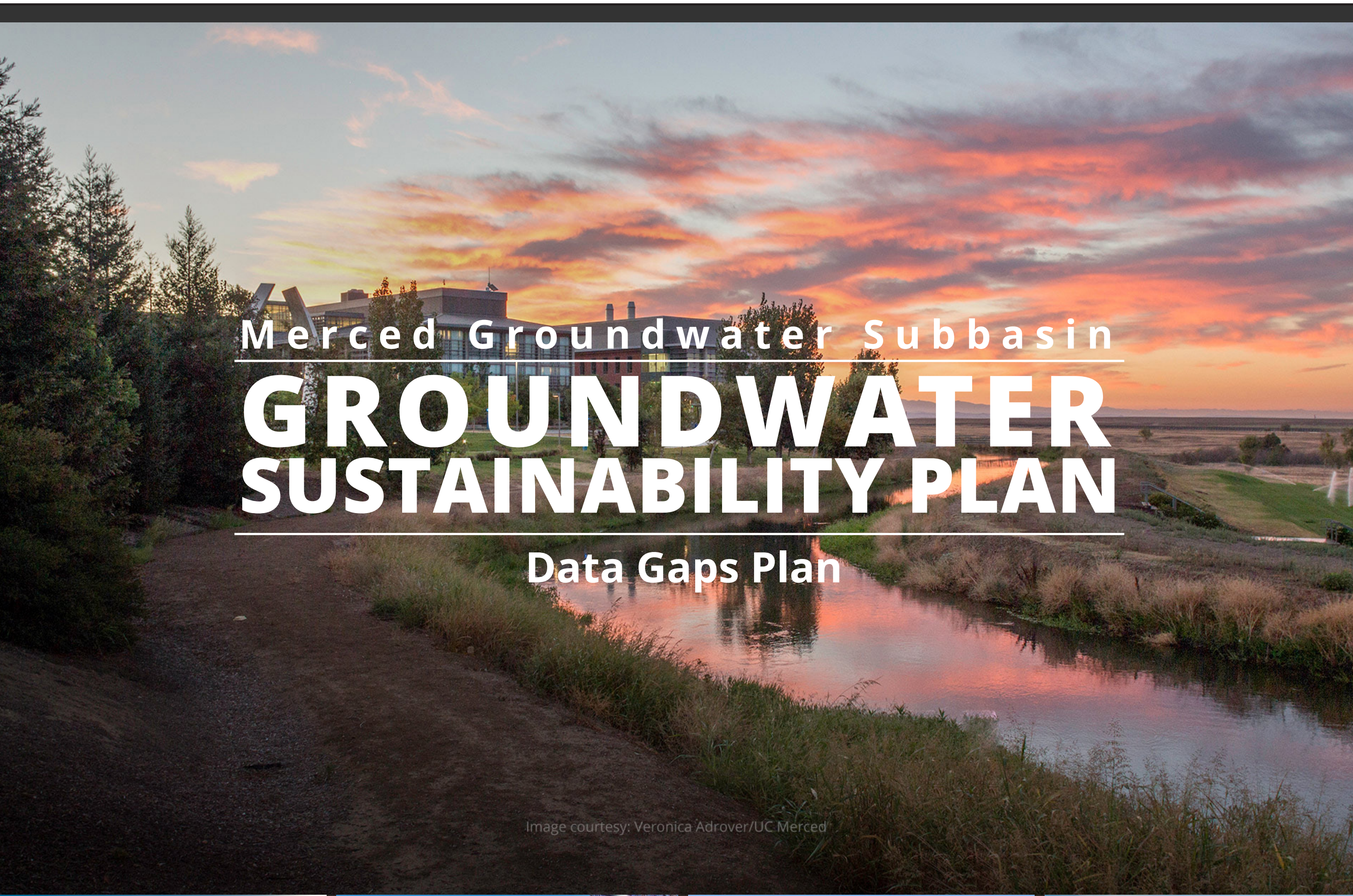
MERCED SGMA

Merced Groundwater Subbasin

GROUNDWATER SUSTAINABILITY PLAN

Data Gaps Plan



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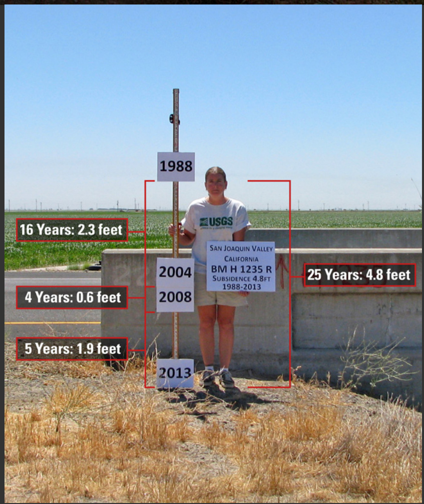

July 2021

MERCED GROUNDWATER SUBBASIN GSP

DATA GAPS PLAN

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APPENDICES

ACRONYMS

Acronym	Definition
AF	Acre-Feet
AEM	aerial electromagnetic
BMP	Best Management Practices
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CIMIS	California Irrigation Management and Information System
DAC	disadvantaged community
DGP	Data Gaps Plan
DWR	Department of Water Resources
ESJWQC	East San Joaquin Water Quality Coalition
GIS	Geographic Information System
GQTM	Groundwater Quality Trend Monitoring
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
MercedWRM	Merced Water Resources Model
MIUGSA	Merced Irrigation-Urban Groundwater Sustainability
MSGSA	Merced Subbasin Groundwater Sustainability Agency
NCCAG	Natural Communities Commonly Associated with Groundwater
PWS	Public Water System
SDAC	Severely Disadvantaged Community
SGMA	Sustainable Groundwater Management Act
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIWD	Turner Island Water District
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey

EXECUTIVE SUMMARY

In January 2020, a Groundwater Sustainability Plan (GSP) was submitted for the Merced Groundwater Subbasin by the three Groundwater Sustainability Agencies (GSAs): 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). The data gaps identified in the GSP include:

- A lack of understanding of **groundwater levels** in poorly monitored portions of the subbasin, partially due to unequal spatial representation of monitoring wells between principal aquifers.
- A lack of **groundwater quality** characterization in the subbasin in the northeastern and southwestern portions of the basin, due in part to insufficient spatial representation of monitoring wells, as well as a lack of construction information for many wells.
- A lack of understanding of the specific depths at which **subsidence** is occurring, mainly due to a lack of extensometers.
- 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.

This Data Gaps Plan provides tools to prioritize filling the data gaps and identifies implementation procedures necessary to fill such gaps. These tools and procedures can be used to develop future updates of the GSP, improve scientific understanding, and support ongoing basin management and policy making. It should be noted that this Data Gaps Plan does not attempt to completely fill the gaps identified herein, but rather acts as a starting point and guidance framework for ongoing efforts to do so.

Most data gaps are due to a lack of spatial representation of monitoring wells. Thus, this Data Gaps Plan involved the development of a tool to determine well locations with opportunities to address multiple needs. Based on a proposed groundwater level monitoring network density goal of 4 wells/100 sq. mi. or higher, a number of new sites are recommended to be added to the network in each principal aquifer in the Subbasin, as summarized in Table ES-1. Such sites may be existing wells or may require installation of new wells, to be determined during the implementation of the tools and procedures defined in this Data Gaps Plan.

Table ES-1: Existing and Recommended Groundwater Monitoring Network

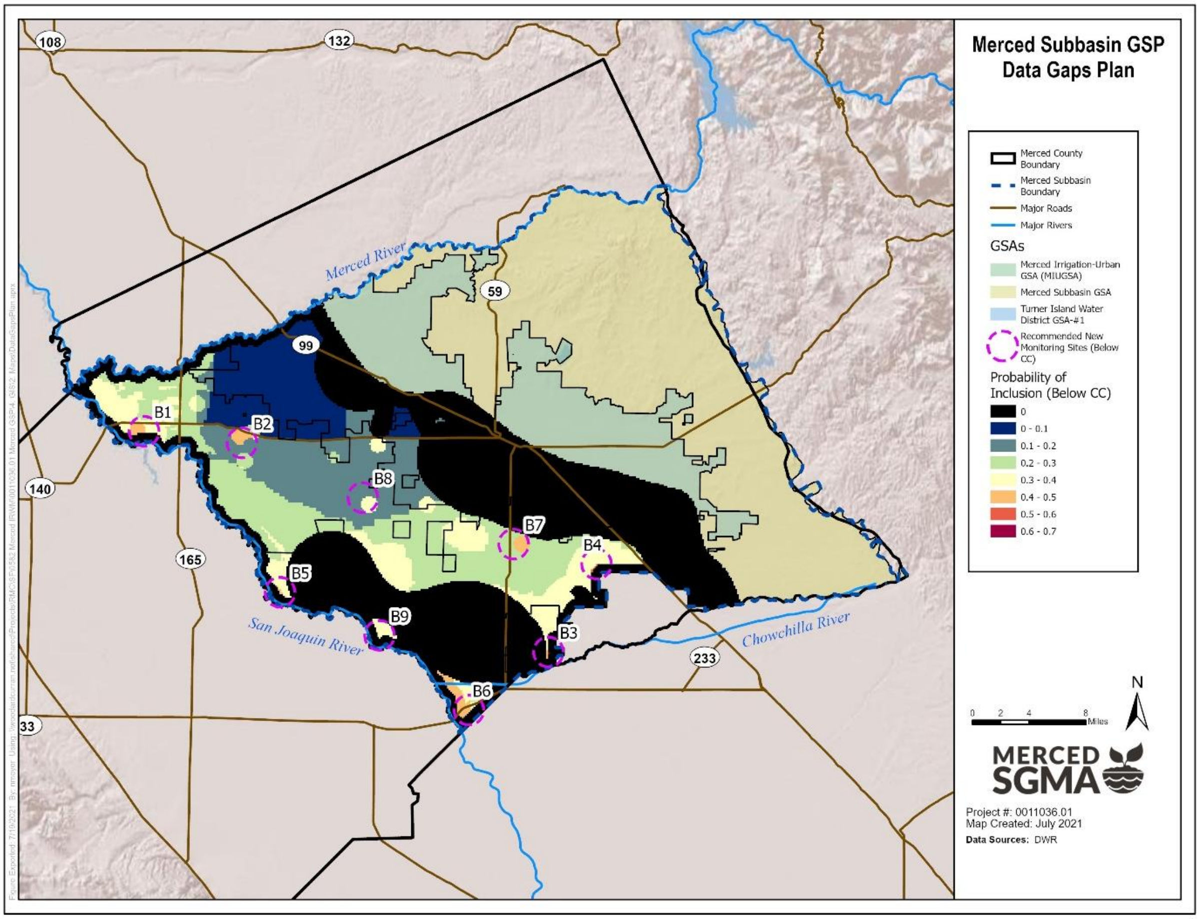
Principal Aquifer	Existing Number of Wells	Existing Density (wells/100 mi^2)	Proportion of Aquifer Requiring New Well(s) to Reach 4+ wells/100 mi^2	Number of New Sites Recommended to Reach 4+ wells/100 mi^2
Above Corcoran Clay	11	2.5	71%	13
Below Corcoran Clay	17	3.9	47%	9
Outside Corcoran Clay	26	7.1	36%	6

A geostatistical and spatial analysis tool was developed to provide the GSAs with a repeatable process by which to strategically site future monitoring wells. This tool combines the following analyses:

- Locations of existing well sites with the potential to be incorporated into the monitoring network.
- Locations of favorable factors related to siting monitoring wells, such as proximity to rivers, depth to groundwater, disadvantaged community locations, and relationship to the Corcoran Clay.
- Locations where groundwater level contouring uncertainty in the existing monitoring network is high due to insufficient or inconsistent data.

An example output of this tool is provided in Figure ES-1, which shows the locations for 9 new monitoring sites recommended for the Below Corcoran Clay Principal Aquifer.

Figure ES-1: Below Corcoran Clay Recommended New Monitoring Sites



Additional recommendations in this Data Gaps Plan include:

- **Water Quality** – Coordinate with existing monitoring programs to increase monitoring frequency and identify additional wells to incorporate into the network.
- **Subsidence** – Identify funding and location for the installation of an extensometer(s) and consider outreach to drillers/well owners to gather information on casing failures to better understand the depth at which subsidence is occurring.
- **Interconnected Surface Waters and related shallow groundwater conditions** – Expand the monitoring network through overlaps with the groundwater level monitoring network design as well as collect and incorporate new data from existing programs.
- **Interbasin Flows** – Coordinate with surrounding basins for collection of near-boundary groundwater level monitoring data.
- **Merced Water Resources Model** – Improve CIMIS evapotranspiration data for model inputs and other data efforts by coordinating site improvements at the one existing site and evaluating the Subbasin using CIMIS criteria to locate an additional monitoring site.

1. INTRODUCTION

1.1 Background

In response to the passage of the Sustainable Groundwater Management Act (SGMA) in 2014, the County of Merced and water purveyors and cities within the Merced Groundwater Subbasin (Subbasin) formed three Groundwater Sustainability Agencies (GSAs): 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). In January 2020, the GSAs submitted one Groundwater Sustainability Plan (GSP) for the Subbasin to the California Department of Water Resources (DWR).

Consistent with SGMA requirements, the Subbasin established monitoring networks capable of collecting sufficient data to monitor trends in conditions for each applicable sustainability indicator: groundwater levels, degraded water quality, land subsidence, and depletions of interconnected surface water. While the monitoring networks reflect a robust history of the Subbasin conditions, data gaps were found to exist and preliminary plans to fill these data gaps were outlined in the GSP.

This Data Gaps Plan (DGP) was funded by a Proposition 68 Sustainable Groundwater Planning Grant, Round 3, from the California Department of Water Resources, awarded to the Subbasin in early 2020, and seeks to advance the development of the GSP by addressing critical data gaps related to groundwater monitoring and basin water use.

1.2 Data Gaps Definition

DWR defines a 'data gap' as a lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of GSP implementation and could limit the ability to assess whether a basin is being sustainably managed (DWR, California Department of Water Resources, 2016a).

1.3 Goal and Purpose

This DGP describes and prioritizes data gaps identified in the Merced Subbasin GSP. The goals of this DGP are to:

- Target data gaps in areas that lack sufficient monitoring (geographical areas with no data), especially areas that will provide information that will benefit Disadvantaged Areas (Severely Disadvantaged Communities [SDAC], Disadvantaged Communities [DAC], and Economically Distressed Areas [EDAs]) in the Subbasin.
- Look for opportunities to address multiple needs (e.g., water level, water quality, subsidence) through strategically placed wells or data collection, including the creation of an estimate of the number of wells needed to provide coverage beyond the minimum DWR density guidance to better respond to needs of the Subbasin.
- Evaluate data gaps related to sustainability indicators and consider data needs to support a parallel project to develop a remote sensing decision support tool, which could include additional CIMIS stations in the basin.
- Result in a near-term strategy to cost-effectively address the most critical data gaps identified in the Subbasin, including the creation of a timeline.
- Provide a methodology to guide siting of monitoring wells or subsidence monitoring stations to support Subbasin characterization and future GSP refinement.

1.4 Use of the Data Gaps Plan

This DGP will be used to aid in the development of the five-year evaluation of the GSP (to be conducted in 2025), improve scientific understanding of the Subbasin, and support ongoing basin management and policy making. This DGP will act as a guide for Subbasin activities in the near future, highlighting the highest priority data gaps and outlining procedures necessary to fill these gaps. Further, this DGP can assist in identifying needs for grant funding.

1.5 Stakeholder Engagement

Consistent with the Proposition 68 Planning Grant, the Subbasin organized public meetings to discuss the DGP and collect input. This included three Merced GSP Coordination Committee meetings (held on February 22, 2021,April 26, 2021, and July 26, 2021) and two Merced GSP Stakeholder Advisory Committee meeting (held on April 12, 2021 and July 12, 2021). Documentation related to these meetings are included in Appendix C.

These meetings were open to the public and conducted via Zoom. Simultaneous Spanish language interpretation was provided. During the meetings, the data gaps in the GSP were presented and participants were asked to provide input on their priorities in filling data gaps. This input took the form of polling and discussion. The input was utilized in developing the DGP and is reflected in the following sections.

2. DATA GAP IDENTIFICATION

2.1 Approach

DWR created a Best Management Practice (BMP) document to assist in the development of monitoring networks and the identification of data gaps within these networks. During development of the GSP and this DGP, the BMP was used to evaluate and identify data gaps in the Merced Subbasin. DWR guidance states that each monitoring network should be capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate GSP implementation and to accomplish the following:

- Demonstrate progress toward achieving measurable objectives described in the GSP.
- Monitor impacts to the beneficial uses or users of groundwater.
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.
- Quantify annual changes in water budget components (DWR, California Department of Water Resources, 2016a).

The main data gaps identified in the Merced Subbasin GSP are listed below and described in greater detail in the following sections:

- Better understand groundwater levels in poorly monitored portions of the subbasin (Section 2.2)
- Improve characterization of groundwater quality without duplicating other efforts (Section 0)
- Better understand specific depth(s) at which subsidence is occurring (Section 2.4)
- Better understand shallow groundwater condition near groundwater dependent ecosystems (GDEs) and rivers (Sections 2.5 and 2.6)
- Better understand aquifer and climate characteristics that impact Subbasin modeling (Section 2.6)

2.2 Groundwater Levels

2.2.1 DWR Guidance

DWR guidance states that groundwater level monitoring networks should demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:

- A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.
- Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions (DWR, California Department of Water Resources, 2016a).

DWR guidance for groundwater level monitoring density ranges from 0.2 to 10 wells per 100 square miles and for frequency ranges from daily to quarterly, depending on basin geology, groundwater use, withdrawals, and definition of undesirable results (see Table 2-1 and Table 2-2).

Table 2-1: Monitoring Well Density Considerations

Reference	Monitoring Well Density (wells per 100 miles²)
Heath (1976)	0.2 - 10
Sophocleous (1983)	6.3
Hopkins (1984) Basins pumping more than 10,000 acre-feet/year per 100 miles²	4.0
Basins pumping between 1,000 and 10,000 acre-feet/year per 100 miles²	2.0
Basins pumping between 250 and 1,000 acre-feet/year per 100 miles²	1.0
Basins pumping between 100 and 250 acre-feet/year per 100 miles²	0.7

Source: DWR, 2016a

Table 2-2: Monitoring Frequency Considerations Based on Aquifer Properties and Degree of Use

Aquifer Type	Nearby Long-Term Aquifer Withdrawals		
	Small Withdrawals	Moderate Withdrawals	Large Withdrawals
Unconfined			
"low" recharge (<5 in/yr)	Once per quarter	Once per quarter	Once per month
"high" recharge (>5 in/yr)	Once per quarter	Once per month	Once per day
Confined			
"low" hydraulic conductivity (<200 ft/d)	Once per quarter	Once per quarter	Once per month
"high" hydraulic conductivity (>200 ft/d)	Once per quarter	Once per month	Once per day

Source: DWR, 2016a

According to the Historical Conditions Water Budget presented in the GSP, 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 (1984) 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 GSAs have selected a monitoring network density goal of 4 wells/100 sq. mi. in each of the three principal aquifers, which reflects the density estimate guidelines established by Hopkins (1984).

2.2.2 Recent Progress

The GSAs began filling data gaps as soon as the GSP was submitted and while this DGP was being developed. As such, there are new monitoring well locations in various stages of progress towards inclusion in the monitoring well network, from new wells that are in place and ready to monitor to existing wells that have been recommended for consideration by stakeholders but lack further analysis or agreements in place. In addition to the monitoring wells identified in the GSP, the DGP includes the following wells in the monitoring network when running calculations of monitoring network density and identifying areas in which to site new monitoring network wells:

- Four newly installed monitoring wells in the El Nido area (two locations, each with two nested wells: one below and one above the Corcoran Clay).
- One newly installed nested monitoring well in the Planada area (Below Corcoran Clay Principal Aquifer).
- Three newly installed or soon to be installed monitoring wells from the City of Merced, located in the UC Merced region (Outside Corcoran Clay Principal Aquifer).
- Three existing wells in TIWD GSA-#1 to be added the monitoring network (one above the Corcoran Clay and two below the Corcoran Clay – exact wells to be determined).

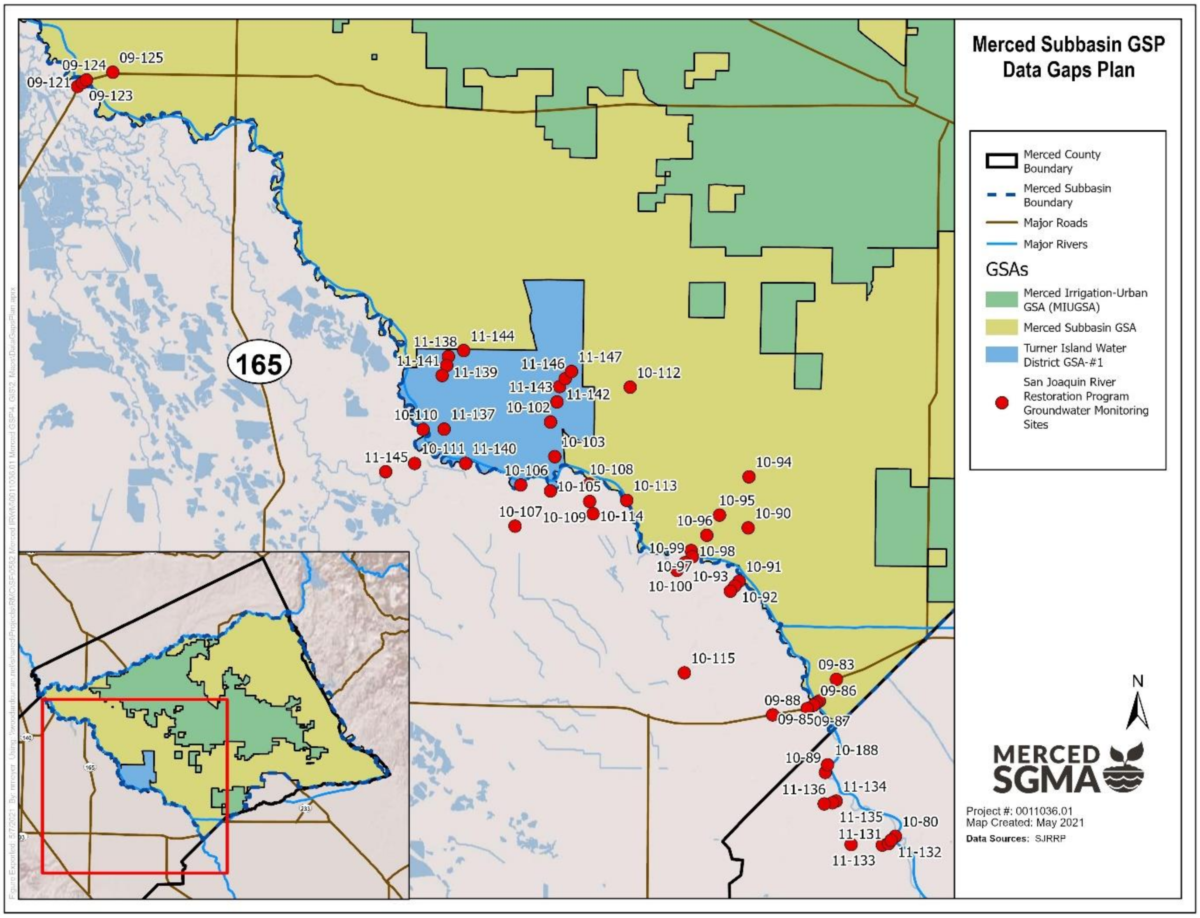
The wells presented in the DGP reflect the current monitoring network. Some monitoring wells initially presented in the GSP have since been removed, as described in the Water Years 2016-2019 and Water Year 2020 Annual Reports.

During preparation of the DGP, additional stakeholders expressed interest in contributing to the monitoring network, but not all wells could be fully evaluated and considered for inclusion.[1] Wells with both construction information (to identify above/below Corcoran Clay) and recent level data were incorporated when possible. Additional wells from interested stakeholders may be incorporated as part of the implementation of the DGP.

Additionally, data from lower reaches of the US Bureau of Reclamation San Joaquin River Restoration Program groundwater monitoring sites were also obtained. These sites may help inform shallow groundwater level monitoring and surface-groundwater interactions in the Above Corcoran Clay Principal Aquifer. Figure 2-1 shows the locations of these existing monitoring sites.

[1] Stakeholder-volunteered wells located in the Outside Corcoran Clay were added to the weighted site analysis (tiering tool output) so they would come up as potential future monitoring sites. Some stakeholder-volunteered wells in the Above and Below Corcoran Clay did not have construction information (well depth or screened interval) to sort them into the Above or Below Corcoran Clay and thus were not included at this time. These wells could be included during future tool runs in the implementation phase for filling data gaps. Where construction information was available, these wells were included.

Figure 2-1: San Joaquin River Restoration Program Groundwater Monitoring Sites

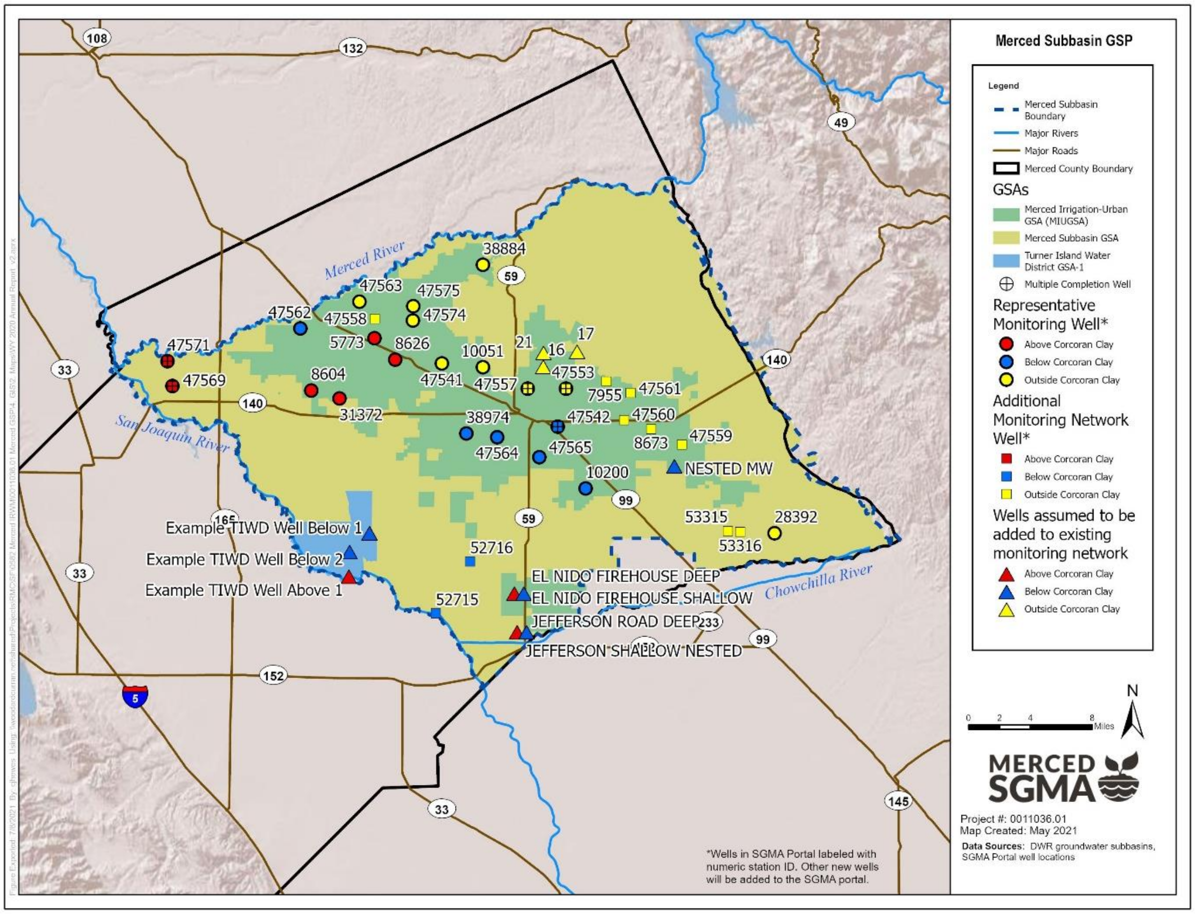


Source: Well Completion Reports from USBR, 2021

2.2.3 SGMA Monitoring Network Data Gaps

The existing groundwater level monitoring network consists of wells selected from the California Statewide Groundwater Elevation Monitoring (CASGEM) Program to provide representative conditions for groundwater levels across the Subbasin, shown in Figure 2-2. CASGEM monitoring originally recorded groundwater levels biannually at the seasonal highs and lows (typically March and October, respectively) as well as some measurements in December. As of early 2021, the GSAs are in the process of executing an agreement with a consultant to perform work related to improving data collection. The GSAs anticipate this consultant will conduct, compile, and analyze data related to the various monitoring networks from the GSP. An example of this work includes transitioning the frequency of groundwater elevation measurements from biannual (March and October) to monthly. In some cases, monitoring well sites are being equipped with data logging pressure transducers and telemetry equipment in order to further increase data collection frequency.

Figure 2-2: Current Groundwater Level Monitoring Network



While some areas in each principal aquifer exceed the density goal of 4 wells/100 sq. mi. (see Table 2-3), the dense areas do not lessen density requirements in unmonitored areas (i.e., consistent spatial representation of 4 wells/100 sq. mi. throughout each principal aquifer is desired). For instance, the total density of the groundwater level monitoring network for the Outside Corcoran Clay Principal Aquifer is 7.1 wells/100 sq. mi. However, as illustrated in Figure 2-3, most monitoring wells are clustered at a higher density along the western edge of the aquifer, so the network for the Outside Corcoran Clay Principal Aquifer requires additional sites in the east to improve spatial representation. Spatial representation is also lacking in various areas of the Above and Below Corcoran Clay Principal Aquifers, summarized in Figure 2-4 and Figure 2-5. Four significant data gaps were identified in the GSP, including:

1. Monitoring frequency is insufficient for all three principal aquifers. All three principal aquifers should be monitored at least quarterly and potentially monthly or daily in some situations.
2. The area located northwest of Merced and northeast of Atwater contains relatively fewer existing wells, which often have limited construction information, and the wells are generally privately owned and require coordination with well owners to obtain permission and data, illustrated in Figure 2-4 and Figure 2-5.

3. The area located along the western edge of the Subbasin has virtually no known monitoring wells; overall well coverage needs to be enhanced through outreach to well owners to identify wells that can be used for monitoring purposes, illustrated in Figure 2-4 and Figure 2-5.

4. The area located along the southern portion of the Subbasin includes known potential monitoring wells, but there are technical or funding issues associated with acquiring data from these wells. These wells are primarily located within a federal wildlife refuge.

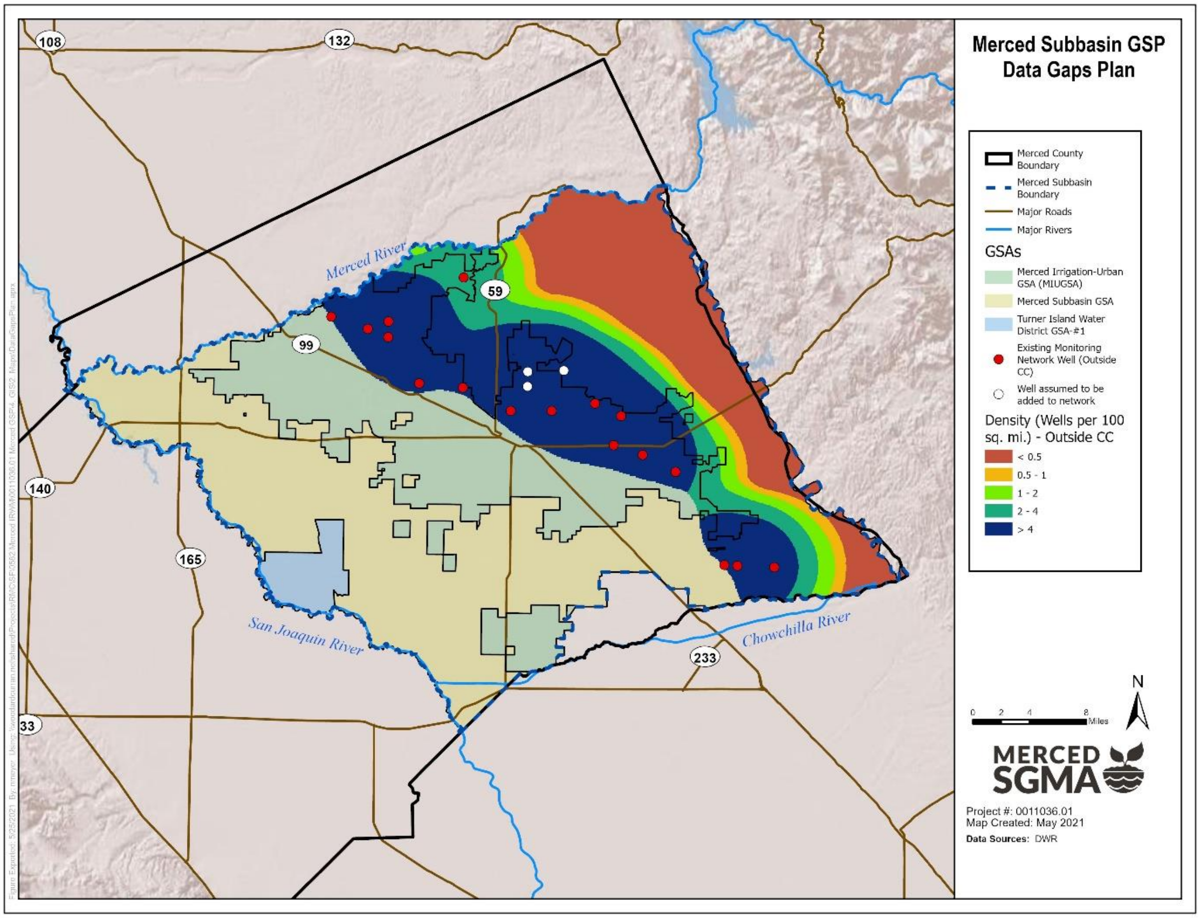
    - Note that, as described in Section 2.2.2, recent progress has been made on installation of some new wells in the El Nido area, but additional wells are still required in the greater southern region of the basin to provide more consistent monitoring well density coverage.

Table 2-3: Current Groundwater Monitoring Network Density

	Above Corcoran Clay	Below Corcoran Clay	Outside Corcoran Clay
Count of Existing Wells [1]	11	17	26
Total Aquifer Area (sq. mi.)	438	438	364
Density (wells per 100 sq. mi.)	2.5	3.9	7.1

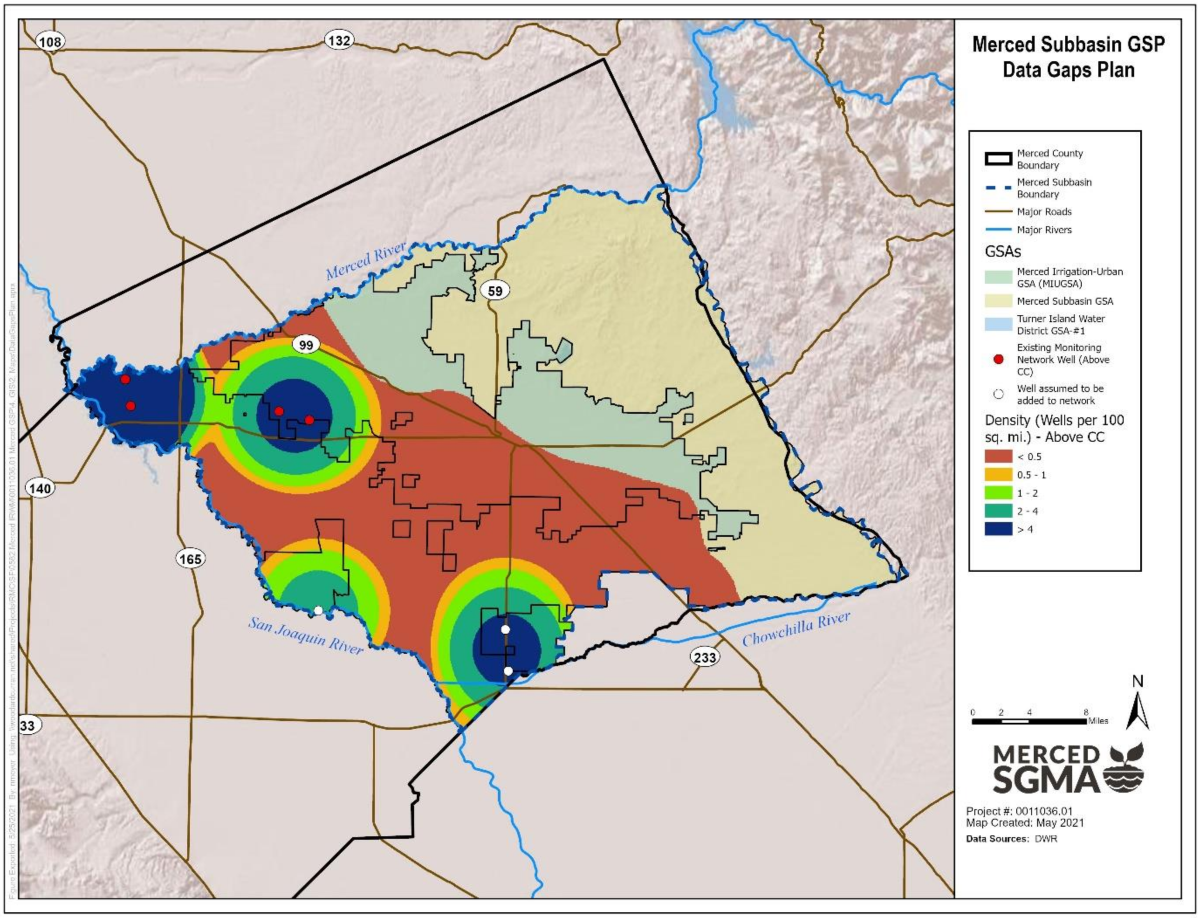
[1] *For the purpose of this DGP, some wells have been added to the network since submittal of the GSP and were included in this analysis (see Section 2.2.2).*

Figure 2-3: Current Outside Corcoran Clay Groundwater Level Monitoring Network Density



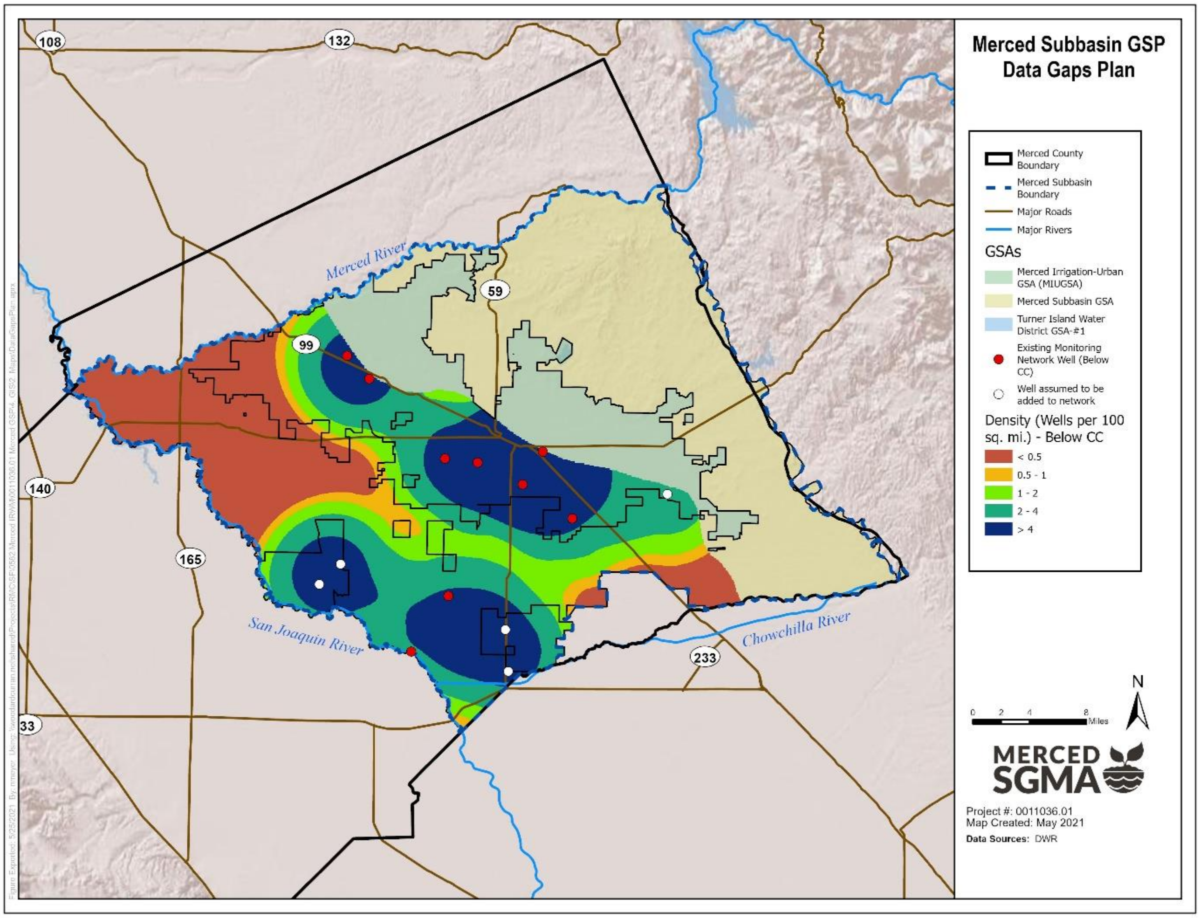
Note: The number of points on the map appears less than the existing well count presented in Table 2-3 due to the presence multi-completion wells.

Figure 2-4: Current Above Corcoran Clay Groundwater Level Monitoring Network Density



Note: The number of points on the map appears less than the existing well count presented in Table 2-3 due to the presence multi-completion wells.

Figure 2-5: Current Below Corcoran Clay Groundwater Level Monitoring Network Density



Note: The number of points on the map appears less than the existing well count presented in Table 2-3 due to the presence multi-completion wells.

2.3 Groundwater Quality

2.3.1 DWR Guidance

DWR guidance states that groundwater quality monitoring networks should collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators to address known water quality issues (DWR, California Department of Water Resources, 2016a).

2.3.2 SGMA Monitoring Network Data Gaps

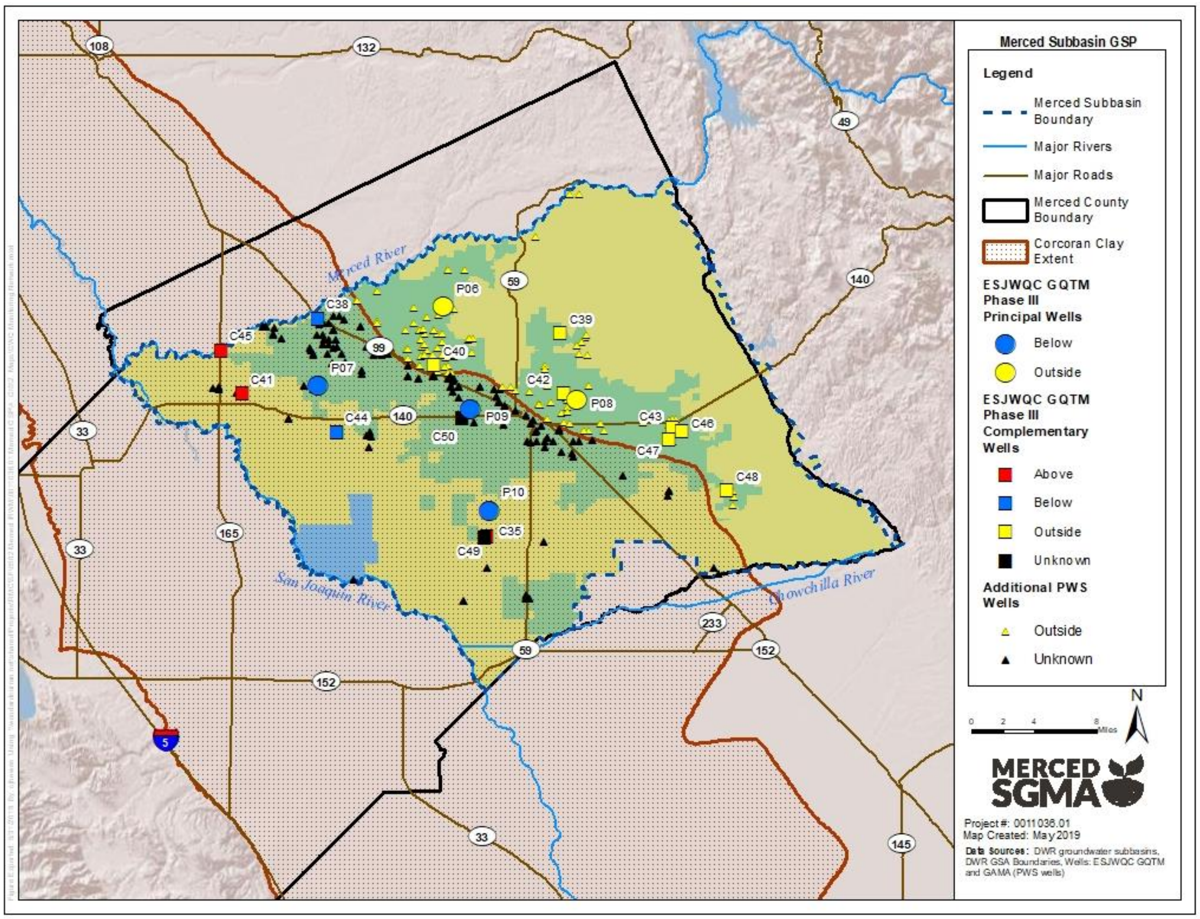
The existing groundwater quality monitoring network, illustrated in Figure 2-6, includes a combination of wells in the Subbasin that are part of the East San Joaquin Water Quality Coalition Groundwater Quality Trend Monitoring Program (described in more detail in Section 2.3.3), as well as public water system wells that report data to the Division of Drinking Water.

Two significant data gaps were identified in the GSP, including:

1. There are relatively few monitoring wells closer to the San Joaquin River located along the southwestern edge of the Subbasin and closer to Mariposa County located along the northeastern edge of the subbasin, illustrated in Figure 2-6.

2. Many wells used for monitoring do not have construction information, which limits the ability to distinguish whether wells are sampling from the Below or Above Corcoran Clay Principal Aquifer.

Figure 2-6: Current Groundwater Quality Monitoring Network



Source: Merced Subbasin GSP, 2019

2.3.3 Previous and Ongoing Efforts

Many programs exist in the Subbasin which involve collection of samples for the purpose of groundwater quality monitoring. Through the Irrigated Land Regulatory Program, the East San Joaquin Water Quality Coalition (ESJWQC) has implemented and is continuously expanding and improving a Groundwater Quality Trend Monitoring (GQTM) program. Its objectives include (LSCE, 2015):

1. Determine current water quality conditions of groundwater relevant to irrigated agriculture;
2. Develop long-term groundwater quality information that can be used to evaluate the regional effects of irrigated agricultural practices and changes in agricultural practices;
3. Understand long-term temporal trends in regional groundwater quality, particularly as they relate to effects from irrigated agriculture on potential sources of drinking water for communities;
4. Evaluate groundwater quality conditions in the Coalition area, particularly in the High Vulnerability Areas, and identify differences in water quality horizontally and vertically within the Coalition region;
5. Distinguish water quality changes associated with irrigated agriculture compared to other non-agricultural factors.

Many of the objectives described above align closely with goals for groundwater quality monitoring in the GSP. The design of ESJWQC's monitoring program includes consideration of (LSCE, 2018):

- Groundwater vulnerability
- Prioritization of High Vulnerability Areas
- Areas contributing recharge to communities reliant on groundwater (including DACs and disadvantaged unincorporated communities)
- Top acreage commodities

Spatial representation, statistical validity, and sufficiency of the GQTM well network will be evaluated by ESJWQC on an annual basis (LSCE, 2018).

Note that the GQTM is focused on monitoring what is referred to as the "Upper Zone", or an area in the Central Valley defined by a weighted average of domestic wells as well as other PWS or irrigation wells completed in the shallower portion of the aquifer system. This selection was made by ESJWQC because deeper groundwater produced below the Upper Zone is not as strongly influenced by land use practices when compared to shallower groundwater. Conversely, very shallow groundwater monitoring is also not ideal for the GQTM monitoring objectives since it can be strongly influenced by localized conditions and does not necessarily provide an accurate regional representation of groundwater quality (LSCE, 2018). The "Upper Zone" is always above or shallower than the depth of the top of the Corcoran Clay (LSCE, 2018).

Additionally, it should be noted that annual monitoring is conducted by ESJWQC at principal wells for electronic conductivity, pH, dissolved oxygen, temperature, and nitrate + nitrate as N. Monitoring for TDS, anions, and cations are conducted every five years (ESJWQC, 2020). The GQTM will utilize monitoring data from complementary wells (typically PWS wells) on an opportunistic basis.

ESJWQC conducted a thorough effort to obtain well completion reports (WCRs) for wells in the monitoring region, including PWS wells, to attempt to build out and expand the GQTM network. This included outreach to monitoring agencies like USGS, DWR, SWRCB, irrigation districts, and PWS. Due to redacted information in WCRs or concerns about confidentiality of well owner contact information, only a very limited number of wells could be evaluated for inclusion in the GQTM (LSCE, 2016).

2.4 Land Subsidence

2.4.1 DWR Guidance

DWR guidance states that land subsidence monitoring networks should identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method (DWR, California Department of Water Resources, 2016a)

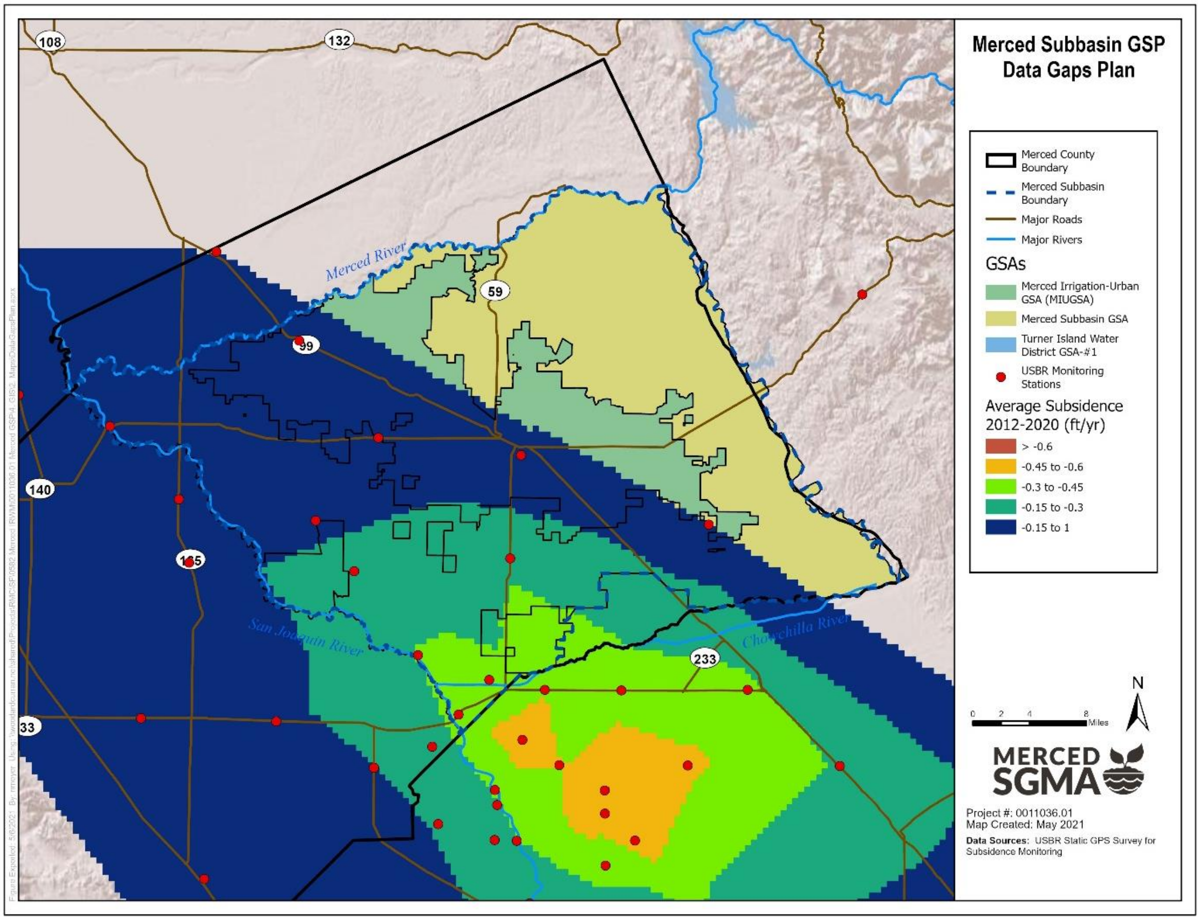
2.4.2 SGMA Monitoring Network Data Gaps

The existing land subsidence monitoring network, illustrated in Figure 2-7, relies on control points monitored by the United States Bureau of Reclamation as part of the San Joaquin River Restoration Program.

Mainly due to a lack of extensometers, two significant data gaps were identified in the GSP, including:

1. An understanding of the depth at which subsidence is occurring.
2. An understanding of the level of compaction.

Figure 2-7: Current Land Subsidence Monitoring Network



2.5 Interconnected Surface Waters

2.5.1 DWR Guidance

DWR guidance states that interconnected surface water monitoring networks should monitor surface water and groundwater, where interconnected surface water conditions exist, 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 shall be able to characterize the following:

- Flow conditions including surface water discharge, surface water head, and baseflow contribution.
- Approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
- Temporal change in conditions 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 (DWR, California Department of Water Resources, 2016a).

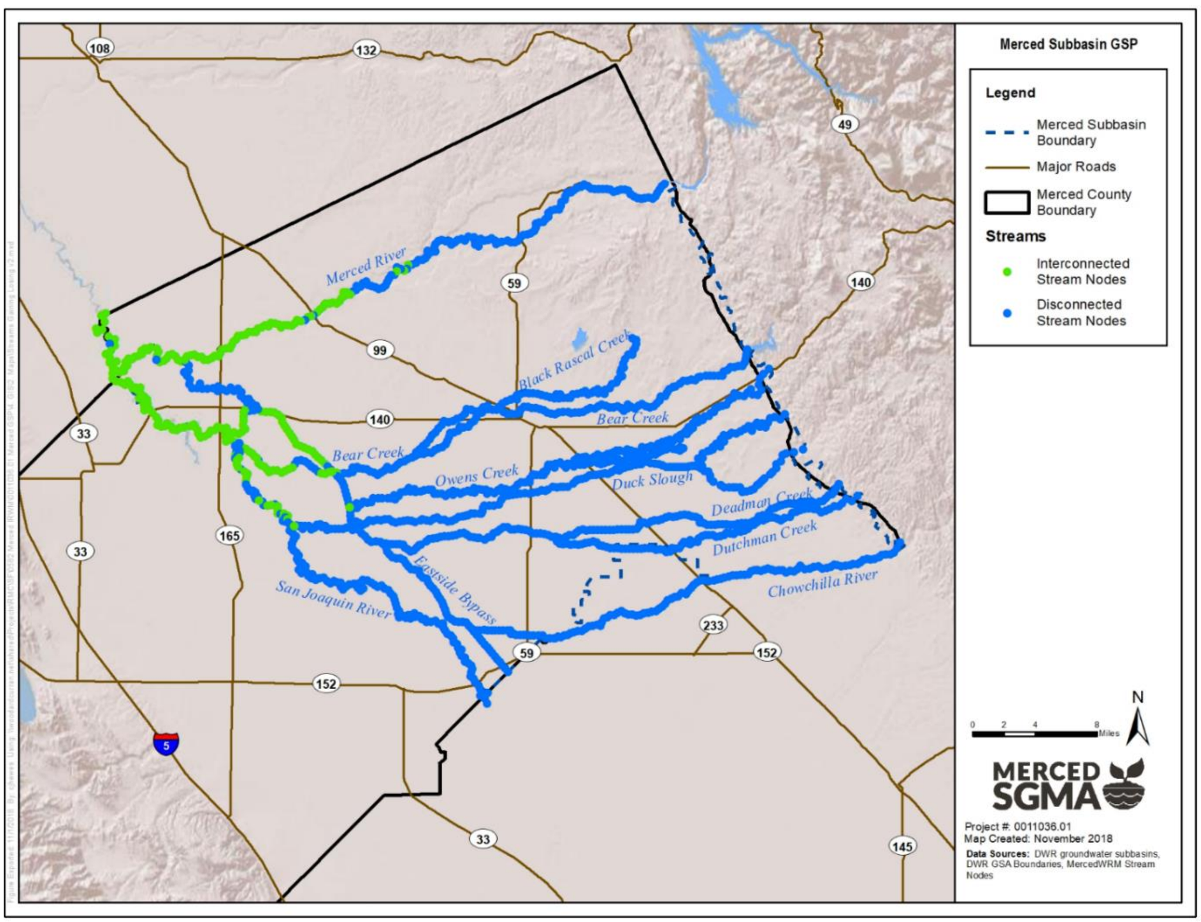
2.5.2 SGMA Monitoring Network Data Gaps

Interconnected surface waters exist primarily around streams in the western portion of the Subbasin, illustrated in Figure 2-8, and are monitored by proxy through the measurement of groundwater levels. 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 Merced Water Resources Model aquifer hydrogeologic structure.

Two significant data gaps were identified in the GSP, including:

1. A need to improve the understanding of depletions of interconnected surface water through additional depth-discrete groundwater elevation data near some rivers and streams.
2. A need to better characterize conditions near rivers and streams, through installation of multi-level monitoring wells, subject to funding availability.

Figure 2-8: Map of Interconnected Surface Waters



Source: Merced Subbasin GSP, 2019

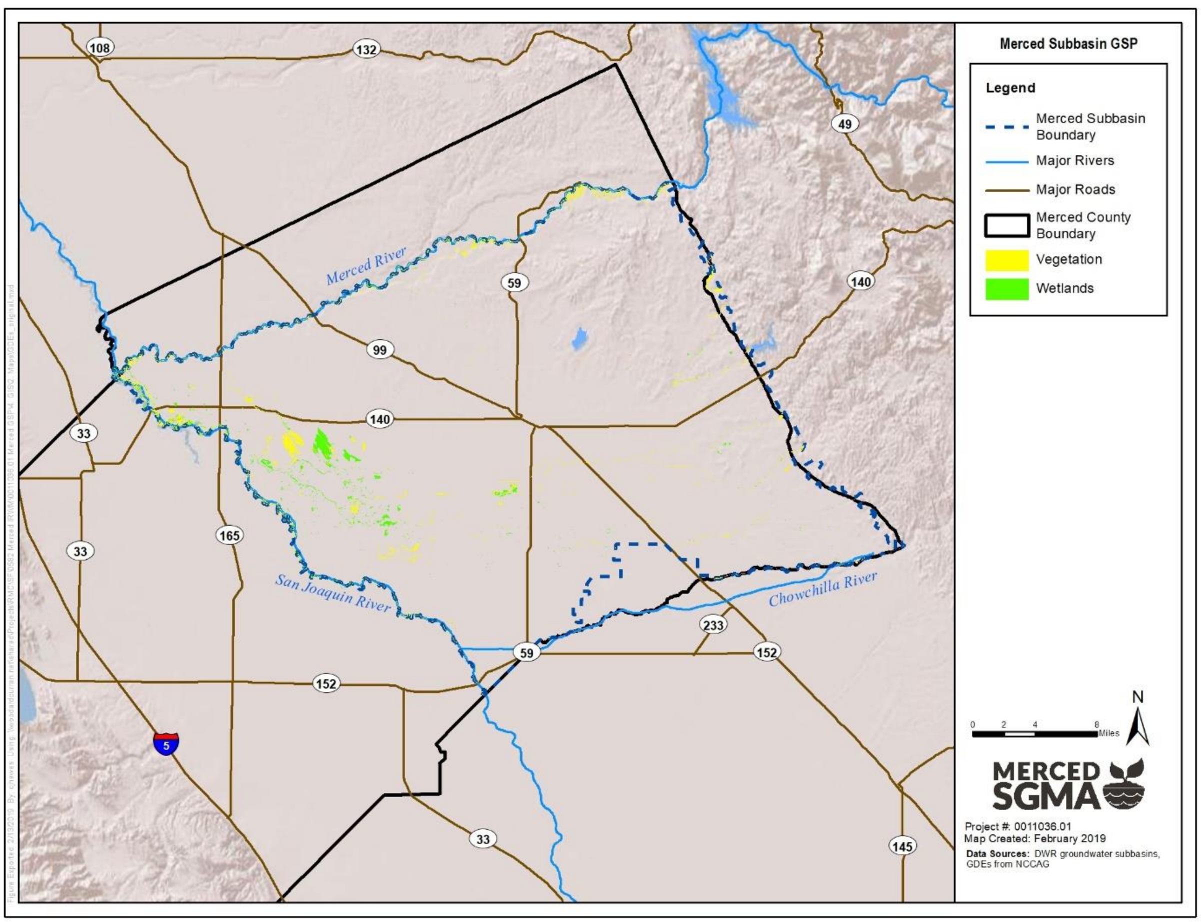
2.6 Other Considerations

2.6.1 Groundwater Dependent Ecosystems

Consistent with §351 of the SGMA Regulations, Groundwater Dependent Ecosystems (GDEs) are defined as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (California Code of Regulations, n.d.). GDEs exist within the Merced Subbasin largely where vegetation accesses shallow groundwater for survival; without the access to shallow groundwater, these plants would die. The Natural Communities Commonly Associated with Groundwater (NCCAG) database was used to identify plants commonly associated with groundwater use. Figure 2-9 shows the locations identified by the NCCAG database within the Merced Subbasin. Based on an analysis of groundwater dependence and the presence of alternate water supplies, NCCAG areas were screened to identify likely GDEs. Such areas are concentrated in two regions within the Merced Subbasin: in the western portion of the Subbasin at the confluence of the Merced and San Joaquin Rivers and in the southern portion of the Subbasin near the San Joaquin River.

Data gaps related to GDEs were found to overlap those related to interconnected surface waters, as described in Section 2.5.2.

Figure 2-9: Natural Communities Commonly Associated with Groundwater



Source: Merced Subbasin GSP, 2019

2.6.2 Interbasin Flows

The Merced Water Resources Model (MercedWRM) simulates groundwater flow between the Merced Subbasin and the neighboring subbasins to the north (Turlock), west (Delta-Mendota) and south (Chowchilla). The rate and direction of this interbasin subsurface flow depends on the groundwater operations and levels during the historical and projected periods on both sides of the boundary. The MercedWRM was calibrated using available data during the development of the Merced Subbasin GSP and modeling showed net flows from the Merced Subbasin to the Turlock Subbasin.

Data gaps identified in the GSP include:

1. There was no readily available data to calibrate the model regarding projected conditions from the neighboring subbasins.
2. Since the neighboring subbasins have either completed their GSP or are in the process of completing their GSP by January 31, 2022, it is expected that additional data and/or assumptions on the groundwater operations would be available from the neighboring subbasins for future updates of the model and assessments of the Merced Subbasin sustainability conditions.
3. Lack of groundwater level monitoring wells along the western edge of the Subbasin.

2.6.3 Model

The Merced Water Resources Model (Merced WRM) is the primary tool to quantify analyze groundwater conditions in the Merced Subbasin. The MercedWRM develops data for water budgets, which 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 GSP using the MercedWRM.

Two significant data gaps were identified, including:

1. Aquifer characteristics (such as hydraulic conductivity) have a significant impact on how projects and management actions 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. Evapotranspiration values used in the current version of the Integrated Water Flow Model Demand Calculator for estimation of the consumptive use of crops are the same for all simulation years, but actually vary annually. The use of more detailed data is recommended.

3. PRIORITIZATION ANALYSIS

3.1 Criteria for Evaluation

To evaluate the identified data gaps, the GSAs sought to achieve the following criteria:

- Target data gaps in areas that lack sufficient monitoring (geographical areas with no data), and especially areas that will provide information that will benefit Disadvantaged Areas (SDAC, DAC, and EDAs) in the Subbasin.
- Address multiple needs through strategically placed wells or data collection, where possible.
- Create an estimate of the number of wells needed to provide adequate coverage per DWR density guidance to better respond to needs of the Subbasin.
- Evaluate data gaps related to sustainability indicators and consider data needs to support remote sensing, which could include additional CIMIS stations in the basin.
- Incorporate existing wells into the monitoring network when possible to avoid high costs of installing additional monitoring wells.
- Provide flexibility in siting new monitoring wells to minimize potentially challenging and time-consuming siting processes.

In addition to criteria set by the GSAs, priorities were identified and ranked by the Stakeholder Advisory Committee and Coordination Committee members and the public. During public meetings, the data gap repeatedly identified as most important to address during polls was to better understand groundwater levels in poorly monitored portions of the subbasin. Stakeholders also identified subsidence areas, shallow zones, and subbasin boundaries as top priority areas for water level monitoring.

3.2 Site Identification Procedures

Described in the section below are three analyses developed to provide GSAs a repeatable process and toolset to identify locations where monitoring wells can fill data gaps. The Weighted Preferential Monitoring Site Analysis (Section 3.2.1) and Uncertainty Analysis (Section 3.2.2) both feed into the Combined Analysis (Section 3.2.3) to identify suggested monitoring locations. These locations are intended to be flexible guidance for identifying suitable existing wells or new well sites.

3.2.1 Weighted Preferential Monitoring Site Analysis

The first analysis focuses on leveraging existing infrastructure by identifying the quality of existing monitoring sites that could be incorporated into monitoring, focusing on high quality sites that have well construction information, a higher frequency of monitoring, and longer period of record. Existing wells were screened and sorted into tiers (Tier 1 is most desirable while Tier 8 has the most limitations). Once the existing monitoring wells were screened for quality of site, an analysis was conducted to identify and quantify other factors that related to siting monitoring wells, such as proximity to rivers, depth to groundwater, DAC/SDAC locations, relationship to the Corcoran Clay, and other factors to identify and prioritize areas with higher needs for monitoring. These factors and their respective weights are summarized in Table 3-1 and are described further in Appendix A. The factors used for the well tiering analysis are described in Table 3-2 and locations of the tiered wells are shown in Figure 3-1.

Table 3-1: Weighted Site Analysis Inputs

Criteria	Rationale	Relative Weighting Factor to Other Criteria	Measurement	Ranking Value
Well tiering analysis	Prioritize wells with quality existing data and/or planned monitoring	2	Tier 1 Tier 2 Tier 3 Tier 4 Tier 5 Tier 6 Tier 7 No Well or Tier 8	1.0 .9 .8 .7 .6 .5 .4 0
Depth to groundwater (above Corcoran Clay)	Prioritize shallowest and deepest groundwater	1	<10’ or >120’ 10-20’ or 100-120’ 20-30’ or 80-100’ 30-40’ or 60-80’ 40-60’	1.0 .8 .6 .4 .2
Depth to groundwater (below & outside Corcoran Clay)	Prioritize shallowest and deepest groundwater	1	<10’ or >250’ 10-20’ or 200-250’ 20-30’ or 150-200’ 30-40’ or 100-150’ 40-100’	1.0 .8 .6 .4 .2
Locations of major rivers and streams	Prioritize areas with groundwater/surface water interaction	1	½ mile 1 mile 1.5 miles 2 miles > 2 miles	0 0.5 1.0 0.5 0
Proximity to water quality concerns	Prioritize areas at risk of migration of poor quality water (TDS)	1	>1,000 mg/L 1,000-900 mg/L 900-800 mg/L 800-700 mg/L 700-600 mg/L 600-500 mg/L <500 mg/L	1.0 0.9 0.8 0.7 0.6 0.5 0
Rate of subsidence	Prioritize areas with subsidence issues	1	> -0.6 ft/yr -0.6 to -0.45 ft/yr -0.45 to -0.3 ft/yr -0.3 to -0.15 ft/yr -0.15 to 1 ft/yr	1.0 0.9 0.8 0.7 0

Criteria	Rationale	Relative Weighting Factor to Other Criteria	Measurement	Ranking Value
Distance to Subbasin boundary	Prioritize areas to understand subsurface flows	0.5	¼ mile ½ mile 1 mile 2 miles > 2 miles	1.0 .75 .5 .25 0
Proximity to GDEs (above & outside Corcoran Clay)	Prioritize areas of ecological importance	1	1 mile > 1 mile	1.0 0
Locations of DACs	Prioritize areas that benefit historically marginalized communities	1	Within DAC Outside DAC	1.0 0
Proximity of stream gauging stations	Prioritize areas to cross-correlate streamflow and groundwater monitoring data	0.5	½ mile 1 mile 1.5 miles 2 miles > 2 miles	0 0.5 1.0 0.5 0
Locations of proposed Below Corcoran Clay sites (Above Corcoran Clay)	Prioritize areas with potential to install nested wells	3	1 mile > 1 mile	1.0 0

Table 3-2: Well Tiering Criteria

Criteria \ Well Tier	1	2	3	4	5	6	7	8
Dedicated monitoring well	X							
Known screened intervals or depth, screened in 1 aquifer	X	X	X	X	X	X	X	
Existing semiannual or more frequent planned monitoring	X	X	X					
Existing annual or more frequent planned monitoring				X	X			
At least 10 years of data (within the last 20 years)	X	X		X		X		
At least 10 data points	X	X		X		X		

Figure 3-1: Well Tiering Analysis

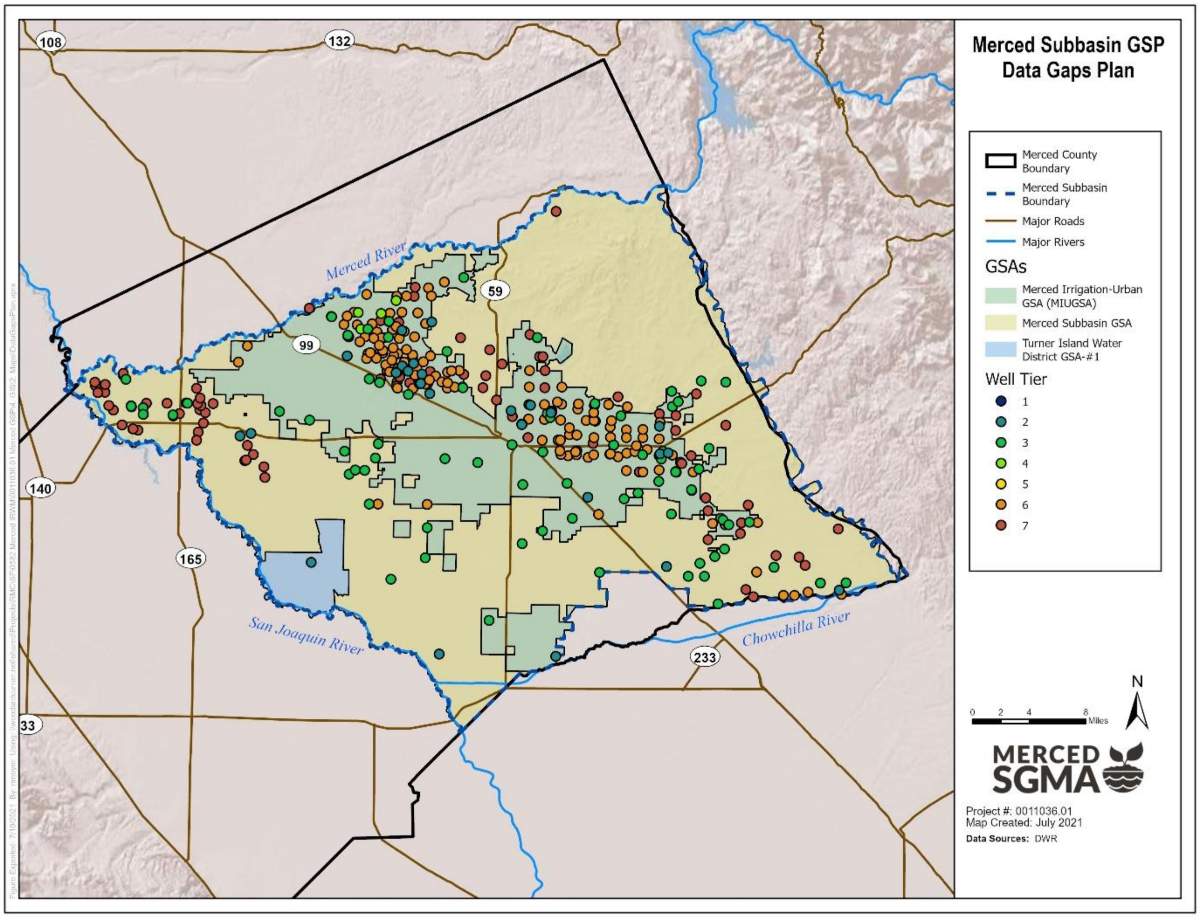


Figure 3-2 (Above Corcoran Clay), Figure 3-3 (Below Corcoran Clay), and Figure 3-4 (Outside Corcoran Clay) show the resultant layer describing preferential monitoring sites throughout each respective principal aquifer.

The following areas were set to a probability of zero, essentially removing them from consideration of siting additional wells:

- Areas where the existing monitoring network has a density of 3.5 wells/100 sq. mi. or higher
  - This avoids siting new or expanded monitoring wells near the existing monitoring network wells.
- For the Above and Below Corcoran Clay Principal Aquifers, areas within 1 mile of the eastern edge of the Corcoran Clay boundary or where the Corcoran Clay is less than 100 feet below ground surface
  - This avoids placement of wells where it may be hard to monitor distinct principal aquifer conditions along the intersection of the three principal aquifers. Additionally, the county's 50-foot minimum annular seal requirement makes use of this thin aquifer challenging.

Figure 3-2: Above Corcoran Clay Weighted Site Analysis

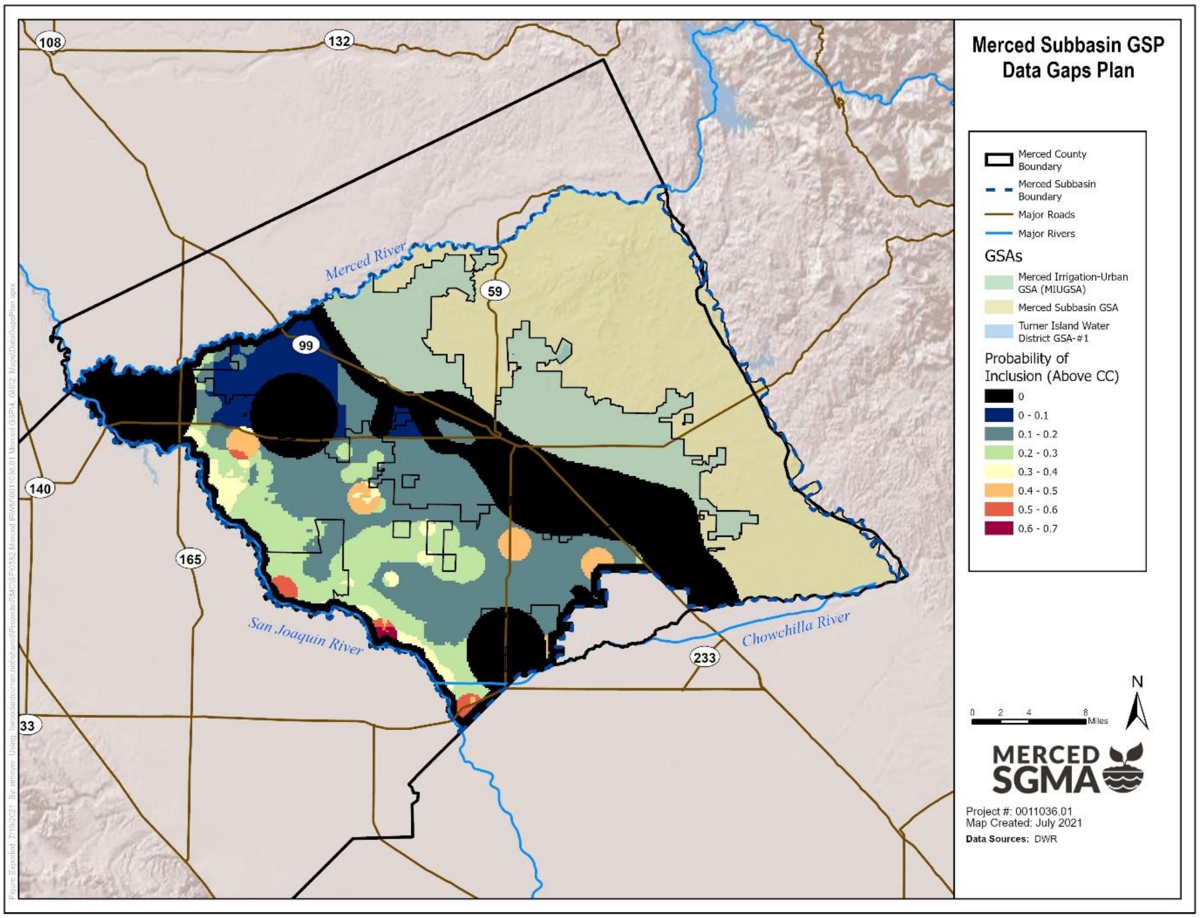


Figure 3-3: Below Corcoran Clay Weighted Site Analysis

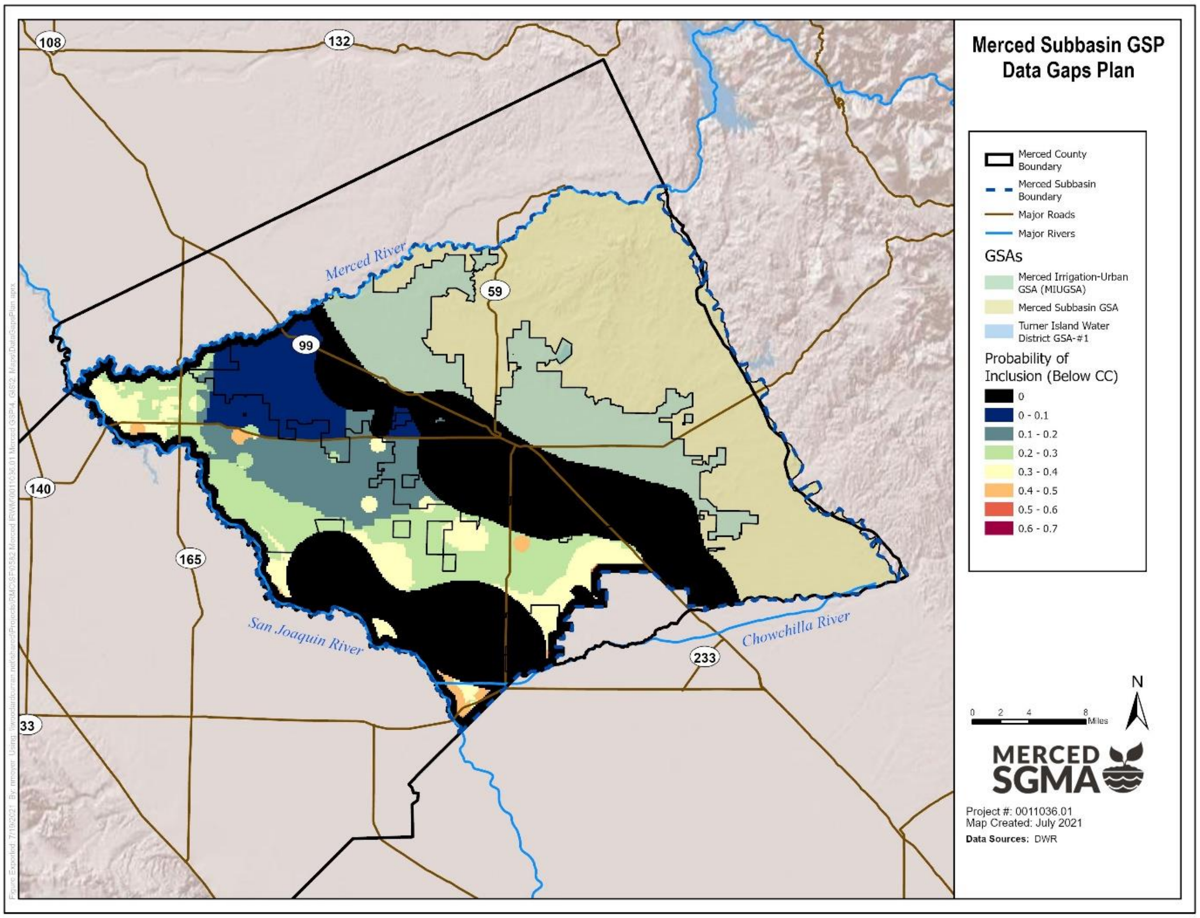
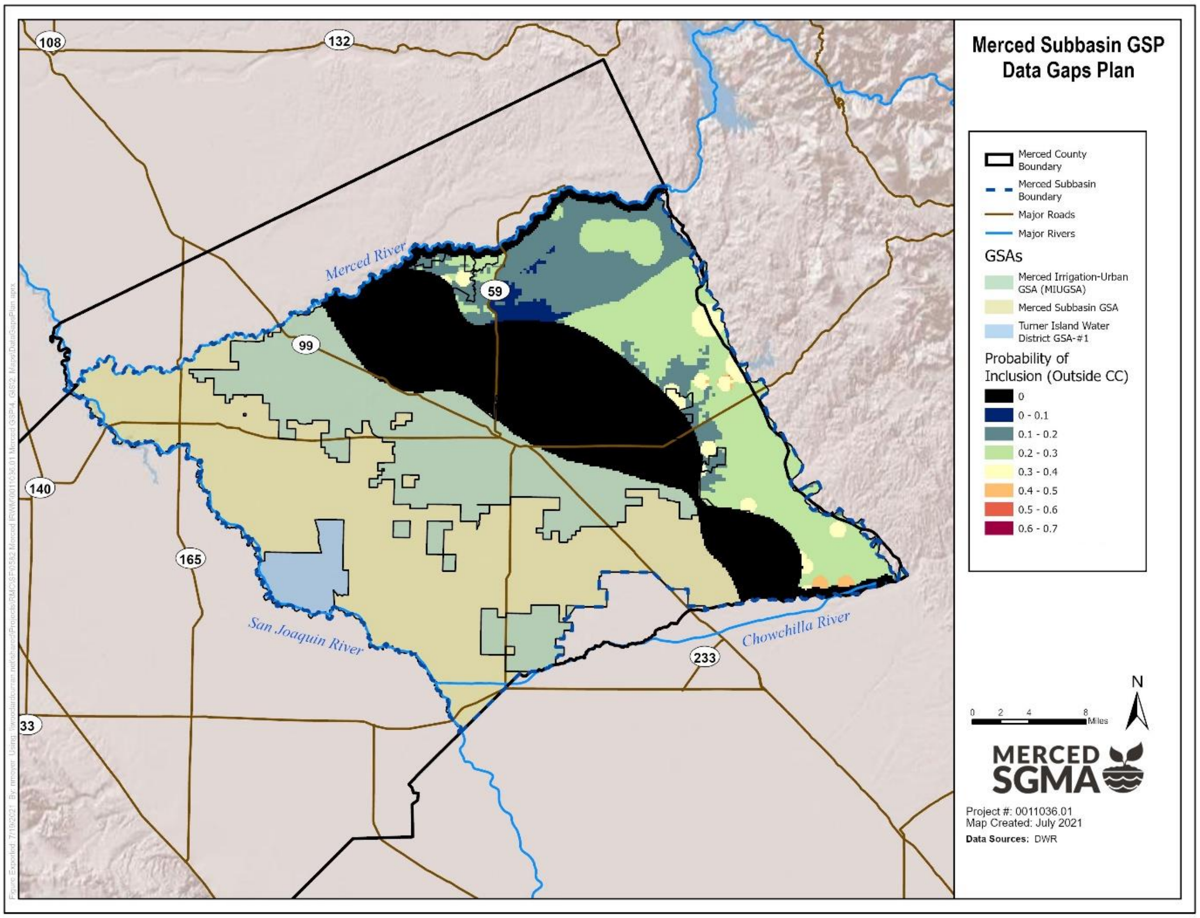


Figure 3-4: Outside Corcoran Clay Weighted Site Analysis



3.2.2 Uncertainty Analysis

The second analysis focuses on the spatial nature of monitoring networks and quantifies uncertainty using kriging standard error to identify which areas are the most beneficial to establish new monitoring. Kriging is a technique often used to contour groundwater data. Standard error identified during kriging quantifies when there is insufficient data or inconsistent data in an area. These standard errors can be used to identify areas in need of new monitoring. Fall 2020 groundwater level measurement data were used for the purpose of the uncertainty analysis. This uncertainty analysis is described in more detail in Appendix A.

In a handful of cases, fall 2020 measurements used for the uncertainty analysis may have been estimated so that the kriging tool would acknowledge that there is a known monitoring point at this location. This estimation was made for one of two reasons:

- In some cases, the measurements for an existing monitoring network well were discounted due to nearby pumping or another data quality flag. A linear regression was applied to estimate the groundwater elevation for the missing fall 2020 period. The linear regression was applied separately at each well for fall measurements (as opposed to spring measurements) where there were several years of historical data.

- A small number of wells (described further in Section 2.2.2) have recently been incorporated into the monitoring network or are expected to be incorporated into the monitoring network. Fall 2020 measurements were estimated for these wells based on the groundwater level contour maps developed for these sites as part of the Merced GSP Water Year 2020 Annual Report (MIUGSA, MSGSA, & TIWD GSA-1, 2021).

Figure 3-5 (Above Corcoran Clay), Figure 3-6 (Below Corcoran Clay), and Figure 3-7 (Outside Corcoran Clay) show the resultant uncertainty through kriging error for each respective principal aquifer.

Figure 3-5: Above Corcoran Clay Uncertainty Analysis

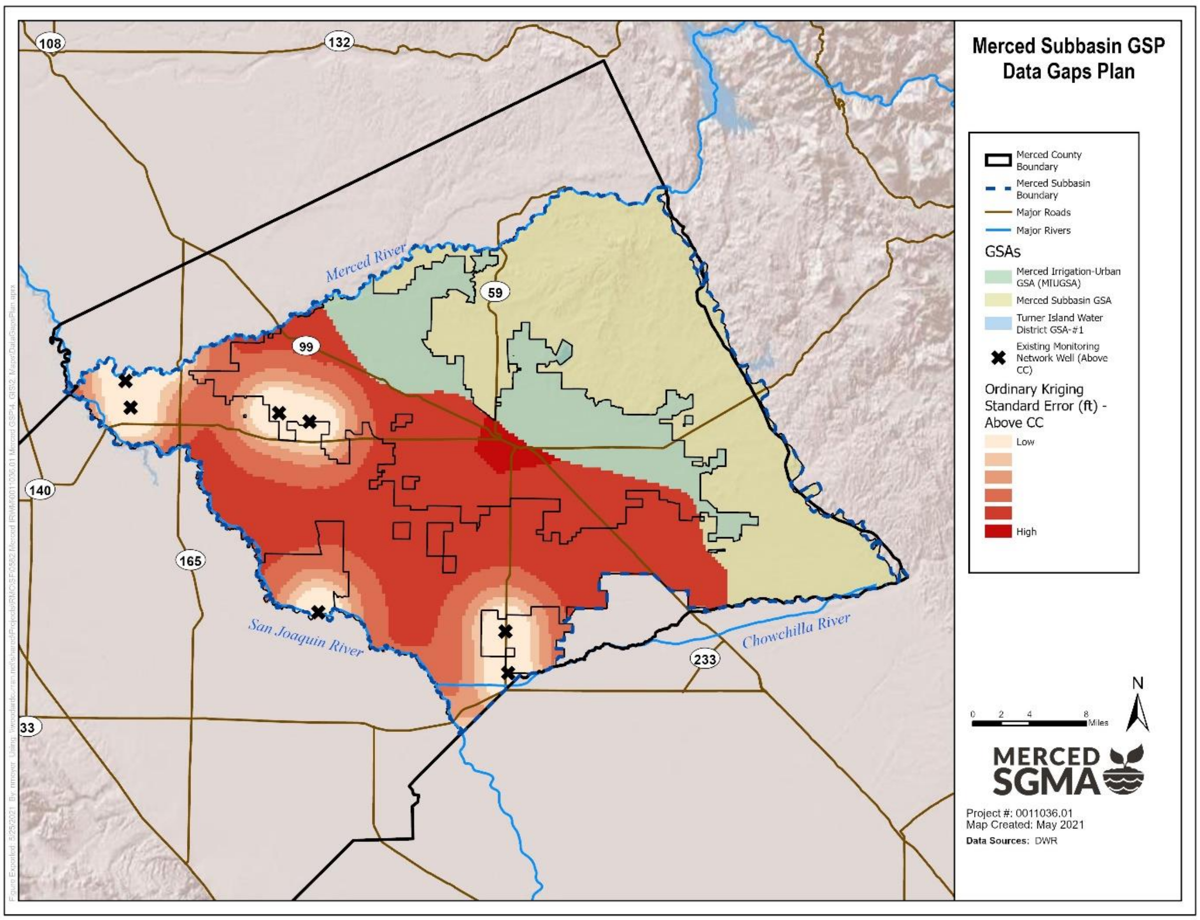


Figure 3-6: Below Corcoran Clay Uncertainty Analysis

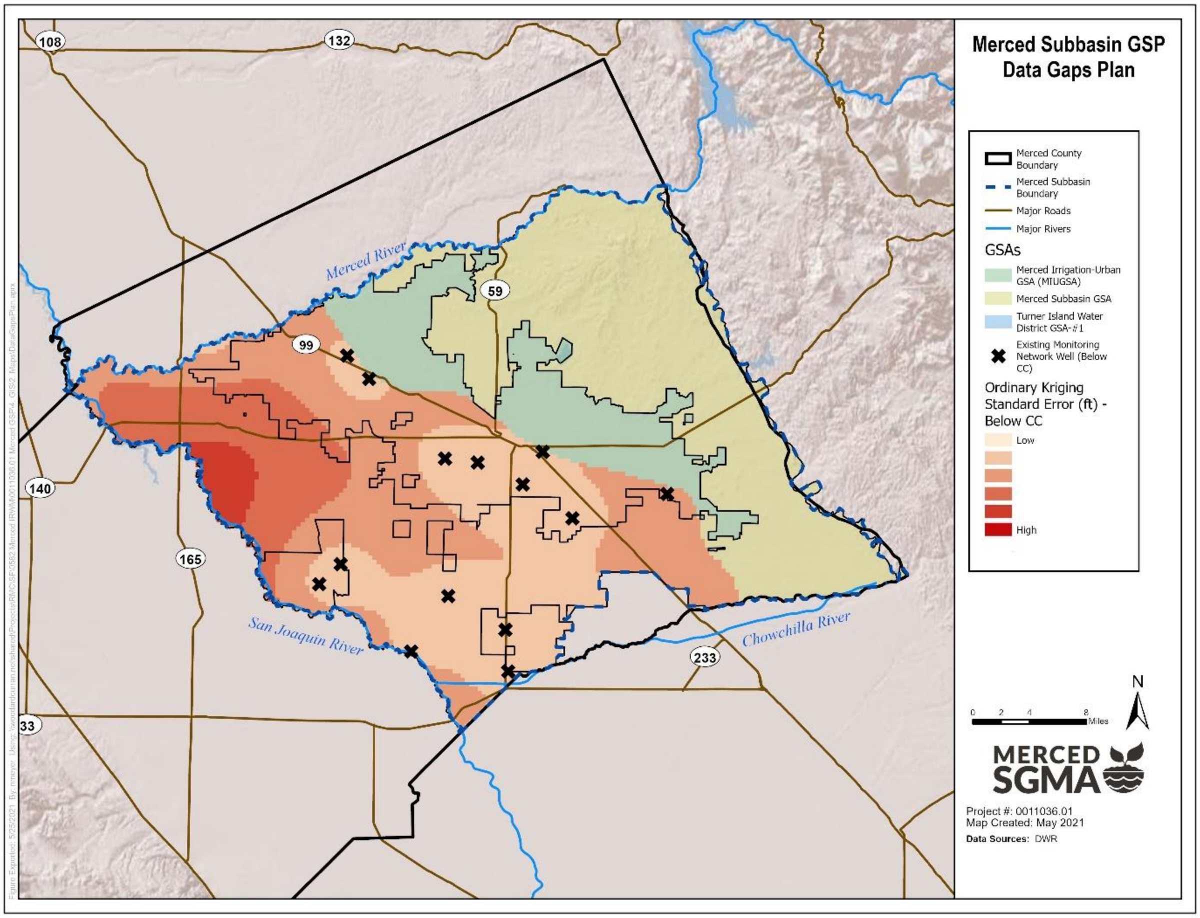
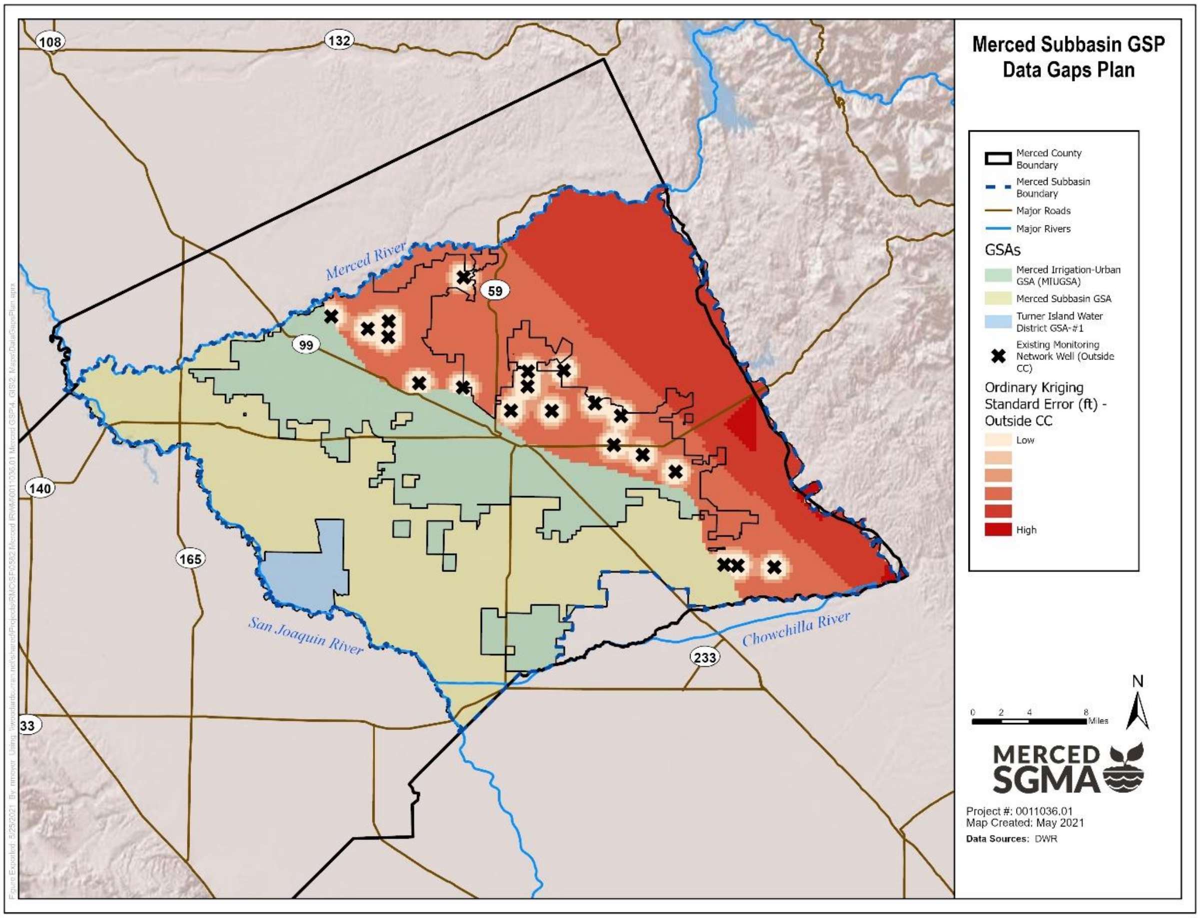


Figure 3-7: Outside Corcoran Clay Prediction Uncertainty Analysis



3.2.3 Combined Analyses

Results from both analyses described above were combined using the Esri ArcGIS Densify Sampling Network tool to recommend new monitoring sites. Suggested new monitoring sites are located both where uncertainty is high and where there is the highest site suitability. An inhibition distance[1] of 4.4 miles was set to limit the proximity of recommended monitoring sites, which prevents sites from being too close together and encourages more even spatial representation. To calculate the number of new sites needed to achieve a density of 4 wells/100 sq. mi. (see Section 2.2.1) throughout each principal aquifer, it was assumed that the additional wells would be evenly distributed. The existing dense areas do not lessen density requirements in unmonitored areas (i.e., consistent spatial representation of 4 wells/100 sq. mi. throughout each principal aquifer is desired). It should also be noted that new sites selected for monitoring in the Below Corcoran Clay Principal Aquifer have the potential to function as a new monitoring point for

[1] Inhibition distance is the minimum distance between new monitoring sites. An inhibition distance of 5.6 miles corresponds to the DWR guidance of 4 wells/100 sq. mi. (i.e., providing an exact 25 sq. mi. circular zone around each well). However, to provide flexibility in siting wells in areas of higher suitability and to provide improved coverage throughout each principal aquifer, the inhibition distance was reduced to 4.4 miles.

the Above Corcoran Clay Principal Aquifer through the installation of a nested groundwater level monitoring well. Thus, in Table 3-3, there is an expectation of overlap between the “Number of New Sites Needed to Reach 4+ wells/100 sq. mi.” column for the Below and Above Corcoran Clay Principal Aquifers.

Table 3-3: Groundwater Network Density and New Sites Needed to Achieve DWR Guidance

Principal Aquifer	Count of Existing Wells	Total Aquifer Area (sq. mi.)	Weighted Aquifer Area (sq. mi.) Requiring New Well to Reach 4+ wells/100 sq. mi.[1]	Number of New Sites Needed to Reach 4+ wells/100 sq. mi.
Below Corcoran Clay	17	438	206 (47%)	9
Above Corcoran Clay	11	438	311 (71%)	13
Outside Corcoran Clay	26	364	132 (36%)	6

[1] A monitoring network density goal of 4 wells/100 sq. mi. in each of the three principal aquifers was set by the GSAs. Additional information about the calculation of the weighted aquifer area requiring a new well to reach the monitoring network density goal can be found in Appendix A.

Additional technical information about the analyses summarized above can be found in Appendix A.

4. IMPLEMENTATION PLAN/RECOMMENDATIONS

Section 4.1 provides initial results of the data tools described in Section 3 (Prioritization Analysis), identifying areas for siting new monitoring wells that provide the large benefits across multiple data gap types. Sections 4.2 through 4.6 provide additional detail on recommendations and approaches for filling the individual data gaps described earlier in Section 2 (Data Gap Identification).

4.1 Data Gap Areas Identified for Prioritization

Recommended new monitoring network sites shown in this section are intended to develop a starting point for the consideration by GSAs to assist in the filling of data gaps in the monitoring network. The process is intended to provide utility, while the initial results are presented only as a starting point. Subsequent updates to the inputs (as described in the implementation plan in Section 4.2) will continue to shift the outputs of the tool as existing sites are identified and remaining data gap areas shrink. This process is reflective of the challenges in obtaining access to wells and well sites, resulting in the need for flexibility.

The process of filling data gaps may take time – due to many constraints, it is not possible to immediately fill every data gap area. The prioritization analysis takes into account multiple data gap types (see Table 3-1). The results of the analysis can help identify areas with the largest benefits for siting new monitoring wells to help guide decision-making about where to spend limited resources first.

Table 4-1 details the location and respective probability, kriging uncertainty, and overall score for the recommended new monitoring sites by principal aquifer. Figure 4-2, and Figure 4-3 show the recommended new monitoring sites for each respective principal aquifer. Similar maps with greater detail and additional landmarks for reference can be found in Appendix B. The results are summarized as follows:

- As the Above Corcoran Clay Principal Aquifer has the greatest need for additional monitoring wells (see Table 3-3), recommended new monitoring sites are more evenly distributed throughout the aquifer, including many recommended sites proposed near the western edge of the aquifer (Figure 4-1). Monitoring along the western edge of the Subbasin for both the Above and Below Corcoran Clay Principal Aquifers provides multiple benefits, including for water levels, water quality, interconnected surface waters, and interbasin flow considerations for groundwater modeling. The results for the Above Corcoran Clay Principal Aquifer also show a preference for utilizing locations of recommended monitoring sites in the Below Corcoran Clay Principal Aquifer, as such areas have the potential to function as new monitoring points for both aquifers through the installation of nested groundwater level monitoring wells (see Section 3.2.3).

- Recommended new monitoring sites in the Below Corcoran Clay Principal Aquifer are concentrated along the western edge of the aquifer, as well throughout the center of the aquifer, where the existing monitoring network lacks sufficient spatial density (Figure 4-2).

- Recommended new monitoring sites in the Outside Corcoran Clay Principal Aquifer are concentrated near the foothills in the northern part of the subbasin, where groundwater level data is incomplete, with a few additional sites in the southern region of the aquifer (Figure 4-3).

Table 4-1: Recommended New Monitoring Sites

Aquifer	Rank	Latitude [A]	Longitude [A]	Weighted Probability	Kriging Uncertainty	Combined Score [B]	Nearest Potential Well [C]	Nearest Potential Well Tier
Above	1	37.1289	-120.6119	63%	35.19	100	R7	3
Above	2	37.2828	-120.7859	58%	34.22	91	MP-24	7
Above	3	37.1774	-120.7484	56%	33.30	85	*none within 5 mile radius*	
Above	4	37.1994	-120.3763	46%	38.76	81	*none within 5 mile radius*	
Above	5	37.0713	-120.5443	55%	28.53	72	*none within 5 mile radius*	
Above	6	37.2221	-120.4909	40%	37.46	69	372235N1205793W001	3
Above	7	37.2635	-120.6483	40%	36.10	66	MW-7D	3
Above	8	37.1166	-120.4466	48%	28.41	62	*none within 5 mile radius*	
Above	9	37.1922	-120.6578	26%	34.07	41	R7	3
Above	10	37.3477	-120.8266	26%	31.04	37	SD-3	7
Above	11	37.3160	-120.5570	15%	38.95	26	373496N1206327W001	3
Above	12	37.3661	-120.6757	15%	35.49	24	373732N1206679W001	2
Above	13	37.1554	-120.5267	16%	27.90	20	371971N1205813W001	3
Below	1	37.3053	-120.8898	45%	33.17	100	SD-18	7
Below	2	37.2959	-120.7824	40%	34.74	94	07S11E20Q001M	2
Below	3	37.1151	-120.4448	65%	20.38	89	371116N1204374W001	2
Below	4	37.1921	-120.3926	52%	25.14	88	371852N1203899W001	3
Below	5	37.1658	-120.7392	43%	29.21	86	08S12E31M001M	2
Below	6	37.0641	-120.5315	44%	27.17	80	09S13E32A001M	2
Below	7	37.2091	-120.4835	46%	24.74	78	372102N1204752W001	3
Below	8	37.2489	-120.6492	38%	28.90	74	372438N1206429W002	3
Below	9	37.1288	-120.6300	37%	25.98	65	09S13E32A001M	2

Aquifer	Rank	Latitude [A]	Longitude [A]	Weighted Probability	Kriging Uncertainty	Combined Score [B]	Nearest Potential Well [C]	Nearest Potential Well Tier
Outside	1	37.3576	-120.2478	51%	103.34	100	Agriculture Well 2	3
Outside	2	37.1753	-120.1292	45%	98.35	84	09S17E09D001M	2
Outside	3	37.2866	-120.2676	36%	98.43	66	Dhillon DW1	3
Outside	4	37.4434	-120.5597	33%	93.72	58	374382N1205621W001	6
Outside	5	37.5196	-120.3177	25%	103.34	49	*none within 5 mile radius*	
Outside	6	37.4919	-120.4051	24%	103.34	47	375005N1204396W001	7

A. Location information should be interpreted as a general area, not a specific location.
B. The "Combined Score" for new monitoring sites was calculated by multiplying the weighted probability and kriging uncertainty values, then normalizing the score via a comparison to the top ranked site in each principal aquifer (designated with a score of 100). In other words, it makes the scores easier to compare relative to each other.
C. Nearest potential wells have not been reviewed for ability for monitoring given ownership or other site factors and will need to be evaluated during the later implementation phase of this Plan.

Figure 4-1: Above Corcoran Clay Recommended New Monitoring Sites

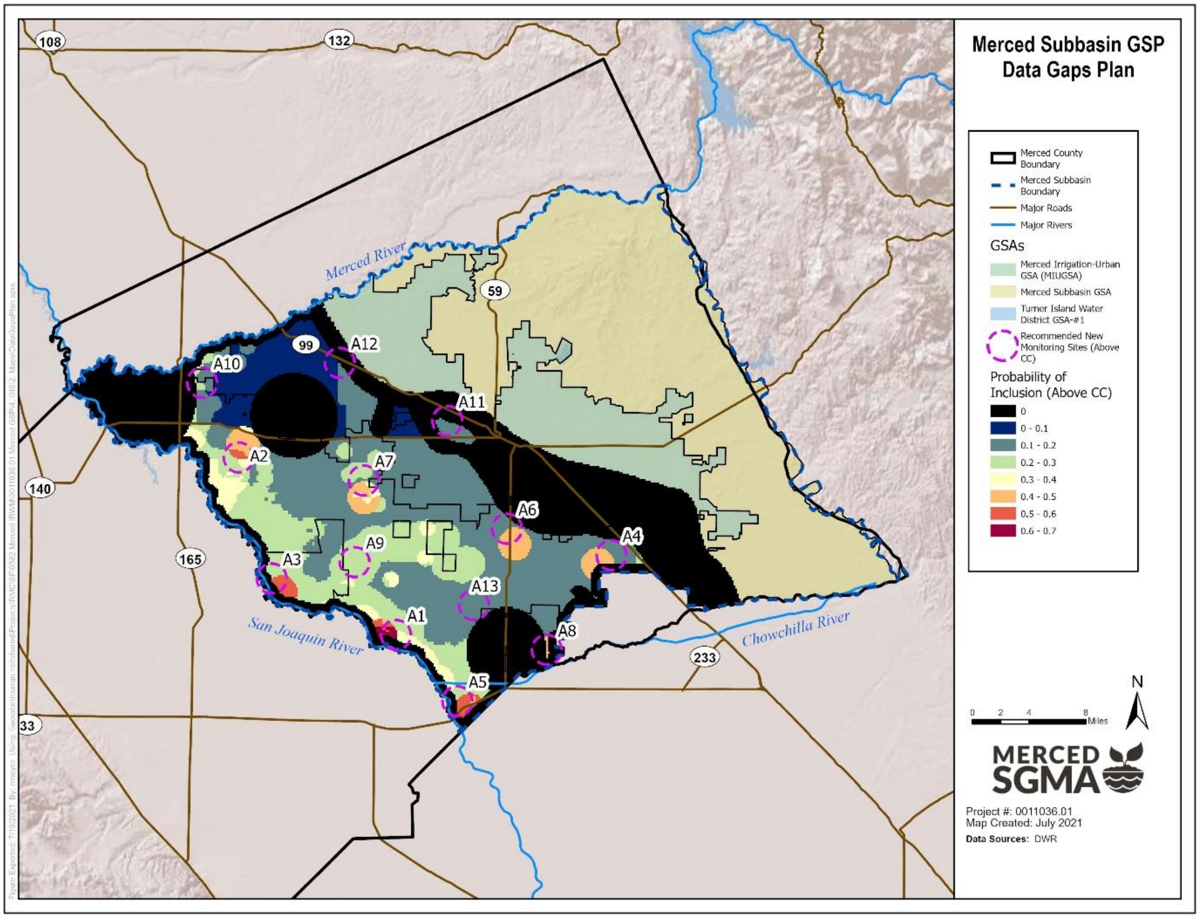


Figure 4-2: Below Corcoran Clay Recommended New Monitoring Sites

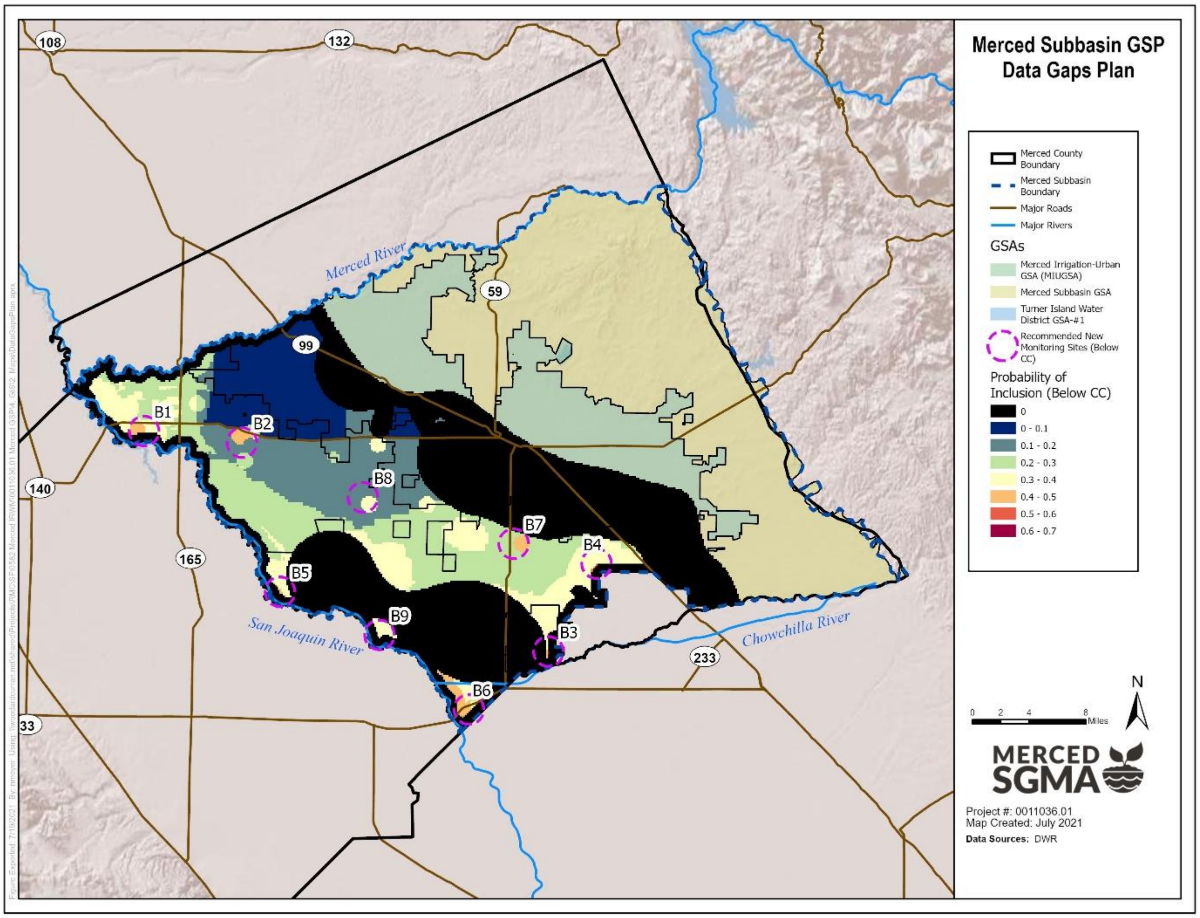
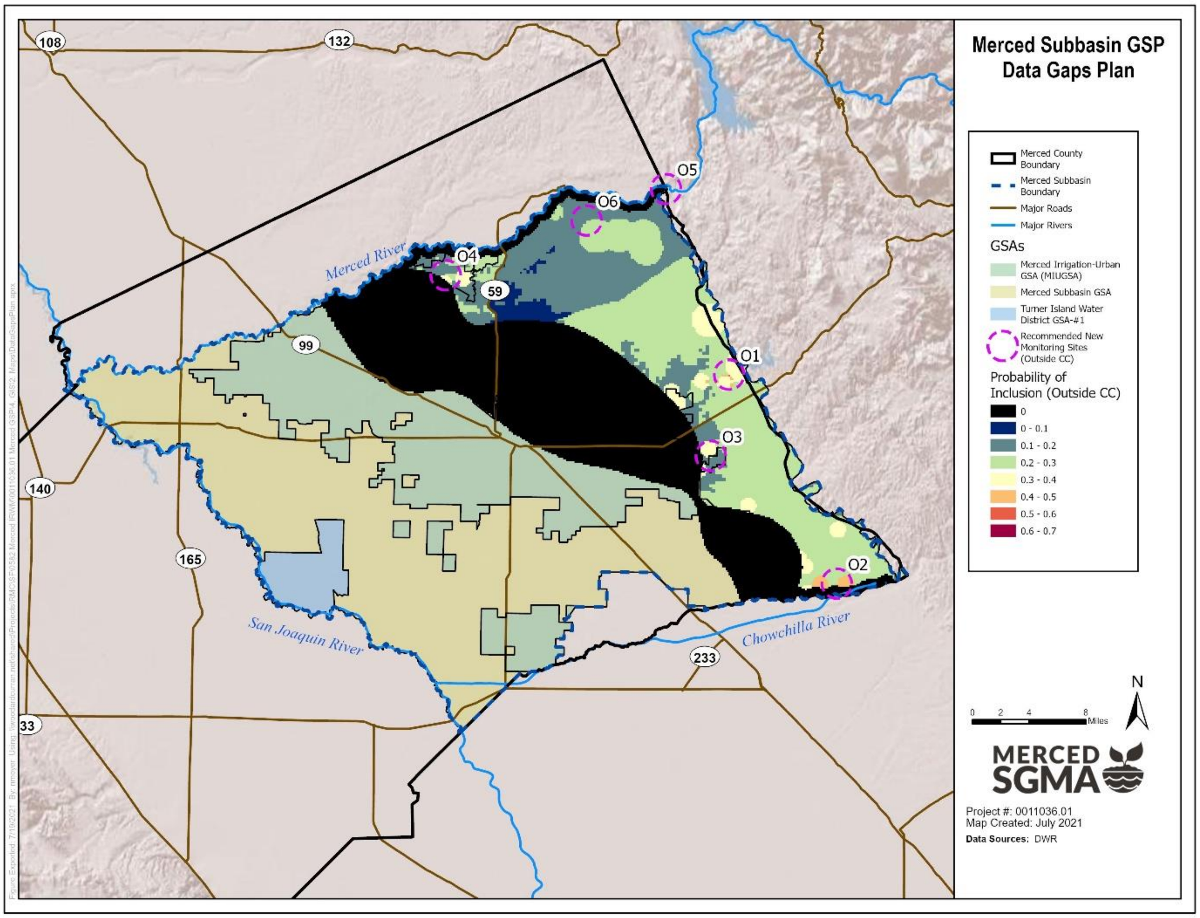


Figure 4-3: Outside Corcoran Clay Recommended New Monitoring Sites



4.2 Approach to Filling Groundwater Level Monitoring Network Data Gaps

The steps below describe a procedure for filling data gaps in the monitoring network that make use of the tools described above to analyze how existing wells can fill data gaps and narrow in on the areas where new monitoring development is needed.

1. **Step 1: Run analysis tools**

   Run the analysis tools described in Section 3.2 to identify areas that could be used to fill data gaps. This step has been completed in this report.

2. **Step 2: Identify existing wells to fill data gaps**

   A critical component of filling this data gap will be to identify existing wells to fill data gaps. Numerous groundwater level wells in the Subbasin exist, but information is often limited, particularly about construction information that would be used to identify that a well is screened within only one aquifer.

Begin with reaching out to property owners in and near the sites identified in Figure 4-1, Figure 4-2, and Figure 4-3 to investigate the potential for incorporation of existing wells into the monitoring network. See Appendix B for detailed mapping of the proposed areas. An ideal well would be:

- No longer in service and no longer equipped with a pump
- Safely accessible to sampling crews
- At an appropriate depth for the principal aquifer
- Away from active production wells that could impact groundwater level measurements
- With known construction information (if needed, construction information can be obtained through video surveys)
- With no known contaminants, including no substantial oil in the casing

3. **Step 3: Coordinate with landowners on well monitoring access**

   Owners of wells identified in Step 2 will need to be contacted to coordinate on access to the well for monitoring.

4. **Step 4: Obtain construction information for existing wells**

   If construction information is not readily available from the owner or a search of public records, then a site visit will be needed to video log the well and confirm its depth and screened interval information.

5. **Step 5: Install new monitoring wells**

   The last step is to install new monitoring wells, as funding allows, in the remaining data gap locations identified in Step 5. The Proposition 68 Planning Grant, awarded to the Subbasin in early 2020, includes $207,266 for the planning, design, and installation of two shallow monitoring wells or a one deep monitoring well in critical locations as identified by this DGP.

   New well sites would ideally:

   - Allow for long-term access to the site – areas in public land or public right-of-way are preferred over private ownership which can change over time
   - Safely accessible to sampling crews and drill rigs
   - In an area with no biological, historical, cultural, etc. impacts
   - Away from active production wells that could impact groundwater level measurements
   - Away from areas of known groundwater contamination that could impact the ability to monitor the well

6. **Step 6: Re-run analysis to identify priority areas with Steps 2-5 complete**

   Once the siting effort is complete, it is expected that some wells will be sited in the recommended areas, some wells will be sited somewhat outside of recommended areas, and some recommended areas will be found to not have suitable locations for wells. At this point, it is recommended that the tool be rerun to incorporate the new sites and to build a new set of recommended sites.

   Step 1 will be repeated using the updated well network with additional existing wells incorporated.

4.3 Approach to Filling Water Quality Monitoring Network Data Gaps

Recommendations for filling data gaps in the Merced GSP groundwater quality monitoring network include:

- **Increase monitoring frequency -** Coordinate with the existing efforts by ESJWQC in the GQTM due an overlap of goals and objectives (see Section 2.3.3). 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. As described in Section 2.3.3, 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.

4.4 Approach Filling Subsidence Monitoring Network Data Gaps

Installation of one extensometer, at multiple depths if possible, is recommended. Any location in the southern region of the Subbasin where subsidence is most pronounced would provide beneficial information. Extensometer(s) located outside of the Subbasin (e.g., likely south) would also be beneficial and may facilitate coordination with other agencies facing similar subsidence issues. It is likely to be beneficial or efficient to install a nested groundwater level monitoring well in the Below and Above Corcoran Clay Principal Aquifers at the same location as the extensometer. The need for additional extensometers would be assessed after data is collected from the first installation.

Key steps for installation of an extensometer will be to:

- **Identify funding -** Extensometers are noted to be expensive. One 2016 USGS project report references $700,000 - $2,500,000 of upfront costs depending on the number and depths of extensometers, plus a $20,000 annual operations and maintenance plus data analysis cost (Eggleston, 2016).

- **Identify location -** Coordinate with the USGS on siting criteria for extensometers to help identify an appropriate location. USGS has previously installed several extensometers in the Central Valley (though many are not currently functioning).

An additional method that can be used to evaluate the extent and impact of subsidence is to contact drillers and well owners in the subsidence region to gather information about casing failures. The depth at which vertical and lateral shearing in casing is occurring may provide some information about the depth at which subsidence is occurring.

Further, participation in DWR's aerial electromagnetic (AEM) surveys can provide more details on subsurface clays.

4.5 Approach to Filling Interconnected Surface Waters Data Gaps

Several approaches are recommended to improve monitoring of interconnected surface waters and related shallow groundwater conditions:

- **Expand monitoring network -** The approach for filling the groundwater level monitoring network data gaps (described in Section 4.2) 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.

- **Incorporate new data -** Newly obtained information from the lower reaches of the San Joaquin River Restoration Program groundwater monitoring sites (see Section 2.2.2) will also help inform very shallow groundwater level monitoring and surface-groundwater interactions in the Above Corcoran Clay Principal Aquifer.

- **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.

4.6 Other Recommended Coordination Actions

4.6.1 Approach to Filling Interbasin Flows Data Gaps

In general, coordination with neighboring subbasins is useful for providing information about interbasin flows. Recommendations include:

- **Coordinate with the San Joaquin River Exchange Contractors** for information from lower and upper aquifer monitoring in the eastern portion of the Delta-Mendota Subbasin to inform groundwater level contouring and analysis in the western portion of the Merced Subbasin.

- **Coordinate with GSAs in the Turlock Subbasin** for information on available (or potential future) monitoring data along the northern banks of the Merced River to coincide with existing and planned groundwater level monitoring in the Merced Subbasin in this area, especially near existing stream gauging stations.

- **Coordinate with Chowchilla Subbasin** for information on groundwater levels to support subsidence understanding and to better understand areas of low and highly variable groundwater levels.

Monitoring well sites that would be beneficial near subbasin boundaries could potentially be wholly or partially covered by wells installed in neighboring subbasins; ongoing coordination is needed to investigate what nearby wells exist along neighboring subbasin boundaries. However, in some cases, it may be beneficial to pair wells on opposite sides of the boundaries for interbasin flow analyses.

4.6.2 Approach to Filling Model Data Gaps

The current version of the Integrated Water Flow Model Demand Calculator uses monthly potential evapotranspiration values that are the same for all simulation years. Because this doesn't account for the annual variability of evapotranspiration data, using more detailed data from California Irrigation Management and Information System (CIMIS) stations to develop annual potential evapotranspiration values for use in the Model would be preferable. While one CIMIS Station currently exists in the Merced Subbasin (CIMIS Station 148), ongoing site maintenance issues have limited the accuracy and usefulness of data collected here. It also only represents one potential climate input for the whole Subbasin; an additional station would be valuable for providing additional spatial resolution and capturing variability.

Ideal siting criteria for CIMIS weather stations include, but are not limited to (DWR, California Department of Water Resources, 2016b):

- Locate in the center of 20 acres of well-maintained, irrigated, cool season perennial grass, as standardized by CIMIS.
- Maintain mowed (three to six inches), healthy, green grass under equipment.
- Maintain 150 yard buffer free of buildings, trees, windbreaks, roads, rivers, and agricultural chemicals.
- Avoid topographic depressions and high points.

If grass cover is not available at an otherwise ideal site, an alternate crop type may be suitable in combination with an evapotranspiration adjustment factor for the reference data being collected by the station, but ideally there should be no periods of bare soil near or adjacent to the station at any time (i.e., as would typically happen during a crop harvest).

Recommendations to fill the CIMIS monitoring network data gap include:

1. Coordinate with landowner of existing CIMIS site to ensure correct land cover type is planted and irrigation is installed to meet site criteria specified above.
2. Evaluate above criteria to site an additional station. Coordinate with DWR to look at variability of ET in subbasin, evaluate topography, coordinate with landowners, etc.

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