemeral or intermittent flowing streams are largely located in the eastern portions of the Subbasin and are not thought to be interconnected with the groundwater system (see Figure 2-10 in Section 2.1.3.5 - Groundwater Recharge and Discharge Areas). So, characterization of the date and location at which they cease to flow has been deemed not associated with groundwater conditions and not applicable for monitoring.

4.10.1 Monitoring Sites Selected for Monitoring Network

Monitoring sites include the groundwater level sites identified in Section 4.5 and the stream gage locations described in 1.2.2.4. The stream gage sites are opportunistically selected, in that they both meet the needs of GSP monitoring for the Subbasin and are being actively monitored for other purposes. The selected sites are not necessarily these specific sites, but rather the sites that continue to be monitored under the DWR, USGS, MID, and USACE monitoring programs. Thus, monitoring would not continue if sites were removed from one of these programs. Additionally, sites added to one of these agency programs would be added to the monitoring network.

Figure 4-8 shows the locations of the stream gages. Table 4-10 shows details about the stream gages.

Figure 4-8: Merced Subbasin GSP Interconnected Surface Water Depletions Monitoring Network Sites

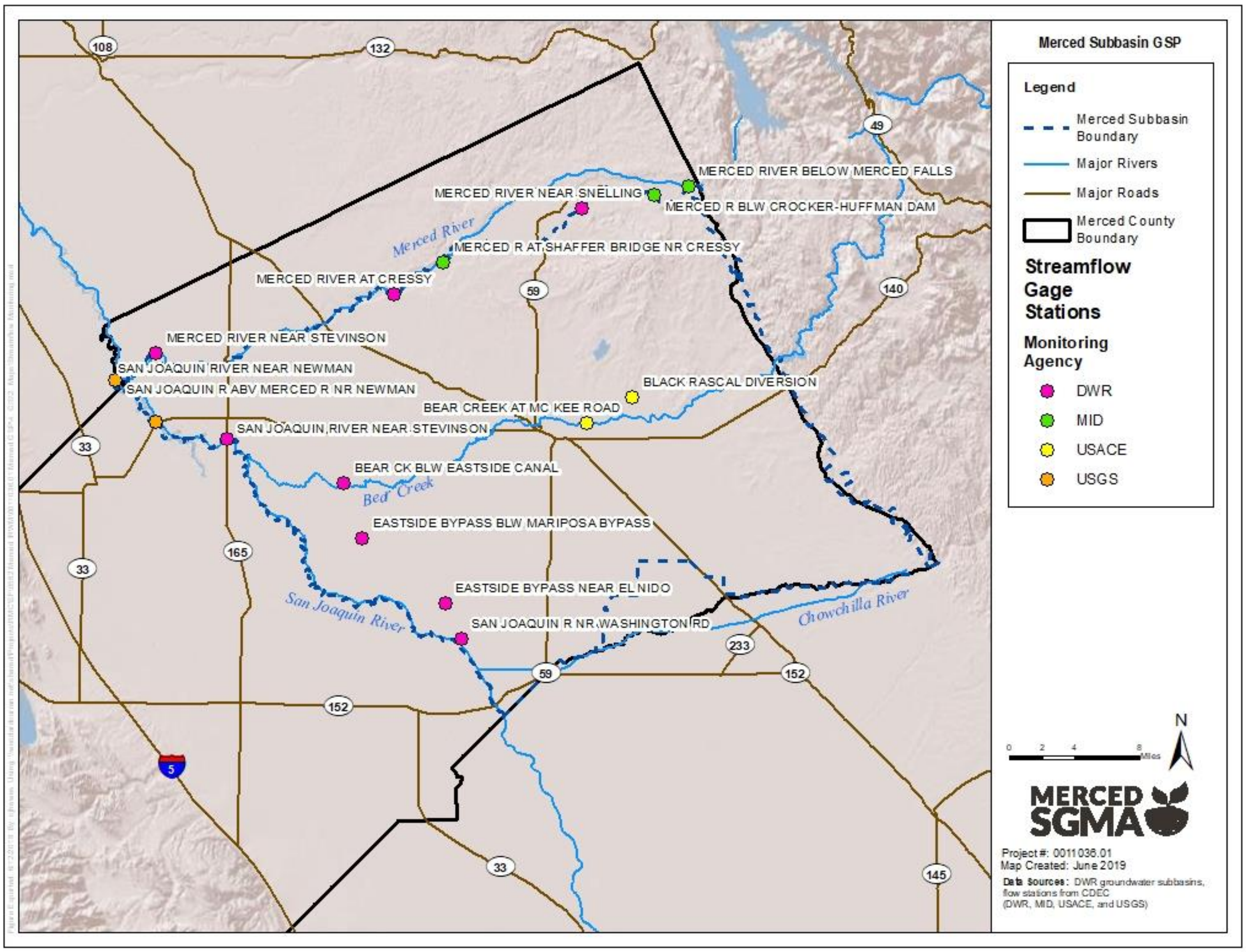


Table 4-10: Merced Subbasin GSP Interconnected Surface Water Depletions Monitoring Network Site Details

Station Code	Station Name	Latitude	Longitude	Monitoring Agency
BSD	BEAR CK BLW EASTSIDE CANAL	37.25470	-120.71940	DWR
MCK	BEAR CREEK AT MC KEE ROAD	37.30920	-120.44560	USACE
BDV	BLACK RASCAL DIVERSION	37.33280	-120.39440	USACE
EBM	EASTSIDE BYPASS BLW MARIPOSA BYPASS	37.20500	-120.69810	DWR
ELN	EASTSIDE BYPASS NEAR EL NIDO	37.14750	-120.60530	DWR
MBN	MERCED R AT SHAFFER BRIDGE NR CRESSY	37.45417	-120.60778	MID
MBH	MERCED R BLW CROCKER-HUFFMAN DAM	37.51500	-120.37000	MID
CRS	MERCED RIVER AT CRESSY	37.42500	-120.66300	DWR
MMF	MERCED RIVER BELOW MERCED FALLS	37.52200	-120.33100	MID
MSN	MERCED RIVER NEAR SNELLING	37.50200	-120.45100	DWR
MST	MERCED RIVER NEAR STEVINSON	37.37100	-120.93100	DWR
SMN	SAN JOAQUIN R ABV MERCED R NR NEWMAN	37.34721	-120.97618	USGS
FFB	SAN JOAQUIN R AT FREMONT FORD BRIDGE	37.30994	-120.93104	USGS
SWA	SAN JOAQUIN R NR WASHINGTON RD	37.11532	-120.58700	DWR
NEW	SAN JOAQUIN RIVER NEAR NEWMAN	37.35049	-120.97715	USGS & DWR
SJS	SAN JOAQUIN RIVER NEAR STEVINSON	37.29500	-120.85100	DWR

4.10.2 Monitoring Frequency

Groundwater level data are collected at the frequency noted in Section 4.5.2. Streamflow data is collected on a more frequent basis, with daily measurement relevant for use in depletion analyses.

4.10.3 Spatial Density

DWR's *Monitoring Networks and Identification of Data Gaps BMP* does not provide specific spatial density guidelines for networks monitoring depletions of interconnected surface water and thus relies on professional judgment on site identification. The depletion monitoring network stations provide an adequate spatial coverage of the Subbasin, allowing for development and calibration of a numerical model to support analysis.

4.10.4 Representative Monitoring

As depletions are managed via a proxy, representative monitoring is completed through the groundwater level sustainability indicator.

4.10.5 Monitoring Protocols

Groundwater level monitoring protocols are discussed in Section 4.5.5. Streamflow monitoring protocols will be followed according to the agencies that implement monitoring. DWR and USGS both follow protocols published in USGS Water Supply Paper 2175 (Rantz, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge., 1982a) and (Rantz, Measurement and Computation of Streamflow: Volume 2. Computation of Discharge., 1982b).

4.10.6 Data Gaps

The understanding of depletions of interconnected surface water could be improved through additional depth-discrete groundwater elevation data near some rivers and streams.

4.10.7 Progress on Filling Data Gaps

A Data Gaps Plan was prepared by the GSAs in 2021 and describes recommendations to improve monitoring of interconnected surface waters and related shallow groundwater conditions (Woodard & Curran, 2021). These recommendations are listed below, with sub-bullets describing the latest progress on filling data gaps.

- Expand monitoring network - The approach [in the Data Gaps Plan] for filling the groundwater level monitoring network data gaps places strong weighting for expanding monitoring near streams, rivers, and GDEs which are also of interest for shallow groundwater conditions. When installing a new monitoring well in these areas (for any three of the principal aquifers), it is relatively easy to include a shallow well completion (approximately 30 feet below ground surface) as a part of a nested well installation or in a nearby shallow borehole.
    - Several of the new groundwater level monitoring wells described in Section 4.5.7 include very shallow screens as part of a multiple completion well installation.
- Incorporate new data - Newly obtained information from the lower reaches of the San Joaquin River Restoration Program groundwater monitoring sites will also help inform very shallow groundwater level monitoring and surface-groundwater interactions in the Above Corcoran Clay Principal Aquifer.
    - The GSAs have reached out to USBR several times to obtain copies of ongoing monitoring data but have not heard back.
- Collect additional data adjacent to Subbasin boundary - Coordination with the San Joaquin River Exchange Contractors is recommended to obtain information from shallow monitoring in the Delta-Mendota Subbasin on the southern/western side of the San Joaquin River. Coordination with the Turlock Subbasin to the north of the Merced River would also be beneficial to better understand conditions. Coordination with the

Chowchilla Subbasin would also be useful, but less so due to the disconnected nature of the stream system in that area.

- The Delta-Mendota Subbasin has shared plans to install one to two monitoring wells located along the San Joaquin River along the river stretch that is adjacent to the Merced Subbasin and would thus benefit the GSAs. The GSAs anticipate reviewing and reporting this data as soon as it becomes available.

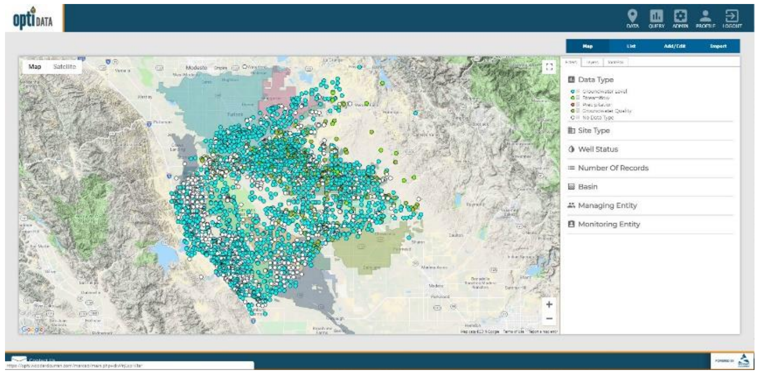
4.10.8 Plan to Fill Data Gaps

Multi-level monitoring wells may be developed to better characterize conditions near rivers and streams, subject to funding availability.

The GSAs continue to implement the Data Gaps Plan. The GSAs continue to monitor for grants and other funding opportunities as well as opportunities for interbasin coordination that would result in installation of new monitoring wells near rivers and streams.

5 DATA MANAGEMENT SYSTEM

5.1 OVERVIEW OF THE MERCED SUBBASIN DATA MANAGEMENT SYSTEM



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

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

5.2 FUNCTIONALITY OF THE DATA MANAGEMENT SYSTEM

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

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

The DMS can be configured for additional tools and functionality as the needs of the Groundwater Sustainability Agencies (GSAs) change over time. The following sections briefly describe the currently configured tools. For more detailed instructions on the usage of the DMS, please refer to the Opti User Guide (see Appendix L).

5.2.1 User and Data Access Permissions

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

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

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

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

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

Table 5-1: Data Management System User Types

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

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

5.2.2 Data Entry and Validation

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

5.2.2.1 Data Collection Sites

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

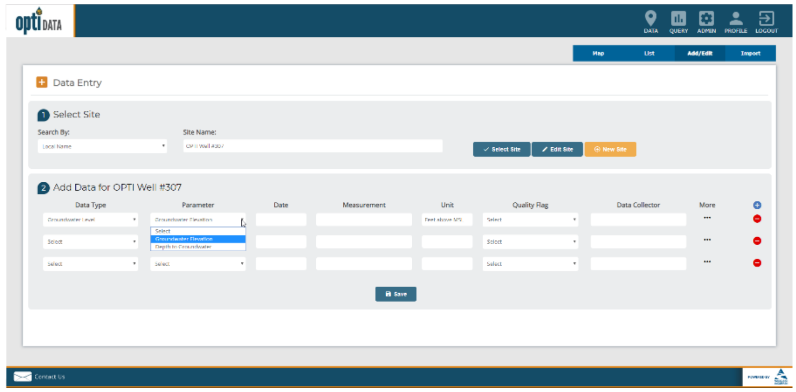
The information that is collected for sites is shown in Table 5-2. Required fields are indicated with an asterisk.

Table 5-2: Data Collection Site Information

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

* Required fields; all other fields are optional

5.2.2.2 Monitoring Data Entry



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

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

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

5.2.2.3 Data Validation

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

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

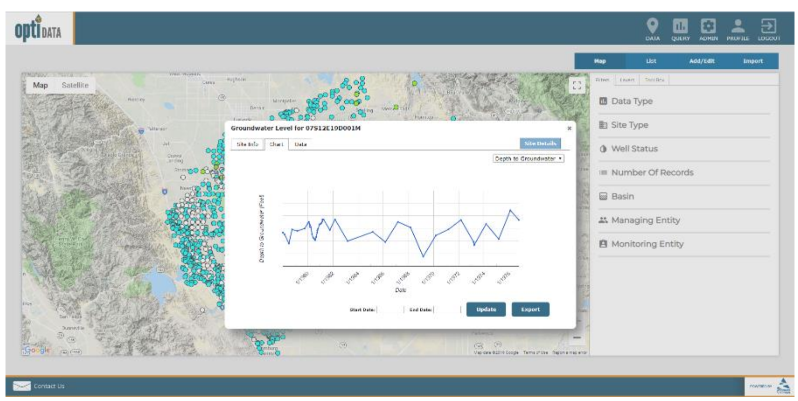
- Duplicate measurements: The database checks for duplicate entries based on the unique combination of site, data type, date, and measurement value.
- Inaccurate measurements: The database compares data measurements against historical data for the site and flags entries that are outside the historical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

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

5.2.3 Visualization and Analysis

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

5.2.3.1 Map View



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

5.2.3.2 List View

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

5.2.3.3 Analysis Tools

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

5.2.4 Query and Reporting

The DMS has the ability to format and export data and analysis at different levels of aggregation, and in different formats, to support local decision making and for submission to various statewide and local programs (i.e., Sustainable Groundwater Management Act [SGMA], California Statewide Groundwater Elevation Monitoring Program [CASGEM], Groundwater Ambient Monitoring and Assessment [GAMA], etc.).

5.2.4.1 Ad-hoc Query

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

- Monitoring or Managing Entity
- Site Name
- Data Type

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

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

5.2.4.2 Standard Reports

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

5.3 DATA INCLUDED IN THE DATA MANAGEMENT SYSTEM

5.3.1 Data Types

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

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

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

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Elevation	Depth to Groundwater	Feet	Yes
	Groundwater Elevation	Feet above MSL	Yes
Groundwater Quality	1,1,1-Trichloroethane	µg/L	Yes
	1,1,2,2-Tetrachloroethane	µg/L	Yes
	1,1,2-Trichloroethane	µg/L	Yes
	1,1-Dichloroethylene	µg/L	Yes
	1,2-Dibromo-3-chloropropane	µg/L	Yes
	1,2-Dichloroethane	µg/L	Yes
	1,2-Dichloropropane	µg/L	Yes
	Alachlor	µg/L	Yes
	Aluminum	mg/L	Yes
	Antimony	µg/L	Yes
	Arsenic	µg/L	Yes
	Atrazine	µg/L	Yes
	Barium	mg/L	Yes
	Barium	µg/L	Yes
	Benzene	µg/L	Yes
	Beryllium	µg/L	Yes
	Bicarbonate	mg/L	Yes

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Quality (Continued)	Cadmium	µg/L	Yes
	Calcium	mg/L	Yes
	Carbofuran	µg/L	Yes
	Carbon tetrachloride	µg/L	Yes
	Chloride	mg/L	Yes
	Dicamba	µg/L	Yes
	Dinoseb	µg/L	Yes
	Endrin	µg/L	Yes
	Fluoride	mg/L	Yes
	Glyphosate	µg/L	Yes
	Heptachlor	µg/L	Yes
	Heptachlor epoxide	µg/L	Yes
	Magnesium	mg/L	Yes
	Manganese	µg/L	Yes
	MBAS	mg/L	Yes
	Methoxychlor	µg/L	Yes
	Molinate	µg/L	Yes
	Nitrate	mg/L	Yes
	Pentachlorophenol	µg/L	Yes
	Picloram	µg/L	Yes
	Potassium	mg/L	Yes
	Sodium	mg/L	Yes
	Sulfate	mg/L	Yes
	Thiobencarb	µg/L	Yes
	Toxaphene	µg/L	Yes
	Dissolved Nitrate	mg/L as N	Yes
	Dissolved Nitrate	mg/L as NO_3	Yes
	1,1-Dichloroethane	TON	Yes
	1,2,4-Trichlorobenzene		Yes
	1,2-Dibromoethane (EDB)	µg/L	Yes
	1,3-Dichloropropene (Total)	mg/L	Yes
	1,4-Dichlorobenzene	µg/L	Yes
	2,4,5-TP (Silvex)	µg/L	Yes
	2,4'-D	µg/L	Yes
	Aluminum - Total	µg/L	Yes
	Antimony - Total	µg/L	Yes
	Apparent Color		Yes
	Arsenic - Total	µg/L	Yes

Data Type	Parameter	Units	Currently Has Data in DMS
Groundwater Quality (Continued)	Atrazine (Aatrex)	µg/L	Yes
	Barium - Total	µg/L	Yes
	Bentazon	µg/L	Yes
	Benzo(a)pyrene	µg/L	Yes
	Beryllium - Total	µg/L	Yes
	Bicarbonate Alkalinity	µg/L	Yes
	Boron - Total	µg/L	Yes
	Cadmium - Total	µg/L	Yes
	Calcium	NTU	Yes
	Calcium - Total	mg/L	Yes
	Carbonate Alkalinity	µg/L	Yes
	Chloride	µg/L	Yes
	Chromium - Total	µg/L	Yes
	Chromium (Total)	pCi/L	Yes
	Chromium (VI)	µg/L	Yes
	cis-1,2-Dichloroethylene	pCi/L	Yes
	Copper - Total	µg/L	Yes
	Cyanide, Total	µg/L	Yes
	Dalapon	µg/L	Yes
	DBCP	µg/L	Yes
	Di(2-ethylhexyl)adipate	µg/L	Yes
	Di(2-Ethylhexyl)phthalate	µg/L	Yes
	Diquat	µg/L	Yes
	EDB	µg/L	Yes
	Endothall	µg/L	Yes
	gamma-BHC (Lindane)	µg/L	Yes
	Hexachlorobenzene	µg/L	Yes
	Hexachlorocyclopentadiene	µg/L	Yes
	Iron - Total	µg/L	Yes
	Lab Turbidity	NTU	Yes
	Lead - Total	µg/L	Yes
	Magnesium - Total	mg/L	Yes
	Manganese - Total	µg/L	Yes
	Mercury - Total	µg/L	Yes
	Nickel - Total	µg/L	Yes
	Nitrate - N	mg/L	Yes
	Nitrate (as N)	mg/L	Yes
	Nitrate (as N)	µg/L	Yes

Data Type	Parameter	Units	Currently Has Data in DMS
	Odor Threshold	TON	Yes
	Oxamyl (Vydate)	µg/L	Yes
	pH		Yes
	Potassium - Total	mg/L	Yes
	Radium 228	mg/L	Yes
	Selenium - Total	µg/L	Yes
	Silica - Total	mg/L	Yes
	Silver - Total	µg/L	Yes
	Simazine (Princep)	µg/L	Yes
	Sodium - Total	mg/L	Yes
	Specific Conductance	umhos/cm	Yes
	Specific Conductance	mg/L	Yes
	Strontium - Total	µg/L	Yes
	TDS	mg/L	Yes
	Technical Chlordane	µg/L	Yes
	Thalli–m - Total	µg/L	Yes
	Total Alkalinity	mg/L	Yes
	Total Hardness	mg/L	Yes
	Total PCBs	µg/L	Yes
	Urani–m - Total	µg/L	Yes
	Vanadi–m - Total	µg/L	Yes
	Zi–c - Total	µg/L	Yes
Groundwater Quality (Continued)	TDS	tons/acre-foot	Yes
	NO_3N	mg/L	Yes
	NO_3-N	mg/L	Yes
	Total Nitrate	mg/L as NO_3	Yes
	Total Nitrate	mg/L as N	Yes
	1,2-Dichlorobenzene	µg/L	Yes
	Dissolved Nitrate	mg/L	Yes
	Various Parameters	Various	
Surface Water Quality	Various Parameters	Various	
Streamflow	Streamflow	cfs	Yes
	Precipitation	inches	Yes
Precipitation	Reference Evapotranspiration (ETo)	inches	Yes
	Average Air Temperature	Degrees F	Yes

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

5.3.2 Manually Imported Data

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

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

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

Table 5-4: Sources of Data Included in the DMS

Data Source	Datasets Collected	Date Collected	Activities Performed
CV-SALTS (includes data from CDPH, DWR, CVDRMP, GAMA, and USGS)	Well Location Well Type (Limited) Well Depth (Limited) Groundwater Quality	8/13/2018	• Removed duplicate records • Matched existing records with other data sources (GAMA, DWR) • Determined if well was screened above, below, or outside of Corcoran Clay (for wells with depth data)
Central Valley Dairy Representative Monitoring Program (CVDRMP)	Well Location Well Type Groundwater Quality	9/14/2018	• Converted well addresses to Lat/Long • Matched records to wells in CV-SALTS
Department of Water Resources (DWR)	Well Location Well Type Groundwater Quality	9/2018	• Removed duplicate records
HydroDMS	Well Location Well Type Well Depth (Limited) Groundwater Elevation Groundwater Quality	Data collected as part of the 2015 IRWMP	• Determined if well was screened above, below, or outside of Corcoran Clay
Groundwater Ambient Monitoring and Assessment (GAMA) (includes data from DHS, DWR, and USGS)	Well Type Well Location Well Depth (Limited) Groundwater Quality	9/10/2018	• Removed duplicate records • Determined if well was screened above, below, or outside of Corcoran Clay (for wells with depth data)
Local Data (Le Grand CSD, Meadowbrook Water Company, Santa Nella Water District)	Well Type Well Depth Well Location Groundwater Quality	5/20–7 - 7/2017	• Tabulated lab results
National Water Information System (NWIS)	Well Type Well Depth (Limited) Well Relation to Corcoran Clay (Limited) Well Location Groundwater Quality	9/2018	• Removed duplicate records • Determined if well was screened above, below, or outside of Corcoran Clay (for wells with depth data)

5.3.3 Ongoing Automated Data Imports

Two automated data imports have been set up within the DMS using application programming interfaces (APIs) to access data from publicly hosted databases.

First, the groundwater levels module receives a regular update of monitoring data reported to the SGMA Data Viewer.

Second, the groundwater quality module receives a monthly update of monitoring data reported to GAMA.

6 PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY GOAL

6.1 INTRODUCTION

This chapter of the Merced Subbasin Groundwater Sustainability Plan (GSP) includes relevant Management Actions and Projects information to satisfy §354.42 and §354.44 of the Sustainable Groundwater Management Act (SGMA) regulations.[41] The first several sections of this chapter focus on Management Actions, including a description of the framework under discussion for the initial basinwide groundwater pumping allocation. The allocation framework will be established by the Groundwater Sustainability Agencies (GSAs) as a first step in establishing limits on groundwater extraction for the Subbasin that will eventually be implemented and enforced by authority granted under SGMA to the GSAs. The framework also helps establish a clearer understanding of the gap that projects and management actions (PMAs) should fill in balancing supply and demand. Management actions will also include rewarding GSAs based on their extracted volumetric groundwater extraction, since 2015, proportioned to other GSAs in the basin. The PMAs described in this chapter will help achieve the Merced Subbasin Sustainability Goal.

6.2 MANAGEMENT ACTIONS

Management Actions are generally administrative, locally implemented actions that the Merced GSAs or member agencies could take that affect groundwater sustainability. Typically, Management Actions do not require outside approvals, nor do they involve capital projects. The five management actions are:

- Integrated Groundwater Allocation Framework (Section 6.2.1)
- Merced Subbasin GSA Groundwater Demand Reduction Management Action (Section 6.2.2)
- Merced Irrigation-Urban GSA Groundwater Allocation Management Action (Section 6.2.3)
- Domestic Well Mitigation Program (Section 6.2.4)
- Above Corcoran Sustainable Management Criteria Adjustment Consideration (Section 6.2.5)

6.2.1 Integrated Groundwater Allocation Framework

Description: As described in Chapter 1 (Introduction and Plan Area) and Chapter 2 (Basin Setting) of this GSP, the Basin is in overdraft conditions. While the PMAs identified in later sections of this chapter would increase the water available to users in the Basin, they are not expected to reduce

[41] SGMA requirements for GSPs can be read here: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf

the groundwater overdraft sufficiently to achieve the Basin's sustainability goals. Given these circumstances, the GSAs identified a need to allocate the sustainable yield of native groundwater in the basin and establish groundwater extraction limits. Based on information in the original 2020 and revised 2022 GSPs, each GSA has individually developed programs and policies to manage groundwater within their jurisdiction, which are described for MSGSA and MIUGSA in subsequent subsections. While these GSA driven programs are successfully moving towards meeting overall Basin goals, the GSAs recognize there may be a need for further refinement of the allocations at a basin scale.

This section describes the integrated framework that has been discussed by the GSAs.

Legal Authority: Under SGMA, GSAs have authority to establish groundwater extraction allocations. Specifically, SGMA authorizes GSAs to control groundwater by regulating, limiting, or suspending extractions from individual wells or extractions in the aggregate.[42] SGMA and GSPs adopted under SGMA cannot alter water rights. With input from multiple Stakeholder Advisory and Coordination Committee meeting discussions, the GSAs agreed to use the framework described below as the initial basis for establishing allocations to each GSA with the understanding that work remains to fill data gaps, refine and document sustainable yield and developed supply estimates, and develop the details of implementation for each GSA.

How the Action Will Be Accomplished: The water allocation framework is intended to generally align with water rights concepts and provide an equitable and transparent means to share the Basin's[43] Sustainable Yield. The framework described below outlines a process that deals exclusively with water allocations and does not affect water rights. The steps of the framework are:

1. Determine the Sustainable Yield of the Basin
2. Subtract groundwater originating from Developed Supply to obtain Sustainable Yield of Native Groundwater
3. Allocate Sustainable Yield of Native Groundwater to GSAs (the specifics of how this will be done, taking into account land area, historical use, appropriative use, and other considerations are still being worked out by the GSAs)

Each step of the framework is described in greater detail below:

[42] California Water Code § 10726.4(a)(2)

[43] The terms "basin" and "subbasin" are used interchangeably in this GSP chapter (and are interchangeable under the definition in SGMA).

1. Determine the Sustainable Yield of the Basin

Per SGMA, Sustainable Yield is "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."[44] As the first step in the allocation framework, the Sustainable Yield for the Basin was estimated by using the Merced Water Resources Model (MercedWRM) simulations for projected basin conditions and reducing pumping until the long-term average change in storage was zero. This analysis is further described in the Water Budget Information Section, in Section 2.3 of this GSP. Based on this analysis, the Sustainable Yield of the Basin is approximately 499,000 acre-feet per year (AFY).

2. Subtract groundwater originating from Developed Supply to obtain Sustainable Yield of Native Groundwater

A portion of the groundwater in the Merced Subbasin originates as surface water supplies imported from outside the Subbasin. This water belongs to the entities that developed the surface supplies and is referred to in this GSP as "Developed Supply."

> *"Water for which a credit is derived is water from outside the watershed or water which is captured that would have been otherwise lost to the subbasin and which is recharged into the groundwater basin…Assuming no prescriptive rights have attached to imported water used to recharge a basin, the imported water generally belongs solely to the importer, who may extract it (even if the basin is in overdraft) and use or export it without liability to other basin users. There are well defined rules regarding leave behinds to address migration of water necessary to keep the subbasin whole."*[45]

In this step of the framework, the portion of Developed Supply that reaches the groundwater basin is estimated and subtracted from the Sustainable Yield estimate. This results in an estimate of the Sustainable Yield of Native Groundwater available for allocation to Basin users.

For this GSP, the Developed Supply reaching the groundwater basin was estimated based on seepage from unlined canals conveying surface water. There are other potential sources of developed supply to the groundwater basin including deep percolation of applied surface water and leakage from lined/piped conveyance.

However, given current available information it is not possible to estimate these flows with confidence at this time. Future refinements of GSP estimates of the developed supplies reaching the groundwater basin may include these and other additional considerations. The full definition

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44 California Water Code §10721(v)

45 Groundwater Pumping and Allocations under California's Sustainable Groundwater Management Act. 2018. Environmental Defense Fund and New Current Water and Land LLC. Page 3

and ownership of developed water needs to be agreed upon by GSAs after GSP adoption, future work needed includes developing, refining and documenting estimates of developed supply and determining rights to confirmed estimates of developed supply.

The agencies that import developed surface water into the Basin and experience seepage due to conveyance via unlined canals are: Merced Irrigation District (MID), Stevinson Water District (SWD), and Turner Island Water District (TIWD). The estimate of Developed Supply reaching the Basin aquifer via seepage from unlined conveyance canals was based on information provided by MID, TIWD, and SWD in early 2019 as shown in Table 6-1.

Table 6-1: Estimated Long-term Annual Average Seepage from Developed Supplies

Water Purveyor	Unlined Canals	Stream Diversions	Seepage Estimate	Data Source
Merced Irrigation District	593 miles	393,000 AFY	121,000 AFY	MID AWMP (2013&2015)
Stevinson Water District	18 miles	17,200 AFY	6,000 AFY	TM prepared by GEI
Turner Island Water District	24 miles	20,600 AFY	3,000 AFY	Email/PDF by LSCE
Total Estimated Seepage of Developed Supply Reaching Groundwater			130,000 AFY	

The long-term annual average seepage shown in the seepage estimate column is used in this chapter to illustrate the water allocation framework.

3. Allocate Sustainable Yield of Native Groundwater to GSAs

SGMA does not alter water rights. The process for sharing the Basin's Sustainable Yield was developed to align with water rights concepts to achieve fairness and transparency. While there is no legal determination of overdraft for the Merced Subbasin, DWR has classified the Subbasin as critically overdrafted.

The types of groundwater use being considered in the allocation framework can generally be described as:

Overlying Use (Overlying Rights)

> *"Overlying rights are used by the landowner for reasonable and beneficial uses on land they own overlying the subbasin from which the groundwater is pumped."*[46]

[46] Groundwater Pumping and Allocations under California's Sustainable Groundwater Management Act. 2018. Environmental Defense Fund and New Current Water and Land LLC. Page 2

Appropriative Use

"…Any party that 1) does not own land overlying the basin, 2) owns overlying land but uses the water on nonoverlying land, or 3) sells the water to another party, or to the public, generally is considered an "appropriator" and not an overlying user…….If a pumper extracts water for a non-overlying use… from an overdrafted basin, the right may ripen into a prescriptive right if the basin overdraft is notorious and continuous for at least five years."[47]

Prescriptive Rights

"A prescriptive right (a groundwater right acquired adversely by appropriators) is acquired by taking
groundwater adverse to existing right holders for a period of normally 5 years). Prescriptive rights do not accrue until a condition of overdraft exists….If a pumper extracts water for a non-overlying use(i.e., pursuant to an appropriative right) from an overdrafted basin, the right may ripen into a prescriptive right if the basin overdraft is notorious and continuous for at least five years."[48]

The Sustainable Yield of Native Groundwater available for allocation to groundwater users would be approximately:

- Sustainable Yield: ~499,000 AFY
- Developed Supply Reaching Basin: ~130,000 AFY
- **"Native Groundwater" Available for Allocation: ~369,000 AFY**

Some of the next steps needed in first five years of GSP to begin implementation of allocations include:

- Agreeing upon details of how allocations to each GSA will be established
- Developing, refining, and documenting estimates of developed supply and determining rights to confirmed estimates of developed supply
- Determining how pumping will be measured through metering program or equivalent
- Establishing sustainable allocation trading and crediting rules
- Implementation schedule and timing
- Conducting outreach and communications

[47] Groundwater Pumping and Allocations under California's Sustainable Groundwater Management Act. 2018. Environmental Defense Fund and New Current Water and Land LLC. Page 2 and 3

[48] Groundwater Pumping and Allocations under California's Sustainable Groundwater Management Act. 2018. Environmental Defense Fund and New Current Water and Land LLC. Page 2 and 3.

Time-Table for Initiation and Completion: The time-table for implementation of the basinwide allocation framework is identified in Table 6-2 below.

Table 6-2: GSP Implementation Timeline

2020 | 2025 | 2030 | 2035 | 2040

Monitoring and Reporting	Preparation for Allocations and Low Capital Outlay Projects	Prepare for Sustainability	Implement Sustainable Operations
• Establish monitoring network • Install new monitoring wells • Reduce/fill data gaps	• Conduct 5-year evaluation/update • Monitoring and reporting continue	• Conduct 5-year evaluation/update • Monitoring and reporting continue	• Conduct 5-year evaluation/update • Monitoring and reporting continue
• GSAs allocated initial allocations • GSAs establish their allocation procedures and demand reduction efforts • Develop metering program	• As-needed demand reduction to reach Sustainable Yield allocation • Metering program continues	• As-needed demand reduction to reach Sustainable Yield allocation	• Full implementation demand reduction as needed to reach Sustainable Yield allocation by 2040
• Funded and smaller projects implemented	• Planning/ design/ construction for small to medium sized projects	• Planning/ design/ construction for larger projects begins	• Project implementation completed
• Extensive public outreach regarding GSP and allocations	• Outreach regarding GSP and allocations continues	• Outreach continues	• Outreach continues

The GSA allocation programs are described in the following two subsections. A phase-in between the 2025 - 2035 time horizon is anticipated for all GSAs, with full implementation and enforcement in place by 2040. Implementation of the allocation framework within each GSA is expected to address all relevant sustainability indicators. The framework also provides a basis from which GSAs can better manage groundwater extractions and plan for and implement recharge projects. Evaluation of expected benefits is expected to occur during each periodic evaluation and, when necessary, GSP update. The Merced Subbasin GSA has also been implementing early voluntary actions to support meeting demand reduction goals by 2040 (see Section 6.2.2). Note that TIWD GSA-1 does not anticipate a formal demand reduction/allocation program within its GSA.

6.2.2 Merced Subbasin GSA Groundwater Demand Reduction Management Action

Description: To reach the Sustainable Yield of Native Groundwater in the basin, the MSGSA's current consumptive use of groundwater will need to decrease substantially, potentially as much as 150,000 AFY based on current modeling. To remedy this estimated deficit and reach sustainability, the MSGSA is implementing a demand reduction program to reduce the consumptive use of groundwater. On November 12, 2021, the MSGSA adopted a Two Phased GSP Implementation Approach via resolution, with Phase 1 focusing on achieving a reduction in consumptive use of groundwater by 15,000 AFY by WY 2025, providing MSGSA the time needed to develop Phase 2, which is a more comprehensive demand reduction program to achieve the large necessary annual reduction.

PHASE 1

The following strategies are part of the Phase 1 approach:

1. **Land Repurposing**: As the primary strategy for Phase 1, the aim of the Phase 1 Land Repurposing Program, designed and launched in WY 2022, was to encourage voluntary landowner participation through the use of an incentive payment system driven by landowner applications. This program prioritized applications that offered significant water savings and targeted areas with known groundwater decline, land subsidence, high domestic well density, and DACs or SDACs. Three rounds of applications were accepted in 2022, 2023, and 2024. Further details on the program's implementation can be found in the GSP's Annual Reports. On June 16, 2023, the MSGSA received an $8.89 million Multibenefit Land Repurposing Program (MLRP) Block Grant from the Department of Conservation, which adds capacity beyond the MSGSA's existing land repurposing efforts, further supporting both Phase 1 and Phase 2 activities. The MSGSA MLRP seeks to promote basin-scale coordinated efforts to build local capacity to repurpose agricultural land from higher to lower (or zero) groundwater land uses while promoting community health, economic wellbeing, water supply, habitat, renewable energy, and climate benefits.
2. **Increased Surface Water Imports**: Phase I also focused on importing surface water (flood waters or purchased water) into the MSGSA service area. In WY 2023, 14 MSGSA landowners diverted approximately 15,000 AF of excess flood flows for groundwater recharge under Executive Orders N-4-23 and N-7-23. Additionally, multiple public agencies and private growers have signed contracts with the Merced Irrigation District for out of district surface water contracts for up to 40,000 AFY.
3. **Remote Sensing Services**: On February 9, 2023 the MSGSA joined a pilot program of the Groundwater Accounting Platform developed by the California Water Data Consortium, Environmental Defense Fund, and Environmental Science Associates, to provide MSGSA landowners with consumptive groundwater use information for their lands. Access to the platform was provided to MSGSA landowners in June of 2024 and will support both Phase 1 and Phase 2 activities.
4. **Phase I Fee**: MSGSA designed and adopted on July 19, 2022 a Phase I fee under Proposition 218 to fund Phase I objectives.

PHASE 2

Phase 2, set to begin in 2026, focuses on implementing the Groundwater Allocation Rule adopted on September 12, 2024 ("Rule"), which will achieve the significant reduction in the consumptive use of groundwater needed to reach sustainability. The Rule will allow the MSGSA to accomplish the 2040 objective by the end of WY 2035. The Rule establishes an allocation of groundwater for each agricultural parcel of land within the MSGSA's boundary. The Allocation includes, at a minimum, Sustainable Yield of Native Groundwater and, for some parcels, a temporary Additional Pumping Allowance. To address spatial variability in hydrogeologic conditions in the MSGSA, eight (8) “Sustainability Zones” were established. Eligible parcels within each Sustainability Zone are allocated thirteen (13) inches of Sustainable Yield of Native Groundwater (SYNG). Beginning in 2026, eligible parcels within each Sustainability Zone’s will receive an Additional Pumping Allowance (APA) of an additional eleven (11) inches of Native Groundwater. The Additional Pumping Allowance will decline by ten percent (10%) per year over a ten (10) year period (2026-2035) until it reaches a value of zero (0) by 2036. In 2030 and 2035, additional data and improved understanding of groundwater level responses to the Rule in each Sustainability Zone will allow the SYNG to be adjusted higher or lower, and the APA to be reduced more quickly or slowly, further assuring sustainability objectives will be achieved.

The MSGSA’s two phased demand reduction program is complemented by water supply enhancement projects and efficiency projects conducted within MSGSA that seek to increase the available water supply (see “Projects” discussed in the following subsection).

Measurable Objective: This program is anticipated to benefit all GSP measurable objectives. Public Noticing: This demand reduction program has been discussed in fa stepwise process over several years through public meetings of the MSGSA Governing Board and meetings of the MSGSA Technical Advisory Committee. Updates have also been provided at the regular meetings of the overall Merced Subbasin GSP Coordination and Stakeholder Advisory Committees. Public outreach and education on the structure of the demand reduction program, as well as feasible monitoring and enforcement mechanisms, have been an important component in planning for successful implementation of the program. Outreach has included public notices, meetings, as well as website, email, and physical mail announcements. Furthermore, the MSGSA has made a concerted effort to actively seek public comment and input on its demand reduction activities. Documents containing proposed objectives, frameworks, and Rules have all undergone extensive public comment and review processes, where feedback from constituents within the MSGSA has been integral to their development.

Permitting and Regulatory Process: Although CEQA is designed to evaluate and mitigate the environmental impacts of projects within California, the legislature recognized that not all projects pose significant environmental risks and incorporated exemptions into the CEQA process. These exemptions streamline the approval process for projects deemed to have minimal or no significant effect on the environment, ensuring that resources are allocated efficiently and that projects with negligible impact can proceed without undue delay. The MSGSA certified the Project as exempt from CEQA pursuant to the common sense exemption, CEQA Guidelines §15061.b(3), and, because adoption of the Rule is an action taken by the MSGSA as directed by SGMA and the GSP for the protection of natural resources and the environment, pursuant to CEQA Guidelines §15307, §15308, and §15378(b)(2). The Rule is intended to ensure the sustainability of agricultural groundwater as required by law, and reduce the negative environmental harm arising from overusing this limited natural resource. The Rule was developed in order to implement the GSP, which was required by SGMA. Adoption of the GSP was statutorily exempt from the California Environmental Quality Act ("CEQA") per Water Code §10728.6. SGMA requires that the Basin operate sustainably by specified timelines; the GSP concluded that reaching sustainability requires reduced groundwater pumping in the Basin. The Rule is intended to meet the requirements imposed by SGMA and the GSP, which require that groundwater pumping be reduced. The proposed Rule does not exceed the scope and impact of the Merced Subbasin Groundwater Sustainability Plan.

Timetable for Initiation and Completion: Initiation of the demand reduction program began soon after adoption of the original GSP in 2019. Phase 1's Land Repurposing Program was designed and launched in WY 2022. Phase 2's demand reduction program was designed in WY 2024 and will be tested between October 10, 2024, and January 1, 2026. Full implementation of the program will begin on January 1, 2026, and continue beyond 2040.

Expected Benefits and Evaluation: A demand reduction program is one component of how the MSGSA will achieve sustainable pumping in the GSA's area of the Merced Subbasin. Implementation and enforcement of a demand reduction program would directly reduce the consumptive use of groundwater. Benefits would be measured by the reduction in the total volume of groundwater consumed within the MSGSA area.

How Project Will Be Accomplished: Desired reductions in groundwater use will be accomplished through the implementation of the Rule, which includes a per-acre allocation of SYNG and a temporary Additional Pumping Allowance of Native Groundwater for eligible parcels within the MSGSA. The MSGSA will utilize various tools and fees as well as reporting, monitoring, enforcement, and management actions to achieve the 2040 objective. Namely, the MSGSA will utilize the Groundwater Accounting Platform, which uses OpenET data, to measure and monitor consumptive use to ensure compliance with the 2040 objective, and will take necessary compliance actions for violations as detailed in the Rule. The implementation of the demand reduction program will continue to include substantial outreach to MSGSA stakeholders and member agencies.

Legal Authority: The MSGSA adopted the Groundwater Allocation Rule under the authority granted by Chapter 5 of Part 2.74 of the CWC. The MSGSA has the authority to charge fees to implement the GSP, and to implement and enforce these Rules pursuant to authority granted by Chapters 8 and 9 of Part 2.74 of the CWC, along with Proposition 26, Proposition 218, the California Constitution, and independent authority of each of the members of the MSGSA.

Estimated Costs and Plans to Meet Costs: Continued development and implementation of the demand reduction program is expected to cost about $500,000 per year. This estimate will support analyses related to the continued development and implementation of the demand reduction program, refinement and development of future policies, as well as maintenance and licensing fees associated with the Groundwater Accounting Platform, and outreach.

6.2.3 Merced Irrigation-Urban GSA Groundwater Allocation Management Action

Description: In 2023, MIUGSA adopted Rules and Regulations that include an allocation program in addition to establishing a framework for measuring, monitoring, and enforcing the groundwater allocation through well registration and groundwater usage reporting systems. The In June 2022, the MIUGSA Board set a groundwater extraction allocation for agricultural parcels of 3.3 AF/ac over three years (1.1 AF/ac/Y on average) starting April 1, 2023 through December 31, 2025 and will require that all wells be registered (MIUGSA, 2023a). In June 2024, the MIUGSA Board adopted an allocation for non-agricultural users of 1.4 AF/ac/Y through 2031, followed by an allocation of 1.1 AF/ac per year after 2031 through 2040. The adopted allocation values were considered consistent with the GSP's sustainable yield of native groundwater at the time. MIUGSA has incorporated flexibility and tools into the rules and policies that will allow users to comply with the allocation. These include combining allocated water over multiple parcels, allowing carry-over of recharged water and any unused water to future years, and accounting for developed supply from an agricultural user's water provider (MIUGSA, 2023b).

On October 12, 2022, a well registration requirement was also adopted, with a goal of establishing an online platform and procedure to register all wells in the GSA prior to December 31, 2025. Significant progress has been made through the time of publishing to register wells. As of July 2024, effectively all agricultural wells serving greater than 10 acres were registered with MIUGSA.

MIUGSA joined a pilot program of the Groundwater Accounting Platform developed by the California Water Data Consortium, and Environmental Defense Fund, funded by California DWR and USBR, to provide MIUGSA staff the ability to monitor and enforce groundwater extraction within MIUGSA and landowners with groundwater account providing details related to available groundwater supply, use, and remaining balance. MIUGSA has begun rolling out the Groundwater Accounting Platform and is actively providing Groundwater Account Statements to landowners.

Measurable Objective: This program is anticipated to benefit all GSP measurable objectives.

Public Noticing: From 2021 to 2023, MIUGSA held six Stakeholder Guidance Committee meetings that guided the process of developing initial principle guidelines and policies within the GSA boundaries. The meetings were guided by a Public Involvement Plan to facilitate communication and provide for the dissemination of information and involvement between the Stakeholder Guidance Committee and the MIUGSA Board (MIUGSA, 2021). Outreach has included public notices, meetings, as well as website and email announcements. MIUGSA continues to work with stakeholders to analyze and vet policies, including for the future use of flow meters.

Permitting and Regulatory Process: Development and implementation of an allocation program is not a project as defined by the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) and would therefore not trigger either.

Time-Table for Initiation and Completion: Initiation of the management action began soon after adoption of the original 2020 GSP. Policy development and stakeholder outreach occurred from 2021-2023. The Rules and Regulations were adopted October 11, 2023. The initial allocation period is 4/1/2023 through 12/31/2025. The MIUGSA Board will determine groundwater allocations and pertinent details such as the amount allocated and length of time on a regular basis.

Expected Benefits and Evaluation: Implementation and enforcement of the allocation program will sustainably manage pumping within the adopted allocation. Benefits will be measured through the groundwater usage reporting system.

How Project Will Be Accomplished: MIUGSA has developed a Groundwater Management Implementation Plan that is designed to complement and augment the Rules and Regulations. It provides "…a framework and additional detail for, among other things, the accounting of Groundwater extraction to count against the Allocation, including for example, accounting for Carryover, Pooling, Reallocations, Developed Water Supply credits and Intentional Recharge Credits" (MIUGSA, 2023b).

Legal Authority: MIUGSA adopted the Rules and Regulations under the authority granted by Chapter 5 of Section 10725.2 of the CWC for the general purpose of implementing SGMA within the boundaries of MIUGSA.

Estimated Costs and Plans to Meet Costs: Costs to implement the allocation program and related tools are estimated by MIUGSA to be approximately $750,000 per year.

In 2020, MIUGSA developed a fee structure to fund the regulatory activities of the GSA. It is a per acre per year (annual) fee paid for by all property owners, except for federal properties. Separate fees are established for agricultural production (defined by Assessor land use codes) and different fees for a variety of defined Urban Residential and Urban Non-Residential land use types, based on Assessor land use codes (MIUGSA, 2020). The fee structure was adopted at the July 28, 2020 Board Meeting. Updated fees are adopted annually depending on the approved budget for the upcoming fiscal year.

6.2.4 Domestic Well Mitigation Program

Description: Since the submission of the revised 2022 GSP, the GSAs have worked collaboratively to define the various roles and responsibilities of a Domestic Well Mitigation Program. The intent of this program is to respond to adverse impacts experienced by domestic well users where regional overdraft conditions occurring after 2015 are causing declining groundwater levels that interfere with groundwater production or quality. Moreover, the program is solely focused on addressing impacts associated with groundwater level declines and not centered on addressing impacts caused by aging, faulty, or ill-maintained domestic well infrastructure.

Based upon the modeling analysis using the determined minimum thresholds, there currently is no indication that a domestic well mitigation program would be necessary in the Merced Subbasin. However, as recommended in DWR's Approval Determination of the Revised 2022 Merced Subbasin GSP dated August 4, 2023, the interim milestones below historical lows and minimum thresholds identified in the GSP warrant the need for a domestic well mitigation program to be in place and initiated prior to a demonstrated need. Given this, the GSAs have formed a Merced Subbasin Domestic Well Mitigation Program Ad Hoc Committee to facilitate the development and implementation of a Domestic Well Mitigation Program (Program). Further, the

MSGSA has spearheaded development of the Program by establishing a funding source through a successful Proposition 218 election which occurred on July 19, 2022.

Collectively, the GSAs are undertaking the following actions to be completed by the submission of the WY 2025 GSP Annual Report:

Item 1: Expand historical and existing services within Merced County, which include water quality testing, bottled water, hauled water, lowering of the drop pipe, or drilling a new domestic well, by coordinating outreach efforts regarding available services and programs as well as exploring opportunities to provide additional funding to expand their existing efforts. Additionally, the Merced Subbasin GSAs will work collaboratively with the Merced County Drought Working Group, which has been active since 2015, to facilitate drought and water shortage preparedness for state small water systems and individual domestic wells within the County's jurisdiction. Merced County received a technical assistance grant from the Department of Water Resources on March 5, 2024 to help prepare a drought resilience plan as required by SB 552 and anticipates completing the plan by the end of 2025. Collaboration with these established partners will ensure that the Domestic Well Mitigation program complements rather than duplicates existing efforts thus ensuring that users in need are efficiently identified and assisted.

Item 2: Undertake a comprehensive modeling analysis using the determined interim milestones to identify potential impacts to domestic well users within the Merced Subbasin.

Item 3: Finalize the Domestic Well Mitigation Program Implementation Roadmap and adopt the Domestic Well Mitigation Program based upon the following estimated timeline:

1. September 2024 to February 2025, develop the Program Eligibility Criteria, which defines the domestic well impacts eligible for mitigation.
2. March 2025 and May 2025, establish Domestic Well Assessment criteria and protocols.
3. June 2025 to August 2025, develop an Appeal Process for property owners who do not meet the Program Eligibility Criteria.

The program is expected to be finalized and adopted by September 2025. Throughout the entire process, ongoing public and stakeholder engagement will be maintained to ensure transparency and inclusivity in the program's development and implementation. Recommendations from Self-Help Enterprises, Leadership Counsel for Justice and Accountability, and the Community Water Center in their publication titled "Framework for a Drinking Water Well Impact Mitigation Program" will be considered during development.

<u>Measurable Objective</u>: This management action is expected to benefit the measurable objectives established for the chronic lowering of groundwater levels and degraded water quality sustainability indicators. Anticipated activities will result in avoiding undesirable results for domestic well users and beneficial users of groundwater.

Public Noticing: The Domestic Well Mitigation program has been and will continue to be discussed at public meetings of the MSGSA, MIUGSA, and TIWD GSA-1 governing boards, relevant GSA committees, the Subbasin's Stakeholder Advisory Committee and Coordination Committee, and the Merced Subbasin Domestic Well Mitigation Program Ad Hoc Committee. Outreach efforts to date have included postings to each of the GSAs' websites and the Merced SGMA website regarding the currently available services from Self-Help Enterprises. As the Domestic Well Mitigation Program development and implementation progresses, outreach efforts will include public notices, meetings, workshops, as well as website, email, and physical mail announcements.

Permitting and Regulatory Process: Development of a domestic well mitigation program is not a project as defined by the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) and would therefore not trigger either. Required permits and will be obtained and environmental documentation prepared as necessary for wells or other relevant projects related to bringing pressurized groundwater of suitable quality to residences.

Timetable for Initiation and Completion: The GSAs have coordinated on the basic roles and responsibilities of the program, with the Merced Subbasin GSA serving as the primary administrator of the program and the other basin GSAs serving in supporting roles as liaisons of the program. As the primary administrator of the program the Merced Subbasin GSA has collected a total of $600,000 with an anticipated total collection of $800,000 by the end of fiscal year 2025-2026 for the Program's development and implementation. The number of domestic wells dewatered during implementation of the GSP (prior to 2040) is heavily dependent on precipitation and snowpack during that time period. Wet conditions may result in few dewatered wells. However, substantial numbers of domestic wells may be dewatered if prolonged drought occurs during early implementation of the GSP, while project and management actions are still being developed and implemented. The attributes of this management action will be evaluated as monitoring continues through GSP implementation to determine if undesirable results are present. It is not anticipated a domestic well mitigation program will be necessary beyond the GSP implementation period, as the Subbasin is expected to reach sustainability (absence of undesirable results) by 2040.

Expected Benefits and Evaluation: The domestic well mitigation program is expected to benefit domestic well users, including disadvantaged communities, who are experiencing adverse impacts (including financial and/or both water supply and/or quality) as a result of overdraft conditions. Expected benefits include improved groundwater supply conditions (including water quantity and quality). Benefits would be evaluated by the number of shallow wells impacted and successfully mitigated under this management action. As previously stated, the comprehensive modeling analysis to be completed by the WY 2025 Annual GSP report will determine the number of domestic wells to be impacted by the interim milestones identified in this GSP.

How Project Will Be Accomplished: Details of how this management action will be accomplished will build on the Domestic Well Mitigation Program Implementation Roadmap. The GSAs will perform outreach and collect feedback from the public and stakeholders (particularly domestic well users) to develop this program. Program details will be documented in a transparent manner so all interested parties have access to program objectives and requirements.

Legal Authority: The GSAs have the legal authority per SGMA to perform any act necessary or proper to implement SGMA regulations, thereby allowing the adoption of rules, regulations, ordinances, and resolutions necessary for SGMA implementation (California Water Code § 10725.2).

Estimated Costs and Plans to Meet Costs: Costs to develop and implement the Domestic Well Mitigation Program are still being determined and will be informed by the updated modeling analysis defined under Item 1. Costs will also be dependent on the number of impacted domestic wells within the Merced Subbasin. The Basin GSA's will continually evaluate the need to pursue additional funding beyond the established funding source by the MSGSA to fund the implementation of the program via grants, technical support services, low interest loans, fees, or general funds of the GSAs. The program will place the burden of sharing liability, regarding impacts to domestic wells, proportionately to the effects of the impact of yet-to-be-determined cumulative volumetric overdraft since January 1, 2015, or other more direct causes if they can be demonstrated to be independent from long term overall groundwater level depletion since January 1, 2015.

6.2.5 Above Corcoran Sustainable Management Criteria Adjustment Consideration

Description: This management action would consider an adjustment to the groundwater level sustainable management criteria for all or a portion of the Above Corcoran Clay Principal Aquifer. The Above Corcoran Clay Principal Aquifer has traditionally seen lower levels of use for water supply. As a result, minimum thresholds in this area are likely to be relatively high, as they are based on fall 2015 levels. A large component of the selection of fall 2015 as the minimum threshold was to limit impacts to domestic well users and to limit impacts of subsidence. Much of the Above Corcoran Clay Principal Aquifer has few domestic wells, and the Above Corcoran Clay Principal Aquifer is not thought to contribute to subsidence.

At the same time, a potential approach to mitigating subsidence impacts in the Below Corcoran Clay Principal Aquifer is to move pumping from below the Corcoran Clay to above the Corcoran Clay.

This management action would consider how the sustainable management criteria could be modified in all or a portion of the area, with consideration of GDEs and depletions of interconnected surface water, among others. Recharge projects may be considered for pairing with increased pumping from above the clay.

Measurable Objective: If undertaken, this management action is expected to benefit the measurable objectives established for the subsidence sustainability indicator. Revised sustainable management criteria could allow for more aggressive actions to address subsidence concerns more rapidly.

Public Noticing: Modifications to sustainable management criteria would be discussed at public meetings of the three GSA governing boards, relevant GSA committees, and the Subbasin's Stakeholder Advisory Committee and Coordination Committee.

Permitting and Regulatory Process: Modifications to sustainable management criteria is not a project as defined by the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) and would therefore not trigger either. No permits would be required.

Timetable for Initiation and Completion: If undertaken, it is likely that the effort would take place prior to 2025, to allow for the development of additional projects to address subsidence.

Expected Benefits and Evaluation: Modifications to sustainable management criteria could allow for more aggressive actions to address subsidence more rapidly, which could result in reduced damage to infrastructure. The value of this would depend on the level of additional action that would ultimately be taken.

How Project Will Be Accomplished: Modifications to sustainable management criteria would be accomplished through modifications to the GSP. This may include establishment of management areas or other approaches to accomplish the desired management within the SGMA framework.

As with the development of the GSP, these modifications would be made through a stakeholder process. The revised GSP would ultimately be adopted by the governing boards of the GSAs following a public hearing. Ninety days prior to adoption, Merced County and the Cities of Atwater, Merced, and Livingston will be provided notice and the GSAs will review and consider comments received.

Legal Authority: The GSAs have the legal authority per SGMA to amend a groundwater sustainability plan. (California Water Code § 10728.4).

Estimated Costs and Plans to Meet Costs: Costs are anticipated to be approximately $50,000 to $100,000, with the lower range of costs associated with analysis without GSP amendments and the higher range of costs associated with analysis with GSP amendments. Potential funding sources include grants or general funds of the GSAs.

6.3 PROJECTS

Since the initial publishing of the GSP in 2020, various projects have been started, completed, and new projects have been added. The different sources of projects are described in the subsections below, after which Table 6-3 and Table 6-4 presents a snapshot overview of all completed, cancelled, and in progress programs.

Full project details are included in the Merced Integrated Regional Water Management (MercedIRWM) Opti project tracker (https://opti.woodardcurran.com/irwm/merced/), which, along with the GSP, is viewed by the GSAs as a "living" document. The list of projects maintained in the MercedIRWM Opti system will be revised periodically and reflects, at any time in the future, the list of PMAs associated with the GSP. When revised, the project list will be approved by the Merced Subbasin Coordination Committee or other body, as appropriate, following updating, and will be made available via the MercedIRWM Opti system. As such, the list of projects maintained in the MercedIRWM Opti system is considered to be the official Merced Subbasin GSP project list; no formal GSP adoption will be required for PMA list updating.

6.3.1 Original 2020 GSP Projects

Projects were identified in the original 2020 GSP through a several month process involving Stakeholder Advisory and Coordination Committees and the general public. This process included a public solicitation process. A template for project submission was created, posted online for the public, and sent to the Stakeholder Advisory and Coordination Committees. This project submission template was also advertised during several committee meetings and remained online for public download on the Merced SGMA website. Project information was received from committee members and interested members of the public. The consulting team additionally reviewed local city plans and projects from the Merced Integrated Regional Water Management Plan Opti database for potentially relevant projects. Project information was compiled into a draft list. This list was discussed and presented during the January and February 2019 committee meetings. Input received from committee members and members of the public was integrated and used to refine the project list into a shortlist of projects for inclusion in the GSP. This shortlist was created on the basis of priorities identified by the public and committee members.

Priorities identified are listed as follows (in no particular order):

- Project addresses Disadvantaged Communities (DACs) and or Severely Disadvantaged Communities (SDACs)
- Project addresses areas with known data gaps (sometimes referred to by Basin stakeholders as the "white areas" as they appear "white" or blank on maps of data)
- Project provides basinwide benefit (i.e., benefits all GSAs)
- Project addresses a subsidence area
- Project focuses on recharge
- Project focuses on conveyance
- Project addresses and or prioritizes drinking water
- Project addresses and or prioritizes water for habitat

- Project focuses on monitoring, reporting, and data modeling activities for data collection to be gathered in first 5 years
- Project provides incentives to reduce pumping and to capture surface water (e.g., including flood flows)
- Project is beyond planning phase
- Project already has a dedicated funding mechanism
- Project identified as priority project by at least one GSA

An additional screening for whether the projects had a "Fatal Flaw" was conducted. A "Fatal Flaw" was defined as a case in which the implementing agency or agency upon whom the project may rely on for surface water identified an overriding issue with the project that would deem it infeasible (e.g., cost ineffectiveness, detrimental to existing surface water supply operations). Projects with Fatal Flaws were eliminated from further consideration and removed from GSP project lists.

These priorities were given equal weight and used as a filter for determining the shortlist. Projects addressing three or more of the above priorities were kept within the shortlist which can be found in the original 2020 GSP document on MercedSGMA.org, while other projects were put in a current running list to be kept for reference upon request of Stakeholder Advisory Committee members and GSA staff.

6.3.2 Projects Added Since the 2020 GSP

The GSAs have identified and pursued numerous additional projects since the original 2020 GSP was published. Most of the projects have been supported by grant funding. A summary of the grant funding sources and the types of projects funded by each grant are listed below. Full project details can be found in the Merced IRWM Opti project tracker.

Proposition 68 SGM Grant Program Planning Grant

The Merced Subbasin was awarded a Proposition 68 SGM Grant Program Planning Grant which was contracted with DWR in May 2020. The grant funded a GSP Development Project for Addressing Critical Data Gaps which consists of developing a Data Gaps Plan, upgrading & incorporating existing wells into the monitoring network, installing new well(s) in critical locations, and stakeholder outreach. It also funded the development of a remote-sensing decision support tool.

Proposition 68 SGM Grant Program Implementation Grant

The Merced Subbasin received Proposition 68 SGM Grant Program Implementation Grant in 2021 for two projects: the El Nido Conveyance System Improvements Project and LeGrand-Athlone Water District Intertie and Recharge Project (Phase 1).

Round 1 Sustainable Groundwater Management Implementation Planning and Projects Grant

At the end of February 2022, the GSAs submitted an application and spending plan to DWR for a cumulative approximately $13.7 million of grant funding for 18 projects and received $7.6 million of funding for 15 of those projects. The funded projects include a wide variety of work, including capital infrastructure to facilitate recharge, monitoring well installation and instrumentation, planning work for new recharge projects, water conservation investments, and modeling work to better understand flooding benefits.

Round 2 Sustainable Groundwater Management Implementation Planning and Projects Grant

In December 2022, the GSAs submitted an application and spending plan to DWR for a cumulative approximately $18.4 million of grant funding for 7 projects and received $3.4 million of funding for 2 of those projects: "La Paloma Mutual Water Company G Ranch Groundwater Recharge, Habitat Enhancement, and Floodplain Expansion – Phase II (Construction)" and "La Paloma Mutual Water Company Bear Creek Ranch Groundwater Recharge, Habitat Enhancement, and Floodplain Expansion – Phase I (Planning)".

Table 6-3: Completed Projects

Project Name	Project Update Description
Project 1: Planada Groundwater Recharge Basin Pilot Project	Cone Penetration Tests did not show favorable geologic conditions for a recharge basin; a dry well recharge facility was installed as an alternative to a traditional recharge basin. Pre-filtration methods designed for the pilot were insufficient; alternative approaches to filtration are being considered and evaluated. Proposed permanent monitoring well installed in September 2020. This well has been added to the Merced Subbasin's Monitoring Network.
Project 2: El Nido Groundwater Monitoring Wells	All planned well site installations have been completed. These wells have been added to the Merced Subbasin's Monitoring Network.
Project 3: Meadowbrook Water System Intertie Feasibility Study	Study completed in January 2021.
Project 5: Merced Irrigation District to Lone Tree Mutual Water Company Conveyance Canal	Completed fall 2022 and currently in operation.
Project 8: Merced Groundwater Subbasin LIDAR	Funding for this project was awarded under the Proposition 1 Round 1 IRWM Implementation Grant in 2020. LIDAR data was collected in December 2020 and will be used in conjunction with weather forecast data to predict local stormflows from rainfall events.
Project 9: Study for Potential Water System Intertie Facilities from MID to LGAWD and CWD	The study has been completed. The GSAs received Proposition 68 Implementation Grant funding for the phase 1 portion of this work in 2021. An additional, separate phase 2 of work has been funded as part of the SGM Implementation Grant Round 1. Further, LGAWD has adopted an assessment with the intention of fully funding the remaining portion of the cost estimate, which is approximately $25,000,000.
Project 11: Mini-Big Conveyance Project	Combined with Project 9 Study for Potential Water System Intertie Facilities from MID to LGAWD and CWD due to substantial overlap in scope.
Project 12: Streamlining Permitting for Replacing SubCorcoran Wells	The study has been completed and has been used by Merced County to support well permitting from below to above the Corcoran Clay in the subsidence area.
Merced Subbasin GSP Development Project for Addressing Critical Data Gaps	The sub-component "Develop Remote Sensing Decision Support Tool for Subbasin" was completed in spring 2023. Funded via Proposition 68 SGM Grant Program Planning Grant.
El Nido Conveyance System Improvements Project	Provides conveyance improvements at four existing siphons/pipelines in MID's El Nido Conveyance System to allow more surface water to be diverted from the Mariposa Creek to the El Nido area, an Underrepresented Community[49] suffering from declining groundwater levels and subsidence. Construction concluded in March 2022. Funded via Proposition 68 SGM Grant Program Implementation Grant.

1. *The following projects were reported previously but are no longer being pursued:*
    a. *GSP "Project 4: Merquin County Water District Recharge Basin" because MCWD is not currently pursuing this project.*
    b. *"Merquin County Water District (MCWD) Sustainable Yield Management Plan and Plan Implementation" because MCWD has withdrawn this project from the SGM Implementation Grant Round 1 grant agreement.*

Table 6-4: Ongoing or Future Planned Projects

Project Source	Project Name	Project Description
Original 2020 GSP Project	Project 6: Merced IRWM Region Climate Change Modeling	This project will link the existing MIDH2O (Merced Irrigation District Hydrologic and Hydraulic Optimization) planning model, developed by the MID, with models developed by DWR's Flood-MAR (Flood-Managed Aquifer Recharge) program, to models developed by the NASA's ASO (Airborne Snow Observatory) for the Merced Basin, and to the Merced's IWFM groundwater model. The MIDH2O model will explore the potential range of climate change impacts to the Merced Region including impacts to water supply, groundwater yield, and the effectiveness of various alternatives designed to help the region adapt to those anticipated changes. By linking the models, the Region can examine alternative water development and management options under a variety of climate change conditions to facilitate and efficiently evaluate multiple future scenarios. Several potential future scenarios will be assembled to the MIDH2O model and simulate a range of future climate changes. These scenarios will be simulated with different potential alternatives of water projects to evaluate the effectiveness in adapting to the climate changes. The results will help fill data gaps and inform the Region as to which projects can perform best in terms of adaptive management. Results will also identify areas where additional or different projects should be recommended to meet future needs. This project includes funding to complete a groundwater well survey for MID.
	Project 7: Merced Region Water Use Efficiency Program	The Merced Subbasin, the Merced Region Water Use Efficiency Program will be implemented by multiple water purveyors in the Region to increase the level of water conservation & ensure long-term water use efficiency by the regions urban and agricultural users. The program promotes water management strategies that support the state's goal of a 20 percent reduction in urban per-capita water use by 2020 and will do so in a way that is beneficial to DACs in the region. This program will assist management of groundwater extractions through reducing overall water demand.
	Project 10: Vander Woude Dairy Offstream Temporary Storage	This project was approved for funding in May 2022 as part of the Round 1 Sustainable Groundwater Management Implementation Planning and Projects Grant ("Vander Woude Storage Reservoir") and reflects some minor modifications to what was initially proposed in the 2020 GSP. The project will build a 30-acre storage reservoir with a capacity of 250 AF. The project will divert flood water from Mariposa and Owens Creeks and store it for later use to meet crop demand. It's estimated the reservoir would be filled 3 times per year for an estimated yield of 750 AFY. In addition, the project will permanently fallow 30-acres of productive farmland that has a crop demand of 150 AFY. The total project yield is 900 AFY. Environmental review is complete, and the design is 95% complete. The project is expected to go out to bid in summer 2024.
Proposition 68 SGM Grant Program Planning Grant	Merced Subbasin GSP Development Project for Addressing Critical Data Gaps	The "Addressing GSP Gaps" component has multiple sub-components: • The Data Gaps Plan document was completed in July 2021 and provides tools to prioritize filling the data gaps and identifies implementation procedures necessary to fill such gaps. The Data Gaps Plan does not attempt to completely fill all identified gaps, but rather acts as a starting point and guidance framework for ongoing efforts to do so.

[49] Underrepresented Communities are defined by the SGM Grant Program as a DAC, SDAC, or EDA; Tribal Lands/Tribes; California Communities Environmental Health Screening Tool Classified DACs (EnvDACs); and Fringe Communities.

Project Source	Project Name	Project Description
		• Upgrade and Incorporate Existing Wells into Monitoring Network – MIUGSA and MSGSA have identified existing candidate wells for potential incorporation into the monitoring network and instrumented several of those wells for monitoring. In early- to mid-2024, the GSAs are completing remaining work to investigate, through video logs, site visits, and well completion reports, then instrument and incorporate the appropriate wells. • Install New Monitoring Well(s) in Critical Locations – new dual completion (2 casings) monitoring well was installed in the southwest corner of the Subbasin.
Proposition 68 SGM Grant Program Implementation Grant	LeGrand-Athlone Water District Intertie and Recharge Project (Phase 1)	The LGAWD Intertie and Recharge Project consists of constructing of an approximately 2.18 mile canal connecting Merced Irrigation District's (MID) Booster Lateral 3 to Dutchman Creek northeast of Santa Fe Road. The new canal would convey 35 cubic feet per second (CFS) of floodwater for Flood Managed Recharge (Flood-MAR) on over 200,000-acres of productive farmland in the Merced Subbasin. The water for the project would come from the Intertie Canal via Little Deadman Creek. The Flood-MAR would occur within LGAWD, the Merced Subbasin white area, Plainsburg Irrigation District, Sandy Mush Mutual Water Company (MWC), Lone Tree MWC and MID. In a typical winter, over 7,000-acre feet of flood water would be utilized for Flood-MAR. The 35 CFS would be discharged from the Intertie Canal into Mariposa Creek, Little Deadman Creek, Deadman Creek, and Dutchman Creek and would be available downstream to be diverted by landowners from existing and temporary pumps. Each Point of Diversion is described in the Permanent Water Rights Application submitted to the State Water Resources Control Board on December 30, 2019 and May 28, 2020.
Projects Funded by the SGM Implementation Grant Round 1[1]	LeGrand-Athlone Water District Intertie Canal (Phase 2)	The proposed LGAWD Intertie and Recharge Project Component (Project Component) completes Phase 2 of the LGAWD Intertie Canal. The LGAWD Intertie Canal would capture and store floodwaters by constructing an approximately 2-mile canal to connect MID's Booster Lateral 3 to Dutchman Creek northeast of Santa Fe Road. The new Intertie Canal would be built to convey 125 cubic feet per second (cfs) of floodwater for Flood Managed Aquifer Recharge (Flood-MAR) on approximately 40,000 acres of productive farmland in the Merced Subbasin.
	Merced Subbasin Integrated Managed Aquifer Recharge Evaluation Tool (MercedMAR)	MercedMAR is an extension and integration of existing Merced models, including the Merced WRM and Groundwater Recharge Assessment Tool, to support exploration of groundwater recharge in the Merced Subbasin. The goal of the tool is to provide a one-stop shop tool and resources for decision makers (including Groundwater Sustainability Agency representatives, surface water operators, growers, drinking water users, domestic well owners, and other stakeholders) to implement and optimize MAR to benefit disadvantaged communities (DACs), growers, the ecosystem, GDEs, and the Subbasin's groundwater health. Additionally, MercedMAR will be used to support benefits and impacts of recharge to the shallow domestic well owners. The integrated tool can also enable the GSAs to account for allocation of recharge credits appropriately and support a basin-wide FloodMAR program.
	Vander Dussen Subsidence Priority Area Flood-MAR Project	The Vander Dussen Subsidence Priority Area Project (Project) will build a 1.25 mile earthen canal from Merced Irrigation District's El Nido Canal to and 685-acres of agricultural fields, of which approximately 325-acres are located within Sandy Mush Mutual Water Company and 333-acres in the Madera County GSA. With 90 days of flood flows, the 20 cubic feet per second (CFS) canal will yield ~3,600 acre-feet (AF) of recharge.
	Vander Woude Storage Reservoir	The project will build a 30-acre storage reservoir with a capacity of 250 acre-feet (AF). The project will divert flood water from Mariposa and Owens Creeks and store it or later use to meet crop demand. It's estimated the reservoir would be filled 3 times per year for an estimated yield of 750 AFY. In addition, the project would permanently fallow 30-acres of productive farmland that has a crop demand of 150 AFY. The total project yield is 900 AFY.
	Filling Data Gaps Identified in Data Gaps Plan	The Merced GSP identifies areas of data gaps in the Merced Subbasin in regard to a lack of understanding of groundwater levels in poorly monitored portions of the subbasin, partially due to unequal spatial representation of monitoring wells and a lack of understanding of shallow groundwater conditions near groundwater dependent ecosystems and rivers, mainly due to a lack of monitoring wells near such areas. Filling these gaps will help to improve scientific understanding, support ongoing basin management and policy making and can be used in developing future updates to the GSP. This project will include geophysical logging of the wells. The Merced GSP Data Gaps Plan, completed in Summer 2021, developed a tool to address the lack of spatial representation of monitoring wells and to determine well locations with opportunities to address multiple needs. This project proposes using the Data Gaps Tool to identify the high priority areas where the GSAs can install monitoring wells to better understand the groundwater conditions and basin water use.
	Amsterdam Water District Surface Water Conveyance and Recharge Project	This project is composed of 5 project components with an estimated benefit of 6,580 acre-feet per year (AFY). The Bert Crane Pipeline component would build approximately 1-mile of 21" pvc pipeline to convey surface water from Canal Creek to an existing 125 acre-foot irrigation reservoir. The project would also build 3 recharge ponds totaling approximately 53-acres - Mark Couchman 8-acre recharge pond, Bert Crane 25-acre recharge pond, and Craig Johnson 20-acre recharge pond.
	Crocker Control Structure Rehabilitation (Formerly "GSP Project 31: Crocker Dam Modification")	This project encompasses installation of automatic gates at MID's Crocker Dam, located just west of Merced at the bifurcation of Black Rascal Creek and Bear Creek. Crocker Dam is a fixed structure with removable plates that are installed every spring (sometimes multiple times depending on late rains) to raise the water level to allow irrigation diversions. The current configuration severely limits the operational flexibility and control over this facility as it is primarily either "up" or "down" with switching between the two a difficult task. It is proposed to replace these plates with automatic gates. The automatic gates would allow for MID to remotely operate the dam and adaptively manage the flows in Bear Creek/Black Rascal Creek. This would provide improved flood control downstream, water storage, and be a supply for groundwater recharge from stormwater (FloodMAR).
	G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project – Planning	La Paloma Mutual Water Company (LPMWC) proposes a planning study to eventually develop the G Ranch Groundwater Recharge & Ecosystem Enhancement Project. The planning Project would consist of the planning, design, and environmental permitting of the combination of groundwater recharge ponds and floodplain re-establishment. The ponds would be designed to enhance the Pacific Flyway wetland habitat. The project would be located on approximately 439 acres within the G-Ranch property. This project would enhance 270-acres of existing wetlands and re-establish the remaining 169 acres of double-cropped farmland to floodplains. The entire project would be utilized for habitat enhancement and groundwater recharge, providing additional wetland habitat for migrating waterfowl.
	G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project - Implementation	See project description in row above. Separate line items were entered for grant funding purposes, but together comprise the same project.
	Purdy Project (E. Purdy, W. Purdy, and Kevin Recharge Basins) (Project No. 38)	Project has not proceeded due to recharge credit being requested in exchange for conveyance of water to the recharge basins. This credit renders the project infeasible for the applicant to pursue.

Project Source	Project Name	Project Description
	Purdy Project (East Pike Recharge Basin) (Project No. 37)	Project has not proceeded due to recharge credit being requested in exchange for conveyance of water to the recharge basin. This credit renders the project infeasible for the applicant to pursue.
	Buchanan Hollow Mutual Water Company Floodwater Recharge Project	The Project is to complete a Groundwater Recharge and Recovery Suitability Study to determine the suitability of recharge within Buchanan Hollow Mutual Water Company (BHMWC). The Soil Agricultural Groundwater Banking Index (SAGBI) indicates that four areas of the site warrant further investigation. This Grant would fund BHMWC to hire a consulting engineer to fulfill a scope of work describing the suitability to recharge groundwater within BHMWC for subsequent extraction. It is expected the engineer would have approximately 8 geotechnical borings drilled to approximately 50 feet below the ground surface and generate lithologic logs. Soil samples would be analyzed for groundwater recharge suitability, likely moisture content, dry unit weight, grain size distribution, plasticity index, expansion potential, hydraulic conductivity (permeability), direct shear, and corrosion potential.
	Turner Island Water District (TIWD) Water Conservation	TIWD's water delivery system consists of a series of open ditches that are fed by wells and surface water pumps. It is fairly inefficient in its delivery and TIWD's growers are constantly maneuvering water in creative ways to recover delivered and return flow water. This project would consist of the construction of a surface water reservoir and installation of pumps/piping to return water to the head of the TIWD system. This would reduce strain on our growers' operations and allow us to limit the pumping of wells. Furthermore, some surface water deliveries to the district are erratic and can be curtailed quite quickly. A reservoir as part of the return system will allow TIWD to store the surface water when available and delay the pumping of wells, thereby reducing strain on wells and thus, the groundwater resources from which these wells draw. Based on this limited pumping, it is believed that this storage/return system could save 1,500 AF or more per year in groundwater extractions. This number does not reflect the ability for this reservoir to capture wet year water and stored for later use, which could be incredibly beneficial in further reducing demand on TIWD wells, potentially to the tune of an additional 750-1,000 AF per year.
	TIWD Shallow Well Drilling	Many of TIWD's wells are screened below the Corcoran Clay. Pumping from this aquifer is more likely to result in land subsidence issues, compared to pumping from the aquifer above the Corcoran Clay. This project would entail the construction of wells, screened above the Corcoran Clay to minimize subsidence impacts. This would require the scoping of the locations of the wells to ensure good production, followed by the drilling and installation of new wells at those desired locations. These shallow wells would be intended to replace existing deeper wells. Additionally, the project would consider geophysical logging of the well.
Projects Funded by the SGM Implementation Grant Found 2[2]	La Paloma Mutual Water Company G Ranch Groundwater Recharge, Habitat Enhancement, and Floodplain Expansion – Phase II (Construction)	See earlier rows for "G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project". Separate line items were entered for grant funding purposes, but together comprise the same project.
	Bear Creek Ranch Ground Water Recharge & Land Repurposing Project	This project involves the planning and design of dual-purpose groundwater recharge ponds to enhance Pacific Flyway wetland habitat. The goal of the Project is to plan and design the re-establishment of approximately 1,171-acres of irrigated farm ground to floodplains, providing habitat for migrating waterfowl. Through the fallowing of this farm ground, the Merced Subbasin would get a net benefit through decreased pumping of approximately 5,400 acre-feet per year. The project would include the installation of four lift pumps from Bear Creek and additional facilities from the Livingston Drain to convey approximately 2,200 AFY of floodwater through approximately 28,000 linear feet of new pipelines distributed across the 2,111-acre ranch. The five points of diversion are included in the Permanent Water Rights Application submitted to the State Water Resources Control Board on December 30, 2019 and May 28, 2020.

6.4 PROJECTS RUNNING LIST

At the request of GSA board members and stakeholders during the initial GSP development in 2019, the Merced Subbasin GSP also contains a running list of potential projects to be revisited on an as-needed basis. These are not intended to be taken directly as projects submitted to DWR as part of the official list of GSP projects. This list only provides a reference for potential future projects, should GSP priorities and available funding mechanisms align. The running list of projects is provided in Table 6-5 below. It has not been updated since 2020 except to remove rows for projects that have since been pursued via one of the funding applications described in earlier sections.

Table 6-5: Projects Running List for Reference

Project Name	Submitting Agency	GSA	Brief Description	Current Status	Estimated Cost
Project 13: Planada Northwest 2019 Water System Improvement Project	Planada Community Services District (2018 IRWMP)	MIUGSA	The proposed project focuses on upgrades to the Planada Community Service District's (District) water distribution system to ensure consistent water delivery to residents of the community. Improvements include: replacement of undersized water lines in the northwestern part of town, with current thin-wall plastic 2", 3" and 4" diameter water lines upsized to 8" diameter Class 900 PVC pipe; upgrading old-style water meters to radio-read meters that have better leak-detection capabilities and can better track water usage and water wasting in the community; replacement of water main valves that are beyond their useful life and no longer operate or do not open and close all the way.	Design	$ 2,184,198
Project 14: Water Efficiencies Rebate Program	City of Merced (2018 IRWMP)	MIUGSA	This proposal's goals are to save water and energy by awarding rebates to customers for upgrading to water efficient appliances. Water efficient new appliances will be rebated as follows: $100 per dish washer, $100 per clothes washer, $50 for converting toilets to ultra-low flow models of 1.6 gpf or less and new pool covers will also be rebated at $50 or 50% of the purchase price, whichever is less. Water conservation is needed to meet state mandates for 20% reduction by 2020. Many older homes have large water consuming appliances and this benefit will help our community to upgrade. By upgrading old appliances to water conserving devices, the customer can reduce water consumption and save energy without changing habits. This project will aid water users in the disadvantaged community of the City of Merced.	Conceptual	$ 100,000
Project 15: Merced Irrigation Flood-MAR Canal Automation	Merced Irrigation District (2018 IRWMP)	MIUGSA	Merced Irrigation District is proposing automation of certain facilities to enhance Flood-MAR capabilities and expand areas which can be recharged with stormwater events. The project consists of automating certain facilities including but not limited to the Washington Lateral, Northside Canal, Livingston Canal, Le Grand Canal, Caton Lateral, Escaladian Canal, Hammett Lateral, Atwater Canal, Cressey Lateral, and Arena Canal. Currently these canals have manual structures which require frequent human adjustment and inputs to safely manage flows. By automatizing these facilities, the district will be able to safely accommodate volatile and unpredictable storm flows while keeping canal levels high enough for Flood-MAR purposes. Additionally, this project will better manage surface water diversions and increase distribution efficiency by reducing spills.	Conceptual	$ 6,500,000
Project 16: Livingston Canal Lining Project	Merced Irrigation District (2018 IRWMP)	MIUGSA	The project will line a portion of the canal section of the Livingston Canal through the City of Atwater. The Livingston Canal is both a stormwater facility and irrigation facility.	Construction	$ 3,100,000
Project 17: Well 20 TCP Treatment	City of Atwater (2018 IRWMP)	MIUGSA	Redesign and install treatment for 1,2,3-TCP at Well 20 in the City of Atwater. Currently Well 20 has been drilled but nothing else has been done since there was found to be high levels of 1,2,3-TCP during pump testing. Well 20 used to be the second highest producing well in the city until high levels of manganese and iron were found due to the well being drilled too deep. A new hole was drilled on the same lot but needs additional money to cover cost of installing water treatment. City suffers from poor water pressure during summer at peak usage hours due to well not being online.	Conceptual	$ 3,000,000
Project 18: Cash for Grass Pilot Program to Eliminate Wasteful Pollution Containing Water Run-off	City of Merced (2018 IRWMP)	MIUGSA	Purpose of project is to educate about storm drains carrying pollution to creeks and begin a pilot program in the City of Merced to rebate water customers for converting their grass landscape into water efficient xeriscape with water efficient changes to their irrigation systems to eliminate pollution containing run-off. Xeriscape refers to landscaping in ways that reduce or eliminate the need for supplemental water from irrigation. Polluted run-off from urban landscapes goes into storm gutters and drains which flow to creeks; primarily Bear Creek and Black Rascal Creek. Excess irrigation of turf leads to increased water consumption, increased costs, it depletes our water supply and its run-off pollutes creeks. The program will serve to educate the public about storm water pollution and rebate them for converting grass and old irrigation systems into qualifying xeriscape with water efficient drip irrigation systems that will pollute less and save more water. Pollution in our creeks is a threat to public health, enjoyment, and the natural beauty of our urban waterways. In 1993, the City of Merced passed a water conservation ordinance and allows only limited irrigation along with prohibitions on wasting water and causing harmful pollution containing run-off. This pilot program will help eliminate pollution containing run-off from entering into local creeks and serve to beautify the community and promote water conserving irrigation practices. The City of Merced is an economically disadvantaged community and with the stimulus these rebates provide the water customers can add value to their property with landscape/xeriscape upgrades and via the conversion to water saving drip irrigation systems. The project will ultimately lead to decreased polluted storm water and trash flowing into our urban waterways. Additionally, the water customers will benefit by the rebate and the long-term benefits will be decreased water consumption. (addresses DACs and water quality)	Design	$ 65,680
Project 19: Black Rascal Creek Flood Control Project	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA, MSGSA	Construction of a regulating reservoir on the Black Rascal Creek Watershed. Project location is immediately north of Yosemite Avenue and Arboleda Drive in northeast Merced. Project will provide protection against a 200-year storm event and will provide much needed flood control on the currently unprotected Black Rascal Creek Watershed. Project will be beneficial to the project area and also to all downstream areas. The reservoir will maintain a deadpool for wildlife purposes. During the flood season, the reservoir will act primarily as a flood control retarding basin. During the irrigation season, the reservoir will regulate irrigation flows thereby increasing Merced Irrigation District system water efficiency without impacting power generation scheduling at New Exchequer Dam with the Independent System Operator (ISO).	Design	$ 35,761,703

Project Name	Submitting Agency	GSA	Brief Description	Current Status	Estimated Cost
Project 20: Black Rascal Creek Flood Control Bypass/ Supplemental Groundwater Supply Improvements	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA, MSGSA	This project proposes a set of gates in MID's Le Grand Canal to replace the breach, which is installed annually, allowing MID to redirect and control flood flows. The Le Grand Canal contributes up to 600 CFS of floodwater to Black Rascal creek. This proposed control structure can also be utilized to send flood flows on alternate, longer routes creating an artificial offset to the timing of peak storm flows as well as permit storm flows to be directed to alternate creeks and artificial groundwater recharge areas.	Planning	$ 1,000,000
Project 21: Study or a pilot recharge basin project on Canal Creek	Amsterdam Water District	MSGSA	Amsterdam Water District, a new district in the MSGSA, has a project for either a study or a pilot recharge basin project on Canal Creek. This project is still in an early phase.	Planning	NA
Project 22: Permitting and Characterization of Merced River Water for Potable Water Supply	City of Livingston (2018 IRWMP)	MIUGSA	This project is for the City of Livingston. This project consists of obtaining sufficient year-round water quality information to determine the feasibility of using Merced River Water to augment the City's groundwater domestic water supply. The project will also include preparing the required environmental documentation to obtain the necessary permits to obtain water from the Merced River. The City prepared a feasibility study to construct a horizontal collector well. The report concluded that a horizontal collector well would produce adequate water quantity.	Conceptual	$ 325,000
Project 23: Weather Based Irrigation Controllers	City of Merced (2018 IRWMP)	MIUGSA	This project is for the purchase and installation of Toro Sentinel Controllers for parks irrigation systems in the City of Merced. The Toro Sentinel Controllers are weather based irrigation controllers. The City began to use the Toro Sentinel Controllers in 2011 and currently has 68 units in the parks and maintenance districts. This powerful, yet simple-to-use controller software is ideal for large sites such as cities as it allows a user to control up to 999 field satellites from a remote location with a desktop or laptop computer. The City has a need for approximately 100 more units. The controllers can remotely shut off water, change irrigation times, days, and set alarms for stations if malfunctions occur such as power outages or extreme flows. Having the Toro Sentinel Controllers reduces manual labor and travel time from controller to controller and most importantly aids in water efficiency as the controller automatically adjusts for changes in weather.	Ongoing Program	$ 540,000
Project 24: Brasil Recharge Project	Bob Kelley, Merced Subbasin GSA/Stevinson Water District	MSGSA	Project would consist of pumping station and conveyance piping 8500' from existing canal to upgradient lands on property owned by Mike Brasil, 18246 1st Ave. Stevinson, CA 95374. Existing lands are leveled to accept recharge water in a 35-acre dedicated basin and networked into existing irrigation pipelines to allow flood irrigation on 360 acres of adjacent contiguous land both east and west of Van Clief Rd. and north of 1st Ave. and west of Griffith Rd. Water would be received in wet years (not dry years) Project Owner is Mike Brasil. Other Participating Agencies (if applicable) include Stevinson Water District. Project Location is 18246 1st Ave. Stevinson, CA 95374 and includes 35-acre Recharge Basin and 360 acres of adjacent land owned by Mike Brasil east and west of Van Clief Rd. north of 1st Ave. and west of Griffith Rd. Phase details: Planning and Initial Study complete. Conceptual Design and Design in process. Existing canal facilities and pumping stations are in place. Upgrading to size of pumps and motor upon completion of design. Determination of size of conveyance piping upon completion of design. NOE for environmental review as project is and will continue existing use as dairy farming land. Funding: Should grant funding be available fine, otherwise private funding. Timing: Likely to be implemented in 2023.	Conceptual Design	$ 300,000
Project 25: Mariposa Reservoir Enlargement and Downstream Levee and Channel Improvements	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA	The enlargement of Mariposa Reservoir and downstream levee and channel improvements would increase the level of flood protection to Planada and Le Grand, both of which are DAC's in Merced County. Mariposa Reservoir was originally constructed to provide protection for up to a 50-year storm event. The State of California has adopted legislation that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation.	Planning	$ 15,000,000
Project 26: Owens Reservoir Enlargement and Downstream Levee and Channel Improvements	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA	Owens Reservoir was constructed in the early 1950's as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The Flood Control Act of 1970 called for three additional flood control reservoirs, enlargement of existing reservoirs, and 52 miles of levee and channel modifications. To date only one additional reservoir has been built (Castle Dam). The enlargement of Owens Reservoir and downstream levee and channel improvements would increase the level of flood protection to Planada and Le Grand, both DAC's. Owens Reservoir was originally constructed to provide protection for up to a 50-year storm event. The State of California has adopted legislation that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation.	Planning	$ 15,000,000
Project 27: Atwater-McSwain Regulating/Recharge Basin	Merced Irrigation District (2018 IRWMP)	MIUGSA	The project entails construction of a regulating/recharge basin. The basin will be excavated, and automated inlet and outlet gates will be constructed along with the necessary flow measurement and control. The overall footprint of the project site is estimated at 20 acres, and the basin will occupy approximately 15 acres. The project will provide groundwater recharge in the area to increase supply and also serve as a regulating reservoir to be use by MID operations personnel.	Planning	$ 3,300,000
Project 28: Rice Field Pilot Study Monitoring Wells	Merced Irrigation District (2018 IRWMP)	MIUGSA	This Project entails construction of at least 3 groundwater monitoring wells to evaluate the efficacy of MID's rice field recharge pilot project.	Planning	$ 250,000
Project 29: Water Meter Conservation Project	City of Atwater (2018 IRWMP)	MIUGSA	Install water meters at connections that feed the biggest lots in the City of Atwater. Currently the City of Atwater has 1/3 of their connections on water meters. Most of these our homes built after 1992 and have smaller lot sizes. The homes with bigger lot sizes are currently not charged based on their water consumption, just on a flat rate. The City would like to install meters on these lots to assist with better billing and better water conservation. It would also help the City with their annual report for water loss.	Design	$ 800,000

Project Name	Submitting Agency	GSA	Brief Description	Current Status	Estimated Cost
Project 30: Real Time Simulation Flood Control Modeling - Bear Creek	Merced Irrigation District (2018 IRWMP)	MIUGSA	This project consists of modeling Bear, Black Rascal, and Burns Creeks. These three creeks (or the confluence of them) run through the City of Merced and have historically caused flooding to the area. The real time simulation model (RTS) would utilize HEC-RAS and HEC-HMS modeling software. The ability to run real time simulations will improve the ability to forecast flood flows and flood events. This forecasting will be critical in utilizing flood flows for FLOOD-MAR projects in the area. Additionally, it will enable MID to be better prepared for flood flows which happen during the irrigation season. Excess surface water is often conservatively spilled in anticipation of a rain event that occurs during the irrigation season due to lack of forecasting information.	Conceptual	$ 100,000
Project 34: TIWD GSA-1 Merced GSP Projects Reservoir	TIWD GSA-1	TIWD GSA-1	Evaluate the construction of a reservoir to hold excess waters that arrive in our area during the rainy season for later use during the irrigation season. TIWD GSA-1 is working with MID on this. Estimation of footprint 600 acres. Banks less than 12ft. (7 or 8ft bank). Flood flows and flows from MID would be captured. (catch winter, off season flows to use during the summer). Estimated Project Life (Years): 40. Funding: Grants and internal funding	Planning/Initial Study	$ 1,500,000
Project 35: University of California Merced Surface Water Augmentation	Merced Irrigation District and the University of California Merced (2018 IRWMP)	MIUGSA	The University of California Merced is in the process of developing sustainable water strategies that include the optimization of water resources. Currently, the only source of UCM Campus water is the city well (aquifer), which provides 100% of water used by the campus. Irrigation accounts for 50% percent of the total potable water used by UCM. The Merced Irrigation District and the University of California Merced are partnering to support the interconnection of the University's irrigation water supply to the Fairfield Canal. Lake Yosemite which the Fairfield Canal originates from will charge the University's Little Lake through a delivery gate located adjacent to Scholars Lane Bridge. This non-potable water source will be used in lieu of ground water for irrigation, leaving groundwater in the Basin for potable uses while optimizing the use of surface water.	Planning	$ 800,000
Project 36: Surface Water for City Park Irrigation	City of Livingston (2018 IRWMP)	MIUGSA	This project would provide surface water for the irrigation of the City's two largest Parks: Gallo Park and Arakelian Park. Water would be obtained from the nearby canals, filtered, and pressurized to irrigate the parks. The combined area of the two proposed parks is almost 15 acres. Most of the park's surface area is turf. The project is estimated to reduce groundwater pumping by almost 100 ac-ft per year. (City of Livingston) The City of Livingston's water supply is solely groundwater. Groundwater levels decline sharply during the spring and summer months and rise during the fall and winter months. In the last five years, the overall year to year groundwater levels have been declining. The groundwater contains arsenic, manganese and TCP which require the City to utilize costly treatment processes to remove them. The cost of producing potable water in the City has been increasing due to the presence of these constituents. Non-potable uses such as irrigation don't require treated groundwater and surface water could reduce the cost of irrigation at the City parks.	Planning	$ 350,000
Project 37: Exchange Recycled Water for Surface Water in Parks	City of Merced (2018 IRWMP)	MIUGSA	This project would take parks off municipal groundwater and replace the irrigation with surface water. The City would provide recycled water to the irrigation district in exchange for the surface water that would be used to water the parks. Initially it would be a demonstration project at a single project and could be expanded to other city parks as a water exchange program.	Conceptual	$ 80,000
Project 38: Marguerite Water Retention Facility	Brad Robson	MSGSA	This project includes up to 13,000 AF off-site storage for possible early season MID water, flood control, migratory waterfowl/wildlife habitat and irrigation water. The project would capture seasonal creek water. Project Owner: Le Grand Athlone District. Location: Between Deadman and Dutchman Creek. Based on report Merced county streams flood control by Army Corp Engineers March 1980.	Planning/Initial Study	NA
Project 39: Le Grand-Athlone Water District Surface Water Extension	2018 IRWMP	MSGSA	This project includes building a conveyance infrastructure from MID's booster 3 or another facility southeast, eventually connecting to Chowchilla Water District facilities near the intersection of the Madera Canal and the Chowchilla River. The connection would allow flexibility in distributing flood and other types of water in the Exchequer and Friant systems. Surface water would be available to Merced SOI growers, Plainsburg Irrigation District, LeGrand-Athlone Water District, Sandy Mush Mutual Water Company and others that predominantly use groundwater only.	Conceptual	$ 20,000,000
Project 40: Bear Reservoir Enlargement and Downstream Levee and Channel Improvements	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA	Bear Reservoir was constructed in the early 1950's as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The Flood Control Act of 1970 called for three additional flood control reservoirs, enlargement of existing reservoirs, and 52 miles of levee and channel modifications. To date only one additional reservoir has been built (Castle Dam). The enlargement of Bear Reservoir and downstream levee and channel improvements would increase the level of flood protection to the most populated areas of Merced County. Bear Reservoir was originally constructed to provide protection for up to a 50-year storm event. The State of California has adopted legislation that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation.	Planning	$ 20,000,000
Project 42: Lake Yosemite Booster Pump Station	Merced Irrigation District (2018 IRWMP)	MIUGSA	Lake Yosemite receives inflows from MID's Main Canal. It has four primary outlets; the Tower Lateral, the Sells Lateral, the Fairfield Canal, and the Le Grand Canal. During winter operations, the lake level is so low that only the Tower Lateral can be used for outflow (unless a major storm event occurs) due to the other 3 canal headgates having a higher invert. This project entails installation of booster pump station to allow for full utilization of Lake Yosemite's storage capacity and diversion facilities. The Booster pump would permit MID to move Lake Yosemite water to other portions of the district and be a key tool in implementing Flood-MAR projects.	Conceptual	$ 100,000
Project 43: Various Storm Basin Improvements	City of Livingston (2018 IRWMP)	MIUGSA	This project would include improving the City of Livingston's storm water basin pump stations. The City relies on storm water pumping stations to control storm water runoff. Several storm water pumping stations need repair. Without these pump stations the City's ability to handle large storm water flows is reduced.	NA	$ 650,000
Project 44: Burns Reservoir Enlargement and Downstream Levee and Channel Improvements	Merced Streams Group (County of Merced, City of Merced, Merced Irrigation District) (2018 IRWMP)	MIUGSA, MSGSA	Burns Reservoir was constructed in the early 1950's as an element of the Merced Streams Group Project authorized by Congress's 1944 Flood Control Act. The Flood Control Act of 1970 called for three additional flood control reservoirs, enlargement of existing reservoirs, and 52 miles of levee and channel modifications. To date only one additional reservoir has been built (Castle Dam). The enlargement of Burns Reservoir and downstream levee and channel improvements would increase the level of flood protection to the most populated areas of Merced County. Burns Reservoir was originally constructed to provide protection for up to a 50-year storm event. The State of California has adopted legislation that calls for a minimum of 200-year flood protection for urbanized areas. This project would meet the requirements of the new flood control legislation.	Planning	$ 15,000,000

Project Name	Submitting Agency	GSA	Brief Description	Current Status	Estimated Cost
Project 45: Fairfield Canal/ El Nido Superhighway	2018 IRWMP	MIUGSA, MSGSA	This project will consist of flood flow capacity improvements and canal automation, which is essential for implementing Flood-MAR projects and conveying water to MID's existing El Nido Groundwater Recharge Basin. The Fairfield and El Nido Canal system conveys water to over 52,000 acres. This project would open that acreage up to potential groundwater recharge and flood control projects. Additionally, it will assist in better management of flood flows which are anticipated to be higher intensity due to climate change. During the irrigation season, canal automation will also help to reduce operational spill and conserve water. This project will be a key component in implementing Flood-MAR to the Merced area providing critical groundwater recharge.	Conceptual	$3,000,000
Project 46: Mariposa Dam Gate Modification	Brad Robson	MSGSA	The Mariposa Dam provides flood control during rain events. It has an open pipe at the bottom of the dam and meters out the storm water. The proposed project is comprised of installing a gate to slow the release of the water when possible. This would provide opportunity for ground water recharge. Mariposa creek traverses an area that has great recharge potential due to its natural soil properties. The project would also benefit stream habitat and the DAC of Le Grand. LGAWD is the submitting agency under the Merced Subbasin GSA and would need to work with the Army Corps of Engineers who currently manages the Mariposa Dam site. The project would benefit DACs and provide opportunities for recharge. Additional benefits include water for habitat. This project supports mitigation of chronic lowering of groundwater levels through recharge.	Planning	NA
Project 47: Infiltration Basin, Clayton Water District	Clayton Water District	MSGSA	The infiltration basin size is proposed to be 100 acres and able to recharge 0.35 acre-feet per day yielding 3,500 AF of annual average storage. Recovery of the stored water will be above the E-Clay, in what is called a shallow zone. There are 3 Recovery wells proposed for this project as well as the utilization of 4 existing wells in and around the area to recover the stored water. Location of the infiltration basin will be defined once funding becomes available. Project is in Planning/Initial Study phase. Project is expected to take 3 years to complete. This includes environmental permitting and compliance. Capital costs are approx. $3.25M. Annual O&M costs are $25K annually. The wells are expected to be replaced every 20 years. Estimated Project Life in years is 60 years. Costs are based on 2019 dollars. Cost estimate was developed using previous projects and water developed at the planning level of the project. First order of funding will be Grant Assistance, second order of funding will be a Prop 218 Election.	Planning/Initial Study	$3,250,000
Project 48: Storage Basin, Clayton Water District	Clayton Water District	MSGSA	The storage basins are proposed to total 1,000 acres at 10 feet deep will yield 10,000 AF plus the demand reduction of 350 AF for a total of 10,350 AF average annual supply. The basins will be designated as storage basins and will not be cropped. Location of the infiltration basin will be defined once funding becomes available. Project is in Planning/Initial Study phase. Project is expected to take 3 years to complete. This includes environmental permitting and compliance. Capital costs are approx. $10M. Annual O&M costs are $50K annually. The recovery pumps are expected to be replaced every 20 years. Costs are based on 2019 dollars. Estimated Project Life in years is 60 years. Cost estimate was developed using previous projects and water developed at the planning level of the project. First order of funding will be Grant Assistance, second order of funding will be a Prop 218 Election.	Planning/Initial Study	$10,000,000
Project 49: Lateral Recharge, Clayton Water District	Clayton Water District	MSGSA	Lateral Recharge project include the placement of lateral leach lines within a permanent crop field (in between the rows) at a depth of at least 4 feet, assuming a 150 acre block there are 58 rows (almonds) 10 AF/day can be recharged and over the course of 100 days, 1,000 AF can be recharge in an average annual basis. Project proposed to find four 150 blocks of participating landowners, yielding 4,000 AF. Location of the infiltration basin will be defined once funding becomes available. Project is in Planning/Initial Study phase. Project is expected to take 2 years to complete, environmental process is assumed to be minimal. Capital cost is $2M per 600-acre block. Annual O&M costs are $25K annually. Leach lines are expected to be replaced every 20 years. Estimated Project Life in years is 20 years. Costs are based on 2019 dollars. Cost estimate was developed using best engineering judgement at the planning level of the project. First order of funding will be Grant Assistance, second order of funding will be a Prop 218 Election.	Planning/Initial Study	$2,000,000 (per acre block)
Project 50: Eastside By-Pass Diversions, Clayton Water District	Clayton Water District	MSGSA	The Clayton Water District is proposing 8 additional diversion in the Eastside By-Pass north of State Route 152, with a capacity of 20 cfs each for a total of 320 AF/day. The project will be to submit a Temporary Appropriative Water Right Application for the use of flood flows in the Eastside bypass, utilizing temporary diversion facilities (to be placed by landowner at their cost). Where water will be diverted for direct use as well as for temporary underground storage, which can be extracted later. Yield in 50 days is 16,000 AF averaged over 4 years totals 4,000 AF of annual average surface water. Location of the diversion points vary along the Eastside Bypass. This project is in Conceptual Design phase. Capital costs are approx. $200K. No annual O&M costs. There are no replacement costs associated with this project. Application for this project is to be renewed yearly. Costs are based on 2019 dollars. Cost estimate was developed using previous projects and was developed at the conceptual level of the project. First order of funding will be Grant Assistance, second order of funding will be a Prop 218 Election.	Conceptual Design phase	$200,000
Project 51: Merced Groundwater Basin Subsidence Area and Supplemental Supply - Phase 1	Clayton Water District	MSGSA	This project consists of an irrigation conveyance facility that connects the Central California Irrigation District's Riverside/Poso Canal to Clayton Water District (including lands to be annexed). The facility would provide supplemental water to an area which is severely impacted by subsidence. The project would be split into two phases; Phase 1 consisting of a feasibility study which would include alternative conceptual designs with Phase 2 consisting of Construction. Conceptually this facility would be approximately 2-3 miles in length and cross the San Joaquin River and East Side Canal to send water from West to East. Total cost for project is $100K. Latitude 37.112065 and Longitude -120.590162. Areas along portion of the San Joaquin River in Merced and Madera Counties have been identified by DWR and the USGS as areas subject to subsidence. In 2013, the project area subsided between 0.5 and 0.75 feet in just 12 months. The subsidence may be attributed, along with other potential factors, to groundwater extraction. Below the surface, subsidence may result in greater depths to groundwater and decreased storage volume within the aquifer. Above the surface, it may lead to infrastructure challenges necessitating canal modifications and road improvements as well as increasing areas that are susceptible to flooding which could include an elementary school, the City of Dos Palos, Highway 152, and many acres of farmland. This project would assist in correcting and/or slowing the rate of subsidence by providing supplemental water to the area and thereby providing both direct and in-lieu recharge to the underlying aquifer and benefits the overall Merced GW Basin sustainability. The California Central Valley is crisscrossed by similar water conveyance projects consisting of canals, pipelines, and pumps. This type of project is typical in water conveyance. MIUGSA is listed as a project partner in the Merced IRWMP Opti database. Objectives of project include: - Correct groundwater overdraft conditions, promote direct and in-lieu recharge, and identify supplemental water. Suppress potential subsidence through reduced groundwater pumping. This project promotes in-lieu recharge by providing a supplemental surface water supply to the area. Additionally, the proposed facility could be utilized for direct recharge.	Planning	$100,000

Project Name	Submitting Agency	GSA	Brief Description	Current Status	Estimated Cost
			- Manage flood flows and stormwater runoff (including those caused by climate change) for public safety, water supply, recharge, and natural resource management. This project would increase the acreage which could benefit from Flood Management Aquifer Recharge (Flood-MAR) projects. Flood-MAR projects in the area would help reduce flood flows in the San Joaquin River system, which has historically caused flood events downstream and threatened public safety and the environment. - Meet demands for all uses, including agriculture, urban, and environmental resource needs. The supplemental supply would directly serve agriculture but the benefits of the in-lieu recharge would be reaped by all groundwater users including urban, agriculture, and the environment. - Improve coordination of land use and water resources planning. This project facilitates augmentation of local water supplies to enhance the sustainability of the groundwater basin as directed by SGMA. - Effectively address climate change adaptation and/or mitigation in water resource management and infrastructure. This project would help mitigate climate change in the following ways;1. Provide surface water to Clayton Water District offsetting the need to pump groundwater thereby reducing energy consumption (Diesel or Electricity) 2. Subsidence is forcing multiple infrastructure projects to be redesigned, including canals which have historically been gravity conveyance systems. If subsidence continues, large energy guzzling pump stations will be necessary to continue to provide historical water deliveries - Maximize water use efficiency, including expanding in-lieu recycled water projects where feasible. This project expands the footprint that Flood-MAR projects could reach thereby allowing otherwise "Lost" water to benefit the groundwater basin, improving basin water efficiency. - Protect and improve water quality for all beneficial uses, consistent with the Basin Plan. The lower San Joaquin river has historically flooded (recently 1997, 2006, 2011, 2017). Each time this flooding occurs, it introduces pollutants, debris, oil, and potentially sewage into the environment. These San Joaquin River Flood-MAR projects would reduce these events (or lessen the extent) thereby improving water quality. - Protect, restore, and improve natural resources. The lower San Joaquin river has historically flooded (recently 1997, 2006, 2011, 2017). Each time this flooding occurs, it introduces pollutants, debris, oil, and potentially sewage into the environment. These San Joaquin River Flood-MAR projects would reduce these events (or lessen the extent) thereby protecting natural resources. - Address water-related needs of disadvantaged communities (DACs). The DAC of El Nido is severely disadvantaged and faces substantial subsidence issues. This project would benefit the area of El Nido. Additionally, it would benefit the entire Merced Groundwater Subbasin including all the DACs within it, by providing in-lieu and direct recharge to the basin, benefiting every user. - Establish and maintain effective communication among water resource stakeholders in the Region. This project would bring multiple water users together as it interconnects multiple irrigation conveyance systems. Effective communication would be established and maintained for proper project operations. This communication includes farmers, water districts, state and federal agencies, irrigation districts, and other interested parties. - Enhance public understanding of water management issues and needs. This project could be utilized as an example of reducing subsidence and mitigating declining groundwater levels to the public. Furthermore, the concept could be reproduced elsewhere. Project benefits all DAC's in the subbasin by the in-lieu and direct recharge provided. Cost estimates are provided in 2018 dollars.		

Note from MID: Local project sponsors (e.g., Lone Tree MWC, Le Grande-Athlone WD, etc.) anticipate that surface water sourced from the Merced Irrigation District may be available through temporary water purchase and sale agreements and may serve as a water supply for the project(s). It is understood that the Board of Directors for the Merced Irrigation District has and shall retain full and absolute discretion regarding whether and when it will enter into temporary water purchase and sale agreement(s), if any, and further, nothing contained in this document creates in any party or parties any right to water controlled by the Merced Irrigation District whether it be surface water or groundwater. Any transferred water made available by MID shall be limited by the terms and conditions contained in any respective temporary water purchase and sale agreement.

6.5 POTENTIAL AVAILABLE FUNDING MECHANISMS

The State Water Resources Control Board (SWRCB) identified some potential funding mechanisms that can be used toward the planning, construction, and implementation of GSP projects. Several funding types may be applicable to the current short list and potential future projects for the Merced GSP including: projects included in an Integrated Water Resource Management Plan (IRWM) Plan, projects addressing drinking water, stormwater recharge, water recycling projects, wastewater and system improvement projects, and projects that focus on DAC or SDAC areas.

The range of applicable projects, per SWRCB Funding Opportunities fact sheet and per Water Code §10727.4(h), include recharge projects, groundwater contamination remediation, water recycling projects, in-lieu use, diversions to storage, conservation, conveyance, and extraction projects. Additional Projects or Management Actions outside of this list that a GSA determines will help achieve the sustainability goal for the Basin may also be applicable (see GSP Regulations §354.44). Many of the available funding mechanisms accept applications on a continuing basis. Table 6-6 provides a brief overview of the project types and available funding and programs as well as important dates to consider for implementation.

Table 6-6: Overview of Project Types and Available Funding Mechanisms

Project Type and Purpose	Funding Type	Program	Important Dates
Water recycling projects	Planning and construction grants and financing	Water Recycling Funding Program (Prop 1 and 13)	Planning applications accepted on continuous basis. Construction applications received by December 31st each year will be used to develop a priority score. Projects which receive a priority score equal to or greater than the yearly fundable list cutoff score will be placed on the fundable list for the upcoming fiscal year
Wastewater treatment for DAC & SDAC projects	Planning and construction grants and financing	Small Community Grant Fund (Prop 1 and CWSRF)	Applications accepted on continuous basis
Drinking Water	Planning and implementation grants	Sustainable Groundwater Management Grant Program	Released as funding becomes available
Public water system improvements	Planning and construction grants and financing	Drinking Water Grants (Prop 1 and 68, and DWSRF)	Applications accepted on continuous basis
Stormwater recharge projects	Implementation grants	Storm Water Grant Program	Released as funding becomes available
IRWM projects (included and implemented in an adopted IRWM Plan)	Implementation Grant	IRWM Implementation Grant Program	Released as funding becomes available

7 PLAN IMPLEMENTATION

The GSAs will work together cooperatively to implement the Merced GSP in compliance with SGMA. Implementation of the GSP will be a substantial undertaking that will include implementation of the PMAs included in Chapter 6, as well as the following:

- Merced GSP implementation program management
- GSAs administration
- Public outreach
- Implementation of the monitoring programs
- Development of annual reports
- Development of periodic evaluations

Chapter 7 (Plan Implementation) provides a description of the above, including contents of the annual and periodic evaluation reports that will be provided to the DWR as required under SGMA regulations.

7.1 IMPLEMENTATION SCHEDULE

A detailed implementation schedule through 2040 is provided in Figure 7-1 which contains information on the GSP Implementation Program management, GSA administration, public outreach, GSP implementation program management, monitoring, Annual and Periodic Evaluation Reports, monitoring, and implementing GSP-related PMAs.

Figure 7-1: GSP Implementation Schedule

Overall Task	Subtask	Approximate Start	Approximate End	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
GSA Administration		12/31/2020	12/31/2040																	
	Merced Irrigation-Urban GSA	12/31/2020	12/31/2040																	
	Merced Subbasin GSA	12/31/2020	12/31/2040																	
	Turner Island Water District GSA-1	12/31/2020	12/31/2040																	
Stakeholder/GSA Board Engagement		12/31/2019	12/31/2040																	
Public Outreach		12/31/2019	12/31/2040																	
Monitoring		12/31/2019	12/31/2040																	
Annual Reports		12/31/2019	12/31/2040	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Periodic Evaluation Reports		1/1/2024	12/31/2040		♦					♦					♦					♦
Project Implementation		5/1/2022	7/13/2029																	
	Merced Subbasin GSP Development Project for Addressing Critical Data Gaps	9/30/2024	2/28/2025																	
	LeGrand-Athlone Water District Intertie and Recharge Project (Phase 1)	9/30/2024	8/1/2025																	
	LeGrand-Athlone Water District Intertie Canal (Phase 2)	9/30/2024	8/1/2025																	
	Merced Subbasin Integrated Managed Aquifer Recharge Evaluation Tool (MercedMAR)	9/30/2024	11/29/2024																	
	Vander Dussen Subsidence Priority Area Flood-MAR Project	4/1/2024	4/1/2025																	
	Vander Woude Storage Reservoir	9/30/2024	11/1/2024																	
	Filling Data Gaps Identified in Data Gaps Plan	9/30/2024	11/1/2024																	
	Amsterdam Water District Surface Water Conveyance and Recharge Project	5/1/2022	5/2/2025																	
	Crocker Control Structure Rehabilitation	9/30/2024	7/13/2029																	
	La Paloma Mutual Water Company G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project - Planning & Implementation AND Phase I (Planning) & Phase II (Construction)	9/30/2024	4/1/2026																	
	Buchanan Hollow Mutual Water Company Floodwater Recharge Project	4/1/2024	4/1/2025																	
	Turner Island Water District (TIWD) Water Conservation	9/30/2024	7/1/2026																	
	TIWD Shallow Well Drilling	9/30/2024	1/30/2025																	
	Bear Creek Ranch Ground Water Recharge & Land Repurposing Project	9/30/2024	1/30/2026																	
Management Action Implementation		1/1/2020	12/31/2040																	
	Initial Groundwater Allocation Framework	1/1/2020	1/30/2030																	
	MSGSA Groundwater Demand Reduction Management Action	1/1/2020	12/31/2040																	
	MIUGSA Groundwater Allocation	1/1/2020	12/31/2040																	
	Domestic Well Mitigation Program	7/1/2024	12/31/2040																	
	Above Corcoran Sustainable Management Criteria Adjustment Consideration	1/1/2025	12/31/2040																	
Adaptive Implementation (as-needed)		1/1/2020	12/31/2040																	
	Evaluate Unimplemented Projects	1/1/2020	12/31/2040																	
	Revisit Projects not included in GSP	1/1/2020	12/31/2040																	

7.2 GSP IMPLEMENTATION PROGRAM MANAGEMENT

GSP Implementation Program Management will primarily consist of oversight of the implementation of the PMAs described in Chapter 6 of this GSP and general GSP administration. This includes coordination of technical activities associated with GSP implementation and management of activities implemented through the GSP across GSAs. GSP Implementation Program Management would also include grant administration for funding awarded for regional projects or programs and/or any future potential Plan updates.

GSP administration includes the joint coordination activities of the GSAs necessary to implement the GSP. GSP development was guided by a Coordination Committee and the GSAs intend to continue to use the Coordination Committee to guide implementation of the GSP. Administrative activities include managing quarterly Coordination Committee meetings and on-going email updates from MIUGSA, MSGSA, and TIWD GSA-1 to the Coordination Committee related to the statewide SGMA program and Merced GSP activities. It also includes oversight of consultants or contractors that may be retained by the GSAs in support of joint GSP activities (including but not limited to GSP updates, annual reporting, and monitoring), and administration of the GSAs Coordination MOU.

Coordination Committee meetings will be held quarterly, generally staggered with respect to the SAC meeting. The Coordination Committee may hold joint meetings with the SAC when appropriate. The Coordination Committee is responsible for steering the Merced GSP Implementation Program, including review of internal drafts of the GSP and subsequent updates along with the annual reports. As described in Chapter 1 (Introduction and Plan Area), the Coordination Committee is responsible for developing recommendations for basin management and considering input from the SAC and the public before presenting recommendations to the GSA Boards. The Coordination Committee will work closely with GSP and GSA staff to manage the Merced GSP Implementation Program. In addition to quarterly meetings, the Coordination Committee will participate in calls and emails as necessary and may meet more frequently as needed, such as during development of annual reports or GSP updates.

Activities under GSP Implementation Program Management also include stakeholder engagement through the Stakeholder Advisory Committee (SAC). The SAC will be maintained as a non-voting body, with the intent to provide input and an exchange amongst a broad range of stakeholder perspectives. This body will meet quarterly to discuss GSP and GSA activities, provide input to the Coordination Committee, and present on items of interest related to the basin. These meetings are to be staggered in a way that allows two weeks to one month’s time before the Coordination Committee. This will enable a formal summary of input to be generated and provided to the Coordination Committee. The focus and frequency of these meetings may be revised depending upon what topics need to be discussed. It is expected that SAC input and discussion will be especially important in the first several years of GSP Implementation, as these initial years will involve key decision-making and project implementation. For the purpose of providing input and encouraging exchange with the Coordination Committee, a liaison position may be created among the members of the SAC. The liaison will report at the Coordination Committee meetings and serve as a direct representative for the SAC body. SAC meetings are held in-person with a virtual attendance option and are generally two hours long. A facilitator may be selected and funded by the GSAs for these meetings. There are currently 23 SAC members, each of whom serve an indefinite term. Opportunities for new members to join the Stakeholder Advisory Committee will occur prior to each GSP update.[50]

7.3 GSA ADMINISTRATION

Each of the GSAs are administered independently and involve coordination and oversight of individual GSA projects and programs. Chapter 1 (Introduction and Plan Area) describes the governance and member agencies of each of the GSAs. GSA administration includes: regular coordination meetings within each GSA; regular email communications to update GSA members on on-going basin activities; coordination activities with the other GSAs; and other activities necessary for GSA operations. GSA staff meetings occur more frequently during Periodic Evaluation years than during non-Periodic Evaluation years, with other oversight and administration activities occurring as needed and on an on-going basis. GSA administration also requires additional effort during GSP updates, and during Annual and Periodic Evaluation Report development.

Although staff from the GSAs and GSA member agencies meet regularly as part of GSA administration, their individual GSA's Board of Directors will meet in accordance with each GSA's Board Calendar or bylaws. Joint calls with the Boards of each GSA for basin-wide updates and coordination activities will be held periodically. The Coordination Committee will be responsible for developing agendas and recommendations for joint Board meetings, while the Coordination Committee members from each GSA will be responsible for providing updates and presenting recommendations to their respective GSA's Board.

7.4 PUBLIC OUTREACH

During GSP development, the Merced GSP Program used multiple forms of outreach to communicate SGMA-related information and solicit input. The GSAs intend to continue public outreach and provide opportunities for engagement during GSP implementation. This will include providing opportunities for public participation, especially from beneficial users, at public meetings, providing access to GSP information online, and continued coordination with entities conducting outreach to DAC communities in the Basin. Announcements will continue to be distributed via email prior to public meetings (e.g., Stakeholder Advisory Committee meetings, Coordination Committee meetings, public workshops, and GSA Board meetings). Emails will also be distributed as specific deliverables are finalized, when opportunities are available for stakeholder input and when this input is requested, or when items of interest to the stakeholder group arise, such as relevant funding opportunities. The Merced SGMA website, managed as part

[50] For further information on Stakeholder Advisory Committee structure and involvement, please see Chapter 1 (Introduction and Plan Area)

of GSP Administration, will be updated a minimum of monthly, and will house meeting agendas and materials, reports, and other program information. The website may be updated to add new pages as the program continues and additional activities are implemented. Additionally, public workshops will be held semi-annually, or more frequently if necessary, to provide an opportunity for stakeholders and members of the public to learn about, discuss, and provide input on GSP activities, progress towards meeting the Sustainability Goal of this GSP, and the SGMA program.

7.5 MONITORING PROGRAMS

The GSP identifies the need for ongoing monitoring and filling of data gaps. The monitoring programs are a critical element of GSP implementation. The GSAs intend to implement the monitoring programs described in Chapter 4 (Monitoring Networks) to track conditions for the applicable sustainability indicators discussed in Chapter 3 (Sustainable Management Criteria). The GSP has identified monitoring networks for groundwater levels, water quality, and subsidence; representative monitoring sites have been selected and minimum thresholds have been established. Monitoring Network data will be collected and used to determine whether Undesirable Results are occurring, better characterize basin conditions, identify trends, and determine if adaptive management is necessary. Monitoring data will be managed using the Merced Data Management System (DMS) developed during GSP preparation specifically for this purpose. The GSP Monitoring Networks make use of existing monitoring programs and develop further monitoring to continue characterization of the Subbasin. As described in Chapter 4 (Monitoring Networks), key components involved in the implementation of the Monitoring Network activities for the Merced GSP by relevant Sustainability Indicator include:

Groundwater Levels

The monitoring program for groundwater levels utilizes existing CASGEM wells in the Subbasin, plus new monitoring wells added since the initial GSP was published. Additional efforts to fill remaining data gaps include:

- Evaluation of other existing wells for additional construction information (where missing) and/or permission for access to wells to collect data.
- Seeking funding to construct additional monitoring wells, which are preferred to active wells due to shorter screened intervals and lack of groundwater production to interfere with measurements. New monitoring well sites should include a very shallow well at the same location for areas near GDEs, to the extent funding and logistics allow.
- Installation of pressure transducers at representative wells that exhibit groundwater levels that are highly variable or difficult to explain to better understand the variability, to the extent feasible. Installations may be temporary or permanent.

Water Quality

The water quality monitoring program for the GSP will utilize monitoring wells and data from existing programs such as the East San Joaquin Water Quality Coalition Groundwater Quality Trend Monitoring and Public Water System wells, and includes the following key activities:

- Active coordination with existing monitoring programs:
    - Annual review of data submitted to the Department of Pesticide Regulation (DPR), Division of Drinking Water (DDW), Department of Toxic Substances Control (EnviroStor), and SWRCB (GeoTracker as part of the Groundwater Ambient Monitoring and Assessment [GAMA] database).
    - Annual check-ins with existing monitoring programs, such as CV-SALTS and ESJWQC GQTM.
    - Annual review of annual monitoring reports prepared by other programs (such as CV-SALTS and ILRP).
    - GSAs will invite representative(s) from the Regional Water Quality Control Board, Merced County Division of Environmental Health, and ESJWQC to attend an annual meeting of the GSAs to discuss constituent trends and concerns in the Subbasin in relation to groundwater pumping.
- Exploratory efforts in obtaining construction information for at least 20 DDW PWS wells in the Corcoran Clay region

Subsidence

The subsidence monitoring program for the GSP will utilize monitoring data from the SJRRP's subsidence control points. Installation of extensometers has been recommended to help understand the depth at which subsidence is occurring. This will involve coordination with the SJRRP, the USGS, and other entities associated with subsidence studies, as well as interbasin coordination efforts with Chowchilla and Delta-Mendota Subbasin on the funding and installation of additional subsidence monitoring that may include extensometers or other measurement methods to better understand trends and any potential correlation to groundwater levels in the different principal aquifers across all subbasins.

Depletion of Interconnected Surface Waters

The GSP will rely on groundwater level monitoring and streamflow monitoring to support characterization of the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. Efforts for coordination and monitoring methods development include:

- Contacting state, federal, and environmental organizations to determine interest in developing a method of tracking the date and location where ephemeral or intermittent flowing streams and rivers cease to flow.
- Seeking funding for development of additional multi-level monitoring wells to better characterize very shallow groundwater conditions near rivers and streams as well as near other deeper monitoring wells.

7.6 DEVELOPING ANNUAL REPORTS

As required under California Code of Regulations §356.2 (SGMA regulations), annual reports must include three key sections: 1) General Information, 2) Basin Conditions, and 3) Plan Implementation Progress. Report information requirements are detailed below and would be completed in a manner and format consistent with the SGMA regulations. As annual reporting continues, it is possible that this outline will change to reflect basin conditions, the priorities of GSAs, and applicable requirements from DWR.

7.6.1 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 description of the sustainability goals, provide a description of GSP projects and their progress as well as an annually updated implementation schedule and map of the Subbasin. Key components as required by SGMA regulations include an Executive Summary and a Map of the Basin.

7.6.2 Basin Conditions

Basin 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 year to historical groundwater data. Pumping data, effects of project implementation (e.g., recharge data, conservation, if applicable), surface water flows, total water use, and groundwater storage will be included. The GSAs will also evaluate the use of the GDE Pulse tool to help assess GDEs. This tool was developed by The Nature Conservancy and ties together satellite (Landsat), rainfall, and groundwater data. Key components of the Annual Report as required by SGMA regulations include:

- Groundwater elevation data from the monitoring network
- Hydrographs of elevation data
- Groundwater extraction data
- Surface water supply data
- Total water use data
- Change in groundwater storage, including maps

7.6.3 Plan Implementation Progress

Progress towards successful plan implementation would be included in the annual report and describe the progress made towards achieving interim milestones as well as implementation of PMAs. Key components as required by SGMA regulations include Plan Implementation Progress and Sustainability Progress.

7.7 DEVELOPING PERIODIC EVALUATION REPORTS

SGMA requires that GSPs be evaluated regarding their progress towards meeting the approved sustainability goals at least every five years, and to provide a written assessment to DWR. An evaluation must also be made whenever the GSP is amended. A description of the information that will be included in the periodic evaluation is provided below and would be prepared in a manner consistent with §356.4 of the SGMA regulations and DWR guidance documents.

7.7.1 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 towards achieving interim milestones and measurable objectives will be included, along with an evaluation of groundwater elevations (being used as direct measure for water level and proxy measure surface water depletions), groundwater quality, and subsidence in relation to minimum thresholds.

7.7.2 Plan Implementation Progress

This section of the Periodic Evaluation report will describe the current status of project and management actions since the previous Periodic Evaluation report. An updated project implementation schedule will be included, along with any new projects that were developed to support the goals of the GSP and identification of any projects that are no longer included in the GSP. The benefits of projects that have been implemented will be included, and updates on PMAs that are underway at the time of the Periodic Evaluation report will be reported.

7.7.3 Reconsideration of GSP Elements

Part of the Periodic Evaluation report will include a reconsideration of GSP Elements. As additional monitoring data is collected during GSP implementation, land uses and community characteristics change over time, and GSP PMAs are implemented, it may become necessary to revise the GSP. This section of the Periodic Evaluation report will reconsider the basin setting, management areas, undesirable results, minimum thresholds, and measurable objectives. If appropriate, the Periodic Evaluation report will recommend revisions to the GSP. Revisions would be informed by the outcomes of the monitoring network, and changes in the basin, including but not limited to, changes to groundwater uses or supplies and outcomes of project implementation.

7.7.4 Monitoring Network Description

A description of the monitoring network will be provided in the Periodic Evaluation report. Data gaps, or areas of the basin that are not monitored in a manner consistent with the requirements of §352.4 and §354.34(c) of the regulations will be identified. An assessment of the monitoring network's function will 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 implemented schedule for addressing gaps and how the GSAs will incorporate updated data into the GSP.

7.7.5 New Information

New information that has become available since the last Periodic Evaluation or GSP amendment will be described and the GSP evaluated in light of this new information. If the new information would warrant a change to the GSP, this would also be included.

7.7.6 Regulations or Ordinances

The Periodic Evaluation report will include a summary of the regulations or ordinances related to the GSP that have been implemented by DWR or others since the previous report and address how these may require updates to the GSP.

7.7.7 Legal or Enforcement Actions

Enforcement or legal actions taken by the GSAs or their member agencies in relation to the GSP will be summarized in this section of the Periodic Evaluation report, along with how such actions support sustainability in the basin.

7.7.8 Plan Amendments

A description of amendments to the GSP will be provided in the Periodic Evaluation report, including adopted amendments, recommended amendments for future updates, and amendments that are underway during development of the Periodic Evaluation report.

7.7.9 Coordination

The Merced GSP will be implemented by the MIUGSA, MSGSA, and TIWD GSA-1. These GSAs will coordinate as appropriate with GSAs in adjacent basins, specifically: The Delta-Mendota Subbasin, the Chowchilla Subbasin, and the Turlock Subbasin. The GSAs have executed or are in the process of executing interbasin agreements or memorandum of intent to coordinate with each neighboring basin.

7.7.10 Schedule for Periodic Evaluations

During the 2020 GSP development, the GSAs identified key areas that would need to be further developed as part of Periodic Evaluation updates. Table 7-1 illustrates the Merced GSP’s schedule for implementation from 2025 to 2040, highlighting the high-level activities anticipated for each five-year period. A more detailed schedule is included in Figure 7-1. These activities are necessary for ongoing Plan monitoring and updates, as well as tentative schedules for PMAs. Additional details on the activities included in the timeline are provided in these activities’ respective chapters of this Plan.

Table 7-1: GSP Schedule for Implementation 2025 to 2040

2025 – 2030: Preparation for Allocations and Low Capital Outlay Projects	2030 – 2035: Prepare for Sustainability	2035 – 2040: Implement Sustainable Operations
• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue, filling additional data gaps as necessary	• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue	• GSAs conduct 5-year evaluation/update • Monitoring and reporting continue
• Continued coordination on allocation program • As-needed demand reduction to reach Sustainable Yield allocation • Implement Metering program	• As-needed demand reduction to reach Sustainable Yield allocation	• Full implementation demand reduction as needed to reach Sustainable Yield allocation by 2040
• Planning/ Design/ Construction for small to medium sized projects	• Planning/ Design/ Construction for larger projects begins	• Project implementation completed
• Outreach regarding GSP and allocations continues	• Outreach continues	• Outreach continues

7.8 IMPLEMENTATION COSTS

In implementing the Merced GSP, the GSAs will incur costs which will require funding. The primary activities that will incur costs are listed and summarized in Table 7-2.

Table 7-2: Costs to GSAs and GSP Implementation Costs

Activity	Estimated Cost[1]	Assumptions
GSP Implementation and Management for GSAs		
GSP Implementation Program Management	$200,000 annually	Assumes annual costs of grant administration for regional projects or programs, or potential Plan updates. Also includes professional services to support the joint activities of the GSAs such as costs for coordination & facilitation of SAC & CC meetings.
GSA Administration	Approx. $1M annually for all GSAs combined[3]	Costs are estimated at $500K per year for MIUGSA, $400K per year for MSGSA, and $140K per year for TIWD. These include general GSA operating costs, professional services, and costs for coordination of GSA Board meetings.
Public Outreach	$75,000 annually	Assumes costs for creating communication materials, website updates (incl. maintenance and hosting), and conducting 2 public workshops per year.
Monitoring Program	$85,000 annually	Assumes costs for GW levels, evaluation of existing water level wells for additional construction information and/or permission for access to wells to collection data, coordination with existing programs[4], obtaining additional construction information for PWS wells, and data management. Does not include costs for new well installation.
Developing Annual Reports	$50,000 annually	Includes data compiling and reporting on 1) General Information, 2) Basin Conditions, and 3) Plan Implementation Progress.
Developing Periodic Evaluation Reports	$800,000 every ~5 years (across 2 fiscal years)	Includes data compiling and reporting on progress for each relevant sustainability indicator, plan implementation progress and updates, monitoring network updates and progress in addressing data gaps, description of new information, amendments, and coordination.
Implementing GSP-Projects and Management Actions		
Merced Subbasin GSP Development Project for Addressing Critical Data Gaps	$500,000	Costs spread over 3 years.
LeGrand-Athlone Water District Intertie and Recharge Project (Phase 1)	$5,035,800	Costs spread over 4 years.
LeGrand-Athlone Water District Intertie Canal (Phase 2)	$11,100,000	Costs spread over 4 years.
Merced Subbasin Integrated Managed Aquifer Recharge Evaluation Tool (MercedMAR)	$920,000	Costs spread over 2 years.
Vander Dussen Subsidence Priority Area Flood-MAR Project	$798,735	Costs spread over 2-3 years.
Vander Woude Storage Reservoir	$980,000	Costs spread over 2 years.
Filling Data Gaps Identified in Data Gaps Plan	$400,000 (40,000 per shallow well; $80,000 per deep well)	Costs spread over 1-2 years.

Activity	Estimated Cost[1]	Assumptions
Amsterdam Water District Surface Water Conveyance and Recharge Project	$1,981,175	Costs spread over 2 years.
Crocker Control Structure Rehabilitation	$30,600,000	Costs spread over 8years.
La Paloma Mutual Water Company G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project - Planning & Implementation and Phase I (Planning) & Phase II (Construction)	$15,586,650	Costs spread over 4 years.
Buchanan Hollow Mutual Water Company Floodwater Recharge Project	$26,000	Costs spread over 1-2 years.
TIWD Water Conservation	$2,000,000	Costs spread over 4 years.
TIWD Shallow Well Drilling	$500,000 per well	Costs spread over 2-3 years.
Bear Creek Ranch Groundwater Recharge & Land Repurposing Project	$750,000	Costs spread over 3-4 years.
Management Action 1 – Integrated Groundwater Allocation Framework	To Be Determined[2]	To Be Determined
Management Action 2 – MSGSA Groundwater Demand Reduction Program	$500,000 per year	Does not include well installation costs. Does include analysis, policies and procedures adoption and refinement, establishing and maintaining monitoring/reporting tools (e.g., Groundwater Accounting Platform), and outreach. Costs to implement the program depend on level of enforcement required to meet allocation each year. Annual cost estimate includes program management.
Management Action 3 – MIUGSA Groundwater Allocation	$750,000 per year	Includes staffing, analysis, policies and procedures adoption and refinement, establishing and maintaining monitoring/reporting tools (e.g., Groundwater Accounting Platform), and outreach. Costs to implement the program depend on level of enforcement required to meet allocation each year. Annual cost estimate includes program management.
Management Action 4 – Domestic Well Mitigation Program	$800,000	Assumed to be $800,000 based on the $600,000 collected at the time of publishing plus additional $200,000 expected by end of fiscal year 2025-2026 by MSGSA. Overall costs to develop and implement program are still being determined. Costs will be dependent on the number of impacted domestic wells within the Merced Subbasin. The GSAs will continually evaluate the need to pursue additional funding sources beyond the established funding source by the MSGSA.

Activity	Estimated Cost[1]	Assumptions
Management Action 5 – Above Corcoran Sustainable Management Criteria Adjustment Consideration	$75,000	Costs are anticipated to be approximately $50,000 to $100,000, with the lower range of costs associated with analysis without GSP amendments and the higher range of costs associated with analysis with GSP amendments.

[1] Estimates are rounded. Costs are presented in year 2024 dollars. All costs presented are subject to change.

[2] Costs of implementing the Integrated Groundwater Allocation Framework will depend on how the framework is implemented and are too speculative to estimate until management action is further developed.

[3] This estimate is updated based on input from GSA staff received for anticipated GSA administrative and operating costs. of GSA Operating costs.

[4] Existing programs include those identified in Chapter 4 Monitoring Networks, particularly monitoring programs for additional water quality, depletion of interconnected surface water, and subsidence.

7.9 IMPLEMENTING GSP-RELATED PROJECTS AND MANAGEMENT ACTIONS

Costs for the PMAs are described in Chapter 6 of this GSP. Financing of the PMAs vary depending on the activity. Financing mechanisms for in progress PMAs are provided in Table 7-3, though other financing may be pursued as opportunities arise or as appropriate. In future plan updates, the GSAs may develop additional management actions and revisit projects not included on the shortlist for this GSP.[6]

Table 7-3: Funding Mechanisms for In Progress Projects and Management Actions

Project/Management Action Title and Type		Responsible Agency	Funding Mechanism
Merced Subbasin GSP Development Project for Addressing Critical Data Gaps		All GSAs	Proposition 68 SGM Grant Program Planning Grant
LeGrand-Athlone Water District Intertie and Recharge Project (Phase 1)	Conveyance	MSGSA	Proposition 68 SGM Grant Program Planning Grant
LeGrand-Athlone Water District Intertie and Recharge Project (Phase 2)	Conveyance	MSGSA	SGM Implementation Grant Round 1
Merced Subbasin Integrated Managed Aquifer Recharge Evaluation Tool (MercedMAR)	Data Modelling	All GSAs	SGM Implementation Grant Round 1
Vander Dussen Subsidence Priority Area Flood-MAR Project	Conveyance Recharge	MIUGSA MSGSA	SGM Implementation Grant Round 1
Vander Woude Storage Reservoir	Storage	MSGSA	SGM Implementation Grant Round 1
Filling Data Gaps Identified in Data Gaps Plan		All GSAs	SGM Implementation Grant Round 1
Amsterdam Water District Surface Water Conveyance and Recharge Project	Conveyance Recharge	MSGSA	SGM Implementation Grant Round 1
Crocker Control Structure Rehabilitation	Storage	MIUGSA	SGM Implementation Grant Round 1
La Paloma Mutual Water Company G Ranch Groundwater Recharge, Habitat Enhancement & Floodplain Expansion Project - Planning & Implementation and Phase I (Planning) & Phase II (Construction)	Recharge Restoration	MSGSA	SGM Implementation Grant Round 1 and Round 2
Buchanan Hollow Mutual Water Company Floodwater Recharge Project	Recharge	MSGSA	SGM Implementation Grant Round 1
TIWD Water Conservation	Conservation	TIWD GSA-1	SGM Implementation Grant Round 1
TIWD Shallow Well Drilling	Subsidence Avoidance	TIWD GSA-1	SGM Implementation Grant Round 1
Bear Creek Ranch Groundwater Recharge & Land Repurposing Project	Recharge Restoration	MSGSA	SGM Implementation Grant Round 2
Management Action 1 - Integrated Groundwater Allocation Framework	Regulatory	All GSAs	Operating Funds per GSA
Management Action 2 - MSGSA Demand Reduction Program	Reduced Groundwater Use	MSGSA	Operating Funds per GSA
Management Action 3 – MIUGSA Groundwater Allocation	Reduced Groundwater Use	MIUGSA	Operating Funds per GSA

Management Action 4 – Domestic Well Mitigation Program	Mitigation	All GSAs, led by MSGSA	MSGSA Operating Funds
Management Action 5 – Above Corcoran Sustainable Management Criteria Adjustment Consideration	Regulatory	All GSAs	To be determined

7.10 GSP IMPLEMENTATION FUNDING

Implementation of the GSP is projected to cost $1.6M per year. Costs for Current in-progress or ongoing projects are estimated to be an additional $71.2M in total. Management actions include two allocation programs at a total $1.3M/year and an additional two management actions with total one-time costs estimated at $875K. Costs for individual projects or management actions range between $26K to $30.6M in total. While the development of the 2020 GSP was substantially funded through a Proposition 1 Sustainable Groundwater Planning Grant, the implementation of the GSP and future SGMA compliance continues to be a substantial and costly undertaking that will has required the GSAs to collect additional fees as well as seek additional outside funding. Costs for GSP project implementation will be shared based on project beneficiaries. Costs of overall GSP administration have been (and are expected to continue to be) shared by the GSAs consistent with the cost share in the MOU (Appendix A). Financing options under consideration include pumping fees, assessments, loans, and grants. Prior to implementing any fee or assessment program, the GSAs would complete a rate assessment study or other analysis consistent with the regulatory requirements. Information on financing options that have been pursued by each GSA are described below.

- MSGSA - On July 23, 2019, the MSGSA Governing Board adopted a Prop 218 landowner fee for all lands within the management area of the Merced Subbasin GSA in order to fund its administrative activities necessary for SGMA compliance. The fee is assessed via annual tax bills from Merced County (Zanjero, 2022).
- MIUGSA – In 2020, MIUGSA developed a fee structure to fund the regulatory activities of the GSA. The fees are adopted annually by the MIUGSA Board and are typically collected through Merced County tax bills (Hansford Economic Consulting, 2020).
- TIWD GSA-1 – The TIWD GSA-1 uses revenue from general operating assessments of its landowners to fund the GSA’s operations related to SGMA.

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APPENDIX A: MERCED SUBBASIN GSAS MEMORANDUM OF UNDERSTANDING

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APPENDIX B: COMBINED MEETING MINUTES FROM COORDINATION COMMITTEE, STAKEHOLDER ADVISORY COMMITTEE, AND PUBLIC MEETINGS

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APPENDIX E: PUBLIC COMMENTS AND RESPONSE

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APPENDIX F: SUSTAINABLE MANAGEMENT CRITERIA HYDROGRAPHS FOR DECLINING GROUNDWATER LEVELS

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APPENDIX H: MERCED TURLOCK INTERBASIN AGREEMENT

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APPENDIX L: MERCED OPTI DATA USER GUIDE

APPENDIX M: METERING AND TELEMETRY TECHNICAL MEMORANDUM

APPENDIX N: MERCED BASIN GROUNDWATER SUSTAINABILITY STAKEHOLDER ENGAGEMENT STRATEGY

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