MADERA SUBBASIN

Sustainable Groundwater Management Act (SGMA)

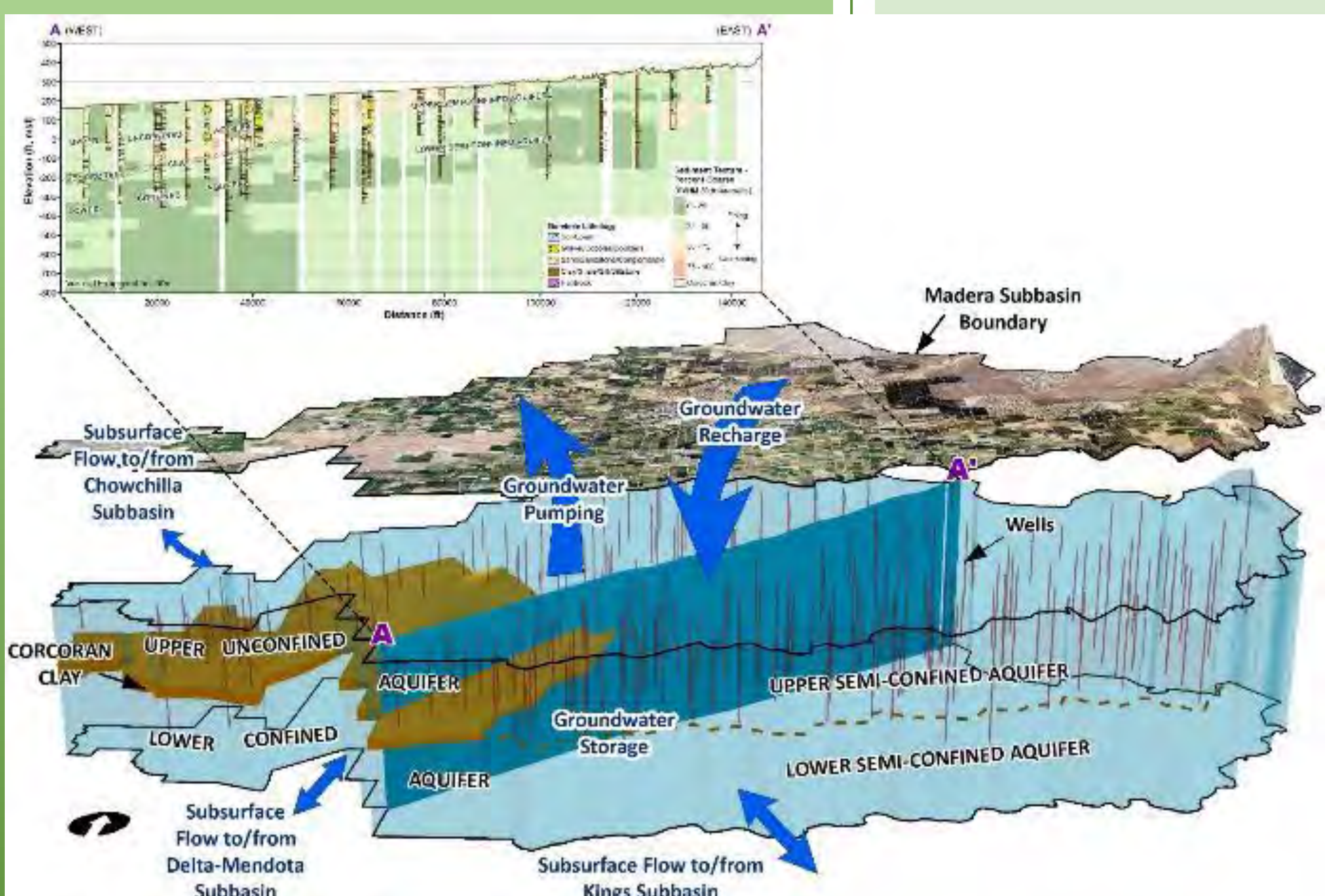
Joint Groundwater Sustainability Plan

City of Madera GSA
County of Madera GSA – Madera
Madera Irrigation District GSA
Madera Water District GSA

January 2020
Revised March 2023
Amended January 2025

Prepared by

Davids Engineering, Inc. *(Amended GSP Team)*
Luhdorff & Scalmanini *(Amended GSP Team)*
ERA Economics
Stillwater Sciences and
California State University, Sacramento



Madera Subbasin

Sustainable Groundwater Management Act

Joint Groundwater Sustainability Plan

January 2020

~~Revised March 2023~~Amended January 2025

Prepared For

City of Madera GSA
County of Madera GSA – Madera
Madera Irrigation District GSA
Madera Water District GSA~~Madera Subbasin Coordination Committee~~

Prepared By

Davids Engineering, Inc. (~~Revised~~ Amended GSP Team)
Luhdorff & Scalmanini (~~Revised~~ Amended GSP Team)
ERA Economics
Stillwater Sciences and
California State University, Sacramento

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

(Figure titles that are bolded can be found at the end of the chapter)

LIST OF APPENDICES

APPENDIX 1. INTRODUCTION

APPENDIX 2. PLAN AREA AND BASIN SETTING

APPENDIX 3. SUSTAINABLE MANAGEMENT CRITERIA

APPENDIX 4. PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY GOAL

APPENDIX 5. PLAN IMPLEMENTATION

APPENDIX 6. REFERENCES AND TECHNICAL STUDIES

LIST OF ABBREVIATIONS

AF	acre-feet
AFY	acre-feet/year
AG	Agricultural Land
AGR	agricultural supply
AN	above normal
AWMPs	Agricultural Water Management Plans
AWS	Automatic Weather Stations
bgs	below ground surface
BMP	Best Management Practice
BN	below normal
C	critical
C2VS~~s~~im	California Central Valley Groundwater-Surface Water Simulation Model
C2VS~~s~~im-FG	fine-grid version of C2V~~s~~Sim
CASGEM	California Statewide Groundwater Elevation Monitoring
CCP	Consensus and Collaboration Program at California State University, Sacramento
CCR	California Code of Regulations
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CM	City of Madera
CSUS	California State University, Sacramento (Consensus and Collaboration Program)
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CWC	California Water Code
CWD	Chowchilla Water District
D	dry
DACs	Disadvantaged Communities
DDW	Division of Drinking Water
DE	Davids Engineering
DMS	Data Management System
DQO	data quality objectives
DTW	depth to water
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ERA	ERA Economics, LLC
ET	evapotranspiration
ET_a	actual ET
ET_{aw}	ET of applied water
ET_c	crop ET
ET_o	grass reference ET
ET_{pr}	ET of precipitation
ET_r	alfalfa reference ET
ET_{ref}	reference crop evapotranspiration
eWRIMS	Electronic Water Rights Information Management System
Flood-MAR	Flood Managed Aquifer Recharge
FTE	full-time-equivalent
FWA	Friant Water Authority
GAMA	Groundwater Ambient Monitoring and Assessment
GDEs	groundwater dependent ecosystems
GFWD	Gravelly Ford Water District
GIS	geographic information system
GMP	Groundwater Management Plan
gpm	gallons per minute
GRF	Gravelly Ford
GSA	Groundwater Sustainability Agencies
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWS	Groundwater system
HCM	hydrogeologic conceptual model
HGL	hydraulic grade line
IDC	Integrated Water Flow Model Demand Calculator
iGDEs	indicators of GDEs
ILRP	Irrigated Lands Regulatory Program
IND	industrial service supply
InSAR	interferometric synthetic aperture radar

IRWM	Integrated Regional Water Management
ISW	interconnected surface water
IWFM	Integrated Water Flow Model
K	hydraulic conductivity
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity
LDC	Little Dry Creek
LSCE	Luhdorff & Scalmanini Consulting Engineers
maf	millions of acre-feet
MC	Madera County
MCL	maximum contaminant level
MCDEH	Merced County Department of Public Health, Division of Environmental Health
MCWPA	Madera-Chowchilla Water and Power Authority
Merced	Merced Irrigation District
mg/L	milligrams/liter
MID	Madera Irrigation District
MO	measurable objectives
MOU	memorandum of understanding
MSL	mean sea level
MT	minimum thresholds
MUN	Municipal and domestic supply
MWD	Madera Water District
MWELO	Model Water Efficient Landscape Ordinance
NASA-JPL	National Aeronautics and Space Administration Jet Propulsion Laboratory
NCCAG	Natural Communities Commonly Associated with Groundwater
NEPA	National Environmental Policy Act
NOAA NCEI	National Oceanic and Atmospheric Administration National Centers for Environmental Information
NRCS	Natural Resources Conservation Service-
NSWD	New Stone Water District
NV	Native Vegetation Land
NWIS	National Water Information System
O&M	operation and maintenance
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
PMAs	projects and management actions
PRO	industrial process supply
PV	Present Value
Q_b	Quaternary flood-plain deposits
QT_{cd}	Quaternary continental rocks and deposits
RCWD	Root Creek Water District
redox	reduction-oxidation
RFP	Request for Proposals
RH	relative humidity
RMS	Representative monitoring sites
RPE	Reference Point Elevation
R_s	solar radiation
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SCS	USDA Soil Conservation Service (renamed Natural Resources Conservation Service)
SCS-CN	SCS curve number
SEBAL	Surface Energy Balance Algorithm for Land
SGMA	Sustainable Groundwater Management Act of 2014
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program
SJV	San Joaquin Valley
SLDMWA	San Luis Delta-Mendota Water Authority
SMC	Sustainable Management Criteria
SOPs	Standard Operating Procedures
SS	Stillwater Sciences
SWRCB	State Water Resources Control Board
SWS	surface water system
Sy	specific yield
T	transmissivity
T_a	air temperature

TAF	thousand acre-feet
TDS	total dissolved solids
TM	Technical Memorandum
TMWA	Truckee Meadows Water Authority
UR	Urban Land
USACE	U.S. Army Corps of Engineers
USBR ~~or Reclamation~~	United States Bureau of Reclamation
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
UWMPs	Urban Water Management Plans
W	wet
WCRs	well completion reports
WDL	Water Data Library
W_s	wind speed
WYI	Water Year Index
YCWA	Yuba County Water Agency
Yield	net groundwater benefit
µg/L	micrograms per liter

EXECUTIVE SUMMARY

In September 2014, the California legislature passed the Sustainable Groundwater Management Act (SGMA), establishing new measures for groundwater management and regulation statewide. SGMA provides for local control of groundwater resources while requiring sustainable management of the state's groundwater basins. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP) for the subbasin. Under the GSP, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

The Madera Subbasin (Subbasin) is identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Therefore, the Madera Subbasin GSAs must develop, adopt, and submit a GSP (or GSPs) to DWR for the entire Madera Subbasin by January 31, 2020. The Madera Subbasin is managed by seven GSAs, of which four have developed a joint GSP and three have developed individual GSPs. These four original GSPs were developed, adopted, and submitted by the January 31, 2020 deadline. This Madera Subbasin Joint GSP (Joint GSP), together with the three individual GSPs, satisfies the requirements established by SGMA and DWR, and outlines the strategy by which the ~~Madera~~ Subbasin GSAs will achieve sustainable groundwater management by 2040.

~~GSP Revisions~~Revisions and Amendments to GSPs

In 2022-2023, the GSAs in the Madera Subbasin revised the four GSPs to resolve deficiencies identified by DWR in September 2022 and clarified during two consultation meetings held with DWR in November and December 2022. The four Revised GSPs, including the Revised Joint GSP, were submitted in March 2023 addressing DWR's comments from the September 2022 letter. Following the submission of the revised GSPs, DWR sent a letter approving the revised GSPs in December 2023. In their approval letter from December 2023, DWR provided a series of recommended corrective actions to further ensure that the GSPs achieve the Subbasin sustainability goal. Consistent with DWR guidance and recognizing the depth and breadth of the proposed revisions, a Plan Amendment to each of the GSPs to address these corrective actions was completed between December 2023 (when the letter was received) and January 2025 (when the first GSP Periodic Evaluations were due). The amended GSPs were adopted before the January 2025 submittal; amendments to the Joint GSP included:

- Text describing the adoption of the Joint GSP (March 2023 Revisions) by all four Joint GSP GSAs and their commitment to implementing the Plan consistent with SGMA (see **Appendix 1.H**).
- A summary of the coordination efforts and commitments the GSAs have taken to eliminate any areas of disagreement ensuring that groundwater sustainability is achieved within the Subbasin. This includes the engagement of facilitator support services to assist the GSAs in working through and eliminating any areas of disagreement; developing consensus regarding data, methods, and use of data across the Subbasin; and signing a new coordination agreement.
- A description of the relationship between the Sustainable Management Criteria (SMC) for chronic lowering of groundwater levels and the other sustainability indicators. This includes an explanation of how the SMC, including IMs, were established to avoid undesirable results for each of the other sustainability indicators and an explanation of how groundwater levels and subsidence are separate sustainability indicators, and that the most restrictive SMC governs.
- Reevaluation and refinement of land subsidence analysis. This includes clearly describing the significant and unreasonable conditions the GSAs are managing the Subbasin to avoid; reviewing

and refining the quantitative metrics that define an undesirable result for subsidence (including identifying and defining the cumulative amount of subsidence that, if exceeded, would substantially impact groundwater and land surface beneficial uses and users); conducting interviews with critical infrastructure owners and operators; and describing Projects and Management Actions (PMAs) that will be implemented to minimize or eliminate subsidence.

- A discussion of the uncertainties related to the Hydrogeologic Conceptual Model (HCM) and a description of HCM data gaps and how these have been or are being addressed.
- A summary of revisions to the SMC for water quality including revisions to undesirable results, justification for undesirable result definitions, an explanation of how IMs were established, and a discussion of uncertainties.
- A summary of coordination efforts and agreements related to interconnected surface water (ISW) between the Madera Subbasin GSAs and Kings Subbasin (McMullin Area GSA and North Kings GSA), United States Bureau of Reclamation (USBR), and Friant Water Authority (FWA).
- An update on PMA planning and implementation since the Revised Joint GSP was completed and submitted in March 2023.

On September 22, 2022, the GSAs in the Madera Subbasin received a letter from DWR documenting the incomplete determination of the four GSPs submitted for the Madera Subbasin in January 2020. The letter described deficiencies identified by DWR that may preclude approval of the submitted GSPs at this time and indicated the GSAs would have the opportunity to perform corrective actions to address the noted deficiencies within a 180-day period concluding on March 21, 2023.

In 2022-2023, the GSAs revised the four GSPs and the Coordination Agreement through an extensive and collaborative coordination process. Following numerous coordination meetings and ongoing communication, consistent revisions have been made to the GSPs and the Coordination Agreement that:

- Resolve the deficiencies identified by DWR in their September 2022 incomplete determination letter and discussed during two DWR consultation meetings between November 2022 and December 2022;
- Summarize the coordinated approach that the GSAs have taken in completing the GSP revisions, as well as planning for future GSP implementation, reporting, and the statutorily required 2025 GSP Updates;
- Summarize the progressive implementation actions taken by the GSAs since submission of the GSPs in January 2020;
- Recognize the GSAs' ongoing work to develop a Domestic Well Mitigation Program, including the development of a memorandum of understanding (MOU); and
- Reaffirm their commitment to implementing the GSPs and achieving sustainable groundwater conditions by 2040.

As of March January 20232025, revisions have been made in various, applicable sections of this Joint GSP and the Coordination Agreement (**Appendix 1.J**) to address these pointsrelated to the items summarized above. However, some text, estimated costs, modeling, benefits, and other analyses related to GSP implementation remain unchanged from the initial Joint GSP submitted in January 2020. Updates to GSP implementation costs, modeling, benefits, and related analyses will continue to be reassessed and reported in future Joint GSP updatesPlan Amendments, Periodic Evaluations, and amendments and Annual Reports as more is known, and to the extent necessary.

Approach to Achieving Sustainability

A pragmatic approach to achieving sustainable groundwater management requires firm understanding of: (1) historical trends and current groundwater conditions in the Subbasin (including, but not limited to, groundwater levels, groundwater extraction, and groundwater quality), and (2) what must change in the future to ensure sustainability without causing undesirable results[1] or negatively affecting beneficial uses and users of groundwater, including potential groundwater dependent ecosystems (GDEs).

In developing this Joint GSP, a Hydrogeologic Conceptual Model (HCM) and water budgets were created to first characterize historical and current groundwater conditions across the entire Madera Subbasin[2], with specific focus on vertical interactions between surface water and groundwater. The historical water budget identified historical trends in surface water availability and groundwater extraction and recharge, while the current water budget identified how current land use and cropping has changed groundwater demand while surface water availability did not change. These water budgets were used to calculate the average annual "net recharge from the surface water system" (net recharge), defined as the average annual sum of all groundwater extraction (negative) and groundwater recharge (positive) to and from the surface and root zone overlying the Madera Subbasin. "Shortage" was also calculated from these water budgets as the inverse of net recharge (sum of all groundwater extraction (positive) and groundwater recharge (negative) to and from the surface and root zone overlying the Madera Subbasin). Lateral subsurface inflows/outflows from/to adjacent subbasins were not considered in these water budget calculations of net recharge or shortage.

The GSAs are aware of uncertainty existing in the HCM. The uncertainty is related to limitations on the amount of available data (e.g., lithologic logs, borehole geophysical logs), reliability of those available data, and the reliability of correlations made from the available data. The amount of available data has been increasing over time as a result of GSA efforts and, in particular, several dedicated multi-completion (nested) monitoring wells have been drilled and installed since 2019 with plans to install additional wells in the future. The GSAs' efforts to address data HCM data gaps and uncertainties are described further in Section 2.2.2.7. The uncertainty in the HCM is expected to decrease in the future as such data are collected and incorporated into HCM updates.

Following creation of the water budgets, Projects and management actions (PMAss) were then developed with the goal of bringing the current net recharge into balance. A total of 285 PMAs are proposed by GSAs in this Joint GSP. Implementation of many projects hads begun prior to GSP submittal (131 projects), while many more werewill be implemented beginning between 2020-2025 (11 PMAs). In wet years, projects will provide direct recharge of surplus surface water and in-lieu recharge from strategic and expanded use of surface water through conveyance and storage efforts. Management actions will reduce groundwater pumping through demand management. These PMAs may change over the GSP implementation period (2020-2040) as landowners within the Subbasin adapt to SGMA implementation and as GSAs practice

[1] California Water Code (CWC) Section 10721(x) defines undesirable results as one of more of the following effects (summarized): chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater storage, significant and unreasonable seawater intrusion, significant and unreasonable degraded water quality, significant and unreasonable land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

[2] The Joint GSP evaluates groundwater conditions, the HCM, and water budgets for the entire Madera Subbasin, inclusive of the Joint GSP Plan Area, as well as the GFWD, NSWD, and RCWD GSP Plan Areas. The Joint GSP thus served as a touchpoint for coordination between the four GSPs to ensure consistency. Further, current, future, and projected water budgets inclusive of one agreed upon sustainable yield for the Subbasin are included in the First Amendment to the Coordination Agreement.

adaptive management while they monitor and learn more about groundwater conditions in the Madera Subbasin. In particular, the volume of groundwater pumping required through demand management may increase or decrease depending on the volume of direct recharge or in-lieu recharge provided by projects and conditions related to the six sustainability indicators. Any changes in the PMAs will be reported in subsequent Periodic Evaluations and Annual ReportsAnnual Reports and/or in future Joint GSP updates.

Importantly, this approach to developing PMAs acknowledges land subsidence and its related impacts and identifies the average annual "shortage" (groundwater extraction in excess of groundwater recharge from the surface water system) of water required to recharge the Subbasin and balance the average annual pumping. The PMAs were developed to fill this shortage, with a preference for projects to the extent that additional surface water is available, depending on hydrology. This strategy will achieve sustainable groundwater management without relying on subsurface inflows to bring the Subbasin into balance. It is expected that subsurface inflows and outflows will decline as the Madera Subbasin and adjacent subbasins all achieve sustainability by 2040.

GSP Development, Coordination, and Outreach

This Joint GSP has been developed through extensive outreach and engagement and considers feedback received from local agencies, agricultural water users, municipal water users, Disadvantaged Community (DAC) members, and other stakeholders in the Subbasin. Public meetings and workshops have been hosted throughout GSP development, including monthly GSA meetings, Coordination Committee meetings, County Advisory Committee meetings, Madera Irrigation District Groundwater Committee meetings, Madera County Farm Bureau Water Forum meetings, and Madera County Regional Water Management Group meetings (see Section 2.1.5). This continued throughDuring the GSP revision process in 2022-2023 and Plan Amendments completed in 2025, as the GSAs continued to conducted further public outreach through public GSA governing body meetings and through various other public meetings with stakeholders. The Madera Subbasin GSAs have met together regularly, and have also met multiple times with GSAs in adjacent subbasins, sharing data and information on GSP projects and management actions to ensure that implementation of the Madera Subbasin GSPs will not interfere with the ability of adjacent subbasins to also achieve sustainable groundwater management by 2040.

Additionally, since original GSA formation, subsequent GSP development, completion of the March 2023 Revised GSP, and now through GSP implementation and the Plan Amendment and Periodic Evaluation process, the GSAs in the Subbasin have committed to continued coordination in an effort to eliminate areas of disagreement. Despite multiple GSPs in the Subbasin, the GSAs have worked continuously over the last several years to seek consensus, striving to bring consistency across the four GSPs where possible and eliminating contradictory policies, procedures, and methodologies. The following sub-sections seek to efficiently and accurately detail continued coordination activities being undertaken by the GSAs in the Subbasin since Fall 2023 (prior to DWR's approval of the March 2023 Revised GSP on December 21, 2023).

Facilitation Support Services (FSS) Grant

Understanding the importance of continued coordination and prior to approval of the March 2023 Revised GSP by DWR on December 12, 2023, the GSAs in the Subbasin were the recipient of a Facilitation Support Services Grant (FSS Grant) from DWR. The Implementation Service Plan (ISP) included assistance in the nine categories listed below.

1. Stakeholder Assessments
2. Governance Development
3. Stakeholder Communication and Engagement Planning and Support
4. Public and Stakeholder Outreach
5. Targeted Outreach to Underrepresented Groundwater Users
6. Tribal Government Outreach and Engagement
7. Meeting Facilitation
8. Intra-Basin and Inter-Basin Coordination Support
9. Interest-Based Negotiation

The original contract for the FSS Grant was held by the MID GSA on behalf of the Subbasin (DWR Contract #4600013267). Upon FSS Grant receipt, the GSAs in the Subbasin embarked on a robust and detailed Stakeholder Assessment. Since completion of the initial Stakeholder Assessment, the original FSS Grant has been closed and the RCWD GSA has applied, and received, a new contract for the FSS Grant. Continued facilitation and coordination is currently focused on 4 of the 9 categories listed above: (1) Governance Development (Coordination Agreement modification(s)), (2) Stakeholder Communication and Engagement Planning and Support, (3) Interest-Based Negotiation, and (4) Meeting Facilitation. A primary focus during the 2025 Plan Amendment has been modification of the Coordination Agreement. Engagement in activities stemming from the FSS Grant have been broadly supported by the GSAs and continued facilitation support services in the Subbasin will continue to be a valuable component of GSP implementation.

DWR Grant for SB 552 Compliance

The MC GSA has been awarded $125,000 grant from DWR to assist with Senate Bill 552 (SB 552) compliance. The grant has two main components: (1) installation of a new monitoring well in the Ranchos and (2) facilitation and related services, in connection with the Domestic Well Mitigation Program (Program). This grant is supporting implementation of the Subbasin Program (**Appendix 4.B**). Related to component 2, the MC GSA has contracted with David M. Ceppos to provide neutral, stakeholder engagement and consultation support to the MC GSA regarding implementation of a Program in the Madera Subbasin with a specific focus on developing rules of said Program. Specific tasks include the following:

1. Conduct Background Review
2. Conduct Engagement Strategy Discussions
3. Conduct Stakeholder Interviews
4. Design and Conduct Program Public Meetings
5. Project Management

Following development of the Memorandum of Understanding (MOU) Establishing a Domestic Well Mitigation Program for the Madera Subbasin of the San Joaquin Valley Groundwater Basin and execution by 5 of the 7 GSAs within the Subbasin, this is a critical and necessary step in advancing a well-functioning and Subbasin-wide Program. For purposes of the 2025 Plan Amendment, it is assumed that the facilitation and related services associated with the Program as set-forth above will result in complete development of the Program such that implementation can begin in 2025 as set-forth and agreed upon in the MOU.

MCSim Groundwater Model

As detailed in Section 2.2.1 of the 2025 Plan Amendment, significant updates have been made to the MCSim Groundwater Model (MCSim Model) for the Madera and Chowchilla Subbasins. Importantly, and aside from the technical updates, the MCSim Model continues to be supported broadly by the GSAs in the Subbasin and serves as a uniform and consistent basis for development of GSA water budgets, future subsidence estimates, and establishment of SMC. Refinements to the MCSim Model as detailed herein were reviewed and discussed in great detail during development of the 2023 Revised GSPs and 2025 Plan Amendment and Periodic Evaluation Processes and have streamlined the GSAs' responses to many of the corrective actions identified by DWR in their December 21, 2023 GSP approval letter. Moving forward the MCSim Model will be updated on a five-year interval and diligently used by the GSAs in the Subbasin as a predictive tool to aid in siting of planned and proposed PMAs and evaluation of the benefit of implemented PMAs, in addition to broader management of the Subbasin.

GSA Technical Meetings

Since development of the 2023 Revised GSPs and serving at the direction of each GSA, the technical teams for each GSA (or group of GSAs in the case of the Joint GSP) have continued meeting on a regular basis. As part of the 2025 Plan Amendment, the technical teams for each GSA have met on a bi-weekly or weekly basis to discuss methodologies and preferred technical approaches for addressing DWR's identified deficiencies. To date, the GSA technical teams have met approximately 12 times to coordinate on 2025 Plan Amendments. Meeting agendas are developed collaboratively and as reflected in each of the four Plan Amendments, these technical team meetings have served as the basis for reaching consensus and ensuring consistent policies, procedures, and methodologies and ultimately, consistent groundwater management across the Subbasin.

The following sections in this Executive Summary provide a concise overview of the complete Joint GSP and changes made as part of the ~~Joint GSP revisions in response to DWR's incomplete determination~~Joint GSP 2025 Plan Amendment.

ES-1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, industrial, and environmental beneficial uses and users throughout the ~~Madera~~ Subbasin[3]. Agriculture in the ~~Madera~~ Subbasin has historically relied on about 500,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the nearly $2 billion dollar Madera County agricultural economy.[4] Groundwater also supports a large portion of Madera County's population of over 156,000 people[5] and related industries. The ~~Madera~~ Subbasin underlies approximately 350,000 acres, all within Madera County. Thus, the sustainable management of groundwater in the ~~Madera~~ Subbasin is important for long-term prosperity within Madera County.

[3] Groundwater basin number 5-022.06, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.
[4] According to the Madera County Department of Agricultural Weights and Measures, the gross value of all agricultural production in the County was $1,973,449,000. (2017 Crop and Livestock Report).
[5] U.S. Census Bureau, 2017 Estimate

The Sustainable Groundwater Management Act of 2014 (SGMA) provides for local control of groundwater resources while requiring sustainable management of these resources. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP) for the subbasin. Under the GSP, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

Sustainable management of groundwater is defined under SGMA as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" (California Water Code (CWC) Section (§) 10721(v)). These undesirable results include significant and unreasonable lowering of groundwater levels, loss of groundwater storage and supply, degradation of water quality, land subsidence, and depletions of interconnected surface water (ISW) that have significant and unreasonable adverse impacts on beneficial uses and users of surface water. Sea water intrusion, while a SGMA-defined undesirable result, is not applicable to the Madera Subbasin.

The Madera Subbasin has been identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Under SGMA, GSAs in critically overdrafted subbasins are required to prepare and adopt a GSP (or GSPs) by January 31, 2020 (CWC § 10720.7(a)(1)).

This is the coordinated Joint GSP for four GSAs that represent approximately 94% of the Subbasin area: the City of Madera (CM) GSA, the County of Madera GSA – Madera Subbasin (also referred to herein as Madera County GSA, or MC), the Madera Irrigation District (MID) GSA, and Madera Water District (MWD) GSA. These four GSAs are collectively referred to as the Joint GSP GSAs. The remaining 6% of the Madera Subbasin is managed under three (3) additional GSPs being prepared individually, but through close coordination at both a technical and policy level, by Gravelly Ford Water District (GFWD) GSA, New Stone Water District (NSWD) GSA, and Root Creek Water District (RCWD) GSA (Figure ES-1). - A coordination agreement has been developed by all seven GSAs in the Madera Subbasin detailing required GSA and GSP cooperation and coordination. The Madera Subbasin will satisfy SGMA requirements through the four (4) GSPs that together cover the entire SubbasinAs of April 2024, all GSAs that are part of the Joint GSP have adopted the Joint GSP (March 2023 Revisions) and are managing groundwater consistent with the Joint GSP and the sustainability goals set-forth thereinimplementing it consistent with SGMA.

The purpose of this Joint GSP is to characterize groundwater conditions in the Madera Subbasin, to evaluate and report on conditions of overdraft, to establish sustainability goals, and to describe PMAs the GSAs intend to implement to achieve sustainable groundwater management by 2040. While this Joint GSP focuses on groundwater management actions by the CM GSA, MC GSA, MID GSA, and MWD GSA, these actions are considered in the context of the entire basin setting and the actions of other GSAs in the Madera Subbasin to achieve subbasin-level sustainability. To this end and as explained in detail in this Joint GSP, significant coordination has occurred across all four GSPs in the Subbasin since submission of the initial GSPs in 2020, with the express goal of eliminating inconsistencies and embracing shared tools and resources, all while working towards a common sustainability goal for the Subbasin.

This Joint GSP also serves to comply with DWR's requirements that the Madera Subbasin GSAs prepare, adopt and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of [GSP] implementation without adversely affecting the ability of an adjacent basin to implement its [GSP] or achieve and maintain its sustainability goal over the planning and implementation horizon" as defined in the California Code of Regulations Title 23 (23 CCR), Section (§) 350.4 (f).

As mandated under 23 CCR § 354.24, GSAs within the ~~Madera~~ Subbasin have established a "sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline." Specifically, this sustainability goal establishes that the ~~Madera~~ Subbasin will be operated within its sustainable yield by 2040, or 20 years following GSP implementation in January 2020. Sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC § 10721(w)).

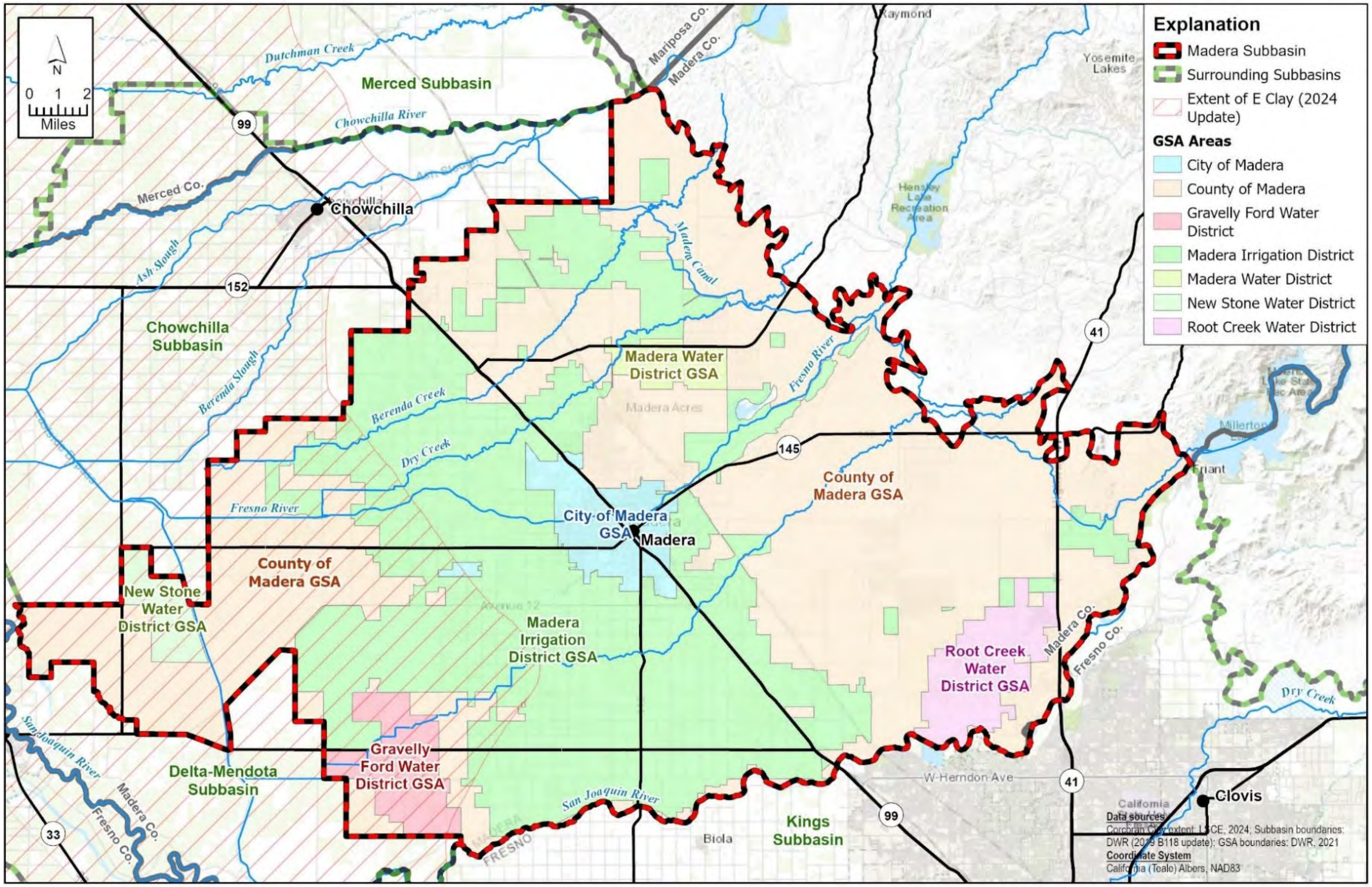


Figure ES-1. Madera Subbasin GSAs Map.[6]

[6] The GSA boundaries have been updated since initial GSP submission and the boundaries shown in the figures contained in this version of the GSP do not include the most recent version of the boundaries. Updates to figures will occur during the second periodic evaluation of the GSP and/or annual reports. This statement applies to all figures contained in this GSP and appendices.

ES-2 PLAN AREA AND BASIN SETTING

The GSP Plan Area is defined as the ~~Madera~~ Subbasin (5-22.06), part of the San Joaquin Valley Groundwater Basin, as described in Bulletin 118 (DWR, 2016) with boundary updates approved in early 2019. The lateral extent of the Subbasin is defined by the Subbasin boundaries provided in Bulletin 118 (DWR, 2016). The Subbasin is bounded in the south by the San Joaquin River and the Kings Subbasin, in the west by the Delta-Mendota Subbasin, in the north by the Chowchilla Subbasin, and in the east by the foothills of the Sierra Nevada (Figure ES-1). The vertical boundaries of the Subbasin are the land surface (upper boundary) and the definable bottom of the basin (lower boundary). The vertical extent of the Subbasin is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone[7], within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

Hydrogeologic Conceptual Model

The ~~Madera~~ Subbasin is generally comprised of relatively flat topography that slopes gently downward to the west. Topographic elevations vary from about 350 feet above mean sea level (MSL) in the east to about 150 feet above MSL in the west over a distance of about 20 miles (Figure ES-2). The major geomorphic features of the Subbasin are the alluvial fan and floodplain associated with sediment deposition from the Fresno and San Joaquin Rivers (Mitten et al., 1970). Soils with higher permeability and infiltration rates are present along river channels (Fresno River, Cottonwood Creek, and San Joaquin River) and west/south of the City of Madera (between the Fresno River and Cottonwood Creek). Another zone of higher soil permeability is present in the south-central portion of the Subbasin between Cottonwood Creek and the San Joaquin River. In addition, it is recognized that hard pan, which tends to greatly limit infiltration capacity, exists in many areas at depths typically in the range of 5 to 10 feet below ground surface. However, many areas with irrigated agricultural (particularly orchards) have constructed holes through the hard pan to facilitate proper drainage.

The stratigraphy of the ~~Madera~~ Subbasin from the surface down is comprised primarily of Continental Deposits of Quaternary Age (Younger and Older Alluvium), Continental Deposits of Tertiary and Quaternary age, Marine and Continental sedimentary rocks, and crystalline basement rock. The Continental Deposits are unconsolidated, and underlying sedimentary and basement rocks are consolidated. It is uncertain if Mehrten and Ione Formation are present in the ~~Madera~~ Subbasin. Younger Alluvium is generally limited to 50 feet thickness and typically unsaturated. The Older Alluvium consists of up to 1,000 feet of interbedded clay, silt, sand, and gravel. Older Alluvium becomes finer-grained with depth and is underlain by the generally finer-grained Continental deposits of Tertiary and Quaternary age (Mitten et.al., 1970). The primary water bearing unit is Older Alluvium (generally equivalent to Turlock Lake, Riverbank, and Modesto Fromations), although recent deeper drilling of agricultural wells is tapping into the underlying Continental Deposits of Tertiary/Quaternary age (Provost & Pritchard, 2014).

The Corcoran Clay occurs in the western portion of the ~~Madera~~ Subbasin (Figure ES-2) within the upper portion of Older Alluvium (Mitten et al., 1970). The Corcoran Clay is also considered to be a member of the Turlock Lake Formation (Page, 1986). The depth to the top of the Corcoran Clay generally ranges from about 150 to 400 feet where present within ~~Madera~~ Subbasin (Provost & Pritchard, 2014). The Corcoran

[7] The depth to the bottom of the root zone varies by crop, but typically ranges from 2-7 feet (ASCE, 2016).

Clay is comprised of clay and silt ranging in thickness from 10 feet at its eastern extent to 80 feet on the western edge of Madera County (Mitten et al., 1970).

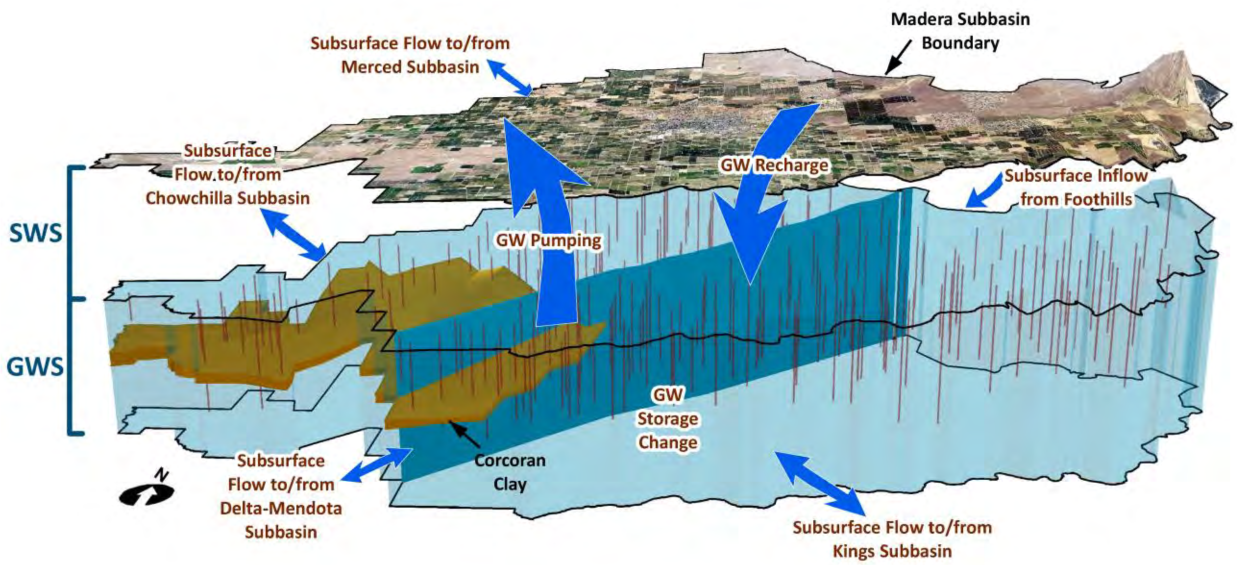


Figure ES-2. Madera Subbasin Hydrogeologic Conceptual Model.

Groundwater recharge can occur throughout the Madera Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources. Net subsurface inflows to the Madera Subbasin from adjacent subbasins also contribute to groundwater recharge (but are not included in water budget "net recharge" or "shortage" calculations described below); however, subsurface inflows and outflows are expected to decline as the Madera Subbasin and adjacent subbasins achieve sustainability by 2040. The main areas with hydrologic group A soils located along and between Berenda and Dry Creeks, and along and between Fresno River and Cottonwood Creek. A relatively large area of hydrologic group A and B soils is located west and south of the City of Madera. There are also small areas of hydrologic group A soils in the southeastern portion of the Subbasin, along the San Joaquin River, and in the far western portion of the Subbasin. Saturated soil vertical hydraulic conductivity (K) shows a similar distribution of areas with higher infiltration potential. A relatively large area comprised of hydrologic group C soils in the south-central portion of the Subbasin is indicated to have vertical soil K of 1.1 to 2.0 feet/day.

Under current and recent historical groundwater conditions, the primary groundwater discharge from the Subbasin is groundwater pumping for agricultural, municipal, domestic, and industrial uses. The majority of domestic wells are located in the central to eastern portions of the Subbasin, agricultural wells are relatively evenly distributed throughout the entire Subbasin (except in the easternmost area adjacent to the foothills of the Seirra Nevada Mountains where primarily range lands are present), and public supply wells are concentrated in the central to eastern portions of the Subbasin. Domestic well depths are variable across the Subbasin, shallower wells (less than 300 feet deep) are more common to the west of Highway 99. Similarly, agricultural wells tend to be shallower (less than 500 feet) to the west of Highway 99 and deeper (500 to greater than 750 feet) to the east of Highway 99. The average well depths for domestic and agricultural wells generally reflect the greater depths to water east of Highway 99.

Groundwater Conditions

The general prevailing groundwater flow direction in the unconfined Upper Aquifer is east to west, although a few notable, localized areas of low water levels (i.e., groundwater levels) exist in the Subbasin. These local depressions cause more local variability in the groundwater flow directions including most prominently in the southeastern part of the Subbasin and in the northern part of the Subbasin between the Fresno River and Dry Creek and extending north to the Subbasin boundary.

Perched groundwater has been identified at several sites in the Madera Subbasin from review and comparison of local groundwater level data from several regulated facility sites obtained from Geotracker and regional groundwater level data from the California Statewide Groundwater Elevation Monitoring (CASGEM) program and other sources.

The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer indicates Lower Aquifer groundwater elevations of between -20 and 50 feet mean sea level (msl) in a small area of the Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 shows relatively lower groundwater elevations between -10 and -30 feet msl in the Lower Aquifer in the same area near Dry Creek and Fresno River. Farther south, groundwater elevations in the Lower Aquifer in 2016 are higher with elevations of about 60 feet msl. Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in Subbasin is challenging.

Varying levels of groundwater level decline have been observed over the historical period across the Subbasin, with wells in the more eastern parts of the Subbasin having the greatest water level declines. Over the period from the mid-1980s to 2015, rates of groundwater level decline increased. The calculated changes in groundwater levels from groundwater elevation contour maps translate to changes in groundwater storage estimated to be about -2.5 million AF between 1988 and 2014 and about -3.6 million AF between 1988 and 2016, assuming a range of specific yield values from 8 to 13 percent.

Key groundwater quality constituents of interest in the Subbasin include nitrate, total dissolved solids (TDS), and arsenic. These constituents have greater potential for presenting broader regional groundwater quality concerns extending beyond localized or site-specific contamination cases and are likely to reflect a range of potential contamination sources.

A large percentage of the wells with nitrate data have maximum historical concentrations below 7.5 milligrams per liter (mg/L) and many have concentrations below 5 mg/L. However, a number of areas of locally high nitrate concentrations above 7.5 mg/L or above 10 mg/L are apparent across the Subbasin. The higher concentrations appear to be more common in the more western parts of the Subbasin. One particular area with a high density of wells with nitrate concentrations above the maximum contaminant level (MCL) of 10 mg/L (as N) is located in the western part of the Subbasin along Highway 145, directly south of where Dry Creek joins the Fresno River. Some of the clusters of wells with high nitrate concentrations are known to be associated with regulated facilities and contamination remediation sites. Most of the higher concentrations are from wells with unknown construction information, although maps of nitrate concentrations by depth zone indicate more wells known to be screened in the Upper Aquifer with higher concentrations than in the Lower Aquifer.

Historical TDS concentrations in groundwater in the Subbasin indicate relatively low salinity groundwater quality across most of the Subbasin with maximum historical TDS concentrations less than 500 mg/L in most places. Higher TDS concentrations in the western part of the Subbasin may be caused by natural salinity present in groundwater occurring within Coast Range derived sediments of marine source material.

Although there are a few wells with higher arsenic concentrations scattered throughout the Subbasin, most of the wells with arsenic concentrations above the MCL of 10 micrograms per liter (µg/L) are located northeast of Highway 99. Although a number of wells exhibit concentrations above the MCL, the dominant fraction of wells with arsenic concentrations are below 5 µg/L with many or most of these wells having concentrations below 2.5 µg/L. Few wells known to be screened in the Upper Aquifer have elevated concentrations.

Recent land subsidence has been a major concern in the northwestern portion of Madera County, primarily impacting the western portion of the adjacent Chowchilla Subbasin. However, there has been some recent subsidence occurring within the Subbasin. Approximately 1 to 2 feet of subsidence occurred between 1926 and 1970 in the northwestern portion of the Subbasin. Subsidence mapping using interferometric synthetic aperture radar (InSAR) data from 2007 to 2011 showed a maximum subsidence of 0.5 to 1 foot for that time period in the northwest part of the Subbasin. Subsidence mapping between 2015 and 2017 showed 1.0 to 1.5 feet of subsidence adjacent to and north of the Fresno River in the northwestern portion of the Subbasin.

Review of available data for ISW indicates that that surface water – groundwater interactions do not occur (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Berenda Creek, Dry Creek, the Fresno River, and Cottonwood Creek in the Subbasin. Comparison of historical regional groundwater levels and stream thalweg elevations suggest the San Joaquin River along the southern Subbasin boundary was likely connected with groundwater over the period of available data from 1958 through 1984, but groundwater levels were found to be generally below (and apparently disconnected from) the San Joaquin River by about 10 to 50 feet from 1989 through 2016. However, recent review of the shallowest groundwater zone along the river (i.e., upper 30 feet) based on San Joaquin River Restoration Project monitoring wells indicates that interconnection may exist at certain locations over certain time periods. An ISW ~~W~~workplan has been developed to further evaluate potential interconnection between the San Joaquin River and shallow groundwater zone (**Appendix 3.I**).

Some areas on the southern and southwestern boundaries of the Subbasin and along/adjacent to the San Joaquin River may be underlain by shallow clay layers that are above the principal aquifers in the area. Shallow groundwater in these areas can likely be considered mounded in that shallow clay layers help to maintain shallow groundwater levels regardless of whether or not an unsaturated zone exists beneath them as occurs in a truly perched groundwater condition. It is likely that seepage from the San Joaquin River is the source of water combined with presence of shallow clay layers, which serves to maintain shallow groundwater levels at these locations. While groundwater levels in this perched zone appear to be approximately 10 to 30 feet below ground surface, water levels in the underlying regional groundwater system are typically much deeper, in excess of 50 feet below ground surface. Based on review of available data, characterization of hydrogeologic conditions related to the potential for ISW is currently based on very limited data. Thus, additional data collection and analyses are needed to update and refine the understanding of how surface water and GDEs may (or may not) be connected to the regional aquifers where groundwater pumping occurs. A data gaps workplan for ISW is provided in **Appendix 3.I** and is described in Section 2.2.2.7.4.

Water Budget

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[8] over a specified period of time. When the water budget volume is an entire Subbasin, the water budget facilitates assessment of the total volume of groundwater and surface water entering and leaving the Subbasin over time, along with the change in the volume of water stored within the Subbasin.

Water budgets were developed for the Subbasin to characterize historical, current, and projected water budget conditions (for all GSAs within the Subbasin). **The water budgets reported herein are those developed for the 2020 GSP. All updates to the water budgets are documented and discussed in the Periodic Evaluation.** A numerical integrated groundwater flow model (MCSim) was developed based on the fine-grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSsim-FG), and was utilized to support development of water budgets for all the Subbasin GSAs, including those that have developed a separate GSP from this Joint GSP. To date, all GSAs have embraced use of the MCSim model as a consistent methodology for determining historical and projected conditions within the Subbasin.

The objective of the historical water budget is to evaluate availability or reliability of past surface water supplies and aquifer response to water supply and demand trends relative to water year type. The historical water budget was calculated for the 1989 through 2014 period in the 2020 GSP, which was found to be representative of long-term average conditions in the Subbasin based on analysis of precipitation, unimpaired flows, and Central Valley Project (CVP) supplies. For the 2025 Plan Amendment, the historical water budget was recalculated for the 1989 through 2023 period. These updates are documented and discussed in the Periodic Evaluation.

The objective of the current water budget is to understand the impact of current land use on water demand in the context of the Subbasin's hydrology and water supply. This requires a water budget that considers current land use conditions and average historical hydrologic and climatic conditions. The current water budget was calculated using land use data from 2015 to compute consumptive use and other root zone components in the Surface Water System water budget, and surface water supply and precipitation data for the 1989 through 2014 period. This approach accounts for changes in land use and water demand occurring over the historical period, most notably in the significant shift from pasture and alfalfa to almonds. With current land use conditions and average 1989 through 2014 hydrology, the current shortage (or shortfall) in the Subbasin is estimated to be approximately 165,900 acre-feet per year (AFY) (Figure ES-3). In this context, shortage represents groundwater extraction in excess of groundwater recharge from the surface water system. Unlike overdraft, calculations of shortage do not consider lateral, subsurface groundwater flows between neighboring subbasins. The current water budget shortage is effectively the current rate of shortage if 2015 land use and water demand conditions continued in the future under average historical hydrologic conditions. PMAs described below were designed to address the current water budget shortage.

[8] Where 'volume' refers to a space with length, width and depth properties, which for purposes of the GSP means the defined aquifer and associated surface water system.

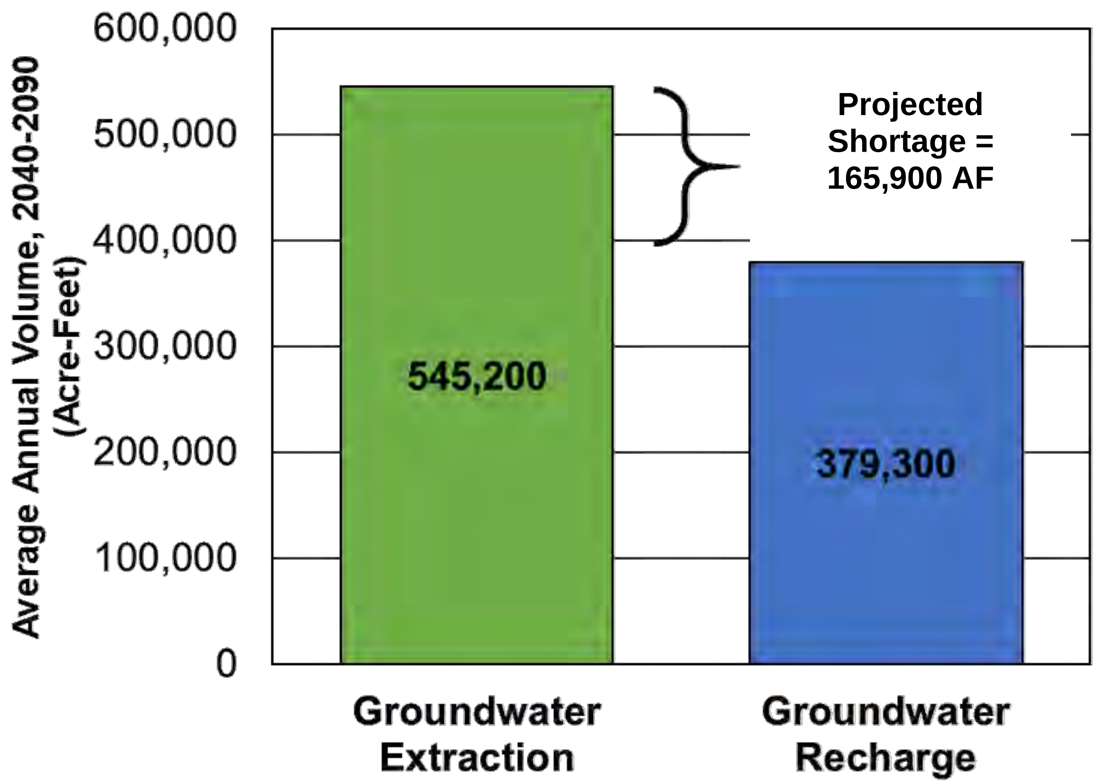


Figure ES-3. Summary Groundwater Budget for Current Subbasin Conditions (2015 Land Use).

The groundwater model was used to estimate projected water budgets over 70 years of future hydrology under different future climate scenarios and to evaluate the effects of PMAs[9] on Subbasin conditions. Two primary projected water budget scenarios were considered: one without projects (no action), and one with projects. Both of these projected scenarios were evaluated in the context of potential effects of climate change on future surface water supply and weather parameters. The climate change scenarios used climate change parameters specified by DWR, and served as a sensitivity analysis for the projected water budgets. While the climate change scenarios show the effects on groundwater resulting from reasonably foreseeable climate change impacts on precipitation, evapotranspiration, and surface water supply, the precise future impacts of climate change are unknown. Ultimately, the GSAs will need to continue adaptive management of the Subbasin to address the climate change scenario that actually occurs.

Two major time periods exist in the future projected model: the implementation period (2020-2039), during which PMAs are implemented to bring the Subbasin into sustainability, and the sustainability period (2040-2090), after which PMAs have been fully implemented. The projected with projects scenario results showed no overdraft in the Subbasin during the sustainability period (Figure ES-4).

[9] Projects and management actions identified to achieve sustainable operation of the Madera Subbasin are discussed in section ES-4.

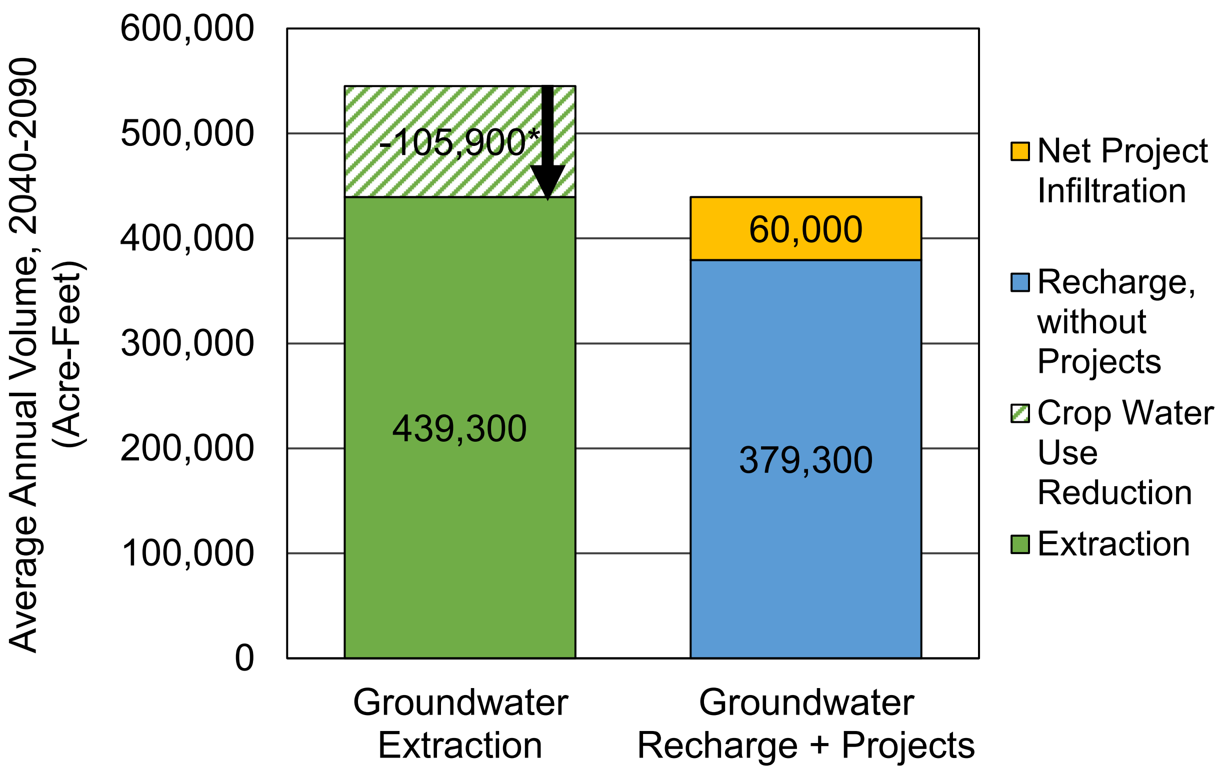


Figure ES-4. Simplified Groundwater Condition With Projects (2040-2090).

**Note: Crop Water Use Reduction Program in Madera County GSA: 90,000 AF. Remaining crop water use reduction due to permanent recharge basins replacing irrigated area and increased use of surface water in lieu of groundwater.*

The GSP regulations require the water budget to quantify the sustainable yield for the Subbasin. Sustainable yield is dependent upon conditions in existence at the time, and would therefore change during the implementation period while PMAs are being implemented. Thus, sustainable yield was calculated for the sustainability period, after all PMAs identified in the GSP are fully implemented (2040-2090).

The model results for the projected with projects scenario demonstrate that sustainability indicator minimum thresholds (MTs) and associated undesirable results are avoided during the sustainability period (2040-2090). Thus, the sustainable yield for the 2040-2090 projected period is the quantity of groundwater "…that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC § 10721(w)). In alignment with the GSP regulations and DWR's Sustainable Management Criteria BMP (DWR, 2017), sustainable yield has been calculated for the 2040-2090 projected period (Table ES-1) with a single value of sustainable yield for the Subbasin as a whole (DWR, 2017).

The sustainable yield is estimated as the average annual groundwater extraction during the 2040-2090 period. This projected groundwater extraction equals the sum of the average annual recharge without projects and the average annual net project infiltration during the projected period. Since average vertical groundwater inflows approximately equal average vertical groundwater outflows after sustainability is reached during the 2040-2090 period, the average annual change in the groundwater storage would be close to zero over this 50-year period. Accounting for all uncertainties in GWS inflows and outflows, the sustainable yield is estimated to range between 329,500 AFY and 549,100 AFY. While a range of sustainable yield is stated above to provide some context for the uncertainty involved in such an analysis, the actual value of sustainable yield is much more likely to occur in the middle of this range. By this method, sustainable yield is estimated to be 439,300 AFY (Table ES-1).

Table ES-1. Summary of Sustainable Yield Estimates from Projected with Projects Water Budget (23 CCR § 354.18(b)(7)).

Quantification Method	Average Volume, 2040-2090 (AF)	Estimated Confidence Interval[1] (percent)	Average minus CI (AF)	Average plus CI (AF)
Groundwater Extraction and Change in GWS Storage[2]	439,300	25%	329,500	549,100

[1] Confidence interval source: Professional judgment based on historical calculations.
[2] Subsurface inflow is expected to decrease as the groundwater system reaches new equilibrium levels following GSP implementation.

ES-3 SUSTAINABLE MANAGEMENT CRITERIA

Section 3 describes the sustainable management criteria (SMC) established in this Joint GSP. The SMC have been developed in coordination with – and are consistent with – the SMC described in the GFWD, NSWD, and RCWD GSPs. Together, the four GSPs will achieve sustainable groundwater management acrossin the entire Madera Subbasin through a consistent approach.

Sustainability Indicators

Undesirable results occur when significant and unreasonable effects for any of the six sustainability indicators defined by SGMA are caused by groundwater conditions occurring in the Subbasin. Table ES-2 summarizes whether, for each of the six sustainability indicators, undesirable results have occurred, are occurring, or are expected to occur in the future in the Subbasin without and with GSP implementation.

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)]. The "planning and implementation horizon" is defined 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" [CWC §10721(r)]. The 50-year planning and implementation horizon in the Madera Subbasin begins after the GSP implementation period. Prior to 2040, the GSAs are implementing PMAs, monitoring, and other efforts described in this GSP to achieve and maintain sustainable groundwater management. However, it is possible that groundwater conditions may temporarily exceed MTs during the GSP implementation period while these actions are occurring. By 2040, GSP implementation is expected to achieve the Subbasin sustainability goal through implementation of PMAs, demonstration that the SMC have been met, and demonstration that no undesirable results are occurring. The sustainability goal will be maintained through proactive monitoring and management by the GSAs.

Table ES-2. Summary of Undesirable Results Applicable to the Plan Area.

Sustainable Indicator	Historical Period (Prior to 2015)	Existing Conditions	Future Conditions without GSP Implementation	Future Conditions with GSP Implementation (after 2040)
Chronic Lowering of Groundwater Levels	Yes	Yes	Yes	No
Reduction of Groundwater Storage	Yes	Yes	Yes	No
Land Subsidence	YesNo	YesNo	YesPossibly	No
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Yes	Yes	Yes	No[1]
Depletion of Interconnected Surface Water	Yes	Possibly[2]	Possibly	No

[1] There may be future continued degradation of groundwater quality that is not related to GSP Projects and Management Actions.
[2] Based on review of available data, characterization of hydrogeologic conditions related to the potential for ISW is currently based on very limited data. A data gaps workplan for ISW (Appendix 3.I) will provide additional data to evaluate this sustainable indicator.

A summary of the MTs, measurable objectives (MOs) and undesirable results is provided in Table ES-3. Locally defined undesirable results were based on discussions with GSA staff and technical representatives, interviews with owners and operators of critical infrastructure within the Subbasin, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Descriptions and locations of the representative monitoring sites (RMS) for each sustainability indicator are provided in Section 3.

Chronic Lowering of Groundwater Levels

The GSP regulations provide that the "[MTs] for chronic lowering of groundwater levels shall be the groundwater level indicating a depletion of supply at a given location that may lead to undesirable results." Chronic lowering of groundwater levels in the Subbasin cause significant and unreasonable declines if they are sufficient in magnitude to lower the rate of production of pre-existing groundwater wells below that necessary to meet the minimum required to support overlying beneficial uses and users where alternative means of obtaining sufficient groundwater resources are not technically or financially feasible. -As shown in Table ES-3, the MT for groundwater levels is defined as the Fall 2015 groundwater level at each RMS well.[10] This MT maintains groundwater levels generally at or 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.

[10] MT is set equal to the Fall 2015 measurement, if this observed data point is available at the RMS. Otherwise, the MT is set equal to the expected Fall 2015 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.

Table ES-3. Summary of Minimum Thresholds, Measurable Objectives, and Undesirable Results.

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result (after 2040)[1]
Chronic Lowering of Groundwater Levels	Set equal to the Fall 2015 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2015 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Set equal to the Fall 2010 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2010 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Same 30 percent of RMS wells within the Subbasin below minimum threshold for two consecutive fall measurements.
Reduction of Groundwater Storage	Same as MTs for chronic lowering of groundwater levels. (Groundwater levels used as a proxy.)	Same as MOs for chronic lowering of groundwater levels. (Groundwater levels used as a proxy.)	Same 30 percent of RMS wells within the Subbasin below minimum threshold for two consecutive fall measurements. (Groundwater levels used as a proxy.)
Land Subsidence	0 feet/year, subject to uncertainty of +/-0.16 feet/year (although not meant to allow a continued rate of 0.16 ft/year)	0 feet/year, subject to uncertainty of +/-0.16 feet/year (although not meant to allow a continued rate of 0.16 ft/year)	Average subsidence across greater thanacross 75 25 percent ofr more RMS exceeding minimum threshold for two consecutive years.
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Nitrate = 10 mg/L or existing level plus 20% (whichever is greater) Arsenic = 10 µg/L or existing level plus 20% (whichever is greater) TDS = 500 mg/L or existing level plus 20% (whichever is greater)	Current constituent concentrations	10 percent of RMS wells above the minimum threshold for the same constituent due to projects and/or management actions, or overall groundwater extraction, based on average of most recent three year period
Depletion of Interconnected Surface Water	A percent of time surface water is connected to shallow groundwater that is equal to historical conditions for a similar climatic/hydrologic period.	A percent of time surface water is connected to shallow groundwater that is equal to historical conditions for a similar climatic/hydrologic period.	Greater than 30 percent of RMS wells below minimum threshold for two consecutive annual five-year rolling average annual evaluations

[1] 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)]. The "planning and implementation horizon" is defined 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" [CWC §10721(r)]. The 50-year time period in the Madera Subbasin begins after the GSP implementation period.

Groundwater levels will be managed with consideration of the MTs to ensure the major aquifers in the Subbasin are not depleted in a manner to cause significant and unreasonable impacts to other sustainability indicators. At the same time, the GSAs recognize that while groundwater levels are anticipated to fall below 2015 levels during the GSP implementation period, the implementation of projects and management actions is expected to cause groundwaters to return to 2015 levels by 2040.

The GSAs within the Subbasin have proceeded with coordination and focused planning efforts to develop a Domestic Well Mitigation Program, including the development of a memorandum of understanding (MOU). Once up and running, tThe Domestic Well Mitigation Program willcould provide assistance to domestic and/or municipal wells adversely impacted by declining groundwater levels that interfere with groundwater production or quality, and is being will be coordinated with the Madera County SB 552 Drought Plan that is also under development. Note that the Domestic Well Mitigation Program is not intended to mitigate well issues not caused by regional groundwater conditions nor is it intended to resolve issues related to normal wear and tear. It is expected that the Domestic Well Mitigation Program would be implemented during the GSP implementation period, as needed, and continue until groundwater sustainability is achieved. After 2040, groundwater levels will stabilize at historical levels, avoiding undesirable results for groundwater users. As of March 2023, the GSAs are developing the Program eligibility criteria, terms, and conditions and are preparing to move forward with Program implementation, as needed, no later than 2025. To fund this effort, the MC GSA has been awarded $125,000 grant from DWR to assist with Senate Bill 552 (SB 552) compliance. The grant has two main components; (1) installation of a new monitoring well in the Ranchos and (2) facilitation and related services, in connection with the Domestic Well Mitigation Program. The Domestic Well Mitigation Program and the MOU are discussed in Section 3.3.1.1.

The selection of SMC for chronic groundwater level decline are also intended to protect against significant and unreasonable impacts to groundwater storage volumes, land subsidence, and some groundwater quality concerns, and also included consideration of GDEs. Further, MTs are set at Fall 2015 levels to be consistent with the other sustainability indicators. The groundwater level MT 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 Joint GSP.

Reduction of Groundwater Storage

The groundwater storage reduction metric will be evaluated using groundwater levels as a proxy in conjunction with annual evaluations of the previous year's groundwater storage change and Pperiodic Eevaluations of long-term groundwater level and storage changes over average climatic periods during the sustainability period. Based on considerations applied in developing the groundwater level MTs, reduction in groundwater storage MTs do not exceed any identified significant and unreasonable level of depleted groundwater storage volume.

Land Subsidence

The cause of Subbasin groundwater conditions that would result in significant and unreasonable land subsidence is excessive overall average annual groundwater pumping and other outflows from the Subbasin that exceed average annual inflows. Locally defined significant and unreasonable conditions were determined based on discussions with GSA staff and technical representatives, interviews with owners and operators of critical infrastructure, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable land subsidence results in significant impacts to infrastructure. The land subsidence MT is set at a rate of 0 feet/year in order to prevent undesirable results. The MT for land subsidence is set recognizing that land subsidence within Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is dependent on the successful implementation of PMAs ~~project and management actions~~ in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are not specifically tied to subsidence thresholds, they are consistent with the objective to limit the potential for continued active~~future~~ subsidence.

Degraded Water Quality

The cause of Subbasin groundwater conditions that would result in significant and unreasonable degraded water quality is implementation of a GSP project or management action that causes concentrations of key groundwater quality constituents to increase to concentrations exceeding the MTs, which are set at the MCLs for drinking water for identified key constituents (10 milligrams/liter (mg/L) for nitrate as nitrogen; 500 mg/L for TDS; 10 micrograms/liter (µg/L) for arsenic) or when existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent. There are no current documented large-scale contaminant plumes in the regional groundwater aquifers. Smaller more localized and shallow contaminant site plumes have been documented in parts of the Plan Area, most notably in the vicinity of the City of Madera, although these contaminants are generally restricted to depths above the regional aquifer system. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Plan Area; therefore, groundwater quality degradation resulting from a GSP project or management action is considered significant and unreasonable based on adverse impacts to this beneficial use. Significant and unreasonable degradation of water quality occurs when beneficial uses for groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs for one of the key constituents (nitrate, arsenic, TDS) at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent.

Depletion of Interconnected Surface Water

It has been determined that a direct hydraulic connection between regional groundwater and streams does not exist for streams in most of the Subbasin; therefore, the surface water depletion sustainability criteria are not applicable over most of the Subbasin. However, water levels in the shallowest groundwater zone below and along parts of the San Joaquin River at the southern boundary of Subbasin periodically rise to elevations equal to or above the stream thalweg. Although it appears this shallow groundwater is associated with infiltration of streamflow from the nearby river resulting from upstream reservoir releases, interim SMC are being established for ISW along the San Joaquin River until additional field investigations, studies, evaluations, and monitoring can be completed to update and refine the hydrogeologic understanding of subsurface conditions and interactions between groundwater and surface water in this area. To complete these studies on the San Joaquin River, the Madera and Kings Subbasins have developed a MOU with the USBR and the FWA that includes a cooperative scope of work for further investigation of possible ISW from along the SJR from Reach 1A to Mendota Pool. A copy of the MOU between Kings, Madera, USBR, and FWA has been included in **Appendix 3.I**, along with updates to the ISW workplan as part of the January 2025 Plan Amendment. The interim MTs are the same as the interim MOs: to maintain the percent of time of surface water – groundwater connectivity consistent with conditions during the baseline historical time period, as measured over a rolling five-year period. The connection between regional groundwater and surface water will be reevaluated after further studies are completed and, if necessary, the interim SMC will be updated.

Seawater Intrusion

The seawater intrusion sustainability criterion is not applicable to this Subbasin.

Monitoring Networks

The GSP groundwater monitoring network was developed using existing wells in the Subbasin and will be supplemented (and/or some initial wells replaced) by new nested monitoring wells. The database for existing wells was reviewed with the following criteria in mind:

- CASGEM wells preferred;
- Known construction (screen intervals, depth) preferred;
- Long histories of water level data (including recent data) preferred;
- Relatively good match between observed and modeled water levels preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Plan Area) and Lower Aquifers preferred.

The selected groundwater level indicator wells, Representative Monitoring Sites (RMS), are distributed throughout the Subbasin to provide broad spatial coverage of the Subbasin, to the extent possible (Figure ES-5). The groundwater quality indicator wells represent a subset of the water level indicator wells with additional wells included from other groundwater quality monitoring programs (Figure ES-6). The monitoring network will be periodically reviewed and modified as needed.

ES-4 SUBBASIN PROJECTS AND MANAGEMENT ACTIONS

To achieve the Subbasin sustainability goal by 2040 and avoid undesirable results through 2090 as required by SGMA regulations, various ~~projects and management actions (~~PMAs~~)~~ have been developed and will be implemented by the GSAs between 2020 and 2040. Projects generally refer to structural features whereas management actions are typically non-structural programs or policies designed to incentivize reductions in groundwater pumping.

The GSAs have prioritized implementation of projects that provide additional surface water supplies to the Subbasin, thereby reducing groundwater pumping. However, recognizing that access to surface water supplies is variable, the GSAs are also planning demand management to directly reduce groundwater pumping to achieve sustainability. The GSAs are also committed to an adaptive management approach to implementing PMAs that is informed by continued monitoring of groundwater conditions using the monitoring networks. As PMAs are implemented and Subbasin conditions are monitored, the GSAs will review PMA timelines, benefits, and the volume of demand management that may be necessary to achieve sustainability. If the GSAs find that adjustments are needed to meet the sustainability goal, the GSAs will evaluate and adjust plans for project implementation and, to the extent necessary, demand management. Any adjustments will be reported in subsequent Periodic Evaluations and Annual Reports~~annual reports, and/or the five-year periodic evaluation and GSP updates~~. A proposed timeline for the ~~2025 GSP update~~2025 Joint GSP Periodic Evaluation and associated Plan Amendment is provided in **Appendix 5.A**. This timeline includes evaluation of projects and management actions to ensure that the Subbasin will be managed sustainably and without undesirable results by 2040. A similar timeline is anticipated for the 2030 and 2035 Joint GSP Periodic Evaluations (and any associated Plan Amendments).

This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed

in the Periodic Evaluation and Annual Reports. A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

Two main types of projects are included for implementation in the Joint GSP: recharge and conveyance. Recharge projects are designed to support sustainability by diverting floodwater or other available surface water for direct infiltration in constructed basins or spreading onto fields. Conveyance projects facilitate the delivery of additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping (in-lieu recharge). Conveyance projects may include structural improvements, operational changes, or both. Some projects have a specific water source, but many of the recharge projects can draw from the same general sources. In addition to projects, the Joint GSP includes several proposed management actions including the Madera County GSA's ~~planned~~ demand management program that will reduce demand by placing restrictions on groundwater pumping, among other actions. Together, the PMAs have been developed and planned to achieve the Subbasin sustainability goal by 2040.

The cost, timing, and gross groundwater benefit (yield) of the PMAs included in the GSP vary by GSA. Table ES-4 lists all PMAs planned at the time of initial GSP development, summarized by GSA or implementing entity, and the estimated implementation timeline, capital cost, operating cost, and anticipated gross benefit of the projects[11] as of January 2020. Table ES-5 further summarizes the anticipated total gross benefits and costs of all PMAs developed for each GSA or implementing entity as of January 2020. Updates regarding PMA implementation activities since initial GSP development are documented in Section~~s~~ 4.9 ~~and 4.10~~.

As estimated in January 2020, t~~T~~he gross yield across all projects at full implementation (2040) equals approximately 215,840 AFY resulting in a net yield equal to the projected shortfall of 165,900 AFY. The gross yield is larger than the projected shortfall due primarily to changes in other water budget elements when flood flows are directed to recharge. This includes the demand management program ~~-~~to be implemented by the Madera County GSA that will reduce net groundwater pumping (by about 90,000 AFY, as estimated in January 2020).

[11] Estimated costs have not been updated since initial Joint GSP development and are presented in 2019 dollars. Estimated costs will be updated by each GSA as project design(s), permitting, and construction proceeds.

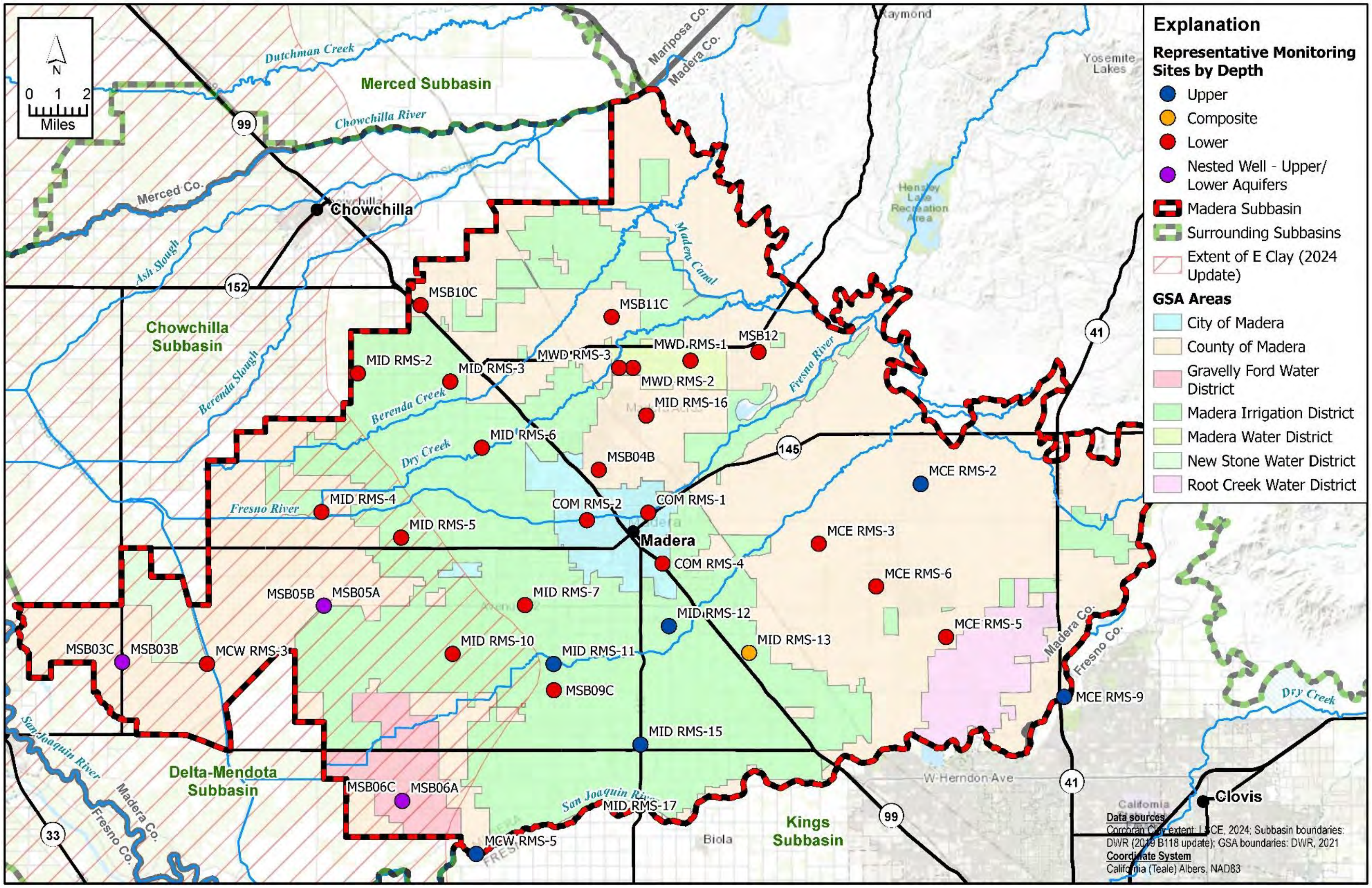


Figure ES-5. Groundwater Level Representative Monitoring ~~Network: CASGEM, Voluntary, and Other Wells~~Sites.

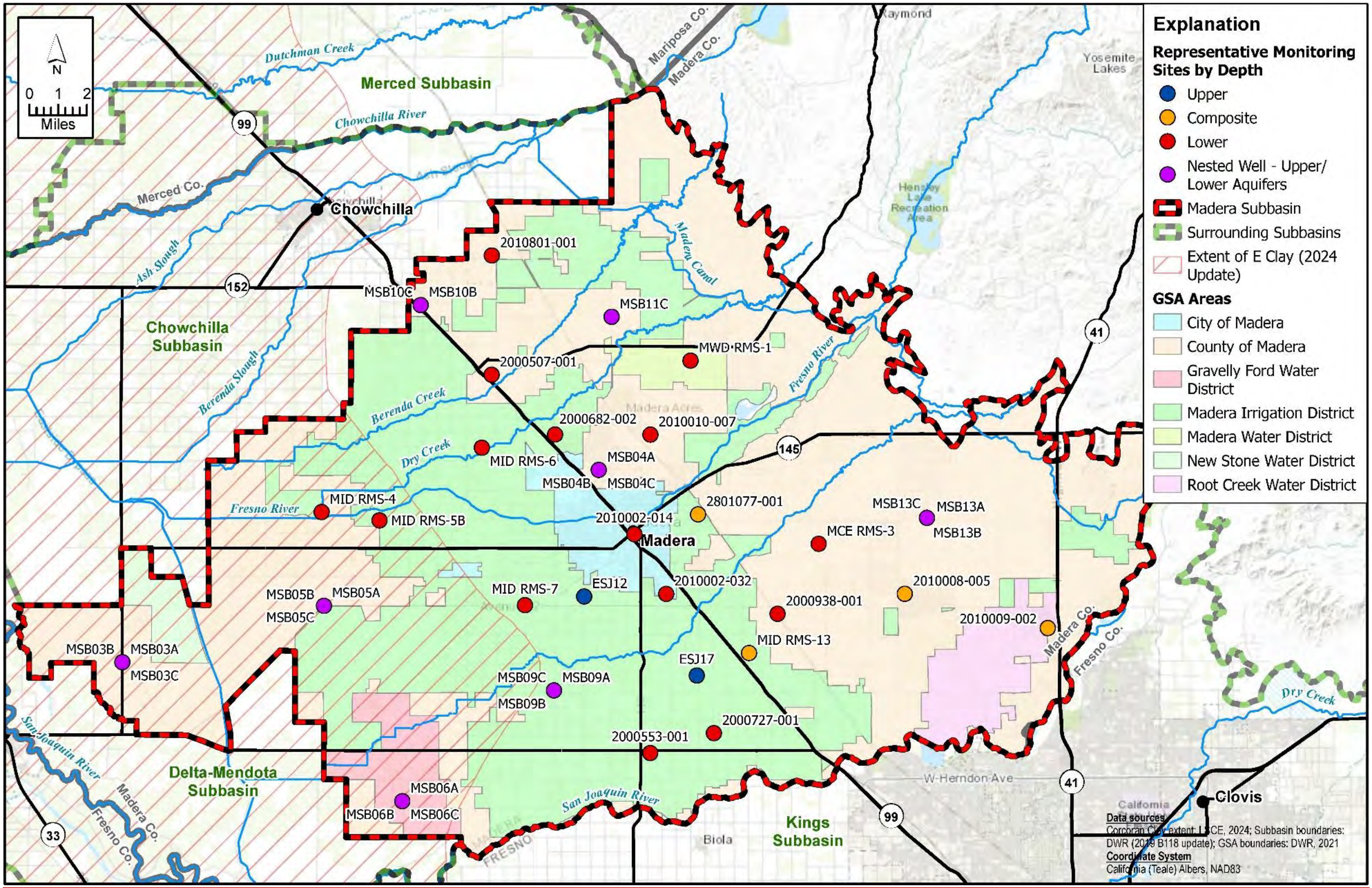


Figure ES-6. Groundwater Quality Representative Monitoring Sites.

Table ES-4. Madera Subbasin Projects and Management Actions (As of January 2020).

GSA	PMA	First Year of Implementation	Average Annual Gross Benefit at Full Implementation (AFY)	Estimated Capital Cost ($ millions)	Estimated Average Annual Operating Cost ($ millions/year)
MWD	Expanded Surface Water Purchase	2023	2,810	14.90	0.90
MID	Rehab Recharge Basins	2016	5,030	0.06	0.43
MID	Ellis Basin	2016	240	0.02	0.02
MID/City of Madera	Berry Basin	2018	20	0.02	0.00
MID	Allende Basin	2019	1,050	0.20	0.07
MID	Additional Recharge Basins Phase 1	2030	5,470	1.00	0.24
MID	Additional Recharge Basins Phase 2	2040	21,890	14.20	3.75
MID	On-Farm Recharge	2015	510	0.00	0.05
MID	Phase 2 On-Farm Recharge	2025	1,690	0.00	0.19
MID	MID Pipeline	2016	420	0.56	0.00
MID	WaterSMART Pipeline	2019	880	1.30	0.00
MID	WaterSMART SCADA	2019	1,230	1.20	0.00
MID	Water Supply Partnerships	2025	3,990	0.00	2.50
MID	Incentive Program	2022	5,010	0.00	3.08
City of Madera	Meters and Volumetric Pricing	2015	3,350	11.00	0.00
City of Madera/MID	Berry Basin	2018	20	0.02	0.00
Madera County	Water Imports Purchase	2025	3,610	0.30	2.49
Madera County	Millerton Flood Release Imports	2025	7,060	31.90	0.45
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 1	2025	12,710	67.00	0.32
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 2	2040	26,470	118.90	1.16
Madera County	Demand Management	2020	90,000	0.00	53.90
GFWD	Recharge Basin and Canals	2020	2,620	*See GFWD GSP*	
NSWD	Water Right Utilization	2020	5,540	*See NSWD GSP*	
RCWD	Purchased Water for In-Lieu Storage	2019	4,380	*See RCWD GSP*	
RCWD	Holding Contracts	2020	9,840	*See RCWD GSP*	
Total			215,840	262.58	69.55

Note: ~~estimated~~ Estimated project benefit values and costs are rounded. Costs are presented in 2019 dollars. This represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.

Table ES-5. Summary of Madera Subbasin Projects and Management Actions by GSA (As of January 2020[1]).

GSA	Average Annual Gross Benefit at Full Implementation (AFY)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
MWD	2,810	14.90	0.90
MID	47,430	18.56	10.33
City of Madera	3,370	11.02	0.00
Madera County	139,850	218.10	58.32[12]
GFWD	2,620	*See GFWD GSP*	
NSWD	5,540	*See NSWD GSP*	
RCWD	14,220	*See RCWD GSP*	
Total	215,840	262.58	69.55

[1] This represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.

[2] Costs of demand management include reduced economic activities in the county, this includes approximately $53.9 million per year in direct economic impacts alone (excluding multiplier effects). Costs are presented in 2019 dollars.

ES-5 PLAN IMPLEMENTATION

This section describes Plan implementation and associated costs as estimated and envisioned during initial GSP development in January 2020. Plan implementation and costs are reported as of January 2020, unless otherwise specified, and do not necessarily include changes to GSP implementation made in the 2023 Revised GSP or the 2025 Plan Amendment. Changes to GSP implementation are discussed in the Periodic Evaluation.

As of January 2020, administering the GSP and monitoring and reporting progress was projected to cost between $3 and $5 million dollars per year across the four Joint GSP GSAs. Costs are expected to be higher during years in which five-year Pperiodic Eevaluations are required, and slightly lower during years in which annual reports are required. These total costs did not include:

- The costs of implementing the Domestic Well Mitigation Program, as needed.
- The costs of implementing the two data gaps workplans that the GSAs identified and have developed in 2022-2023. Additional information about the ISW and subsidence workplans is provided in Section 2.2.2.
- The capital and annual operating cost of PMAs.
- Refinements to costs for GSP planning, updates, and implementation that were refined since initial GSP development.

Development of the 2020is GSP and the 2023 Revised GSP was funded through a Proposition 1 Ggrants, and contributions from individual GSAs (e.g., through in-kind staff time, or separately contracted consulting services). Funding for this 2025 Plan Amendment is being paid for by the Joint GSP GSAs. Individual GSAs are also funding additional, ancillary studies and implementation efforts. To fund GSA operations and GSP implementation, GSAs are developing a financing plan that will include one or more of the following financing approaches:

- **Grants and low-interest loans**: GSAs will continue to pursue grants and low interest loans to help fund planning studies and other GSA activities. However, grants and low-interest loans are not expected to cover most GSA operating costs for GSP implementation.

- **Groundwater extraction charge**: A charge per AF of groundwater pumped cwould be used to fund GSP implementation activities.
- **Other Fees and charges**: Other fees may include permitting fees for new wells or development, transaction fees associated with contemplated groundwater markets, or commodity-based fees, all directed at aiding with sustainability objectives. Depending on the justification and basis for a fee, it may be considered a property-related fee subject to voting requirements of Article XIII D of the California Constitution (passed by voters in 1996 as Proposition 218) or a regulatory fee exempt from such requirements.
- **Assessments:** Special benefit assessments under Proposition 218 could include a per-acre (or per-parcel) charge to cover GSA costs.
- **Taxes:** This could include general property related taxes that are not directly related to the benefits or costs of a service (ad valorem and parcel taxes), or special taxes imposed for specific purposes related to GSA activities.

GSAs are pursuing a combined approach, targeting available grants and low interest loans, and considering a combination of fees and assessments to cover operating and program-specific costs. As required by statute and the Constitution, GSAs would complete an engineer's report, rate study, and other analysis to document and justify any rate, fee, or assessment. For example, Madera County initiated two separate rate studies in 2019. At the time of initial GSP adoption in January 2020, the initial rate study was producing an engineering report to adequately fund an existing flood control and water conservation agency, which would allow for the agency to adequately control flood flows with existing infrastructure. In the second rate study, an engineering report was being produced for the ongoing costs associated with running the three County GSAs, which would include administration as well as sufficient planning funds for eventual project implementation.

The GSP implementation schedule allows time for GSAs to develop and implement PMAs and meets all sustainability objectives by 2040. While some projects began immediately after SGMA became law and are already contributing to Subbasin goals (Figure ES-76), the GSAs will begin implementing other GSP activities in 2020, with full implementation of PMAs to achieve sustainability by 2040. Figure ES-87 illustrates the GSP implementation schedule for PMAs implemented by each GSA. The GSP implementation schedule also shows mandatory reporting and updating for all GSAs, including annual reports and five-year PPeriodic updates (eEvaluations) prepared and submitted to DWR.

The GSP implementation plan uses the best available information and the best available science to provide a road map for the Madera Subbasin to meet its sustainability goal by 2040 and comply with the SGMA regulations. During each Periodic Evaluationfive-year update, progress will be assessed, and the implementation plan revised as necessary, to achieve the sustainability goal by 2040 and comply with the SGMA regulations.

Figure ES-76. Madera Subbasin Projects in Response to SGMA (2015-2019).[1]

[1] Implementation plans shown in this figure reflect the original design of PMAs in the initial GSP (January 2020). These plans may have changed due to various factors, as reflected in Annual Reports and the Periodic Evaluation. Please refer to the Annual Reports and Periodic Evaluation for updates on PMAs implementation, benefits, and timelines.

Figure ES-87. Madera Subbasin Implementation Schedule (2020-2040).[1]

[1] Implementation plans shown in this figure reflect the original design of PMAs in the initial GSP (January 2020). These plans may have changed due to various factors, as reflected in Annual Reports and the Periodic Evaluation. Please refer to the Annual Reports and Periodic Evaluation for updates on PMAs implementation, benefits, and timelines.

1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, and industrial beneficial uses and users throughout the ~~Madera~~ Subbasin[12]. Agriculture in the ~~Madera~~ Subbasin (Subbasin) has historically relied on about 500,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the nearly $2 billion dollar Madera County agricultural economy.[13] Groundwater also supports a large portion of Madera County's population of over 156,000 people[14] and related industries. The ~~Madera~~ Subbasin underlies approximately 350,000 acres, all within Madera County, and represents approximately 70% of the three groundwater subbasins that underlie the County. Thus, the sustainable management of groundwater in the ~~Madera~~ Subbasin is important for long-term prosperity within Madera County.

The Sustainable Groundwater Management Act of 2014 (SGMA) provides for local control of groundwater resources while requiring sustainable management of these resources. Under the provisions of SGMA, local agencies must establish governance of their subbasins by forming local Groundwater Sustainability Agencies (GSAs) with the authority to develop, adopt, and implement a Groundwater Sustainability Plan (GSP) for the subbasin. Under the GSP, GSAs must adequately define and monitor groundwater conditions in the subbasin and establish criteria to maintain or achieve sustainable groundwater management within 20 years of GSP adoption.

Sustainable management of groundwater is defined under SGMA as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" (California Water Code (CWC) Section (§) 10721(v)). These undesirable results are defined in CWC § 10721(x)[15] and include significant and unreasonable lowering of groundwater levels, loss of groundwater storage and supply, degradation of water quality, land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. Sea water intrusion, while a SGMA-defined undesirable result, is not applicable to the ~~Madera~~ Subbasin.

The ~~Madera~~ Subbasin has been identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Under SGMA, GSAs in critically overdrafted subbasins are required to prepare and adopt a GSP (or GSPs) by January 31, 2020 (CWC § 10720.7(a)(1)).

This is the coordinated Joint GSP for four GSAs that represent approximately 94% of the Subbasin area: the City of Madera (CM) GSA, the County of Madera GSA – Madera Subbasin (also referred to herein as Madera County GSA, or MC), the Madera Irrigation District (MID) GSA, and the Madera Water District (MWD) GSA. These four GSAs are collectively referred to as the Joint GSP GSAs. The remaining 6% of the ~~Madera~~ Subbasin is managed under three (3) additional GSPs being prepared individually by Gravelly Ford Water District (GFWD) GSA, New Stone Water District (NSWD) GSA, and Root Creek Water District (RCWD)

[12] Groundwater basin number 5-022.06, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.

[13] According to the Madera County Department of Agricultural Weights and Measures, the gross value of all agricultural production in the County was $1,973,449,000. (2017 Crop and Livestock Report).

[14] U.S. Census Bureau, 2017 Estimate

[15] CWC §10721(x) defines undesirable results as one of more of the following effects (summarized): chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater storage, significant and unreasonable seawater intrusion, significant and unreasonable degraded water quality, significant and unreasonable land subsidence, and depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

GSA. A coordination agreement has been developed by all seven GSAs in the Madera Subbasin detailing required GSA and GSP cooperation and coordination. The Madera Subbasin will satisfy SGMA requirements through the four (4) GSPs that together cover the entire Subbasin.

The Joint GSP covers the extent of the Subbasin that is managed by the four Joint GSP GSAs: CM GSA, MC GSA, MID GSA, and MWD GSA. The four Joint GSP GSAs collectively adopted and submitted the initial Joint GSP in January 2020, and later revised and resubmitted the Joint GSP in March of 2023 (March 2023 Revised GSP) to address deficiencies identified by DWR and incorporate new information made available since 2020. As documented in the March 2023 Revised GSP, the MID GSA took action to approve the First Amendment to the Madera Subbasin Coordination Agreement and the Memorandum of Understanding Establishing a Domestic Well Mitigation Program for the Madera Subbasin of the San Joaquin Valley Groundwater Basin, but did not take action to approve the March 2023 Revised GSP. On April 16, 2024 and as documented in MID GSA Resolution NO. 2024-GSA01, the MID GSA took action to approve and adopt the March 2023 Revised GSP (**Appendix 1.H**). To date, all four Joint GSP GSAs have taken action to approve the March 2023 Revised GSP and are committed to implementing the Plan consistent with SGMA.

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this Joint GSP is to characterize groundwater conditions in the Madera Subbasin, to evaluate and report on conditions of overdraft, to establish sustainability goals, and to describe projects and management actions (PMAs) the GSAs will implement to achieve sustainable groundwater management by 2040. While this plan focuses on groundwater management actions by City of MaderaCM GSA, Madera CountyMC GSA, Madera Irrigation DistrictMID GSA, and Madera Water DistrictMWD GSA, these actions are considered in the context of the entire basin setting and the actions of other GSAs in the Madera Subbasin to achieve subbasin-level sustainability.

This Joint GSP also serves to comply with DWR's requirements that the Madera Subbasin GSAs prepare, adopt and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of [GSP] implementation without adversely affecting the ability of an adjacent basin to implement its [GSP] or achieve and maintain its sustainability goal over the planning and implementation horizon" as defined in the California Code of Regulations Title 23 (CCR), Section (§) 350.4 (f).

1.2 Sustainability Goal

As mandated under 23 CCR § 354.24, GSAs within the Madera Subbasin have established a "sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline." Specifically, this sustainability goal establishes that the Madera Subbasin will be operated within its sustainable yield by 2040, or 20 years following GSP implementation in January 2020.

SGMA regulations define 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" (CWC § 10721(w)). Subbasin sustainable yield must therefore be determined in the context of the complete basin setting, which includes historical, current, and projected conditions regarding groundwater, surface water, and land use.

To achieve the sustainability goal, this Joint GSP details accounting of the Madera Subbasin used to identify sustainable yield, and establishes the criteria for GSAs to operate sustainably. Finally, planned monitoring networks, projects, and management actions are proposed to achieve and verify sustainable groundwater use. To facilitate review, Table 1-1 aligns the regulations with this Joint GSP's corresponding section.

Table 1-1. Sustainability Goal Development and Associated GSP Sections.

Sustainability Goal Development	23 CCR Section	Requirement	GSP Section
Context, basis for goal	§ 354.12	Basin Setting	2.2
	§ 354.14	Hydrogeologic Conceptual Model	2.2.1
	§ 354.16	Groundwater Conditions	2.2.2
	§ 354.18	Water Budget	2.2.3
	§ 354.20	Management Areas	2.2.4
Establishment of goal	§ 354.24	Sustainability Goal	3.1
	§ 354.26	Undesirable Results	3.4
	§ 354.28	Minimum Thresholds	3.3
	§ 354.30	Measurable Objectives	3.2
Measures of ensuring goal achievement	§ 354.32	Introduction to Monitoring Networks	3.5
	§ 354.34	Monitoring Network	3.5.1, 3.5.2
	§ 354.36	Representative Monitoring	3.5.3
	§ 354.38	Assessment and Improvement of Monitoring Network	3.5.4
	§ 354.44	Projects and Management Actions	4

1.3 Agency Information

Seven local agencies ~~have~~ formed GSAs covering the full extent of the ~~Madera~~ Subbasin as of initial GSP development: City of Madera (CM) GSA, Gravelly Ford Water District (GFWD) GSA, Madera County (MC) GSA, Madera Irrigation District (MID) GSA, Madera Water District (MWD) GSA, New Stone Water District (NSWD) GSA, and Root Creek Water District (RCWD) GSA. Figure 1-1 delineates the areas managed exclusively by each GSA. Since initial GSP development, several GSA boundaries have been updated and may not yet be captured in the tables and figures within this Plan Amendment. Updates to figures will occur during the second Periodic Evaluation of the GSP and/or annual reports as those updates are finalized.

Information on each GSA's organization and management structure, jurisdictional area, irrigated lands, and water supplies are described below and summarized in Table 1-2. Information provided by each GSA to DWR pursuant to CWC § 10723.8 is included in **Appendix 1**. Additional contact information for each GSA is provided in Table 1-3.

Table 1-2. Summary of Madera Subbasin Groundwater Sustainability Agencies.

GSA	GSA Abbreviation	GSA Area, Acres[1]	Average Irrigated Area (2015), Acres
City of Madera GSA	CM GSA	10,100	1,600
Gravelly Ford Water District GSA	GFWD GSA	8,400	7,500
County of Madera GSA – Madera Subbasin	MC GSA	177,800	84,900
Madera Irrigation District GSA	MID GSA	133,850	106,600
Madera Water District GSA	MWD GSA	3,700	3,400
New Stone Water District GSA	NSWD GSA	4,200	4,000
Root Creek Water District GSA	RCWD GSA	9,550	8,200
	Total	347,600	216,200

[1] The GSA boundaries have been updated since initial GSP submission and the boundaries contained in this version of the GSP do not include the most recent version of the boundaries. Updates will occur during the second ~~P~~periodic ~~E~~evaluation of the GSP and/or annual reports as those updates are finalized.

Table 1-3. Madera Subbasin Groundwater Sustainability Agencies' Contact Information.

Groundwater Sustainability Agency	Contact Person	Contact Title	Mailing Address	Phone Number	Email Address
City of Madera	Keith Helmuth	City Engineer, City of Madera	205 W. 4th St., Madera, CA 93637	(559) 661-5423	khelmuth@cityofmadera.com
Gravelly Ford Water District	Don Roberts	District General Manager	18811 Rd 27, Madera, CA 93638	(559) 474-1000	donroberts717@gmail.com
County of Madera – Madera Subbasin	Stephanie Anagnoson	Director of Water and Natural Resources, County of Madera	200 W. 4th St., Madera, CA 93637	(559) 598-0362	stephanie.anagnoson@ maderacounty.com
Madera Irrigation District	Thomas Greci	District General Manager	12152 Rd ¼1/4, Madera, CA 93637	(559) 673-3514	tgreci@madera-id.org
Madera Water District	Phil Janzen	Director	16943 Rd 26. Suite 103 Madera, CA 93637	(559) 479-0514	phil@agrilandfarming.com
New Stone Water District	Roger Skinner	District Representative	9500 S. De Wolf, Selma, CA 93662	(559) 834-6677	rskinner@lionraisins.com
Root Creek Water District	Julia Berry	General Manager	P.O. Box 27950 Fresno, CA 93729	(559) 970-8778	julia@rootcreekwd.com

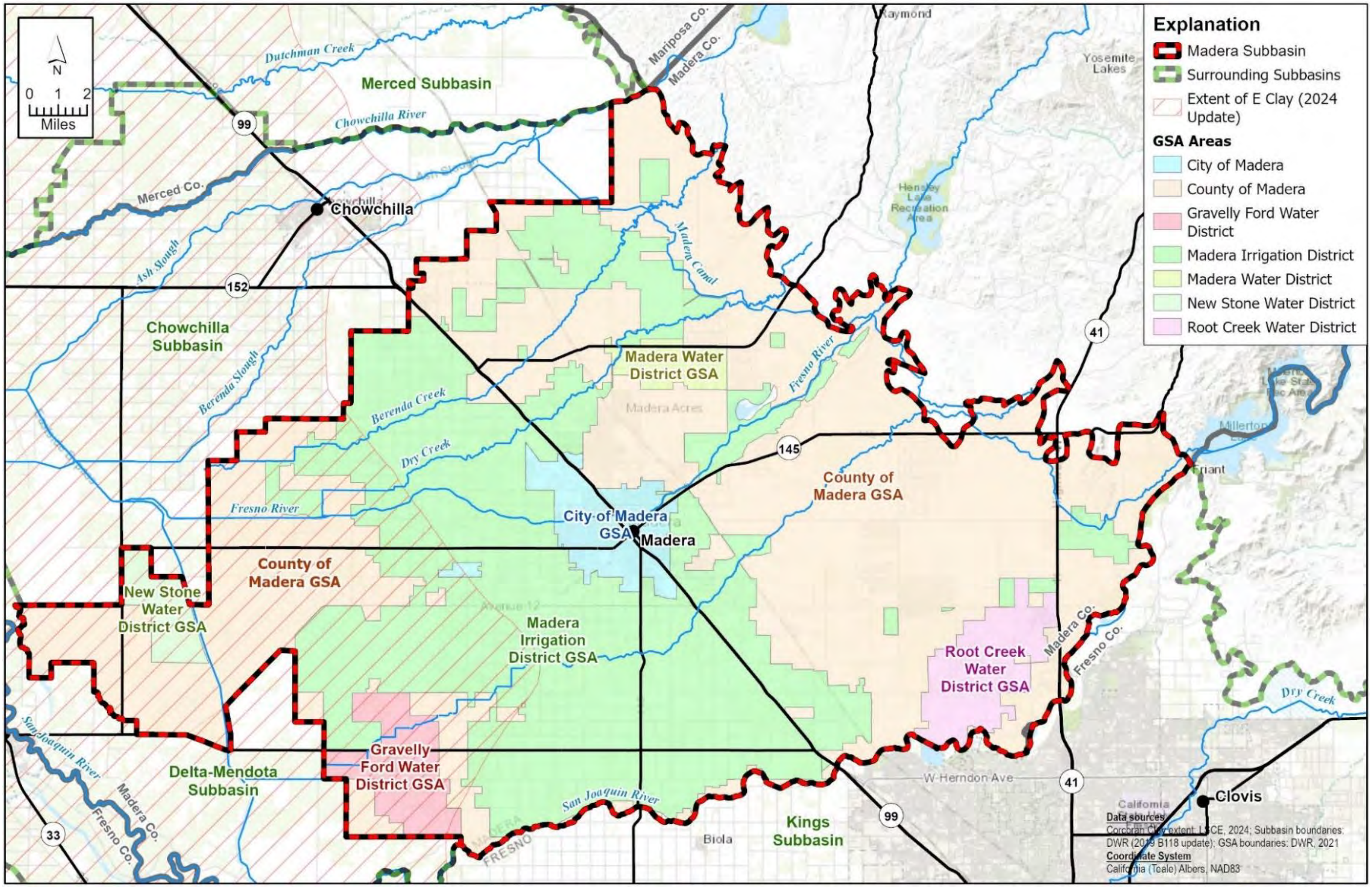


Figure 1-1. Madera Subbasin GSAs Map.[16]

[16] *The GSA boundaries have been updated since initial GSP submission and the boundaries shown in the figures contained in this version of the GSP do not include the most recent version of the boundaries. Updates to figures will occur during the second periodic evaluation~~update~~ of the GSP and/or annual reports. This statement applies to all figures contained in this GSP and appendices.*

1.3.1 Organization and Management Structure of the Groundwater Sustainability Agencies

A summary is provided in the sections below for each GSA detailing its formation date, management structure, and background regarding typical land use and water supply availability. As of April 2024, all GSAs have adopted their respective GSP and are implementing it consistent with SGMA.

1.3.1.1 City of Madera GSA

City of Madera (CM) GSA was formed on August 17, 2016, and manages approximately 10,100 acres of the ~~Madera~~ Subbasin (Figure 1-2). As of 2015, much of this area is developed land (79%), including urban, semi-agricultural, and industrial land. The remaining area is primarily agricultural land (16%), with some native vegetation (4%) and water surface (1%).

In 2015, irrigated agricultural land represented over 1,500 acres in CM GSA (Figure 1-3). Much of this area is used for cultivating grapes and almonds. The majority of irrigated agricultural lands in CM GSA are located within the boundaries of the ~~Madera Irrigation District (~~MID~~)~~ and have the ability to receive surface water in accordance with MID's normal operating practices. Some owners have utilized surface water from MID to meet a portion of their agricultural water needs, while others have chosen to rely solely on groundwater.

The Board of Directors for CM GSA is the Madera City Council. Joint meetings of the Madera City Council acting as the CM GSA Board of Directors are open to the public. ~~and~~ During initial GSP development, the ~~CM GSA Board of Directors~~meetings were ~~are~~ typically held on the first Wednesday of every month at 6:00 p.m. in the Council Chambers at Madera City Hall (205 West Fourth Street, Madera, CA 93637). During the 2025~~4~~ Plan Amendment, meetings were held on the first and third Wednesday of every month at 6:00 p.m. in the same location. The CM GSA has ~~As of April 2024, all GSAs that are a part of the joint GSA have~~ adopted the Joint GSP and ~~are~~is implementing it consistent with SGMA (see **Appendix 1.H**~~.~~ ~~Refer to Appendix 1 H. to see~~ for the GSP adoption resolution).

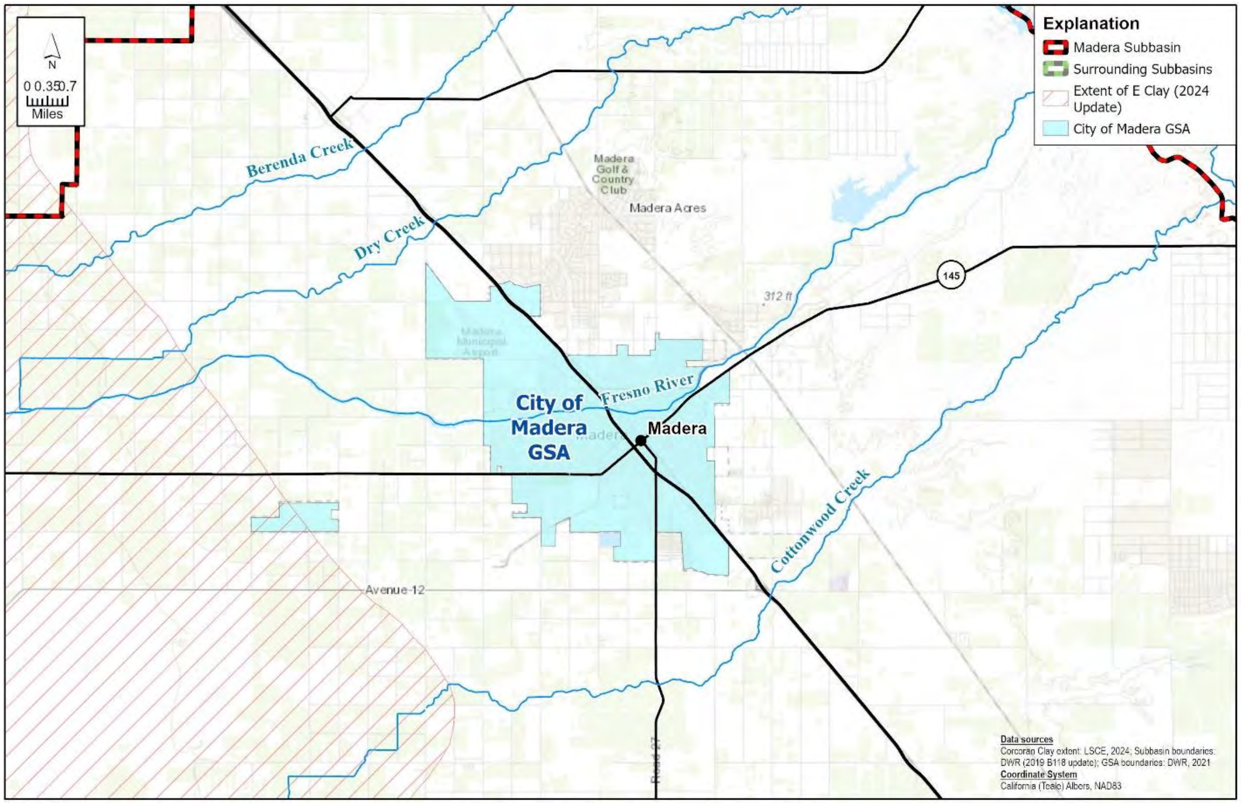


Figure 1-2. City of Madera GSA Map.

Figure 1-3. Orchard Crops in City of Madera GSA.

1.3.1.2 Gravelly Ford Water District GSA

Gravelly Ford Water District (GFWD) GSA was formed on June 8, 2016 and manages approximately 8,400 acres of the ~~Madera~~ Subbasin (Figure 1-4). As of 2015, this area is predominantly agricultural land (90%) and developed land (urban, semi-agricultural, or industrial land) (7%). A small portion of the GSA area is covered by native vegetation (2%) and water surface (1%).

In 2015, irrigated agricultural land represented approximately 7,500 acres in GFWD GSA. Much of this area is used for cultivating grapes, almonds, and pistachios. To support agriculture, GFWD GSA receives significant surface water supplies in the form of CVP water received from San Joaquin River (Figure 1-5) and from Madera Canal via MID~~adera Irrigation District~~. The remaining agricultural water demand is GFWD GSA is fulfilled by groundwater.

The Board of Directors for GFWD GSA is the GFWD Board of Directors. Since initial GSP development, ~~Meetings~~ meetings of the GFWD GSA Board of Directors ~~are~~ have been held concurrently with the GFWD Board of Directors meetings typically on the third Monday of each month at 1:30 p.m. These meetings are open to the public and are held at the Schafer Ranch office (25176 Avenue 5 ½, Madera, CA, 93637). The GFWD GSA has adopted their GSP and is implementing it consistent with SGMA (see GFWD GSP for adoption resolution).

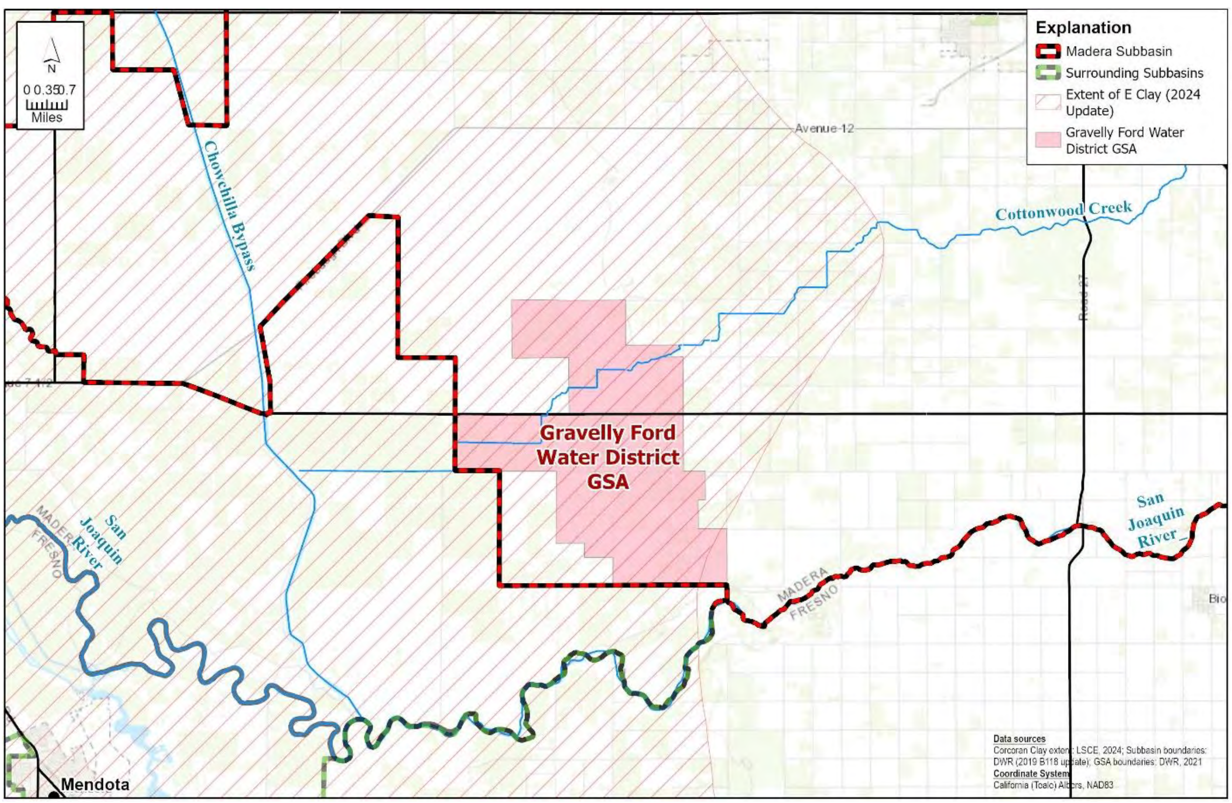


Figure 1-4. Gravelly Ford Water District GSA Map.

Figure 1-5. San Joaquin River Diversion to Gravelly Ford Water District GSA.

1.3.1.3 Madera County GSA

Madera County (MC) GSA was formed on January 27, 2017 and manages approximately 177,800 acres of the ~~Madera~~ Subbasin, representing the largest jurisdictional area within the Subbasin (Figure 1-6). As of 2015, the majority of this area is comprised of agricultural land (48%) or native vegetation (39%). The remaining area is primarily developed land (includes urban, semi-agricultural, and industrial land) (12%), though some water surface exists (1%).

In 2015, irrigated agricultural land represented over 82,000 acres in MC GSA. Much of this area is used for cultivating orchard crops (primarily almonds and pistachios) and grapes (Figure 1-7). Surface water supplies available for agriculture in MC GSA include riparian deliveries to water rights users along the San Joaquin River and the Fresno River, as well as a small volume of ~~Central Valley Project (~~CVP~~)~~ supply received under contract with the U.S. Bureau of Reclamation (Reclamation). Agricultural water demand in MC GSA is primarily fulfilled by groundwater.

The Board of Directors for MC ~~GIA~~ GSA is the Madera County Board of Supervisors. As the MC GSA Board of Directors, the Board of Supervisors typically meets ~~on the first or second Tuesday of each month~~ at the end of the regularly scheduled Board of Supervisors Meeting, which occur ~~-~~on the first three Tuesdays of each month. During initial GSP development, the GSA meetings were typically on the first or second Tuesday of each month; during the 20254 Plan Amendment development, the GSA meetings were typically on the first and third Tuesday of each month. These meetings are open to the public (200 West Fourth Street, Madera, CA, 93637) and are recorded and available for public viewing on the Madera County website (maderacounty.com). ~~Madera County~~MC GSA also has an Advisory Committee that meets bimonthly and provides feedback to the Board of Supervisors on SGMA-related matters. Members of the committee also serve as ambassadors in their communities regarding water issues. The MC GSA has adopted the Joint GSP and is implementing it consistent with SGMA (see **Appendix 1.H** for the GSP adoption resolution).

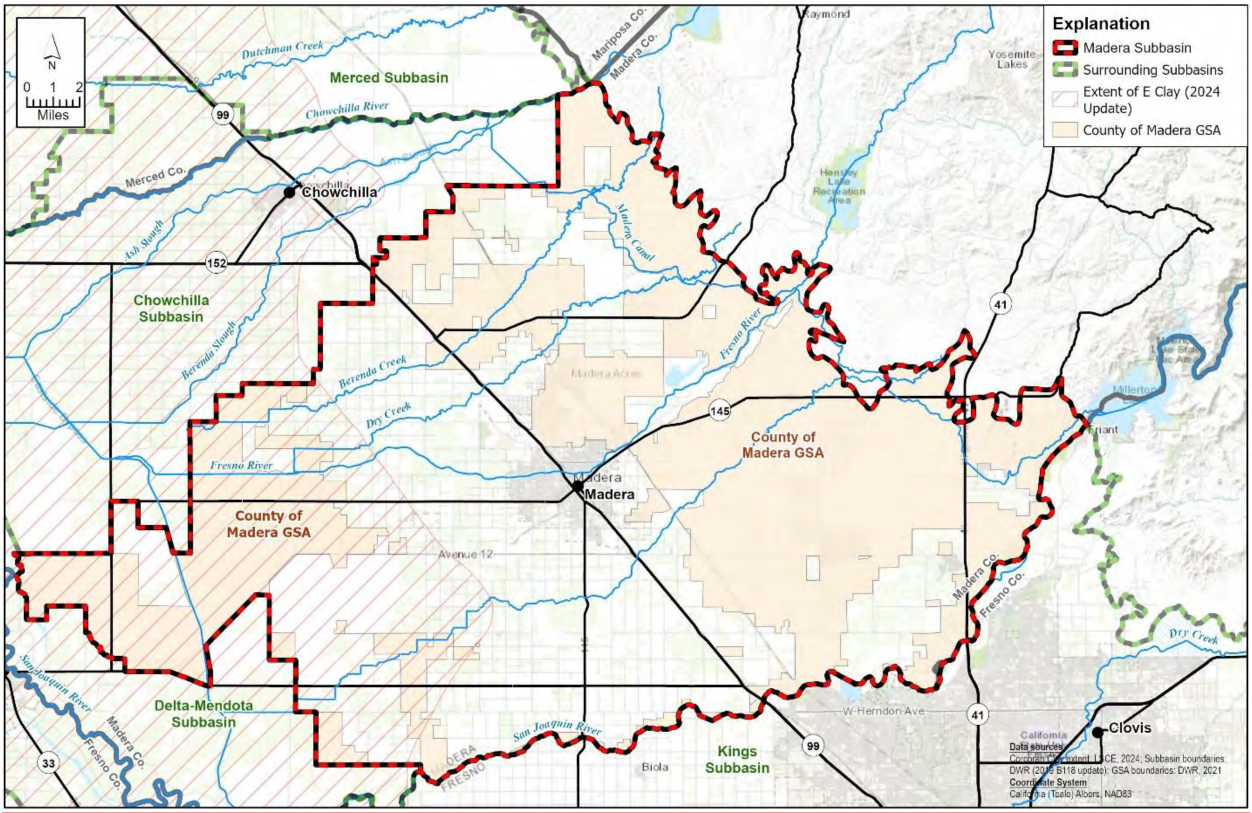


Figure 1-6. Madera County GSA Map.

Figure 1-7. Almond Orchard in the Madera Subbasin.

1.3.1.4 Madera Irrigation District GSA

Madera Irrigation District (MID) GSA was formed on March 31, 2016 and manages approximately 133,850 acres of the ~~Madera~~ Subbasin (Figure 1-8). As of 2015, the majority of this area is comprised of agricultural land (80%). Much of the remaining area consists of native vegetation (12%) or developed land (7%), including urban, semi-agricultural, and industrial land. A small portion of the GSA is also covered by water surfaces (1%).

In 2015, irrigated agricultural land represented over 106,600 acres in MID GSA. This area is used primarily for cultivating almonds, grapes, and pistachios. MID GSA receives substantial surface water supplies to support agriculture. These include CVP supplies received under contract with Reclamation from the Madera Canal and local supplies received from Hidden Dam releases along the Fresno River (Figure 1-9), along with the MID's Pre 1914 water rights. Remaining agricultural water demand in MID GSA is fulfilled by privately owned groundwater wells.

The Board of Directors for MID GSA is the MID Board of Directors. Since initial GSP development, ~~The~~ the MID GSA Board of Directors meetings ~~are~~ have been held concurrently with the regular MID Board of Directors meetings typically on the third Tuesday of every month at 1:00 or 2:00 p.m. These meetings are open to the public at the ~~Madera Irrigation District~~MID offices (12152 Road 28 1/4, Madera, CA, 93637). The MID GSA has adopted the Joint GSP and is implementing it consistent with SGMA (see **Appendix 1.H** for the GSP adoption resolution).

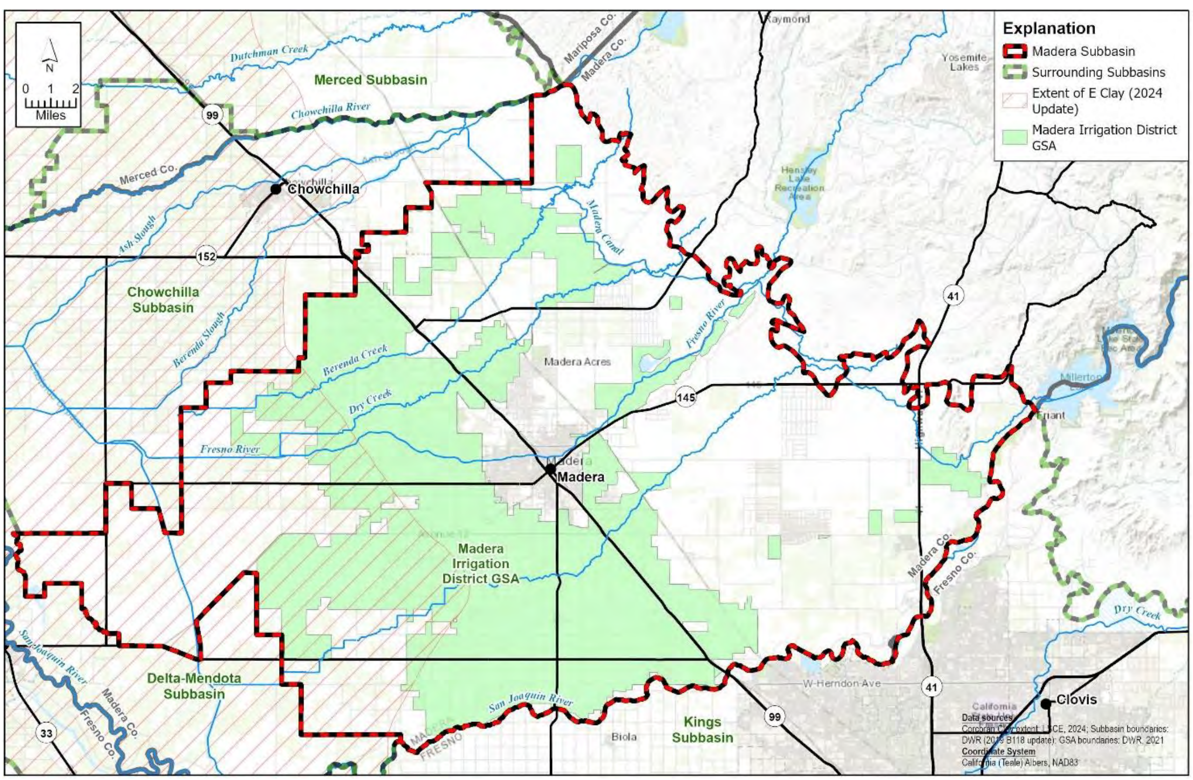


Figure 1-8. Madera Irrigation District GSA Map.

Figure 1-9. Franchi Diversion Dam along Fresno River in Madera Irrigation District GSA.

1.3.1.5 Madera Water District GSA

Madera Water District (MWD) GSA was formed on July 13, 2016 and manages approximately 3,700 acres of the Madera Subbasin (Figure 1-10). As of 2015, most of this area is comprised of agricultural land (91%) or developed land (urban, semi-agricultural, or industrial land) (8%). A small portion of the GSA is also covered by native vegetation (1%) and water surfaces (1%).

In 2015, irrigated agricultural land represented approximately 3,400 acres in MWD GSA. This area is used for cultivating pistachios. To support agriculture, MWD GSA receives surface water supplies from MID via Dry Creek (Figure 1-11). Remaining agricultural water demand in MWD GSA is fulfilled by groundwater.

The Board of Directors for MWD GSA is the MWD Board of Directors. Since initial GSP development, The the MWD GSA Board of Directors meetings are have been held concurrently with or directly following the regular MWD Board of Directors meetings typically on the second Wednesday of each month at 9:00 am. These meetings are open to the public and are held at either Madera Water DistrictMWD (16943 Road 26 Suite 103, Madera, CA, 93637) or at Blankenship & Company (1663 N. Schnoor Street, Suite 105, Madera, CA 93637). The MWD GSA has adopted the Joint GSP and is implementing it consistent with SGMA (see **Appendix 1.H** for the GSP adoption resolution).

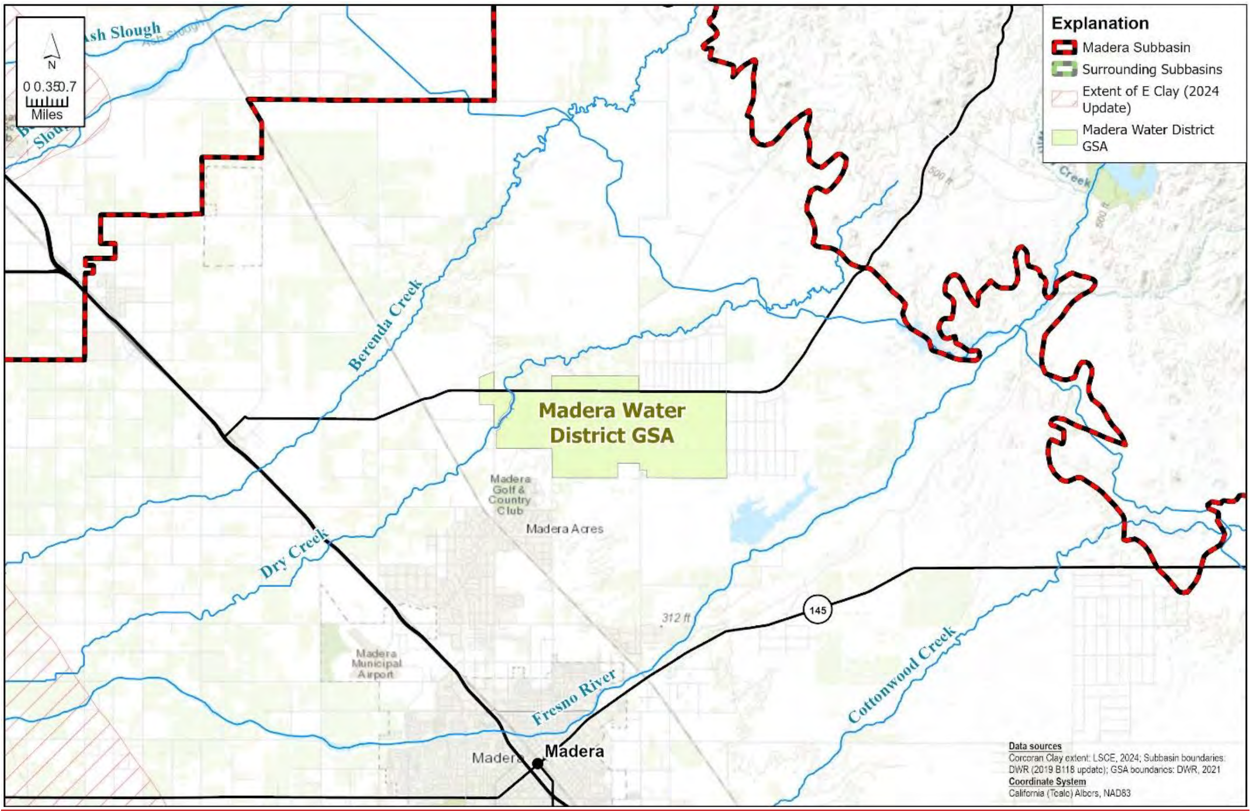


Figure 1-10. Madera Water District GSA Map.

Figure 1-11. Madera Water District Turnout Along Dry Creek.

1.3.1.6 New Stone Water District GSA

New Stone Water District (NSWD) GSA was formed on December 13, 2016 and manages approximately 4,200 acres of the ~~Madera~~ Subbasin (Figure 1-12). As of 2015, most of this area is comprised of agricultural land (94%) or native vegetation (4%). A small portion of the GSA is also comprised of developed land (urban, semi-agricultural, or industrial land) (1%) and water surfaces (1%).

In 2015, irrigated agricultural land represented approximately 3,900 acres in NSWD GSA. Much of this area is used for cultivating grapes (Figure 1-13). NSWD holds a water right permit to divert surface water from the Chowchilla Bypass during high-flow conditions and continues to work on necessary infrastructure to perfect the right, resulting in only nominal historic diversions. As a result, agriculture in NSWD GSA is primarily reliant on groundwater.

The Board of Directors for NSWD GSA is the NSWD Board of Directors. The NSWD GSA Board of Directors meetings are held concurrently with the NSWD Board of Directors meetings. Since initial GSP development, ~~These~~ these meetings are open to the public and ~~are~~ have typically been held quarterly in March, July, September, and December of each year. The NSWD GSA has adopted their GSP and is implementing it consistent with SGMA (see NSWD GSP for adoption resolution).

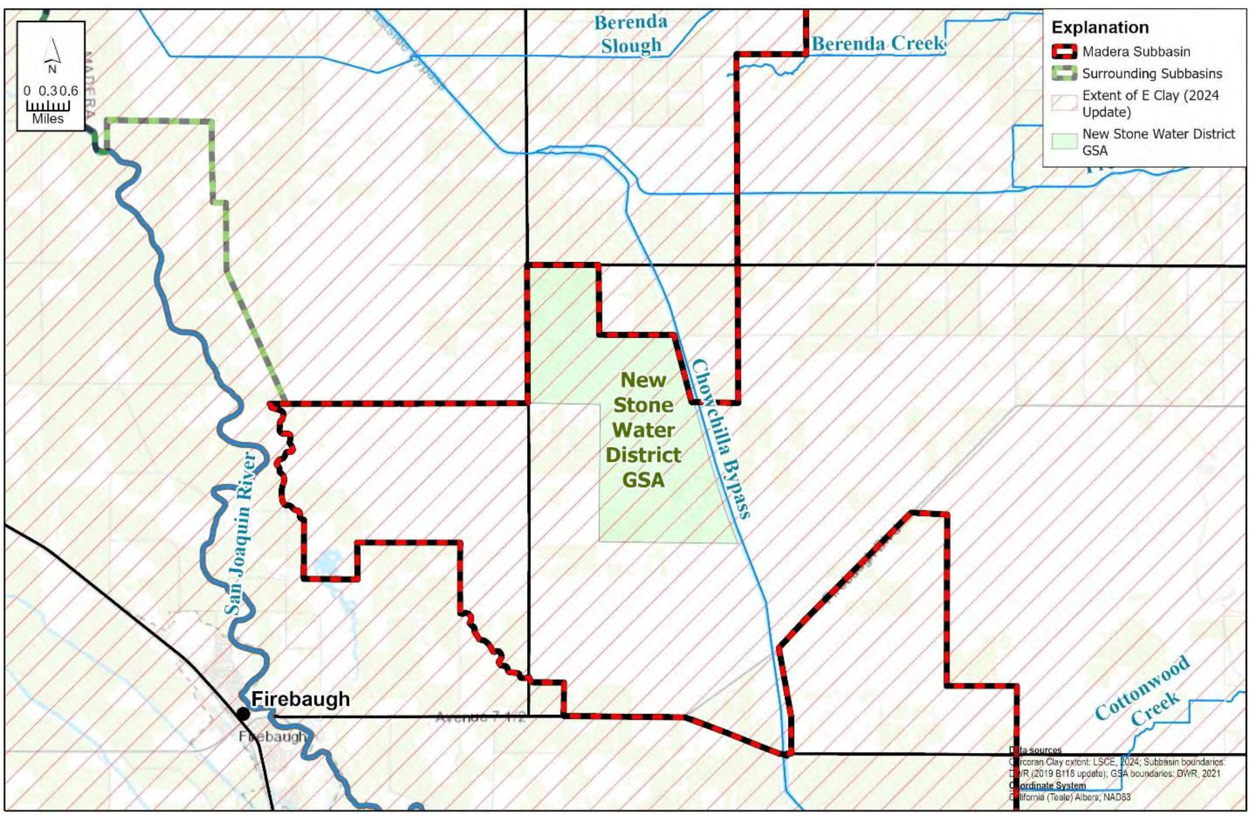


Figure 1-12. New Stone Water District GSA Map.

Figure 1-13. Viticulture in the Madera Subbasin.

1.3.1.7 Root Creek Water District GSA

Root Creek Water District (RCWD) GSA was formed on June 8, 2016 and covers approximately 9,300 acres of the ~~Madera~~ Subbasin (Figure 1-14). In 2018, annexations occurred increasing the size of the District to approximately 9,550 acres and the GSA boundaries reflect this change. Most of this area is comprised of agricultural land (89%) or native vegetation (8%). A small portion of the GSA is also covered by developed land (urban, semi-agricultural, or industrial land) (3%) and water surfaces (<1%), although the portion of developed land is increasing through several community development projects being constructed or planned within RCWD.

In 2015, irrigated agricultural land represented approximately 8,000 acres in RCWD GSA. This area is used for cultivating orchard, citrus, and subtropical crops (Figure 1-15). Agricultural water demand in RCWD GSA has historically been fulfilled by groundwater and supplemented with available surface water deliveries over roughly 5,400 irrigated agricultural acres. Prior to SGMA, surface water supplies available for agriculture in RCWD GSA consisted of riparian deliveries to individual water rights users, approximately 3,000 acres of holding contract lands along the San Joaquin River, and surface water supplies delivered to approximately 2,400 acres arising from water supply contracts with both public agencies and private suppliers.

The Board of Directors for RCWD GSA is the RCWD Board of Directors. Since initial GSP development, ~~The~~ the RCWD GSA Board of Directors meetings ~~are~~ have been held immediately following the regular RCWD Board of Directors meetings on the second Monday of each month at 11:00 a.m. These meetings are open to the public and are held at Riverstone Lodge (370 Lodge Road South, Madera, CA, 93636). The RCWD GSA has adopted their GSP and is implementing it consistent with SGMA (see RCWD GSP for adoption resolution).

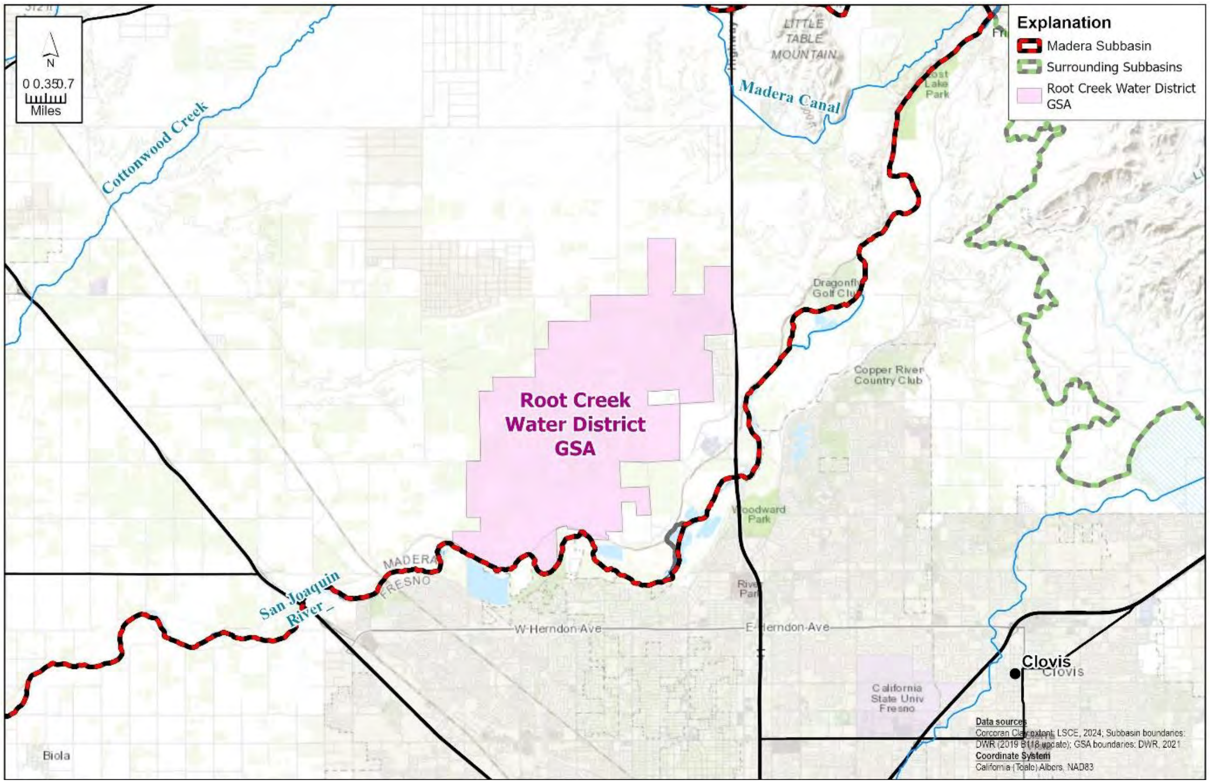


Figure 1-14. Root Creek Water District GSA Map.

Figure 1-15. Citrus Crops in the Madera Subbasin.

1.3.1.8 Madera Subbasin Coordination Committee

During initial GSP development, t~~T~~he ~~Madera~~ Subbasin GSAs ~~have~~ jointly formed the Madera Subbasin Coordination Committee (the "Committee"). The Committee was ~~developed~~ formed in early 2018 to serve as the coordinating body for guiding the ~~Madera~~ Subbasin GSAs through development of the ~~Madera~~ Subbasin GSP(s), as defined in the Committee charter. In this role, the Committee and Ad Hoc Work Groups advises the GSAs' governing bodies on GSP development, implementation, and public engagement consistent with each GSA's policies.

The Committee was chartered in February 2018 with six coordinating GSA member agencies: ~~City of Madera~~ CM GSA, ~~Gravelly Ford Water District~~GFWD GSA, ~~Madera County~~MC GSA, ~~Madera Irrigation District~~ MID GSA, ~~Madera Water District~~MWD GSA, and ~~Root Creek Water District~~RCWD GSA. At that time, ~~New Stone Water District~~NSWD GSA chose to prepare a separate individual GSP. In late 2018 and early 2019, ~~Gravelly Ford Water District~~GFWD GSA and ~~Root Creek Water District~~RCWD GSA, respectively, also chose to prepare separate individual GSPs.

Since the adoption of the initial 2020 GSPs and Coordination Agreement, the Subbasin GSAs have formed a Coordination Workgroup, consistent with Section 5.1 of the 2020 Coordination Agreement. The Coordination Workgroup is intended to provide a formal forum for the Subbasin GSAs to coordinate the GSPs for the Subbasin and satisfy the coordination obligation of SGMA. The Coordination Workgroup consists of GSA Representatives (one GSA Representative and one Alternate GSA Representative for each of the seven GSAs). At this time, the Coordination Workgroup serves as the coordinating body for all Subbasin GSAs (Table 1-4). Specific authorities of the Coordination Workgroup are defined in Section 5.3 of the Coordination Agreement.

The Coordination Workgroup has met on several occasions following submission of the initial 2020 GSPs to discuss:

1. 2023 Revised GSPs
2. Facilitation support services
3. 2025 GSP Plan Amendment and Periodic Evaluation
4. Domestic Well Mitigation Program
5. Other topics requiring coordination among the Subbasin GSAs

Each GSA's governing body members consider the Coordination Workgroup's recommendations when making policy decisions for their individual GSAs. In the event that any GSA governing body disagrees with the Coordination Workgroup's recommendations, that governing body is asked to provide explanation for its final decision to allow discussion and revisions to recommendations within the Coordination Workgroup or through the GSA Dispute Resolution process. Ultimately, GSA governing bodies have the authority to adopt and implement the GSP.

~~At this time, the Committee and Ad Hoc Work Groups coordinate GSP development for the four coordinating Joint GSP GSA member agencies (Table 1-4). An intra-basin coordination agreement will be formed between these four Joint GSP GSAs and the three individual GSAs to comply with SGMA requirements that multiple GSPs developed by multiple GSAs within the same groundwater subbasin be coordinated pursuant to a single coordination agreement (CWC § 10727 (b) (3)).~~

~~The Committee consists of two (2) representatives from each coordinating GSA, including one member capable and authorized as a spokesperson for the GSA governing body to facilitate coordination efforts and one member serving as a technical expert.~~

~~The aim of the Committee and Ad Hoc Work Groups, as defined by the Committee charter, is to provide a shared forum for the GSAs to review and discuss elements of GSP development. Specifically, the~~

Committee serves to identify elements of agreement or disagreement requiring more in-depth discussion among GSAs and makes recommendations for GSA governing bodies to consider in their decision-making process. In this process, the Committee aims to reach varying levels of consensus among the GSAs on all interim or final recommendations. Consensus is determined by Committee members' voiced approval that is consistent with what the Committee members feel can be approved by their GSA governing bodies.

Table 1-4. Summary of Madera Subbasin Groundwater Sustainability Plans and Coordination.

Groundwater Sustainability Agency	Coordinating Body	Groundwater Sustainability Plan Type
Madera County	Coordination Workgroup Madera Subbasin Coordination Committee	Joint GSP
Madera Irrigation District		
City of Madera		
Madera Water District		
Gravelly Ford Water District	N/A	Individual GSP
Root Creek Water District	N/A	Individual GSP
New Stone Water District	N/A	Individual GSP

The Committee is chartered to review or provide recommendations to the GSAs' governing bodies on the following topics:

- Development, adoption, or amendment of the GSP
- Sustainability goals and objectives
- Technical and reporting standards, including best management practices, data management and reporting
- Monitoring programs
- Annual work plans and reports (including mandatory five-year milestone reports)
- Modeling scenarios
- Inter-basin coordination activities
- PMAs to achieve sustainability
- Grant funding proposals
- Community outreach and engagement
- Local regulations to implement SGMA
- Fee proposals
- General Coordination in response to GSA inquiries

The Committee's discussions and recommendations are relayed to GSA governing bodies through (1) reports on the consensus (or other outcomes) of Committee discussions provided by the Committee Secretary, and (2) individual reports prepared by Committee members to confirm areas of agreement.

Each GSA's governing body members consider the Committee's recommendations when making policy decisions for their individual GSAs. In the event that any GSA governing body disagrees with the Committee's recommendations, that governing body is asked to provide explanation for its final decision to allow discussion and revisions to recommendations within the Committee or through the GSA Dispute Resolution process. Ultimately, GSA governing bodies have the authority to adopt and implement the GSP.

1.3.2 Legal Authority of the GSAs

The GSAs involved in development of this Joint GSP have the legal authority and are pursuing the financial resources necessary to implement the GSP.

Madera County, City of Madera, Madera Irrigation District, and Madera Water District are each local agencies[17] overlying the Madera Subbasin as defined under SGMA and are therefore eligible to serve as separate GSAs within the Madera Subbasin (CWC § 10723(a)). Pursuant to CWC § 10724(a), Madera County serves as the GSA for all areas within the Madera Subbasin outside the management area of other GSAs.

The election to establish each GSA was made through meetings of the Madera Subbasin GSA Formation Committee. This committee was formed to assemble all local agencies and related parties responsible for managing groundwater resources in the Madera Subbasin, meeting quarterly between early 2015 and 2017. Voluntary participants in this committee included: Aliso Water District, City of Madera, Gravelly Ford Water District, Madera Irrigation District, Madera County, Madera Water District, New Stone Water District, and Root Creek Water District.

City of Madera, Madera County, Madera Irrigation District, and Madera Water District each elected to become a GSA pursuant to CWC § 10723.8(a) and SGMA for the portions of the Madera Subbasin identified in **Appendix 1**.

Each agency held public hearings regarding the establishment of a GSA in accordance with CWC § 10723(b). Public notice for these hearings was provided in accordance with Government Code § 6066. After holding these hearings, the governing bodies of each agency adopted resolutions to establish the associated GSAs. No new bylaws or ordinances were adopted by the GSAs in conjunction with these actions.

Pursuant to CWC § 10723.2, the aforementioned GSAs "shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans."

1.3.3 Coordination Among the GSAs

For purposes of the 2025 Plan Amendment, it is assumed that the facilitation and related services associated with the Program as set-forth above will result in complete development of the Program such that implementation can begin in 2025 as set-forth and agreed upon in the MOU.

Since original GSA formation, subsequent GSP development, completion of the March 2023 Revised GSP, and now through GSP implementation and the Plan Amendment and Periodic Evaluation process, the GSAs in the Subbasin have committed to continued coordination in an effort to eliminate areas of disagreement. Despite multiple GSPs in the Subbasin, the GSAs have worked continuously over the last several years to seek consensus, striving to bring consistency across the four GSPs where possible and eliminating contradictory policies, procedures, and methodologies. Specific areas of coordination between the GSAs are described below.

[17] CWC § 10721(n): "Local agency" means a local public agency that has water supply, water management, or land use responsibilities within a groundwater basin.

MCSim Groundwater Model

As detailed in Section 2.2.1 of the 2025 Plan Amendment, significant updates have been made to the MCSim Model for the Madera and Chowchilla Subbasins. Importantly, and aside from the technical updates, the MCSim Model continues to be supported broadly by the GSAs in the Subbasin and serves as a uniform and consistent basis for development of GSA water budgets, future subsidence estimates, and establishment of SMC. Refinements to the MCSim Model as detailed herein were reviewed and discussed in great detail during development of the 2023 Revised GSPs and 2025 Plan Amendment and Periodic Evaluation Processes and have streamlined the GSAs' responses to many of the corrective actions identified by DWR in their December 21, 2023 GSP approval letter. Moving forward the MCSim Model will be updated on a five-year interval and diligently used by the GSAs in the Subbasin as a predictive tool to aid in siting of planned and proposed PMAs and evaluation of the benefit of implemented PMAs, in addition to broader management of the Subbasin.

Domestic Well Mitigation Program

The Subbasin GSAs have also continued to coordinate on the domestic well mitigation program plan and implementation which is discussed in Section 4.9.5. To date, the MC GSA has been awarded $125,000 grant from DWR to assist with Senate Bill 552 (SB 552) compliance. The grant has two main components:; (1) installation of a new monitoring well in the Ranchos and (2) facilitation and related services, in connection with the Domestic Well Mitigation Program (Program). This grant is supporting implementation of the Subbasin Program (**Appendix 4.B**). Related to component 2, the MC GSA has contracted with David M. Ceppos to provide neutral, stakeholder engagement and consultation support to the MC GSA regarding implementation of a Program in the Subbasin with a specific focus on developing rules of said Program. Specific tasks include the following:.

1. Conduct Background Review
2. Conduct Engagement Strategy Discussions
3. Conduct Stakeholder Interviews
4. Design and Conduct Program Public Meetings
5. Project Management

Following development of the MOU Establishing a Domestic Well Mitigation Program for the Subbasin of the San Joaquin Valley Groundwater Basin and execution by 5 of the 7 GSAs within the Subbasin, this is a critical and necessary step in advancing a well-functioning and Subbasin-wide Program. For purposes of the 2025 Plan Amendment, it is assumed that the facilitation and related services associated with the Program as set-forth above will result in complete development of the Program such that implementation can begin in 2025 as set-forth and agreed upon in the MOU.

GSA Technical Meetings

Since development of the 2023 Revised GSPs and serving at the direction of each GSA, the technical teams for each GSA (or group of GSAs in the case of the Joint GSP) have continued meeting on a regular basis. As part of the 2025 Plan Amendment, the technical teams for each GSA have met on a bi-weekly or weekly basis to discuss methodologies and preferred technical approaches for addressing DWR's identified deficiencies. To date, the GSA technical teams have met approximately 12 times to coordinate on 2025 Plan Amendments. Meeting agendas are developed collaboratively and as reflected in each of the four Plan Amendments, these technical team meetings have served as the basis for reaching consensus and ensuring consistent policies, procedures, and methodologies and ultimately, consistent groundwater management across the Subbasin.

~~1.3.3~~1.3.4 Estimated Cost of GSP Implementation

Please note that costs have not been updated since initial GSP development and costs represent 2019 dollar values.

The estimated annual costs of GSP implementation for the four Joint GSP GSAs included under this GSP are shown in Figure 1-16 (in ~~current~~ 2019 dollars). Additional detail is provided in Chapter 5. Also illustrated are the estimated annual operations and maintenance (O&M) costs (in current dollars) for the GSP PMAs to be implemented by the four Joint GSP GSAs together developing this GSP that are described in more detail in Chapter 4. This figure does not include the cost that the ~~Madera County~~MC GSA demand management program would impose on growers and the County economy. Average annual operating costs for projects increase from $0.5 million per year in 2020 to over $14 million per year by 2040. Project costs will be refined by GSAs as the GSP is implemented. GSA implementation costs total about $3 million per year.

Individually, the GSAs manage their own financing, staffing, contracting, and daily operations related to GSP implementation. The approach to meeting the GSP implementation costs varies between GSAs.

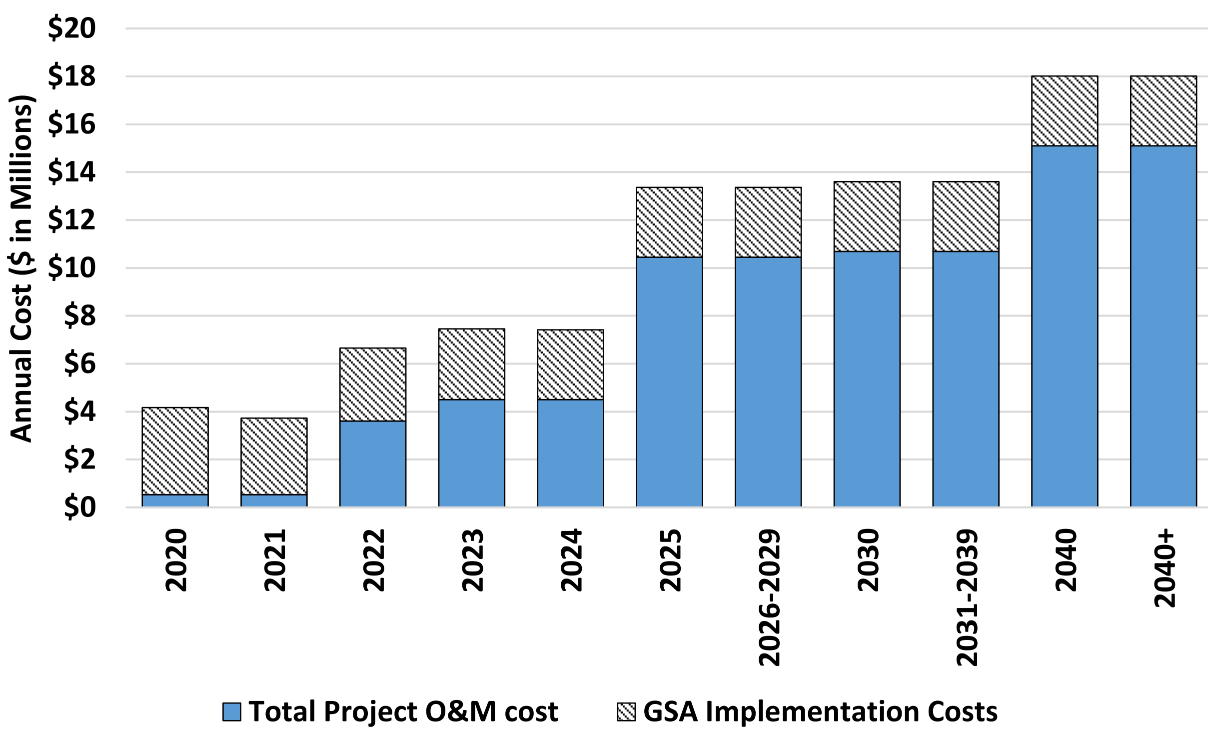


Figure 1-16. Madera Subbasin Estimated Annual Costs (in 2019 dollars) for Project O&M and GSA Implementation

Table 1-5 provides a summary of the estimated capital costs (in current dollars) and the average annual gross recharge benefit anticipated at full implementation of each GSA's PMAs. In total, GSP PMAs are estimated to provide a gross average annual benefit of about 216,000 AF to Subbasin recharge[18] from all seven GSAs with an estimated average annual operating cost of $69,550,000 for the four Joint GSP GSAs together developing this GSP (see the GSPs developed by GFWD, NSWD and RCWD for operation costs of their projects). Annual operating costs include the direct cost of demand management (crop revenue loss from fallowing) but do not include additional indirect, or "multiplier," effects on the Madera County economy. The total capital cost of all PMAs implemented by the four Joint GSP GSAs together developing this GSP is around $260 million dollars. All costs are preliminary estimates that will be refined by the GSAs. Additional information is provided in Chapter 4.

Table 1-5. Summary of Madera Subbasin Groundwater Sustainability Plan Implementation Costs (2019 Dollars, Estimated As of January 2020).

GSA	Average Annual Gross Benefit at Full Implementation (AFY)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
MWD	2,810	14.90	0.90
MID	47,430	18.56	10.33
City of Madera	3,370	11.02	0.00
Madera County	139,850	218.10	58.32[1]
GFWD	2,620	*See GFWD GSP*	
NSWD	5,540	*See NSWD GSP*	
RCWD	14,220	*See RCWD GSP*	
Total	215,840	262.58	69.5

[1]Costs of demand management include reduced economic activities in the county, this includes approximately $53.9 million per year in direct economic impacts alone (excluding multiplier effects).

[2] This represents the planned PMAs and anticipated costs of GSP implementation at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.

[18] The gross yield is larger than the projected shortfall due primarily to changes in other water budget elements when flood flows are directed to recharge.

1.4 GSP Organization

The initialis Joint GSP whas been developed by the consulting team on behalf of City of MaderaCM GSA, Madera CountyMC GSA, Madera Irrigation DistrictMID GSA, and Madera Water DistrictMWD GSA. The original Joint GSP consulting team wais comprised of Davids Engineering (DE), Luhdorff & Scalmanini Consulting Engineers (LSCE), ERA Economics, LLC (ERA), Stillwater Sciences (SS), and the Consensus and Collaboration Program at California State University, Sacramento (CSUS or CCP). The Joint GSP Revisions in March 2023 and Plan Amendment in January 2025 were completed by a consulting team comprised of DE and LSCE.

The GSP is organized in accordance with 23 CCR § 354 as follows:

- Section 1 of this GSP provides an introduction to the Madera Subbasin GSAs and the development of this Joint GSP.
- Section 2 provides a detailed summary of the GSP Plan Area and development of the basin setting, including the hydrogeologic conceptual model, current and historical groundwater conditions, water budgets, and management areas (as applicable).
- Section 3 establishes the Subbasin sustainability goal to be achieved through coordination among all GSAs in the Subbasin. This section also establishes measurable objectives (MOs), minimum thresholds (MTs), and undesirable results for each sustainability indicator, followed by a description of the proposed monitoring network to track and verify progress toward the Subbasin sustainability goal.
- Section 4, PMAs are proposed for achieving the Subbasin sustainability goal.
- Section 5, proposes the GSP implementation strategy, costs, and schedule.

To facilitate DWR review and assure compliance with all applicable GSP regulations, Table 1-6 was prepared to cross-reference between sections of this Joint GSP to applicable sections and the GSP regulations. Terminology in this Joint GSP has also been used in alignment with the SGMA definitions provided in CWC § 10721 and in 23 CCR § 351. These definitions are provided as **Appendix 1.I**.

Table 1-6. Cross Reference of GSP Regulations[19] and Associated GSP Sections.

Subarticle	Section	Paragraph	Requirement	GSP Section
1. Administrative Information	4. General Information	(a)	Executive summary	Executive Summary
		(b)	List of references and technical studies	6
	6. Agency Information	-	Agency information pursuant to CWC § 10723.8, along with:	App. 1
		(a)	Agency name and mailing address	1.3
		(b)	Agency organization and management structure, persons with management authority for Plan implementation	1.3.1
		(c)	Plan manager name and contact information	1.3
		(d)	Legal authority of agency	1.3.2
		(e)	Estimate of Plan implementation costs and description of how Agency plans to meet costs	1.3.3, 5.1
	8. Description of Plan Area	(a)	Maps of Plan area	2.1.1
		(b)	Written description of Plan area	2.1.1
		(c)-(d)	Identification of existing water resource monitoring and management programs, and description of any such planned programs	2.1.2
		(e)	Description of conjunctive use programs	2.1.2
		(f)	Description of the land use elements or topic categories	2.1.3
		(g)	Description of additional Plan elements (CWC § 10727.4)	2.1.4
	10. Notice and Communication	(a)	Description of the beneficial uses and users of groundwater in the subbasin	2.1.5
		(b)	List of public meetings	2.1.5
		(c)	Comments and responses regarding the Plan	2.1.5
		(d)	Description of communication procedures	2.1.5
2. Basin Setting	12. Introduction to Basin Setting	-	Information about the basin setting (physical setting, characteristics, current conditions, data gaps, uncertainty)	2.2
	14. Hydrogeologic Conceptual Model	(a)	Description of the subbasin hydrogeologic conceptual model	2.2.1
		(b)	Summary of regional geologic and structural setting, subbasin boundaries, geologic features, principal aquifers and aquitards	2.2.1
		(c)	Cross-sections depicting major stratigraphic and structural features	2.2.1
		(d)	Maps of subbasin physical characteristics	2.2.1

[19] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents

Subarticle	Section	Paragraph	Requirement	GSP Section
	16. Groundwater Conditions	(a)-(g)	Description of current and historical groundwater conditions including: 1. Groundwater elevation 2. Change in storage 3. Seawater intrusion 4. Groundwater quality issues 5. Land subsidence 6. Interconnected surface water systems 7. Groundwater dependent ecosystems	2.2.2
	17. Water Budget	(a)	Water budget providing total annual volume of groundwater and surface water entering and leaving the subbasin, including historical, current and projected water budget conditions, and change in storage.	2.2.3
		(b)-(f)	Development of a numerical groundwater and surface water model to quantify current, historical, and projected: 1. Total surface water entering and leaving by water source type 2. Inflow to the groundwater system by water source type 3. Outflows from the groundwater system by water use sector 4. Change in groundwater storage 5. Overdraft over base period 6. Annual supply, demand, and change in storage by water year type. 7. Estimated sustainable yield	2.2.3
	20. Management Areas	(a)	Description of management areas	2.2.4
		(b)	Describe purpose, minimum thresholds, measurable objectives, monitoring, analysis	2.2.4
		(c)	Maps and supplemental information	2.2.4
3. Sustainable Management Criteria	22. Introduction to Sustainable Management Criteria	-	Criteria by which an Agency defines conditions that constitute sustainable groundwater management for the subbasin	3
	24. Sustainability Goal	-	Description of subbasin sustainability goal, including basin setting information used to establish the goal, sustainability indicators, discussion of measures to ensure the subbasin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved and maintained.	3.1
	26. Undesirable Results	(a)	Processes and criteria used to define undesirable results applicable to the subbasin.	3.4
		(b)-(c)	Description of undesirable results, including cause of groundwater conditions and potential effects on beneficial uses and users of groundwater.	3.4

Subarticle	Section	Paragraph	Requirement	GSP Section
	28. Minimum Thresholds	(a)	Establish minimum thresholds to quantify groundwater conditions for each applicable sustainability indicator.	3.3
		(b)-(d)	Describe information and criteria to select, establish, justify, and quantitatively measure minimum thresholds.	3.3
	30. Measurable Objectives	(a)-(g)	Establish measurable objectives, including interim milestones in increments of five years, to achieve and maintain the subbasin sustainability goal.	3.2
4. Monitoring Networks	32. Introduction to Monitoring Networks	-	Description of monitoring network, monitoring objectives, monitoring protocols, and data reporting.	3.5
	34. Monitoring Network	(I (e)-(g)	Development of monitoring network to yield representative information about groundwater conditions.	3.5.1
		(b)-(d)	Monitoring network objectives.	3.5.1
		(h)	Maps and tables of monitoring sites.	3.5.1
		(i)	Monitoring protocols.	3.5.2
	36. Representative Monitoring	(a)-(c)	Designation of representative monitoring sites.	3.5.3
	38. Assessment and Improvement of Monitoring Network	(a)-(d)	Evaluation of monitoring network, including uncertainty, data gaps, and efforts to fill data gaps	3.5.4
		(e)	Adjustment of monitoring frequency and density to assess management action effectiveness	3.5.4
	40. Reporting Monitoring Data to the Department	(f)	Copy of monitoring data from data management system	
5. Projects and Management Actions	44. Projects and Management Actions	(a)-(c)	Description of projects and management actions to achieve and maintain the subbasin sustainability goal.	4

2 PLAN AREA AND BASIN SETTING

2.1 Description of the Plan Area (23 CCR § 354.8)

The GSP Plan Area (Plan Area) is defined as the ~~Madera~~ Subbasin (5-22.06), part of the San Joaquin Valley Groundwater Basin, as described in DWR Bulletin 118 (DWR, 2016) with boundary updates approved in early 2019.

The lateral extent of the Subbasin is defined by the Subbasin boundaries provided in Bulletin 118 (DWR, 2016). The Subbasin is bounded in the south by the San Joaquin River and the Kings Subbasin, in the west by the Delta-Mendota Subbasin, in the north by the Chowchilla Subbasin, and in the east by the foothills of the Sierra Nevada (Figure 2-1).

The vertical boundaries of the Subbasin are the land surface (upper boundary) and the definable bottom of the basin (lower boundary). The definable bottom was established as part of development of the preliminary hydrogeologic conceptual model (HCM) during previous data collection and analysis efforts conducted by DE and LSCE (2017). The vertical extent of the Subbasin is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone[20], within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

2.1.1 Summary of Jurisdictional Areas and Other Features (23 CCR § 354.8(b))

As identified in Section 1.3, the ~~Madera~~ Subbasin is divided among seven GSAs for GSP development. Table 1-2 and Figure 1-1 delineate the areas managed exclusively by each GSA in this Joint GSP (CM, MC, MID, MWD), the areas managed by other GSAs in the ~~Madera~~ Subbasin (GFWD, NSWD, RCWD), and subbasins adjacent to the Plan Area. No area in the Subbasin is covered by an alternative. The entire Subbasin lies within the jurisdictional boundaries of Madera County. The area covered by the City of Madera General Plan is contained within the CM GSA boundaries.[21] The ~~Madera~~ Subbasin is not adjudicated and contains no considerable state land or federal land.[22]

[20] The depth to the bottom of the root zone varies by crop, but typically ranges from 2-7 feet (ASCE, 2016).

[21] City of Madera General Plan, October 7, 2009.

[22] Federal land includes primarily rights of way along canals conveying USBR Central Valley Project water. State land includes primarily California Department of Parks and Recreation land along San Joaquin River near Friant, California.

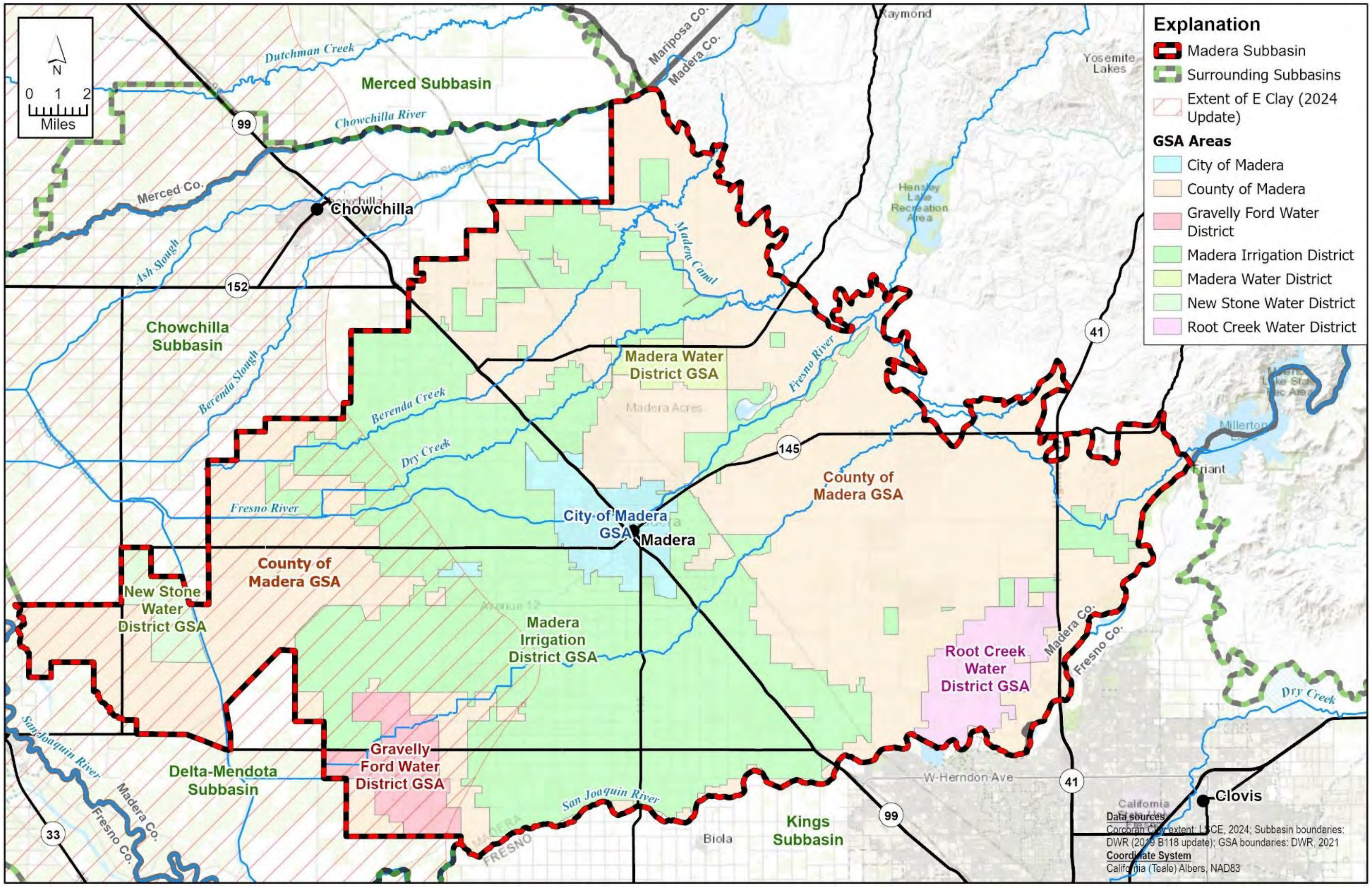


Figure 2-1. Madera Subbasin GSAs Map.

2.1.1.1 Land Uses

Land use areas in the ~~Madera~~ Subbasin are broadly classified across three sectors: agricultural, urban, and native vegetation. Agricultural land use (and water use) encompasses all agricultural crops reported in the ~~Madera~~ Subbasin, including idle agricultural land and dairies. Urban land use includes urban, industrial, and semi-agricultural land.

Figure 2-2 depicts land use in the ~~Madera~~ Subbasin as reported in the 2011 DWR Madera County Land Use spatial coverage[23]. Annual land use areas within the ~~Madera~~ Subbasin were derived from DWR spatial land use surveys of Madera County, Land IQ remotely sensed land use data obtained through DWR, and Madera County Agricultural Commissioner annual crop production area reports. Additional detail for the process used to develop an annual land use database for Madera County is provided in **Appendix 2.A.**

Annual land use within each of the four sectors are summarized in Figure 2-3 and Table 2-1 for the ~~Madera~~ Subbasin between 1989-2015. Agricultural land use categories are further detailed in Figure 2-4 and Table 2-2. Average land use across each sector and category is provided for the 1989-2014 historical water budget period, which is described below in Section 2.2.3. Land use summaries are provided for each GSA in **Appendix 2.F.**

[23] The 2011 DWR Madera County Land Use Survey is the most recent parcel-based land use data available at the time of GSP development. Field-based data is also available in 2014 from Land IQ, LLC. The DWR Land Use interpolation tool was used to estimate spatial land use data in years without parcel-based or field-based data, including 2015.

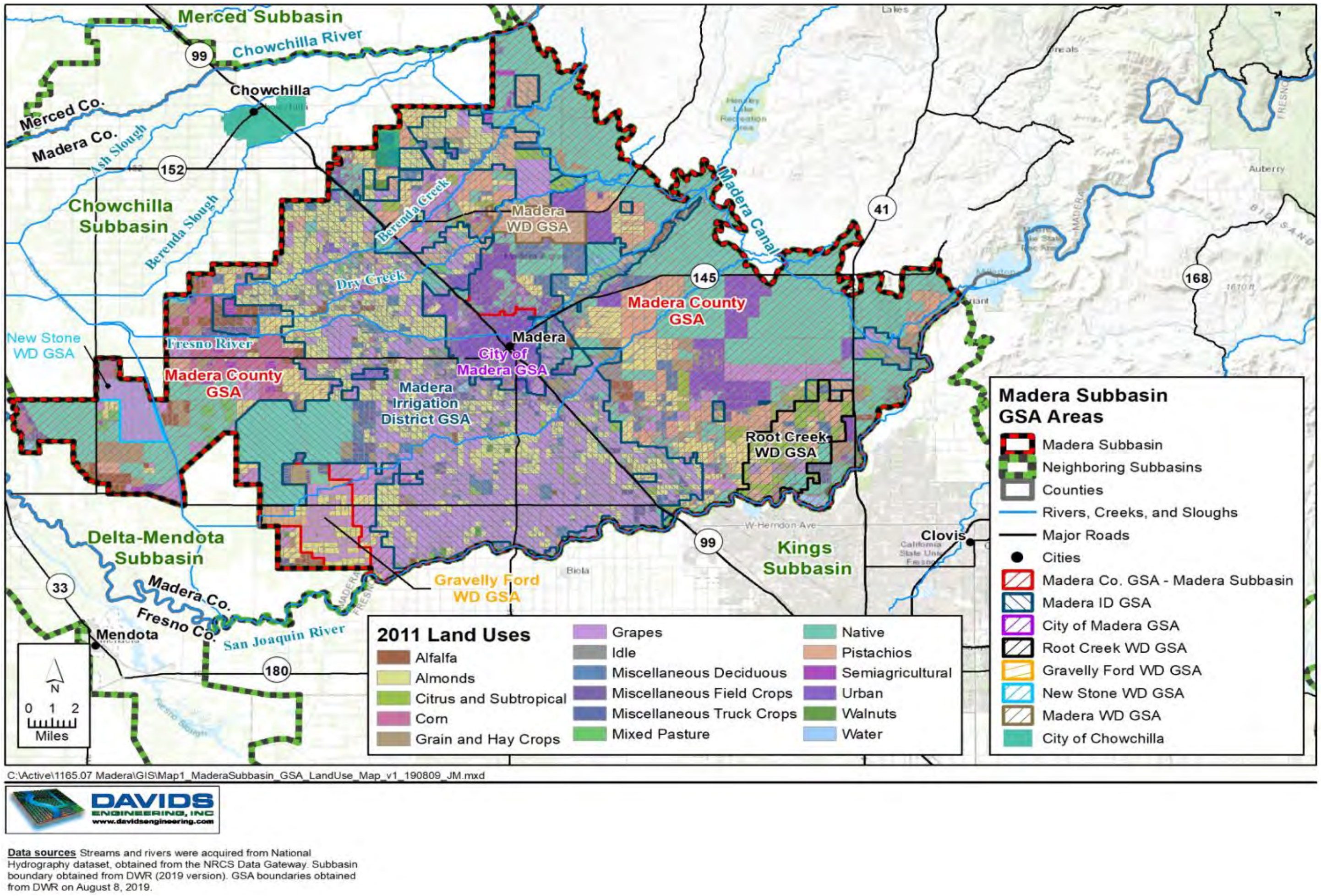


Figure 2-2. Madera Subbasin 2011 Land Use Map.[24]

[24] 2011 Land Uses extracted from the 2011 DWR spatial land use survey results.
Water Use Sectors: Native Vegetation (Native and Water land uses), Urban (Semi-agricultural and Urban land uses), and Agricultural (all other land uses).
Water Source Type: Much of the agricultural land in the Madera Subbasin has access to use of both surface water and ground water. Madera ID GSA, City of Madera GSA, Gravelly Ford WD GSA, Madera WD GSA, and localized areas in Madera County GSA have access to CVP and local surface water supplies. Root Creek WD GSA has access to local surface water supplies, and New Stone WD GSA has used nominal historic diversions of local surface water supplies. The remaining agricultural and urban water use demand is met through groundwater. The mixture of groundwater and surface water sources depends on the GSA (see **Appendices 2.F.a.** through **2.F.g**).

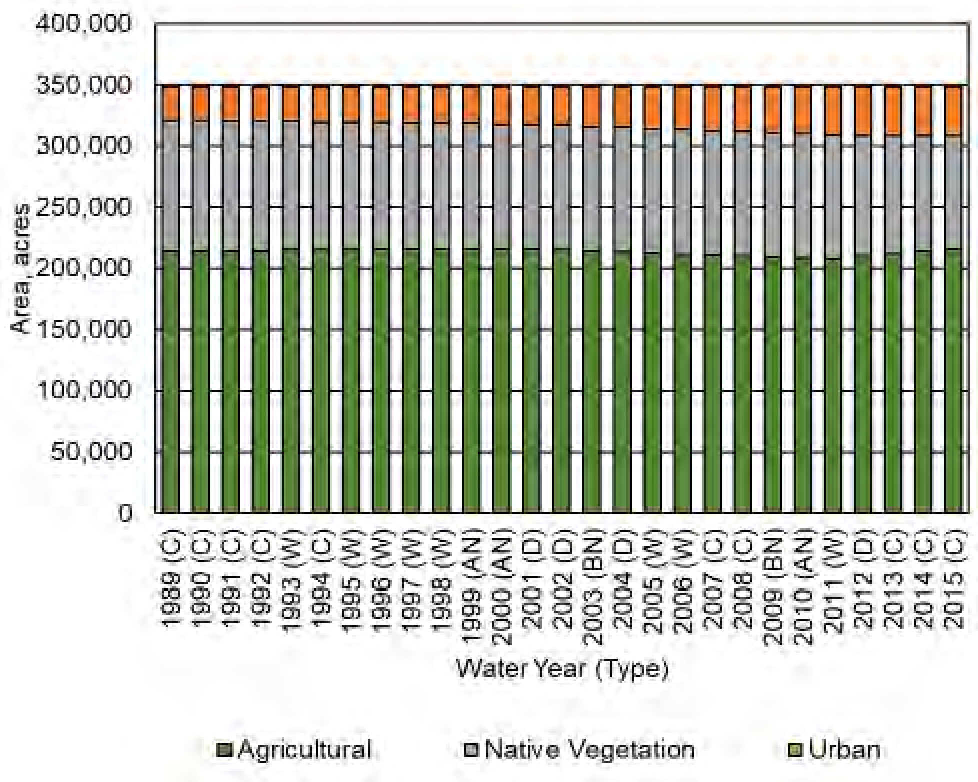


Figure 2-3. Madera Subbasin Land Use Areas.

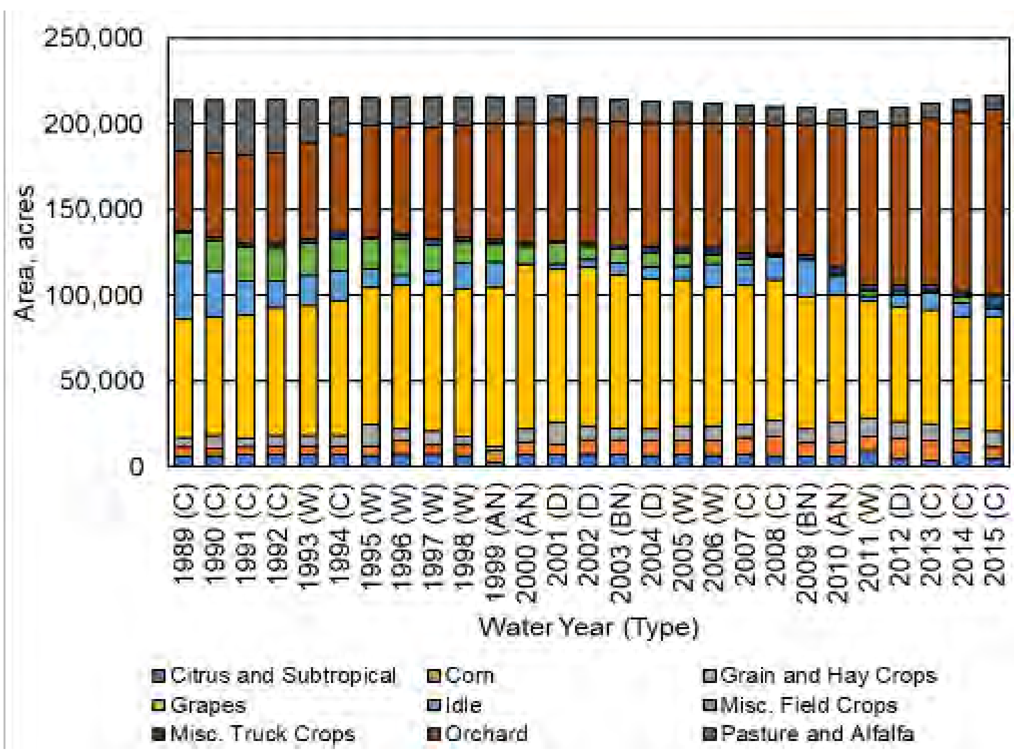


Figure 2-4. Madera Subbasin Agricultural Land Use Areas.

Table 2-1. Madera Subbasin Land Use Areas (Acres).

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	213,924	106,906	26,742	347,572
1990 (C)	214,083	106,463	27,026	347,572
1991 (C)	214,196	106,078	27,298	347,572
1992 (C)	214,554	105,455	27,564	347,572
1993 (W)	214,757	104,987	27,828	347,572
1994 (C)	215,092	104,383	28,097	347,572
1995 (W)	215,385	103,823	28,364	347,572
1996 (W)	215,515	103,410	28,647	347,572
1997 (W)	215,649	102,993	28,930	347,572
1998 (W)	215,779	102,580	29,213	347,572
1999 (AN)	215,912	102,165	29,495	347,572
2000 (AN)	216,043	101,751	29,778	347,572
2001 (D)	216,177	101,334	30,061	347,572
2002 (D)	215,327	101,305	30,940	347,572
2003 (BN)	214,476	101,276	31,820	347,572
2004 (D)	213,626	101,247	32,699	347,572
2005 (W)	212,773	101,218	33,581	347,572
2006 (W)	211,922	101,189	34,461	347,572
2007 (C)	211,072	101,160	35,341	347,572
2008 (C)	210,222	101,130	36,220	347,572
2009 (BN)	209,369	101,101	37,101	347,572
2010 (AN)	208,519	101,072	37,981	347,572
2011 (W)	207,669	101,043	38,861	347,572
2012 (D)	209,727	98,856	38,989	347,572
2013 (C)	211,791	96,663	39,117	347,572
2014 (C)	213,852	94,475	39,245	347,572
2015 (C)	216,158	91,919	39,496	347,572
Average (1989-2014)	213,362	102,079	32,131	347,572

[1] Area includes land classified as native vegetation and water surfaces.
[2] Area includes land classified as urban, industrial, and semi-agricultural.

Table 2-2. Madera Subbasin Agricultural Land Use Areas (Acres).

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops[25]	Misc. Truck Crops[26]	Orchard[27]	Pasture and Alfalfa	Total
1989 (C)	6,071	5,266	5,548	69,562	32,783	17,189	1,217	46,219	30,069	213,924
1990 (C)	6,264	4,676	7,183	70,011	25,527	18,146	2,078	49,243	30,956	214,083
1991 (C)	6,930	4,396	5,294	71,643	19,928	20,035	2,010	51,456	32,505	214,196
1992 (C)	6,921	4,873	6,316	74,583	15,756	19,184	2,262	53,180	31,478	214,554
1993 (W)	7,032	5,199	6,270	75,780	17,182	19,291	2,657	54,973	26,372	214,757
1994 (C)	7,193	5,046	5,780	79,140	17,624	18,116	4,188	56,697	21,308	215,092
1995 (W)	6,600	5,493	12,680	79,919	10,649	17,587	1,363	65,024	16,070	215,385
1996 (W)	7,429	7,496	7,357	83,404	5,677	21,565	2,508	62,451	17,628	215,515
1997 (W)	7,485	5,356	7,759	85,931	8,133	14,880	3,146	64,874	18,085	215,649
1998 (W)	6,606	6,331	4,829	86,546	14,708	12,520	2,413	65,726	16,100	215,779
1999 (AN)	2,938	6,635	2,250	92,564	15,075	10,633	2,243	67,712	15,862	215,912
2000 (AN)	7,349	7,077	7,461	95,974	347	10,857	1,259	70,458	15,261	216,043
2001 (D)	6,880	6,584	12,438	89,443	3,096	12,556	1,258	69,992	13,929	216,177
2002 (D)	7,433	8,278	8,247	92,184	4,437	8,116	1,628	71,566	13,437	215,327
2003 (BN)	7,078	8,579	6,829	89,422	6,731	8,119	2,030	72,742	12,946	214,476
2004 (D)	6,514	8,648	7,111	87,319	6,533	8,955	3,097	72,995	12,454	213,626
2005 (W)	7,236	7,877	8,898	85,057	8,225	7,627	2,869	73,023	11,962	212,773
2006 (W)	6,719	8,556	8,461	81,573	12,806	5,463	3,792	73,082	11,470	211,922
2007 (C)	6,963	10,090	7,276	81,391	11,999	3,678	3,871	74,826	10,978	211,072
2008 (C)	6,493	11,380	8,906	82,092	13,729	947	1,486	74,703	10,487	210,222
2009 (BN)	5,738	8,352	7,911	77,005	21,763	125	2,686	75,795	9,994	209,369
2010 (AN)	5,945	8,834	10,872	74,371	11,672	1,546	2,897	82,879	9,503	208,519
2011 (W)	8,796	8,641	10,879	68,136	3,075	3,424	3,043	92,664	9,011	207,669
2012 (D)	4,827	11,432	10,029	67,291	6,493	2,312	3,527	93,783	10,033	209,727
2013 (C)	4,233	10,908	10,272	66,441	9,779	837	3,953	97,164	8,204	211,791
2014 (C)	8,260	6,955	6,741	65,594	8,231	4,001	2,328	104,985	6,757	213,852
2015 (C)	4,512	6,963	9,118	67,489	4,198	409	7,480	108,407	7,581	216,158
Average (1989-2014)	6,613	7,422	7,831	79,707	11,998	10,296	2,531	70,700	16,264	213,362

[25] Miscellaneous field crops include beans, cotton, flax, hops, millet, safflower, sorghum, sudan, sugar beets, sugar cane, and sunflowers.
[26] Miscellaneous truck crops include artichokes, asparagus, berries, broccoli, Brussels sprouts, cabbage, carrots, cauliflower, celery, cucumbers, garlic and onions, green beans, lettuce, melons, peas, peppers, potatoes, sweet potatoes, spinach, squash, tomatoes, other greenhouse crops, and flowers, and nurseries.
[27] Orchard crops include primarily almonds and pistachios, and also walnuts and miscellaneous deciduous crops.

2.1.1.2 Groundwater Wells

The densities of domestic, irrigation, and public supply wells per section within the Madera Subbasin are shown in **Figures**[28] **2-5**[29]**,2-6**[30], and **2-7**[31] respectively. Notably, the number of wells reported by section were determined from Well Completion Report (WCR) data provided by DWR. These numbers include only reported wells and may not reflect the total number of existing or active wells in the Subbasin. Since initial GSP development, the Madera Subbasin GSAs conducted a domestic well inventory in 2021-2022 to improve data and mapping of domestic wells in the Subbasin. Final documentation of the inventory was completed in spring 2022, including new maps (**Appendix 2.G**). The highest concentrations of reported domestic wells are centered primarily around the City of Madera and Bonadelle Ranchos-Madera Ranchos to the east. Reported irrigation wells are generally less concentrated and more evenly distributed across the Subbasin, though slightly higher concentrations are found in some sectors within rural MC GSA, MID GSA, and RCWD GSA.

2.1.2 Water Resources Monitoring and Management Programs (23 CCR § 354.8(c), (d), (e))

Existing surface water and groundwater monitoring and management programs within the Madera Subbasin are identified below following a summary of water planning documents applicable to the Subbasin GSAs.

Continued monitoring is required to track the progress of the GSP implementation plan by providing data on groundwater and surface water availability in the Subbasin. One overarching project in the implementation plan adds additional monitoring to fill data gaps (see Section 4 for more details).

2.1.2.1 Water Planning Documents

As stewards of the water resources within their jurisdictions, the local agencies that have formed each of the Madera Subbasin's GSAs have prepared and adopted several water planning documents in the past. As of initial GSP development, tThese include:

- Regional Water Plans
    - Madera Integrated Regional Water Management Plan (approved in 2008, updated in 2015)
        - This plan is a collaborative effort to improve regional coordination in management of water resources among the 17 groups and agencies forming the Madera Regional Water Management Group as well as other interested parties. These agencies include six currently organized as GSAs in the Madera Subbasin (CM, GFWD, MC, MID, MWD, RCWD). The plan establishes regional water management goals and serves as a basis for pursuing funding to accomplish these goals.
    - Madera Regional Groundwater Management Plan (adopted in 2014)
        - This plan provides a framework for regional groundwater management among six participating groups and agencies, including three currently organized as GSAs in the Madera Subbasin (CM, MC, MID). The objectives of the plan are to establish collaborative governance, stabilize and recover groundwater levels, mitigate

[28] Figure titles that are bolded can be found at the end of each chapter.
[29] Based on DWR Well Completion Report data. May not represent all active domestic wells.
[30] Based on DWR Well Completion Report data. May not represent all active irrigation wells.
[31] Based on DWR Well Completion Report Data. May not represent all active public water supply wells.

subsidence, improve public awareness, and maintain and improve the economic viability of the Madera region.

- Water Management Plans
  - Gravelly Ford Water District Water Management Plan (adopted in 2012)
  - Madera Irrigation District Water Management Plan (dated 2013)
  - City of Madera Urban Water Management Plan (adopted in 2011, updated in 2017)
- Groundwater Management Plans
  - Gravelly Ford Water District Groundwater Management Plan (dated 1998)
  - Madera County Groundwater Management Plan (adopted in 2002)
  - Madera Irrigation District Groundwater Management Plan (dated 1999, amended in 2000)
  - Madera Water District Groundwater Management Plan (adopted in 1997, amended in 2014)
  - Root Creek Water District Groundwater Management Plan (dated 1997)
- Other Plans
  - Community Plans[32]:
    - Fairmead Colony (in process)
    - Gateway Village Area Plan (2006)
    - Gunner Ranch West Area Plan (1994)
    - Rio Mesa Area Plan (1995)
    - River West – Madera (in process)
    - Madera Ranchos (in process)
    - Southeast Madera County (in process)
  - General Plans:
    - City of Madera General Plan (2009)
    - Madera County General Plan (updated 2015)
  - Municipal Service Reviews:
    - City of Madera Municipal Service Review (2018)
    - Root Creek Water District Municipal Service Review (2018)
  - Other:
    - City of Madera Water System Master Plan (dated 2014)
    - Madera County Storm Water Resource Plan (2017)
    - PG&E San Joaquin Valley Operations & Maintenance Habitat Conservation Plan (HCP) (2006, permit issued 2007)[33]

Information developed for these plans regarding GSA surface water and groundwater supplies, distribution infrastructure, and monitoring programs have contributed to the development of this Joint GSP.

[32] Community plans, area plans, master plans, or enhancement plans that are adopted or in process in the Madera Subbasin. Other adopted plans in Madera County are outside the subbasin (Ahwahnee/Nipinnawasee, Coarsegold, North Fork/South Fork, Oakhurst, O'Neals, Raymond).

[33] The goal of this HCP is to "minimize, avoid, and compensate for possible direct, indirect, and cumulative adverse effects on threatened and endangered species" that could result from PG&E operations and maintenance efforts. The HCP covers all land owned by PG&E and/or associated with PG&E gas and electrical facilities, access routes, and mitigation areas, and therefore may overlap with any adjacent GDEs or ISW habitats identified in the subbasin.

GSP implementation will support all HCP goals to minimize and avoid adverse effects to threatened and endangered species in the ~~Madera~~ Subbasin. There are currently no Natural Community Conservation Plans that overlap with the ~~Madera~~ Subbasin.

Development and implementation of this Joint GSP has and will continue to consider the interests of all beneficial uses and users of groundwater, including agricultural water users, municipal water users, disadvantaged communities (DACs), ~~interconnected surface water (~~ISW~~)~~ habitats, groundwater dependent ecosystems (GDEs), and other stakeholders.

Implementation of this Joint GSP will support all goals for the protection of natural resources and DACs, including those established in the plans above, consistent with SGMA and GSP regulations. This includes recognition and support of:

- Madera County General Plan, SB 244 Disadvantaged Unincorporated Communities (DUC) Amendments[34]: Identification of the water service needs of DUCs in the county, including the communities of Fairmead, River Road Estates, Valley Lake Ranchos/Lake Madera County Estates in the ~~Madera~~ Subbasin.
- PG&E San Joaquin Valley Operations and Maintenance HCP: Establishes goals to minimize and avoid adverse effects to threatened and endangered species in the ~~Madera~~ Subbasin.

2.1.2.2 Surface Water Monitoring and Management Programs

Surface water flows into and within the ~~Madera~~ Subbasin are extensively monitored through existing federal, state, regional, and local programs. Data and spatial information from these monitoring programs have been incorporated directly into this Joint GSP to support water budget development, per 23 CCR § 354.18.

These sources and the data they provide are summarized below.

Federal, State, and Regional Programs

In support of GSP development, surface water data were collected from the following agencies and programs:

- California Data Exchange Center (CDEC)
- California State Water Resources Control Board (SWRCB)
  - SWRCB GeoTracker
- Department of Water Resources Water Data Library (WDL)
- Madera-Chowchilla Water and Power Authority (MCWPA)
- San Joaquin River Restoration Program (SJRRP) [35]
- San Luis Delta-Mendota Water Authority (SLDMWA)

[34] This Joint GSP also considers the water service and supply needs of other DACs in the subbasin not discussed in the Madera County General Plan, SB 244 DUC Amendments, including La Vina.

[35] SJRRP requires the release of flows from Friant Dam to the confluence with the Merced River to support the life-stages of salmon and other fish species. The amount of water available for the SJRRP – the Restoration Allocation – depends upon the amount of runoff in the San Joaquin River watershed above Friant Dam. The SJRRP develops Allocations and Default Flow Schedules to identify the annual volume of Restoration Flows available. Each year, the Restoration Allocation is adjusted, often many times, between the date of the initial allocation and the final allocation, based on the hydrologic conditions. In May 2019, a Restoration Allocation of over 556,5000 thousand acre-feet (TAF), as measured at Gravelly Ford (GRF), was calculated by Reclamation using the 50% exceedance forecast. For more information, see http://www.restoresjr.net/restoration-flows/flow-schedule/.

- United States Army Corps of Engineers (USACE)
- United States Bureau of Reclamation (Reclamation)
- United States Geological Survey (USGS)
    - National Water Information System (NWIS)

Key federal and state surface water monitoring stations and the agency collecting the data are identified in Table 2-3. In the Madera Subbasin, streamflow along the San Joaquin River, Fresno River, and Madera Canal is monitored by USGS stations. CDEC and WDL compile streamflow data for Chowchilla Bypass and Fresno River inflows to the Subbasin at stations managed by SLDMWA and USACE. These monitoring stations are important for monitoring surface water available to interconnected surface water (ISW) habitats and groundwater dependent ecosystems (GDEs).

Deliveries of Central Valley Project (CVP) water along Madera Canal to lands within the Madera Subbasin are managed by MCWPA. Reclamation monitors and reports these deliveries as part of the CVP Friant Division.

Local Programs

Water data were also collected from the following local monitoring programs:

- The City of Madera's SCADA system and records of monthly volumes pumped from groundwater supply wells (available since 2013).
- GFWD's records of surface water diversions from the San Joaquin River, Cottonwood Creek, and MID's Lateral 6.2 (available since 2004).
- GFWD's records of deliveries to growers (available since 1982).
- Madera County's requirement to include a flow measurement device on new wells and the resulting groundwater pumping records.
- MID's extensive network of recorders (Table 2-4) and records of key inflows and outflows to waterways and the MID conveyance system (available since the 1950s).
- MID's expanding SCADA system.
- MID's records of grower deliveries in their STORM database (available since 1999).
- MWD's well monitoring program and records of pumping volumes from MWD's wells (available since 1993).
- MWD's records of surface water diversions into the District from Dry Creek (available since 1993)
- RCWD's records of surface water deliveries to parcels on the pipeline constructed to supply surface water from MID's Lateral 6.2 to RWCD (available since 2017).
- Stations and MID recorders along waterways were used to prepare time series datasets for Subbasin surface water inflows and outflows. MID recorders at spillage sites were used to prepare time series datasets for MID conveyance system outflows. Records of groundwater pumping and deliveries were used to prepare time series datasets for agricultural land inflows. These data and methodologies are described in Section 2.2.3 and **Appendix 2.F.**

Program Limitations on Operation Flexibility in Basin

Continued operation of these water monitoring programs will support tracking the progress of the GSP implementation plan by providing data on water availability and inflows and outflows from the Subbasin. Limitations on surface water deliveries will limit operational flexibility by reducing surface water supplies available for conjunctive use programs.

Table 2-3. Surface Water Monitoring Stations.

Waterway	Source	Site ID	Site Name	Available Data Period	Details
Chowchilla Bypass	CDEC	CBP	Chowchilla Bypass	1997-2018	Station operated by SLDMWA
Chowchilla Bypass	WDL	B07802	Chowchilla Bypass at Head Below Control Structure	1978-1991	
Fresno River	USGS	11258000	Fresno R Bl Hidden Dam Nr Daulton	1941-1990	
Fresno River	CDEC	HID	Hidden Dam (Hensley)	1993-2018	Station operated by USACE
Madera Canal	USGS	11249500	Madera Cn A Friant CA	1948-2016	
Madera Canal	Reclamation	Indicated by Mile	Miles 6.1, 13.06, 18.8, 24.1, 27.5, 30.4, 30.5, 32.2	1989-2018	CVP water deliveries to MID reported by Mile
San Joaquin River	USGS	11251000	San Joaquin R Bl Friant CA	1920-2018	

Table 2-4. MID Recorder Network.

Recorder Number	Recorder Name	Site Type	Available Data Period
2	Berenda Creek Spill	Streamflow	1966-2017
3	Dry Creek Spill	Streamflow	1966-2018
4	Fresno River Rd. 16	Streamflow	1951-2018
5	Dry Creek Head Flood Water	Streamflow	1966-2017
6	Head of M C and I	Canal Heading	1939-2012
7	Fresno River	Streamflow	1951-2010
9	6.2 Spill	Spillage	1964-2018
10	Cottonwood Creek Spill	Streamflow	1951-2018
11	6.2 ex. 18.4 16.9 15.9 Spill	Spillage	1964-2018
12	Madera Lake Recorder	Reservoir Level	1966-1966
13	Berenda Creek Head	Streamflow	1970-2004
14	Cottonwood Creek @ Ave. 13	Streamflow	1970-2018
15	24.2 Spill	Spillage	1972-2018
16	17.0 Spill	Spillage	1972-2018
17	24.2-13.2 Spill	Spillage	1972-2018
18	Dry Creek Lat. Spill	Spillage	1973-2017
19	24.2-17.0 End	Spillage	1973-2018
20	24.2-14.2 Spill	Spillage	1974-2009
23	Main 1 Head	Canal Heading	1979-2014
24	Rd. 9 at Fresno River	Streamflow	2005-2013
26	Rd. 9 at East Side Bypass	Streamflow	2011-2011

2.1.2.3 Groundwater Monitoring and Management Programs

There are a variety of local, state, and federal monitoring programs currently and historically conducted in the Madera Subbasin related to groundwater levels, groundwater quality, and land subsidence. Each monitoring category is described in more detail in the sections below.

Groundwater Level Monitoring

Groundwater level monitoring has been conducted historically by a variety of entities in the Subbasin including Madera Irrigation DistrictMID, Madera County, DWR, United States Bureau of Reclamation (USBR), and Geotracker GAMA. The California State Groundwater Elevation Monitoring Program (CASGEM) was initiated in 2011, with the Madera-Chowchilla Groundwater Monitoring Group as the local monitoring entity. This Group includes Madera Irrigation District, Madera County, Madera Water District, Gravelly Ford Water District, and Root Creek Water District, along with other entities in Chowchilla Subbasin. Groundwater levels are collected and submitted each Fall and Spring as part of the CASGEM program. **Appendix 2.E** includes a map presenting the well locations and most recent monitoring date for historical groundwater level monitoring conducted in the Subbasin.

Groundwater Quality Monitoring

Groundwater quality monitoring has historically been conducted by a variety of entities in the Subbasin including the City of Madera, Madera Valley Water Company, and other public drinking water suppliers, regulated facility operators and other contaminant site monitoring for the RWQCB, the East San Joaquin Water Quality Coalition (the third-party entity representing growers in the area) as part of the Irrigated Lands Regulatory Program (ILRP), USGS for the Groundwater Ambient Monitoring and Assessment Program (GAMA), and other programs under the direction of agencies such as the RWQCB, DPR, EPA, DTSC, USGS. Some historical groundwater quality monitoring has also been conducted by well owners in the Subbasin for other purposes.

All public drinking water supply systems must conduct groundwater quality monitoring as part of requirements for the Division of Drinking Water (DDW). The required frequency and constituents for DDW monitoring vary by water system and monitoring point. Groundwater quality monitoring is also conducted at regulated facilities and contaminant sites for the RWQCB in association with tracking and reporting on the status of groundwater contamination near these sites. More recently, groundwater quality monitoring required by the Irrigated Lands Regulatory Program has been initiated. Groundwater quality assessment and monitoring for the ILRP included preparation of a Groundwater Quality Assessment Report with five-year updates, including delineation of High Vulnerability Areas relative to groundwater quality impacts from irrigated agricultural practices and also includes development and maintenance of a network of wells for groundwater quality sampling as part of a Groundwater Quality Trend Monitoring (GQTM) program. The GQTM program includes annual monitoring results reporting and five-year evaluations of groundwater quality trends and conditions relative to irrigated agriculture. Additionally, as part of the ILRP, all domestic wells on parcels enrolled in the agricultural coalition must also be tested for nitrate. The ILRP domestic well monitoring efforts are newly underway and neither results nor well locations related to this monitoring are available at the time of preparation of this report. **Appendix 2.E** includes a map presenting the well locations, monitoring programs, and most recent monitoring date for historical groundwater quality monitoring conducted in the Subbasin.

The Madera Subbasin is identified as a Priority 2 Area for nitrate control efforts to be required under the Nitrate Control Program included in the Basin Plan Amendment approved by the RWQCB in May 2018 and in the process of undergoing approval by the SWRCB (anticipated Summer or Fall 2019). After adoption of the Basin Plan Amendment, the RWQCB is expected to begin issuing notices to comply to Priority 2 areas within two to four years, which once issued will start the clock on requirements of the Nitrate

Control Program. As a requirement of the Nitrate Control Program, dischargers in the ~~Madera~~ Subbasin will need to develop an approach to ensure shallow groundwater is protected. The Nitrate Control Program requires development of Early Action Plans in areas where nitrate discharges to groundwater may be impacting public drinking water supplies. Once in effect, it is expected that the Nitrate Control Program will include considerable analysis and/or monitoring of groundwater quality conditions and development of actions to address groundwater quality impacts from nitrate discharges.

Land Subsidence Monitoring

Land subsidence monitoring has been conducted by various agencies including USGS, DWR, USBR, USACE, San Luis & Delta-Mendota Water Authority (SLDMWA), Central California Irrigation District (CCID), California Department of Transportation (Caltrans), National Geodetic Survey (NGS), UNAVCO, and others (MRGMP, 2014). A key ongoing subsidence program is conducted by USBR in conjunction with DWR, USGS, and USACE, which collects and publishes subsidence data twice per year as part of the SJRRP. **Appendix 2.E** includes a map presenting the monitoring sites and most recent monitoring data for historical land subsidence monitoring conducted in the Subbasin and the surrounding vicinity. Additionally, through remote sensing and similar data acquisition methods such as InSAR, maps of periodic snapshots of spatial distribution of land subsidence have been historically generated including by DWR, USGS, and The Jet Propulsion Laboratory (JPL). The frequency of such land subsidence mapping efforts has been variable but has increased in frequency and regularity since 2010 and are anticipated to continue in the future.

2.1.2.4 Conjunctive Use Programs

To support overall water management objectives, water distributors in the ~~Madera~~ Subbasin strategically manage their conjunctive use of surface and groundwater supplies.

MID receives surface water supplies from Millerton Reservoir (along Madera Canal) and Hensley Lake (along Fresno River). MID can also deliver or wheel water to MWD, RCWD, GFWD, City of Madera and Madera County. The districts practice conjunctive use of these surface water supplies through policies to encourage grower use of surface water when available. Additionally, some growers along the San Joaquin River, the Chowchilla and Eastside Bypass, and the Fresno River exercise surface water rights when sufficient supply is available. These combined practices reduce groundwater pumping and increase groundwater recharge in wet years providing increased groundwater supplies available for use by private or district-operated groundwater wells in dry years. For growers, the historical advantages of groundwater perceived are many and include greater flexibility in providing water for frost protection, chemigation, and fertigation and to better align irrigations with crop water demands, field activities, and harvest. Because of these many perceived advantages, policies encouraging surface water use when the water is available are important. Irrigation by surface water supplies provides the advantage of in-lieu recharge of groundwater, and brings an additional resource into the Basin to help meet crop water demands.

The City of Madera relies on groundwater for municipal and industrial uses within the City limits. Irrigated agriculture within the City limits also generally relies on groundwater pumped through private wells. The City's potable water system includes 19 wells with completion depths between 300 and 700 feet, with a total capacity of approximately 27,000 gallons per minute (gpm) to serve approximately 13,500 connections.[36] Some City agricultural users also receive surface water supplies from MID in areas surrounding the City within the bounds of MID.

[36] Madera Regional Groundwater Management Plan, December 2014. Pg. 131.

The City of Madera Wastewater Treatment Plant receives and treats over five million gallons of wastewater per day, on average, and releases treated wastewater to fourteen 20-acre ponds. In Madera County, effluent from several small sewer systems is also disposed through evaporation ponds and/or spray fields. Implementation of proposed recovery wells for utilizing this water has met regulatory challenges.[37]

Conjunctive use programs in the Subbasin also include the indirect reuse and recharge of treated wastewater and/or stormwater in City of Madera and Madera County, recharge of captured stormwater and floodwater in MID, as well as recharge of other surface water supplies, as available, in GSAs across the Subbasin. In addition, MID to encouraging encourages growers to use surface water when available, MID utilizes a number of basins to provide groundwater recharge from captured stormwater and flood water.[38] Updates to conjunctive use efforts – including development and use of recharge basins, on-farm recharge activities, and other PMAs – are provided in the Annual Reports

Madera County and MID also have an MOU to use Ellis Basin for groundwater recharge. The facility was used to recharge approximately 800 AF in 2017/2018.

The City of Madera conducted a pilot study of groundwater recharge in 2009 using 300 AF of floodwater purchased from MID.[39] The City also maintains stormwater recharge facilities, several of which are linked to MID irrigation distribution facilities[40]. The City of Madera and MID partnered in connecting one of the City's storm drain basins to the MID delivery system in late 2018. MID directed approximately 50 AF into the basins in 2019.

The City of Madera Wastewater Treatment Plant receives and treats over five million gallons of wastewater per day, on average, and releases treated wastewater to fourteen 20-acre ponds. In Madera County, effluent from several small sewer systems is also disposed through evaporation ponds and/or spray fields. Implementation of proposed recovery wells for utilizing this water has met regulatory challenges.[41]

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans (23 CCR § 354.8 (f))

The Madera Subbasin lies entirely within Madera County and the Madera County General Plan is applicable. Additionally, the City of Madera General Plan is applicable to land in the CM GSA, defined by boundaries of City of Madera.

Implementation of this Joint GSP will support the goals and policies established in these plans, consistent with SGMA and GSP regulations. Development and implementation of this Joint GSP has and will continue to consider the interests of the beneficial uses and users of groundwater, including agricultural water users, municipal water users, disadvantaged communities (DACs), interconnected surface water (ISW) habitats, groundwater dependent ecosystems (GDEs), and other stakeholders.

[37] Madera Regional Groundwater Management Plan, December 2014. Pg. 132-133.
[38] Madera Regional Groundwater Management Plan, December 2014. Pg. 134.
[39] Madera Integrated Regional Water Management Plan, February 2015. Pg. 3-16.
[40] Madera Regional Groundwater Management Plan, December 2014. Pg. 131.
[41] Madera Regional Groundwater Management Plan, December 2014. Pg. 132-133.

2.1.3.1 Madera County General Plan

In the Madera County General Plan updated in 2015[42], Madera County affirms its general land use policies to designate sufficient land for projected population growth in Madera County (Policy 1.A.2), but plans for this growth through higher-density, or infill, development in existing communities and "designated new growth areas" to minimize urban encroachment into agricultural lands and other open spaces and to consolidate infrastructure expansion (Policies 1.A.3-4, 1.B.2, 1.C.2). Furthermore, Madera County restricts development in "areas with sensitive environmental resources" (Policy 1.A.5).

With regard to agricultural land, Madera County maintains policies to encourage water conservation, re-use of reclaimed water, soil conservation practices, land improvement programs, and enrollment of agricultural land in the Williamson Act program (Policies 3.C.11-12; 5.A.6-8,12).

County policies regarding domestic water supply are summarized in Section 3.C (Policies 3.C.1-10). The county has policies that limit new development unless an adequate water supply is demonstrated, require supplies serving new development to meet state water quality standards, and limit development in areas with severe water table depression to uses without high water usage or to uses served by surface water supplies.

County policies regarding water resources are summarized in Section 5.C (Policies 5.C.1-9). Madera County's policies are to "protect and preserve areas with groundwater recharge capabilities" (Policy 5.C.1), minimize groundwater overdraft by utilizing surface water for urban and agricultural use where available, and support the policies of the San Joaquin River Parkway Plan (SJRPR), including maintaining a wildlife corridor along the San Joaquin River between Friant Dam and Highway 145 (Policy 5.E.11).

County policies regarding wetland and riparian areas are summarized in Section 5.D (Policies 5.D.1-8), and policies regarding fish and wildlife habitat are summarized in Section 5.E (Policies 5.E.1-11). Madera County supports the protection of "critical nesting and foraging areas, important spawning grounds, migratory routes, waterfowl resting areas, oak woodlands, wildlife movement corridors, and other unique wildlife habitats critical to protecting and sustaining wildlife populations" (Policy 5.E.1), and complies with the wetlands policies of the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife to ensure that appropriate mitigation measures and the concerns of these agencies are adequately addressed (Policy 5.D.1).County policies regarding natural vegetation and open spaces are summarized in Section 5.F (Policies 5.F.1-8) and Section 5.H (Policies 5.H.1-5). Madera County supports the preservation of natural vegetation, land forms, and resources as open space, with permanent protection where feasible (Policy 5.H.1). Madera County also supports the preservation and protection of outstanding areas of natural vegetation (including, but not limited to, riparian areas) as well as rare, threatened, and endangered plant species (Policies 5.F.3,5).

Implementation Effects on Water Demands and Sustainability

Implementation of proposed land use developments under this general plan is not expected to shift water demands because the county has a net zero ordinance that requires developers to bring in enough water supply for the development such that it does not increase demand.

Implementation of the general plan's policies to restrict development in "areas with sensitive environmental resources" and to support preservation of natural resources provides for the protection of wetlands, aquatic resources, and other ISW habitats and GDEs. This Joint GSP supports these policies by identifying and considering the effects of GSP implementation on groundwater-surface water interactions (Section 2.2.2.5) and GDEs (Section 2.2.2.6, **Appendix 2.B**) in the ~~the Madera~~ Subbasin. Consistent with GSP regulations, the minimum thresholds (MTs) established by this Joint GSP and the measurable

[42] Madera County General, Plan Policy Document Adopted October 1995, housing element updated November 2015.

objectives (MOs) monitored throughout GSP implementation will confirm the protection of wetlands, aquatic resources, and other GDEs and ISW habitats identified in the Subbasin

GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the ~~Madera~~ Subbasin to be operated within its sustainable yield by 2040, which will include restrictions on groundwater pumping and implementation of projects to increase groundwater recharge. However, urban water use has historically represented a small fraction of all water consumption in the Subbasin and is unlikely to be as significantly affected as agricultural water use. Furthermore, some of this urban development is expected on agricultural land and will lower water use requirements. New development and retrofitted landscape water efficiency standards are governed by the Model Water Efficient Landscape Ordinance (MWELO). The MWELO increases water efficiency standards for new and retrofitted landscapes by encouraging more efficient irrigation systems, graywater usage, and onsite storm water capture, and by limiting the portion of landscapes that can be covered in turf. Studies and reviews by Olmos and Loge (2013), Englehardt et al. (2016), and Loux et al. (2012) support the feasibility of achieving these standards through adoption of such water conservation measures in California and elsewhere, particularly when considered in early planning stages of developments.

Generally, implementation of policies related to agricultural land, water supply, water resources, wetlands, riparian areas, natural vegetation, and open spaces are in alignment with GSP planning efforts and are expected to support achievement of Subbasin sustainability.

2.1.3.2 City of Madera General Plan

In the City of Madera General Plan adopted in October 2009[43], City of Madera establishes several core principles, including that: (1) future development should be more compact and accommodate higher-density urban growth, (2) the Fresno River should be incorporated as a major feature in future development, and that (3) agricultural land outside of planned urban development areas should be protected.

In the plan, City of Madera identifies approximately 12,500 acres of agricultural land within the city's planned growth boundary. Of this, approximately 1,500 acres were within the 2015 city limits. This growth boundary is considered the physical limits of development in City of Madera (Policy LU-10). Lands within this boundary are eligible for rezoning to be consistent with planned land use, including rezoning of some agricultural land to other uses (Policy LU-1,3,32). The plan prioritizes residential infill development to reduce the rate of agricultural land conversion (Policy LU-40) but allows for lands within the growth boundary to eventually shift toward primarily residential and commercial uses, with scattered public open spaces (Policy LU-1).

However, the City of Madera plans for a greenbelt of lands classified as "Resource Conservation/Agriculture" (designated to remain agricultural land) outside the growth boundary, with a permanent greenbelt segment along the City's western edge, and "encourages the use of Williamson Act contracts and similar mechanisms to ensure the maintenance of the greenbelt" in the future (Policy LU-11,30).

Implementation Effects on Water Demands and Sustainability

Similar to the Madera County General Plan, implementation of proposed land use developments under the City of Madera General Plan is expected to reduce water demands because new developments are required to follow the MWELO.

---

[43] City of Madera General Plan, Adopted October 7, 2009.

GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the ~~Madera~~ Subbasin to be operated within its sustainable yield by 2040, which will include restrictions on groundwater pumping and implementation of projects to increase groundwater recharge. Because the City of Madera only relies on groundwater, expanding its service as population grows will result in more groundwater use by the City. However, urban development would extend primarily into agricultural lands, which also consume significant groundwater resources. Thus, water use requirements will actually decrease under the plan, benefitting Subbasin sustainability.

Implementation of the GSP will also provide for recharge projects to achieve Subbasin sustainability. The City of Madera has opportunities for recharge, which will benefit sustainability and help to offset potential increases in water use associated with urban development.

2.1.3.3 Permitting Process for Wells in Madera Subbasin

Within Madera County, including the entire ~~Madera~~ Subbasin, the Madera County Environmental Health Division is entrusted with all permitting and enforcement for the construction, reconstruction, and destruction of wells. Wells under their oversight include, but are not limited to, agricultural wells, observation/monitoring wells, community water supply wells, and individual domestic water supply wells.

The application process for Water Well Permits is handled online through the Madera County Permits Online website: https://www.maderacounty.com/services/county-permits-online. This site allows parties to apply for a permit, submit plans, remit payment, and monitor the status of their permit. Annular seal appointments are scheduled by contacting the Madera County Water Wells Permitting Program by phone.

Madera County Environmental Health Division restricts work on all water wells to be performed only by those possessing an active C-57 Water Well Contractors License. Destruction of wells within City of Madera are handled by the City of Madera Building Department.

Pursuant to Senate Bill (SB) 252, the Madera County Environmental Health Division will begin posting all new well applications for public review beginning in 2020 on their website: https://www.maderacounty.com/government/community-economic-development-department/divisions/environmental-health/water-well-program.

Since initial GSP development, Executive Order N-7-22 was issued providing further considerations for well permitting and issuance in order to mitigate drought-related impacts to groundwater conditions. Well permitting processes in Madera County are consistent with all applicable requirements.

GSAs in the ~~Madera~~ Subbasin will work with the county to ensure that future well permitting aligns with the Subbasin sustainability goal established under this Joint GSP. In alignment with the findings of California's Third Appellate District, future well permitting will also align with the requirement that counties consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses. Furthermore, future well permitting processes will consider and address permitting steps required by local or state law or other orders.

2.1.3.4 Effects of Land Use Plans Outside Subbasin

Outside the ~~Madera~~ Subbasin, other land use plans have been developed as part of the general plans for Merced County and City of Chowchilla to the north and the City of Fresno to the south. These general plans are similar in scope to the Madera County and City of Madera General Plans described above.

The subbasins underlying Merced County, City of Chowchilla, and City of Fresno have also been identified by DWR as critically overdrafted and are also required to prepare and be managed under a GSP by January 31, 2020 (CWC § 10720.7(a)(1)). As such, future land use changes in these jurisdictions will also need to be managed to achieve sustainability in the subbasins adjacent to the ~~Madera~~ Subbasin. As long as these subbasins are managed to achieve sustainability, these land use plans are not expected to affect the ability of the ~~Madera~~ Subbasin GSAs to achieve sustainable groundwater management.

2.1.4 Additional GSP Elements (23 CCR § 354.8 (g))

There are various GSP elements to be addressed in this subsection of the GSP as described below. In some cases, the related information is provided elsewhere in the GSP and the section where the information is provided is noted. In other cases, additional information is provided below.

2.1.4.1 Control of Saline Water Intrusion

Seawater intrusion is not applicable to the ~~Madera~~ Subbasin as explained in Section 3.2.6. It should also be noted that the Lower Aquifer in the Subbasin is underlain by brackish water below the base of fresh water as described in Section 2.2.1.2. Upward movement of brackish water from greater depths has not been a reported problem historically or currently, but excessive pumping from the lowermost coarse-grained layers (should it occur in the future) may have the potential to cause such upward migration of brackish water in the future. The Madera Regional Groundwater Management Plan (MRGMP) (Provost & Pritchard, Wood Rodgers, KDSA, 2014), which includes most of the Plan Area, lists no existing activities, but did include the following planning activities: 1) amend County well standards for new well designs to ensure proper sealing of test holes that penetrate below the known base of fresh water; 2) amend County well standards to require exploratory test holes to be sealed with approved materials from total depth to ground surface; and 3) use well permitting process to require use of borehole geophysical surveys in all new boreholes that have potential to penetrate the base of fresh water, which would enhance groundwater protection by aiding in the current and future design of well seals to help prevent upward migration of brackish water.

2.1.4.2 Wellhead Protection

Wellhead protection refers to both the immediate location of the well in terms of well and pump station design features (e.g., well pad, annual seal) and the broader area surrounding the well. As noted in the MRGMP, a wellhead protection area is the area surrounding a public water supply well through which contaminants are reasonably able to move towards the well (i.e., the recharge area that provides water to the well).

The Madera County and City of Madera well ordinances do not specifically address wellhead protection, but do include requirements related to placement of annual seals. The MRGMP lists existing activities as: design new wells with appropriate wellhead protection features. The MRGMP lists planned actions as: 1) manage potential sources of contamination to minimize threat to drinking water sources; 2) develop contingency plan to prepare for emergency well closing and to plan for future water supply needs; 3) encourage establishment of wellhead project areas for non-municipal wells; and 4) develop more detailed wellhead protection standards for Madera County and City of Madera.

2.1.4.3 Migration of Contaminated Groundwater

Migration of contaminated groundwater can occur through improperly constructed wells, which can become conduits for vertical flow of poor quality water between aquifers. Inadequate surface sanitary seals can allow downward migration of contaminants from ground surface into the well structure and ultimately the aquifers screened by the well. Abandoned and improperly destroyed wells are also potential conduits for migration of contaminants in the subsurface. There are also numerous types of facilities and land uses that can be potential sources of chemical constituents that migrate down through the vadose zone and into aquifers with subsequent migration to pumping wells.

The MRGMP describes the main sources of information related to groundwater contamination including: the California Water Resources Control Board (SWRCB), the Department of Toxic Substance Control (DTSC), and the Groundwater Ambient Monitoring and Assessment Program (GAMA). The MRGMP describes related existing activities as including: 1) current County regulation for new well construction permitting that requires sanitary/annular seal depths sufficient to avoid creating conduit for contamination of shallow groundwater or co-mingling of aquifers with different water quality; and 2) current County regulation to properly abandon existing wells when connecting to a municipal water system. Planned actions listed in the MRGMP included: 1) review online databases for existing plumes and ensure that existing and new well operations do not induce downward migration of contaminants; 2) during new well construction permitting - require sanitary/annular seal depths sufficient to avoid creating conduit for downward migration of shallow groundwater contamination or co-mingling of aquifers with different water quality; 3) design a well abandonment program to identify abandoned wells and develop plans to properly destroy wells.

2.1.4.4 Well Abandonment and Well Destruction Program

An existing Madera County ordinance and state law require proper abandonment of wells. Madera County is responsible for administration and enforcement of the well ordinance and oversees well abandonment in the Subbasin, including within cities, irrigation districts, water districts, and private wells. Wells are required to be abandoned in accordance with State standards as delineated in Water Well Standards (DWR, 1981). The County requires that a property owner properly destroy any abandoned or unused wells prior to permitting construction of a new well (unless it is determined the well is appropriate for use as a monitoring well). In addition, the City of Madera requires that existing wells be destroyed per requirements of County Environmental Health Department standards prior to connecting to the City municipal water system (MRGMP, 2014). The MRGMP lists existing related activities as encouraging property owners to abandon wells in accordance with County and State standards. Planned actions listed in the MRGMP included: 1) outreach and education for property owners about well abandonment standards and proper conversion of abandoned wells to monitoring wells; 2) conduct inventory of unused/abandoned wells to identify wells for abandonment or conversion to monitoring wells; and 3) emphasize and promote to the extent possible the conversion of production wells to monitoring wells when appropriate.

2.1.4.5 Replenishment of Groundwater Extractions

The replenishment of groundwater extractions occurs through various forms of recharge. The types and amounts of historical and current recharge are described in detail in Section 2.2.3 (Water Budget Information), and future estimates of recharge are detailed in **Appendix 6.D** (Groundwater Model Documentation). Future replenishment for groundwater extractions that will occur with implementation of PMAs for this Joint GSP are described in detail in Chapter 4.

2.1.4.6 Conjunctive Use and Underground Storage

Historic and current conjunctive use operations in the Plan Area have primarily been conducted by Madera Irrigation District. MID's activities and other Subbasin conjunctive use activities are described in more detail in Section 2.1.2.4 (Conjunctive Use Programs). There have also been recent efforts by Madera Irrigation District, along with some private landowners, to conduct recharge for underground storage during wet years in 2016-17 and 2018-19, and the County and City have both recently partnered with MID to pilot mutually beneficial recharge projects. Planned future conjunctive use and underground storage operations are described in detail in Chapter 4, and simulated by the groundwater model as described in **Appendix 6.D.**

2.1.4.7 Well Construction Policies

Well construction policies are described in Section 2.1.3.3 (Well Permitting Process for Wells in Madera Subbasin).

2.1.4.8 Groundwater Contamination Cleanup, Recharge, Diversions to Storage, Conservation, Water Recycling, and Extraction Projects

Monitoring and remediation of pre-existing and historical groundwater contamination areas are primarily being addressed by various regulatory programs under the RWQCB and DTSC. Various types of projects (e.g., recharge, extraction, diversions) are described in Section 2.2.3 Water Budget Information) and in the Chapter 4 discussion of PMAs. There are no significant water recycling projects in the Plan Area, because such projects are generally not feasible in sparsely populated areas that dominate in the ~~Madera~~ Subbasin. Water conservation projects are covered under Section 2.1.4.9 (Efficient Water Management Practices) below.

2.1.4.9 Efficient Water Management Practices

Water conservation and efficient water management practices are described in Section 2.1.3 (Land Use Elements or Topic Categories in Applicable General Plans). In addition, agricultural irrigation practices have been evolving towards use of more efficient irrigation methods such as drip irrigation and decreased use of less efficient methods such as flood irrigation.

2.1.4.10 Relationships with State and Federal Agencies

The GSAs in the Plan Area have relationships with a number of State and Federal agencies related to surface water supply, water quality, and water management. Madera Irrigation District obtains a portion of its surface water supply from Millerton Lake/Friant Dam via Madera Canal; Friant Dam is owned and operated by the ~~United States Bureau of Reclamation (~~USBR~~)~~. The County holds a contract with USBR for water from Millerton/Friant Dam. The USBR is also the lead agency for the San Joaquin River Restoration Project (SJRRP), which establishes instream flow requirements along the San Joaquin River between Friant Dam and the Merced River to support the life-stages of salmon and other fish species, and consequently requires current and future reductions in surface water diversions for irrigation.[44] The GSAs also apply for and occasionally receive grants from various State/Federal agencies for water-related projects; a current grant being implemented is drilling of several new monitoring wells in the Subbasin to provide better definition of Subbasin geology, water levels, and water quality; and for ultimate incorporation in the GSP monitoring network. The State Regional Water Quality Control Board (RWQCB) provides oversight of contaminant sites within the Subbasin, the Irrigated Lands Regulatory Program, and is considering potential adoption of a Basin Plan amendment related to salt and nutrient management issues. There are many other important GSA relationships with Federal/State agencies, some of which are described throughout this Joint GSP, including in Chapter 5 (Plan Implementation).

[44] The SJRRP develops Allocations and Default Flow Schedules to identify the annual volume of Restoration Flows available. Each year, the amount of water available for the SJRRP – the Restoration Allocation – is adjusted, often many times, between the date of the initial allocation and the final allocation, based on the hydrologic conditions. In May 2019, a Restoration Allocation of over 556,5000 thousand acre-feet (TAF), as measured at Gravelly Ford (GRF), was calculated by Reclamation using the 50% exceedance forecast. For more information, see: http://www.restoresjr.net/restoration-flows/flow-schedule/.

2.1.4.11 Land Use Plans and Efforts to Address Potential Risks to Groundwater Quality and Quantify

Land use plans are described in Section 2.1.3 (Land Use Elements or Topic Categories in Applicable General Plans).

2.1.4.12 Impacts on Groundwater Dependent Ecosystems

Potential impacts to groundwater dependent ecosystems (GDEs) are described in detail in various sections in Chapters 2 and 3, and in **Appendix 2.B**.

2.1.5 Notice and Communication (23 CCR § 354.10)

2.1.5.1 Overview

California's Sustainable Groundwater Management Act (SGMA) of 2014 requires broad and diverse stakeholder involvement in GSA activities and the development and implementation of GSPs for 127 groundwater basins around the state, including the ~~Madera~~ Subbasin. The intent of SGMA is to ensure successful, sustainable management of groundwater resources at the local level. Success will require cooperation by all stakeholders, and cooperation is far more likely if stakeholders have consistent messaging of valid information and are provided with opportunities to help shape the path forward.

To facilitate stakeholder involvement in the GSA process, a Stakeholder Communication and Engagement Plan (**Appendix 2.C.a**) was created for the GSAs in the ~~Madera~~ Subbasin to:

- Provide GSAs, community leaders, and other beneficial users a roadmap to follow to ensure consistent messaging of SGMA requirements and related ~~Madera~~ Subbasin information and data.
- Provide a roadmap to GSAs, community leaders, and other beneficial users to ensure stakeholders have meaningful input into GSA decision-making, including GSP development.
- Ensure the roadmap demonstrates a process that is widely seen by stakeholders as fair and respectful to the range of interested parties.
- Make transparent to stakeholders their opportunities to contribute to the development of a GSP that can effectively address groundwater management within the ~~Madera~~ Subbasin.
- Ensure that information reaches all beneficial users who have an interest in the Basin.

This plan was originally developed in June 2018 and has been updated several times since then.

2.1.5.2 Description of Beneficial Uses and Users in the Basin

Under the requirements of SGMA, all beneficial uses and users of groundwater must be considered in the development of GSPs, and GSAs must encourage the active involvement of diverse social, cultural, and economic elements of the population. Beneficial users, therefore, are any stakeholders who have an interest in groundwater use and management in the ~~Madera~~ Subbasin community. Their interest may be related to GSA activities, GSP development and implementation, and/or water access and management in general.

To assist in identifying categories of beneficial uses and users in the ~~Madera~~ Subbasin, the Communications and Engagement Plan included a Stakeholder Engagement chart (Table 2-5).

2.1.5.3 Communications

Decision-making Processes

As noted above, the ~~Madera~~ Subbasin is divided among seven GSAs for GSP development. Four of the GSAs have jointly developed this coordinated Joint GSP (CM, MC, MID, MWD), while the remaining three GSAs have prepared individual GSPs (GFWD, NSWD, RCWD).

GSA Boards are the final decision-makers for the ~~Madera~~ Subbasin. To assist in GSP development, the GSAs convened a Technical Experts Committee made up of technical experts associated with the various Subbasin GSAs, which met many times over the course of the planning process. In addition to coordinating between the GSAs, the Technical Experts Committee developed recommendations for GSP development which were presented to the GSA boards in public meetings as well as at Subbasin-wide public meetings.

Table 2-5. Stakeholder Engagement Chart for GSP Development.

Category of Interest	Examples of Stakeholder Groups [45]	Engagement purpose
General Public	• Citizens groups • Community leaders	Inform to improve public awareness of sustainable groundwater management
Land Use	• Municipalities (City, County planning departments) • Regional land use agencies	Consult and involve to ensure land use policies are supporting GSPs
Private Users	• Private pumpers (domestic and agricultural) • Domestic users • Schools and colleges • Hospitals	Inform and involve in assessing impacts to users
Urban/ Agricultural Users	• Water agencies • Irrigation districts • Municipal water companies • Resource conservation districts • Farmers/Farm bureaus	Collaborate to ensure sustainable management of groundwater
Industrial Users	• Commercial and industrial self-supplier • Local trade association or group	Inform and involve in assessing impacts to users
Environmental and Ecosystem Uses	• Federal and State agencies: CA Dept. of Fish and Wildlife • Environmental groups: The Nature Conservancy, Audubon California, American Rivers, Clean Water Action/Clean Water Fund	Inform and involve to consider/incorporate potential ecosystem impacts to GSP process
Economic Development	• Chambers of commerce • Business groups/associations • Elected officials (Board of Supervisors, City Council) • State Assembly members • State Senators	Inform and involve to support a stable economy

[45] The groups and communities referenced are examples identified during initial assessment. GSA Interested Parties lists shall maintain current and more exhaustive lists of stakeholders fitting into these groups.

Category of Interest	Examples of Stakeholder Groups [45]	Engagement purpose
Human Right to Water	• ~~Disadvantaged communities~~DACs: Fairmead Community and Friends, La Vina Residents, Líderes Campesinas, etc. • Small water systems • Environmental justice groups/community-based organizations: Leadership Council for Justice and Accountability, Self-Help Enterprises, Community Water Center, etc.	Inform and involve to provide safe and secure groundwater supplies to all communities reliant on groundwater
Tribes	Federally Recognized Tribes and non-Federally Recognized Tribes with lands or potential interests in Madera Subbasin: • North Fork Rancheria of Mono Indians of California • Picayune Rancheria of Chukchansi Indians • North Fork Band of Mono Indians	Inform, involve and consult with tribal government
Federal Lands	• Bureau of Reclamation (USBR) • Bureau of Land Management	Inform, involve and collaborate to ensure basin sustainability
Integrated Water Management	• Regional water management groups (Integrated Regional Water Management (~~(~~IRWM) regions) • Flood agencies • Recycled water coalition	Inform, involve and collaborate to improve regional sustainability

Public Engagement Opportunities

There were a number of different meetings at which the public had the opportunity to engage during the GSP development process:

- **GSA meetings**: Each of the seven[46] GSAs in the ~~Madera~~ Subbasin held regular public meetings, generally on a monthly schedule and in many cases in conjunction with standing board meetings.
- **Coordination Committee meetings:** The intent of the Coordination Committee was to provide a forum to GSAs to share perspectives and participate in review and discussion of elements for GSP development. The Coordination Committee membership included representatives from each of the coordinating GSAs and meetings were often attended by representatives from the other GSAs in the Subbasin.
- **Subbasin-wide technical workshops:** Subbasin-wide public workshops were held throughout the GSP development process to provide opportunities for the public to learn about the SGMA process and GSP components, receive updates about GSP planning activities, and provide input on GSP development. These "technical workshops" often included presentations by the GSP preparation consultants about technical aspects of GSP preparation, on topics such as basin setting, water budgets, and undesirable results. Subbasin-wide public workshops were held in varied locations and at varied hours in order to encourage participation by a wide range of stakeholders. Spanish translation was available at Subbasin-wide workshops. Numerous Subbasin-wide meetings were live-streamed, and summaries of the meetings were posted online so that anyone unable to attend the meeting in person could remain informed about the GSP.
- **County Advisory Committee**: The Madera County GSA was supported by an advisory committee which consisted of members from different demographic groups and communities, including DAC representatives. The Advisory Committee provided feedback on GSP development to the board

[46] All GSAs held public meetings, including the four Joint GSP GSAs that have developed this coordinated Joint GSP and the three GSAs that have developed individual GSPs.

of the Madera County GSA as well as relaying information back to the communities to which the committee members belong. The County Advisory Committee met quarterly in 2018 and bi-monthly in 2019.

- **MID Groundwater Committee**: MID GSA was supported by a groundwater committee comprised of two MID Board Members. The MID Groundwater Committee was utilized to provide input and recommendations to the MID Board of Directors and the MID GSA on matters pertaining to the GSA and GSP planning process. The MID Groundwater Committee meetings were scheduled as needed in 2017-2019.

Figure 2-8 describes the GSP process steps, including topic development, technical review, and public meetings both at the Subbasin and individual level:

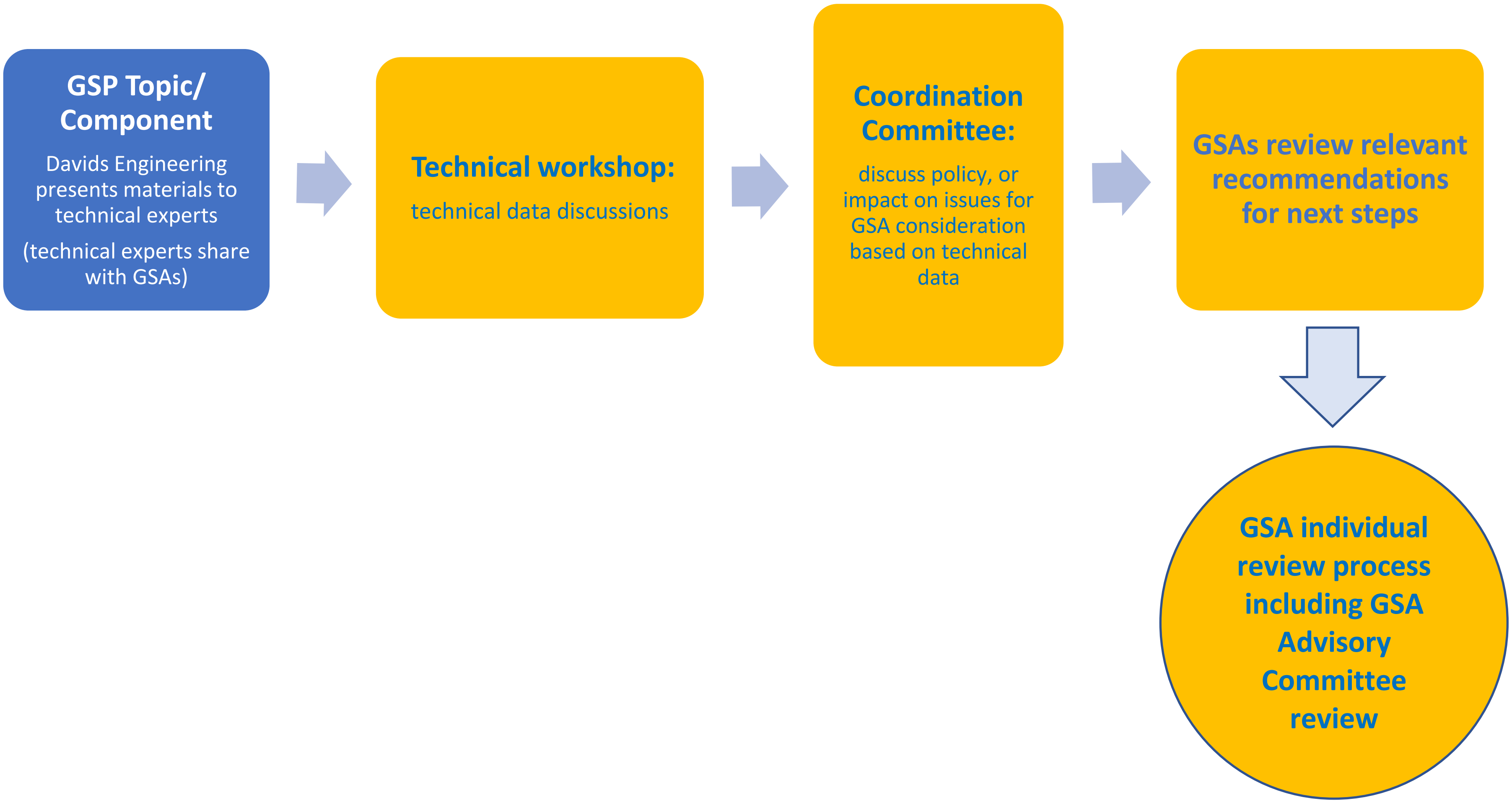


Figure 2-8. Plan Development Sequence (public meetings in yellow).

Encouraging Active Involvement

There were also activities related to encouraging involvement and building capacity for engagement. Madera County worked with Self-Help Enterprises (SHE) and the Leadership Counsel for Justice (LCJA) and Accountability, organizations that represent DAC communities, to inform DAC members about the plan and encourage their involvement. LCJA and SHE were also consulted to help determine how to participate by DAC members in outreach activities, for example by holding workshops at different times or locations. The following activities were organized in coordination with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability:

- **Capacity-building workshops**: Workshops encouraged and prepared community members to participate in GSP development by providing technical information as well as information about opportunities for engagement.
- **Pop-ups**: Information about SGMA and opportunities for engagement in the ~~Madera~~ Subbasin GSP preparation were provided through pop-up information stations in locations such as the Madera County Library to invite people to attend workshops and meetings.
- **Educational tours**: Tours provided members of the public with additional opportunities to hear about the concerns of people with differing perspectives. Tours included stops in the community of Fairmead, La Vina, a farm, and at a groundwater recharge basin.
- **Presentations in communities**: Self-Help Enterprises and the Leadership Counsel for Justice and Accountability both encouraged participation in GSP preparation through presentations held in communities around the Subbasin, including a visit by a Madera County representative.

In addition to the activities organized in coordination with Madera County, these two organizations also conducted further outreach and workshops in the communities they work in. LCJA and SHE each received grants between $750,000 to $1 million from the Department of Water Resources for outreach to promote meaningful participation of ~~S~~DACs in groundwater sustainability activities in multiple subbasins in the state, including the ~~Madera~~ Subbasin. Under the grants, they promoted community participation through community involvement, outreach, and technical assistance. The GSAs provided letters of support for SHE and LCJA's applications for this funding.

Soliciting Written Comments

In addition to soliciting feedback at GSA meetings, ~~an~~ opportunit~~y~~ies ~~was~~ have been provided to offer written comments on the plan~~ via an online comment form or letter~~.

During the initial GSP development process, a~~A~~n informal comment period began when the draft of the first chapter of the GSP was released in April 2019, and an official 90-day comment period began on the date the full draft of the GSP was released, on August 9, 2019, and continued through November 9, 2019. In addition, a special Coordination Committee meeting was held on October 22, 2019 to solicit written comments. All comments received via the comment form or a letter were circulated to the GSAs. The written comments and responses can be found in Appendix 2.C.e of the initial Joint GSP adopted and submitted in January 2020.

During the 2025 Periodic Evaluation and Plan Amendment process, an official 45-day public comment period on Joint GSP 2025 Plan Amendment occurred between November-December 2024. The written comments and responses can be found in **Appendix 2.C.e** of this Joint GSP 2025 Plan Amendment adopted and submitted in January 2025.

2.1.5.4 Informing the Public about GSP Development Progress

Interested Parties List

An email distribution list of Subbasin-wide stakeholders and beneficial users was developed for outreach throughout the GSP planning process. The list was maintained and updated by the County of Madera and is included in **Appendix 2.C.b**. In many cases, information was distributed in both English and Spanish. Any interested member of the public could be added to the list by signing up via the Madera County website: https://www.maderacountywater.com/join-list/.

Distribution of Flyers

Typically, before a public meeting in the ~~Madera~~ Subbasin, a flyer was created with key information provided in both English and Spanish. The flyer was emailed out to the Interested Party list as well as to the GSAs for electronic distribution. The flyer was also handed out at GSA meetings, other public meetings and pop-up events (Figure 2-9).

Press Outreach

Press releases were issued at key junctures and decision-making points for the ~~Madera~~ Subbasin, which included the execution of the Proposition 1 grant agreement, which funded the GSP development and groundwater monitoring wells, and the release of Chapter ~~One~~ 1 of the Madera Joint GSP.

Social Media

Information about the GSP development process, including information about public meetings, has been provided via social media. (See **Appendix 2.C** for details.)

Figure 2-9. GSA Public Event.

A Centralized Madera Subbasin Website

Throughout the planning process (and beyond) the County has maintained a Subbasin website (http://www.maderacountywater.com) with information about the ~~Madera~~ Subbasin-wide planning efforts related to SGMA.

The ~~Madera~~ Subbasin website contains:

- Calendar of public meetings and other events
- Information about past public meetings, including relevant meeting materials
- Links to external sites (e.g., Department of Water Resources SGMA portal) and other resources such as white papers
- Links to the websites of the other ~~Madera~~ Subbasin GSAs
- Information about the County GSAs and Advisory Committee
- GSP documents (Coordination Committee charter, technical memoranda, draft GSP documents)
- GSA fact sheets and Subbasin maps

Engagement Matrix

The Engagement Matrix, in **Appendix 2.C.c**, provides details about the implementation of each of the communication methods outlined above. The matrix presents each communication strategy, as required by statute or laid out in the ~~Madera~~ Subbasin Communication and Engagement Plan, along with details about specific instances of that strategy. For example, each public GSP-related meeting is listed with information about the date, topic, and location of the meeting as well as how it was publicized, to whom it was targeted, what opportunities for feedback were provided, and who participated.

Stakeholder Input and Responses

The engagement opportunities described above provided various avenues for stakeholders to provide input on GSP development. The matrix in **Appendix 2.C.d** summarizes the public comments received, organized by type of water user, and outlines how this input influenced decision-making in GSP development.

Public Outreach During GSP ~~Revision~~ Amendment Process

During development of the January 2025 Plan Amendment ~~for the Joint GSP revision process in 2022-2023during 2024~~, the GSAs conducted further public outreach through public GSA governing body meetings and through various other public meetings with stakeholders.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model (23 CCR § 354.14)

A preliminary hydrogeologic conceptual model (HCM) was developed for the ~~Madera~~ Subbasin (DWR Subbasin No. 5-22.06) based on existing reports/data and published in a previous report (DE/LSCE, July 2017). Various aspects of the preliminary HCM were subsequently updated for GSP efforts, and are documented in this Joint GSP. Overall, this chapter of the GSP provides the updated HCM based on a combination of previous reports/data and recent updated analyses performed as part of GSP preparation efforts. The HCM continues to be reviewed and updated by the GSAs, as is helpful and beneficial (at least every five years as part of a Plan Amendment and/or Periodic Evaluation); Section 2.2.2.7 describes certain data gaps for the HCM and associated uncertainties and has been updated as part of the January 2025 Plan Amendment. Section 4.9.5 describes jointly implemented PMAs, including workplans for subsidence and interconnected surface waters that will help address HCM data gaps.

2.2.1.1 Regional Geologic and Structural Setting

The ~~Madera~~ Subbasin is generally comprised of relatively flat topography that slopes gently downward to the west. Topographic elevations vary from about 350 feet above mean sea level (MSL) in the east to about 150 feet above MSL in the west over a distance of about 20 miles (**Figure 2-10**). The major geomorphic features of the Subbasin are the alluvial fan and floodplain associated with sediment deposition from the Fresno and San Joaquin Rivers (Mitten et al., 1970). A map of hydrologic soil groups in the~~Madera~~ Subbasin is provided in **Figure 2-11**, and a map of soil saturated hydraulic conductivity (K_{sat}) is provided in **Figure 2-12** These maps indicate that soils with higher permeability and infiltration rates are present along river channels (Fresno River, Cottonwood Creek, and San Joaquin River) and west/south of the City of Madera (between the Fresno River and Cottonwood Creek). Another zone of higher soil permeability is present in the south-central portion of the Subbasin between Cottonwood Creek and the San Joaquin River. It should be noted that these soil maps are relatively general in nature, and localized areas of higher permeability/infiltration capacity may exist in areas otherwise indicated to be low permeability/infiltration capacity in these figures and vice versa. In addition, it is recognized that hard pan, which tends to greatly limit infiltration capacity, exists in many areas at depths typically in the range of 5 to 10 feet below ground surface. However, many areas with irrigated agricultural (particularly orchards) have constructed holes through the hard pan to facilitate proper drainage.

Surface geology maps are provided in **Figures 2-13 and 2-14**. The surficial geology of the ~~Madera~~ Subbasin is dominated by Younger and Older Alluvium (generally equivalent to Modesto, Riverbank, and Turlock Lake Formations), which are described in more detail below. Younger Alluvium is most prevalent along the Fresno and San Joaquin Rivers and in an area immediately south and west of the City of Madera.

The Preliminary HCM Report provided some existing geologic cross-sections distributed throughout the Subbasin, which varied considerably in quality and level of detail. In addition, new cross-sections were developed as part of GSP tasks performed subsequent to publication of the Preliminary HCM Report. The existing and new geologic cross-sections are further described in the section below (and in **Appendix 2.D**) on Major Aquifers/Aquitards.

The stratigraphy of the ~~Madera~~ Subbasin from the surface down is comprised primarily of Continental Deposits of Quaternary Age (Younger and Older Alluvium), Continental Deposits of Tertiary and Quaternary age, Marine and Continental sedimentary rocks, and crystalline basement rock. The Continental Deposits are unconsolidated, and underlying sedimentary and basement rocks are consolidated. It is uncertain if Mehrten and Ione Formation are present in the ~~Madera~~ Subbasin. Younger Alluvium is generally limited to 50 feet thickness and typically unsaturated. The Older Alluvium consists of up to 1,000 feet of interbedded clay, silt, sand, and gravel. Older Alluvium becomes finer-grained with depth and is underlain by the generally finer-grained Continental deposits of Tertiary and Quaternary age (Mitten et.al., 1970). The primary water bearing unit is Older Alluvium, although recent deeper drilling of agricultural wells is tapping into the underlying Continental Deposits of Tertiary/Quaternary age (Provost & Pritchard, 2014).

The Corcoran Clay occurs in the western portion of the ~~Madera~~ Subbasin (**Figure 2-15**) within the upper portion of Older Alluvium (Mitten et al., 1970). The Corcoran Clay is also considered to be a member of the Turlock Lake Formation (Page, 1986). The depth to the top of the Corcoran Clay generally ranges from about 150 to 400 feet where present within the ~~Madera~~ Subbasin (Provost & Pritchard, 2014). The extent of the Corcoran Clay was refined within Madera Subbasin based on review of well completion reports and has also been incorporated into the recent MCSim Model update (**Appendix 6.D**). The Corcoran Clay is comprised of clay and silt ranging in thickness (**Figure 2-16**) from 10 feet at its eastern extent to 80 feet on the western edge of Madera County (Mitten et al., 1970).

2.2.1.2 Lateral and Vertical Subbasin Boundaries

The Madera Subbasin is bordered by the Sierra Nevada Mountains to the east, Kings Subbasin to south, Chowchilla Subbasin to the north, and Delta-Mendota Subbasin to the west (**Figure 2-17**). Bedrock to the east represents a hydrogeologic boundary, whereas the other three boundaries are political/agency boundaries across which groundwater flow can and does occur. There is a small amount of fractured bedrock groundwater inflow to the Madera Subbasin on the east.

The base of fresh water was evaluated by Page (1973), and was defined in this study as including water with conductivity up to 3,000 micromhos/centimeter (umhos/cm). Overall, the base of freshwater was mapped as ranging approximately from elevation -400 to -1,200 feet msl within the Madera Subbasin. In general, the shallowest depths to base of fresh water were along the western boundary of the Subbasin, and the greatest depths were areas located just north of the City of Madera in the eastern portion of the Subbasin (**Figure 2-18).** This base of fresh water mapped by Page should be considered approximate and might be expected to be slightly shallower, because fresh water is generally considered to have total dissolved solids of less the 1,000 milligrams/liter (mg/L) or conductivity of less than 1,600 umhos/cm. The base of fresh water will be refined over time as more data are collected, including lithologic, geophysical, water level, and water quality data currently being collected as part of the 2019-2020 nested monitoring well program.

Maps of the depth to basement rock (**Figure 2-19**) and elevation of basement rock (**Figure 2-20**) show increasing depths (and decreasing elevations) to basement rock from northeast to southwest across the Subbasin. The depths to bedrock range from less than 500 feet (essentially zero at the eastern Subbasin boundary) to greater than 4,000 feet at the southwestern boundary of the Subbasin. In general, the aquifer base is controlled mostly by the base of fresh water provided in **Figure 2-18** except in the far eastern portions of the Subbasin. Recent refinements to the elevation basement rock (**Figure 2-20**) were completed in 2024 based on review of DWR AEM data, DWR well completion reports, and geologic maps in the eastern portion of the Subbasin along the Sierra Nevada Mountains. Overall, the depth to bedrock was revised to be shallower throughout the area within about 5 miles of the eastern Subbasin boundary with the Sierra Nevada Mountains. The most significant updates and modifications were made in the vicinity of Highway 41 where bedrock outcrops at the surface (see +500 feet elevation contour on **Figure 2-20**), thereby resulting in a portion of DWR's defined Subbasin that does not contain any unconsolidated sediments. It should also be recognized that wells drilled and screened below the currently defined base of fresh water likely will still have a hydraulic connection with the overlying fresh water zone and are considered part of the Madera Subbasin. While the extent of any extraction from well screens below the base of fresh water is unknown, such extraction is likely negligible given that the TDS at the defined base of freshwater by Page (1973) is relatively high (TDS of approximately 2,000 mg/L) and groundwater exceeding a TDS of 2,000 mg/L exceeds the standards needed for the primary beneficial uses in the basin (e.g., drinking water, irrigation water).

2.2.1.3 Major Aquifers/Aquitards

Geologic cross-sections are a key element of the HCM required in a GSP under SGMA. Related work completed for this Joint GSP included review of existing literature to extract the available geologic cross-sections and construction of additional new geologic cross-sections based on data compiled for GSP efforts. This section of the GSP (and **Appendix 2.D**) provides a general description of the existing and new cross-sections, and documents the source of available existing geologic cross-sections along with details of how the new cross-sections were developed.

2.2.1.3.1 *Existing Geologic Cross-Sections*

The geologic cross-sections derived from previous reports are presented in **Appendix 2.D** and were described in a previous report (DE/LSCE, 2017). Two of these existing cross-sections are described below to provide overall regional context for the stratigraphy of the Subbasin (Davis et al.,1959; Page, 1986). The locations of these two existing geologic cross-sections are provided in **Figure 2-21**, and the individual cross-sections are provided in **Figures 2-22 and 2-23**. A summary of the two regional geologic cross-sections is provided below.

Davis' (1959) cross-section D-D' (**Figure 2-22**) runs from southwest to northeast through the center of the Madera Subbasin, and extends to a depth of about 800 feet below ground surface (bgs). The Corcoran Clay is indicated to be present at an approximate depth of 400 feet bgs at the western edge Madera County, with depth and thickness decreasing towards the northeast (to a depth of about 200 feet at the eastern edge of the clay layer). Sediments consist primarily of sands to sandy clay and silty clay to clay and shale. Layers of gravel are present in the upper 200 feet primarily in the center of Madera County.

Page (1986) cross-section B-B' (**Figure 2-23**) runs northwest to southeast through the western edge of the Madera Subbasin, and extends down to an elevation of 9,000 feet below mean sea level (msl). Within this portion of the Madera Subbasin, the Corcoran Clay is present throughout, at an elevation of approximately -200 feet msl. Thin deposits of Quaternary flood-plain deposits (Qb) are present at the surface, underlain by Quaternary continental rocks and deposits (QTcd). A layer of Tertiary marine rocks and deposits interfinger the QTcd layer. A layer of Pre-Tertiary and Tertiary continental and marine rocks and deposits underlies these units.

2.2.1.3.2 *New Geologic Cross-Sections*

New geologic cross-sections were developed during GSP preparation efforts utilizing data collected for the GSP. A location map for new geologic cross-sections is provided in **Figure 2-21**. The new geologic cross-sections include some that do not cross theMadera Subbasin, but are included here because they occur within the Model Domain for the MCSim Model developed for theMadera Subbasin. The CVHM well log dataset and DWR well log database developed for this project were reviewed to select logs for relatively deep wells that had fairly detailed descriptions of geologic units encountered. Locations for screened well logs were plotted to selected representative well logs at a reasonable spacing along each geologic cross-section line.

New geologic cross-sections C-C', D-D', E-E', and F-F' (**Figures 2-26, 2-27, 2-28, and 2-29**) extend from southwest to northeast across theMadera Subbasin towards (perpendicular to) the Sierra Nevada Mountains, with C-C' being furthest north and F-F' being furthest south. Each cross-section generally shows the ground surface, the lithology associated with each well log, the Spring 2014 unconfined groundwater level, the Corcoran Clay (from C2VSim), and the base of fresh water (from Page 1986). The well logs generally range from very close to section lines to one mile of offset from the section line. The cross-sections generally illustrate the interbedded and variable nature of fine- and coarse-grained sediments both laterally and vertically. In general terms, the cross-sections tend to show a greater percentage of coarse-grained sediments in the upper 200 to 400 feet (Upper Aquifer) as compared to greater depths (Lower Aquifer). This is particularly the case in the central to western portion of the cross-sections, as illustrated in D-D'. Overall, fine-grained sediments comprise a larger percentage of the subsurface than do coarse-grained sediments. Thus, it can be expected that vertical hydraulic conductivity (Kv) values will likely be orders of magnitude lower than horizontal hydraulic conductivity (Kh) values for a given aquifer. Geologic cross-sections C-C' through F-F' also illustrate the extent of Corcoran Clay is limited to the western portion of the Subbasin, although other clay layers are prominent throughout the

Subbasin. New geologic cross-sections A-A' and B-B' (**Figures 2-24 and 2-25**) are included here but not described further as they do not cross the Madera Subbasin.

New geologic cross-sections G-G' through K-K' (**Figures 2-30, 2-31, 2-32, 2-33, 2-34**) were constructed parallel to the Sierra Nevada Mountain front starting from the southwestern northwestern end of the Madera Subbasin and progressing towards the northeast southeast (i.e., cross-section G-G' furthest from and parallel to the Sierra Nevada Mountain front and K-K' is closest to the mountain front). These geologic cross-sections further demonstrate and confirm the features/characteristics described above for the cross-sections perpendicular the Sierra Nevada Mountains. In particular, this set of cross-sections illustrates that general trend of higher percentages of coarse-grained sediments in the upper 200 to 400 feet, and the variability in Page's (1986) map of base to freshwater. While it is challenging to reliably correlate coarse-grained units in these cross-sections, they do illustrate well the general distribution of coarse- and fine-grained sediments both laterally and vertically. The textural analysis described in a subsequent GSP chapter for input to the groundwater model attempts to capture the somewhat disconnected distribution of coarse-grained sediments reflected in the cross-sections.

2.2.1.3.3 *Geologic Cross-Section Summary*

The existing geologic cross-sections provided in Davis et al. (1959) and Page (1986) illustrate the vertical distribution of major geologic formations, but do not provide any detail on distribution of fine- and coarse-grained sediments of the major aquifer units. The new geologic cross-sections generally illustrate in a fairly detailed manner the lateral and vertical distribution of fine- and coarse-grained sediments throughout the Subbasin. It is apparent from these cross sections that the Upper Aquifer (generally the upper 200 to 400 feet) has a higher overall percentage of coarse-grained sediments compared to deeper intervals, although significant coarse-grained intervals are present to the full depths of most borings shown on the cross sections. These cross sections further demonstrate that Kv values are likely to be orders of magnitude less than Kh values.

2.2.1.3.4 *Groundwater System Conceptualization*

The primary water-bearing sediments are comprised of unconsolidated Older Alluvium, which is generally equivalent to the Turlock Lake (oldest), Riverbank, and Modesto (youngest) Formations. The maximum thicknesses of these geologic formations are 800, 200, and 100 feet, respectively (California Division of Mines and Geology, 1962). The Madera Subbasin is underlain by the Corcoran Clay over approximately the western one-third of the Subbasin area. The depth to top of Corcoran Clay varies from 100 to 150 feet at its northeastern extent to in excess of 300 feet in the southwestern portion of the Subbasin (**Figure 2-15**).

Where the Corcoran Clay aquitard exists, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure 2-35**). The upper unconfined and lower confined aquifers in the area where Corcoran Clay is present are defined as principal aquifers in the Subbasin for this GSP. The lateral boundaries of the unconfined upper aquifer and the confined lower aquifer include the extent of the Corcoran Clay on the east, the boundary with Chowchilla Subbasin on the north, and the boundary with Delta-Mendota Subbasin on the west and south. The upper boundary of the unconfined Upper Aquifer is the land surface, although the saturated aquifer upper boundary is at the water table. The confined Lower Aquifer upper boundary is at the base of the Corcoran Clay, and the lower boundary of the unconfined Upper Aquifer is the top of the Corcoran Clay (**Figures 2-15 and 2-16**). The lower boundary of the confined Lower Aquifer is the base of fresh water (**Figure 2-18**).

-In the central and eastern portions of the Subbasin where the Corcoran Clay does not exist, the aquifer system consists of undifferentiated sediments (meaning no continuous aquitard layer is present) and is generally considered to be unconfined. However, it may gradually transition to a semi-confined aquifer at depth with discontinuous ~~clay layers interspersed with~~ more permeable coarse-grained units interbedded in predominantly fine-grained sediments (**Figure 2-35**). ~~For discussion purposes, ~~I~~i~~n the eastern part of the Subbasin, the undifferentiated ~~semi-confined~~ unconfined aquifer is defined as a principal aquifer, and for discussion purposes can be subdivided into an upper unconfined~~semi-confined~~ ~~-~~aquifer and a lower unconfined to semi-confined aquifer at a somewhat arbitrary depth that ranges from 200 to 400 feet bgs (generally corresponding to the depth of Corcoran Clay at its eastern extent). The lateral boundaries of the unconfined undifferentiated aquifer include the Subbasin boundaries on the north (Chowchilla Subbasin), east (Sierra Nevada Mountains), and south (Kings Subbasin), and the extent of Corcoran Clay on the west. The upper boundary of the unconfined undifferentiated aquifer is the land surface, although the saturated aquifer upper boundary is at the water table (**Figure 2-36**). The lower boundary of the unconfined undifferentiated aquifer is the base of fresh water (**Figure 2-18**) or the top of bedrock (Figures 2-19 and 2-20).

In addition to the generally higher percentages of coarse-grained material in the Upper Aquifer, the available cross-sections described above and provided in **Appendix 2.D** generally indicate that approximately the upper 500 feet of the Lower Aquifer are comprised of a greater percentage of coarse-grained sediments as compared to deeper zones within the Lower Aquifer. Thus, it can be anticipated that most wells will obtain close to their maximum yield within approximately the upper 800 feet of sediments. The vast majority of water wells are constructed within the upper 1,000 feet because sediments generally become finer with depth and towards the center of the valley (Provost and Pritchard, 2014).

The general occurrence of higher percentages of coarse-grained sediments at shallower depths is further illustrated by the sediment texture model developed by the United States Geological Survey (USGS) for the Central Valley Hydrologic Model (CVHM). **Figures 2-37~~6~~ and 2-38~~7~~** illustrate the spatial distribution of coarse-grained sediments at 50-foot depth intervals from the ground surface to a total depth of 1,400 feet. These maps indicate percentages of coarse-grained sediments are noticeably greater in the upper 400 feet compared to deeper depths.

2.2.1.4 Aquifer Parameters

A detailed summary of aquifer parameter data derived from existing reports was presented in the Preliminary HCM and is included in **Appendix 2.D**. For Madera County as a whole, the Madera Regional Groundwater Management Plan indicates the Older Alluvium generally has transmissivity values ranging from about 20,000 to 250,000 gpd/ft. Well test data indicate that wells tapping a significant thickness of coarse-grained materials in the upper 500 feet tend to have the highest specific capacities. The underlying Continental Deposits are reported to have transmissivities ranging from 10,000 to 30,000 gpd/ft (Provost and Pritchard, 2014).

Specific yield (Sy) values for Madera County were evaluated in previous studies for use in groundwater storage change calculations (Provost and Pritchard, 2014; Todd, 2002). These county-wide studies used Sy values ranging from 0.10 to 0.13. A study specific to the ~~Madera~~ Subbasin (DWR, 2004) cited a specific yield value of 0.104 for use in calculating total groundwater in storage. Given that sediments generally become finer grained with depth, it is possible that the Sy value from DWR (2004) being on the lower end of the county-wide range is due to evaluation of specific yield to a deeper depth than in the other studies.

As part of recent GSP efforts related to the HCM, DWR well completion reports (WCRs) were reviewed to obtain additional specific capacity data from various wells throughout the ~~Madera~~ Subbasin and the greater model domain. The details of the specific wells, well construction data, and specific capacity data are summarized in **Appendix 2.D**. The specific capacity data were converted to transmissivity values based on methodology developed by Driscoll (1986). Maps of transmissivity (T) values were prepared for the Upper Aquifer (**Figure 2-39~~8~~**), Lower Aquifer (**Figure 2-40~~39~~**), and for composite wells screened in both aquifers (**Figure 2-410**). There are 14 transmissivity values displayed on the map for the Upper Aquifer (**Figure 2-398**) with seven of those wells in the central portion of the Subbasin, two wells in the northwestern part of the Subbasin, and five wells in the southwestern part of the Subbasin. Transmissivity values were quite variable ranging from 25,000 to greater than 100,000 gpd/ft in the central and northwestern Subbasin areas and from less than 25,000 to greater than 100,000 in the southwestern Subbasin area.

The transmissivity map for the Lower Aquifer (**Figure 2-4039**) includes data for 33 wells with clusters of 8 wells in the central portion of the Subbasin, six wells in the north central Subbasin and 19 wells in the northeastern Subbasin area. All three cluster areas showed significant variability in estimated transmissivity values from less than 25,000 to greater than 100,000 gpd/ft. Relative to the Upper Aquifer, the proportion of wells with T greater than 100,000 gpd/ft is substantially less and the proportion of wells with T less than 25,000 is substantially greater.

Tthe map of transmissivity values for 29 composite wells (**Figure 2-410**) shows wells scattered throughout the Subbasin, but most concentrated in the western, central, and southeastern portions of the Subbasin. Most transmissivity values are in the less than 25,000 to 50,000 gpd/ft range, with about 25% of wells having T values greater than 75,000 gpd/ft.

2.2.1.5 Recharge and Discharge Areas

Groundwater recharge can occur throughout the Madera Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources.[47] However, some areas may provide greater potential for existing recharge and future managed recharge that may occur during GSP implementation. Areas with increased recharge potential were evaluated using soil mapping data and the Soil Agricultural Groundwater Banking Index (SAGBI) index. Soils data are evaluated for infiltration potential and categorized into one of four hydrologic groups with hydrologic group A having highest infiltration potential and hydrologic group D having lowest infiltration potential (**Figure 2-11**). The map of hydrologic soil groups shows the main areas with hydrologic group A soils located along and between Berenda and Dry Creeks, and along and between Fresno River and Cottonwood Creek. A relatively large area of hydrologic group A and B soils is located west and south of the City of Madera. There are also small areas of hydrologic group A soils in the southeastern portion of the Subbasin, along the San Joaquin River, and in the far western portion of the Subbasin.

Mapping of saturated soil vertical hydraulic conductivity (K) (**Figure 2-12**) shows a similar distribution of areas with higher infiltration potential as the soil hydrologic group map with a few slight differences. One difference is that about half of the large area hydrologic group A/B soils south and west of City of Madera is indicated to have relatively low soil vertical K of 0.6 to 1.0 feet/day. Also, a relatively large area comprised of hydrologic group C soils in the south central portion of the Subbasin is indicated to have vertical soil K of 1.1 to 2.0 feet/day.

The SAGBI provides a characterization of potential for groundwater recharge on agricultural land. The SAGBI index is based on five main factors: deep percolation, root zone residence time, topography, chemical limitations, and oil surface conditions. The unmodified (by tilling) SAGBI map (**Figure 2-421**) shows the main areas of high deep percolation potential as the region located south and west of the City of Madera, and along Berenda Creek and Fresno River. The modified SAGBI map (**Figure 2-432**) shows

[47] Net subsurface inflows to the Madera Subbasin from adjacent subbasins also contribute to groundwater recharge; however, subsurface inflows and outflows are expected to decline as the Madera Subbasin and adjacent subbasins achieve sustainability.

similar results as the unmodified SAGBI map with addition of a relatively large area in the western portion of the Madera Subbasin.

Another mechanism of groundwater recharge is subsurface inflow from adjacent subbasins, including Kings and Delta Mendota Subbasins. Subsurface groundwater inflows (and outflows) were evaluated with the Subbasin groundwater model and are summarized in **Appendix 6.D.** Groundwater Model Documentation.

Overall, the primary areas with the highest recharge potential occur along rivers/creeks and in the central portion of the Subbasin and along the San Joaquin River, and secondary areas with greater recharge potential occur in the southeastern and western portions of the Subbasin. **Figure 2-443** shows areas of higher recharge potential if defined by mapped soils with relatively high vertical hydraulic conductivities (greater than 2 feet/day).

Under current and recent historical groundwater conditions, the primary groundwater discharge from the Subbasin is groundwater pumping for agricultural, municipal, domestic, and industrial uses. Maps of general locations of domestic, agricultural, and public supply wells are provided in **Figures 2-5, 2-6, and 2-7**. Maps of the average depths of domestic, agricultural, and public supply wells by section are provided in **Figures 2-454, 2-465, and 2-476**. These maps generally indicated the majority of domestic wells are located in the central to eastern portions of the Subbasin, agricultural wells are relatively evenly distributed throughout the entire Subbasin (except in the far eastern portion of the Subbasin where range lands are prevalent and agricultural wells are quite limited),, and public supply wells are concentrated in the central to eastern portions of the Subbasin. While domestic well depths are variable across the Subbasin, shallower wells (less than 300 feet deep) are more common to the west of Highway 99. Similarly, agricultural wells tend to be shallower (less than 500 feet) to the west of Highway 99 and deeper (500 to greater than 750 feet) to the east of Highway 99. The average well depths for domestic and agricultural wells generally reflect the greater depths to water east of Highway 99. A secondary mechanism of groundwater discharge is subsurface outflow to adjacent subbasins, primarily to Chowchilla Subbasin. Subsurface groundwater outflows (and inflows) were evaluated with the Subbasin groundwater model and are summarized in **Appendix 6.D.** Groundwater Model Documentation.

2.2.1.6 Surface Water Bodies and Source/Delivery Points for Local and Imported Water Supplies

The primary surface water bodies within the boundaries of the Madera Subbasin include Berenda Creek, Dry Creek, Fresno River, Cottonwood Creek, San Joaquin River, and Madera Lake. The major reservoirs within the watersheds upstream of the Madera Subbasin include Hensley Lake along the Fresno River and Millerton Lake along the San Joaquin River. These surface water features are shown on several maps describing the HCM (e.g., **Figures 2-10** and **2-13**), and are described in more detail in the subsequent water budget section of Chapter 2. In addition, the sources and delivery points for local and imported water are described in detail in the water budget section.

2.2.2 Current and Historical Groundwater Conditions (23 CCR § 354.16)

2.2.2.1 Groundwater Levels

Considerable historical groundwater level data are available in the Madera Subbasin. These data include water level (i.e., groundwater level) observations in wells and groundwater elevation contour maps prepared by others. Additional groundwater elevation maps and hydrographs were generated to evaluate historical and current groundwater level conditions in the Subbasin. The existing data and maps are described below, along with updated groundwater elevation contour maps and hydrographs prepared as part of this Joint GSP. The discussion of groundwater elevation contour maps focuses on Spring season water levels (as opposed to Fall) to limit influences actively pumping wells may have on interpretations of groundwater conditions. However, available historical Fall groundwater elevation contour maps were compiled and are included in **Appendix 2.E.**

Groundwater Elevation Contours

Maps of groundwater elevation from the early 1900s indicate groundwater flow from northeast to southwest prior to significant development of groundwater in the ~~Madera~~ Subbasin. The western portion of the Subbasin was considered part of an "artesian zone" running through the center of the San Joaquin Valley (Mendenhall, 2016). More recently, groundwater elevation contour maps developed by DWR are available for selected years between 1958 and 1989, and annual maps were published from 1989 to 2011 (**Appendix 2.E**). Groundwater elevation data and GIS data files of groundwater contours are also available from DWR for 2012 to 2016 (**Appendix 2.E**). Although the DWR maps are developed with water level measurements that include wells with unknown construction details, DWR has categorized these groundwater contour maps as being representative of unconfined and semi-confined aquifer groundwater levels across the ~~Madera~~ Subbasin. To evaluate recent groundwater level conditions in the Subbasin, separate groundwater elevation contour maps were prepared for Winter/Spring 1988, Winter/Spring 2014, and Winter/Spring 2016 for unconfined groundwater and for the Lower Aquifer within the extent of the Corcoran Clay. For the purpose of mapping groundwater elevations, the aquifer system in areas outside the Corcoran Clay was treated as a single unconfined groundwater system. In areas within the Corcoran Clay, the aquifer system was separated into an unconfined system above the Corcoran Clay and a confined Lower Aquifer below the Corcoran Clay. Contour maps of the different depth zones are presented and discussed below. Historical groundwater contour maps of unconfined groundwater prepared by others are referenced in the discussion below and are provided in **Appendix 2.E.**

Unconfined Groundwater

Groundwater elevation contour maps of unconfined/semi-confined groundwater from DWR for the late 1950s to early 1980s indicate primarily north or northwest to east or southeast oriented contour lines indicating generally east to west or northeast to southwest groundwater flow directions. Groundwater levels represented on these maps suggest unconfined groundwater elevations ranging from between about 100 and 140 feet msl at the northwestern edge with considerably higher elevations of 300 to 400 ft msl towards the eastern edge of the Subbasin. Groundwater elevations were also typically higher along the Fresno River through the City of Madera and along the San Joaquin River. During this time period, groundwater elevations ranged from about 170 to 220 feet msl near the City of Madera. A relatively consistent pattern of groundwater flow towards the Subbasin from the western edge near the San Joaquin River is apparent in most of the contour maps from the 1950s through early 1980s.

Contours of groundwater elevations in Winter and Spring 1988 (**Figure 2-48~~7~~**) show similar patterns as historical groundwater elevations although several areas of lowered groundwater levels are evident in 1988. An area of locally lower groundwater levels is apparent in **Figure 2-48~~7~~** in the southeastern part of the Subbasin and groundwater flow directions in the northern part of the Subbasin are oriented more northerly towards an area of relatively lower groundwater levels along the northern Subbasin boundary. Locally higher groundwater levels are apparent in 1988 along the Fresno River and east of the City of Madera and along the San Joaquin River. In Winter/Spring 1988 groundwater elevations near the City of Madera are between about 160 and 200 feet msl, slightly lower than during the previous decades. Groundwater elevation contours in the western part of the Subbasin suggest a groundwater flow direction into the Subbasin from the west near the San Joaquin River.

In Winter/Spring 2014, unconfined groundwater elevations in the Subbasin are lower than in 1988 with several groundwater depressions apparent in **Figure 2-49~~8~~**. Although the general prevailing groundwater flow direction remains east to west, a few notable, localized areas of low water levels (i.e., groundwater levels) exist in the Subbasin. These local depressions cause more local variability in the groundwater flow directions including most prominently in the southeastern part of the Subbasin and in the northern part of the Subbasin between the Fresno River and Dry Creek and extending north to the Subbasin boundary. Although more limited water level data are available in Winter/Spring 2016, a contour map of groundwater elevation in 2016 is presented in **Figure 2-5049** for comparison and illustrates similar patterns in groundwater flow and relative elevations. Groundwater elevation contours in the western part of the Subbasin continue to indicate groundwater flowing into the Subbasin from the west near the San Joaquin River in 2014 and 2016. Considerably more groundwater level data are available along the San Joaquin River in 2014 and 2016, in part because of recent monitoring being conducted in association with the San Joaquin River Restoration Program. However, it is worth noting that many of the San Joaquin River Restoration Program monitoring wells are very shallow (less than 50 feet) and exhibit water levels that may be shallower than the regional groundwater system. In evaluating and comparing groundwater level contour maps, it can be difficult to distinguish between influences of the unique water level datapoints used for each contour snapshot from what may be actual differences in water level conditions. Some of the differences in the contour maps for 2014 and 2016 are a result of differences in the spatial distribution of water level datapoints.

Perched Aquifers

The definition of perched groundwater is shallow groundwater present above a low-permeability (e.g., clay) layer with an unsaturated zone present between the perching layer and the regional water table. Perched groundwater has been identified at several sites in theMadera Subbasin from review and comparison of local groundwater level data from several regulated facility sites obtained from Geotracker and regional groundwater level data from CASGEM and other sources (Table 2-6). These regulated facilities have shallow monitoring wells that reflect shallow groundwater conditions that can differ from regional groundwater levels in the deeper zones in which groundwater supply wells are screened. It is likely that other occurrences of perched groundwater exist in the Subbasin, although their existence may not be apparent due to lack of available information on water levels at different depths. From review of available data, documented areas of perched groundwater occur at a site about six miles southeast of the City of Madera at the former MacGillis and Gibbs Pole Treating Facility, at a site within the City of Madera, and also at a site near Fairmead about ten miles northwest of the City of Madera (see Table 2-6). These sites show perched groundwater levels ranging from 3 to 27 feet below ground surface (bgs) southeast of the City of Madera, at about 100 feet bgs within the City of Madera, and between 105 and 130 feet northeast of the City of Madera. The perching layer in these areas is not the regional Corcoran Clay (which pinches out to the west of these sites), but rather more local and discontinuous clay layers. For example, at the MacGillis and Gibbs Pole Treating site, it was noted that, "…perched water occurs as separate water bearing lenses with variable gradients that are not in hydraulic communication with each other…" (TRC, 2015). Based on this review of five regulated facility sites in the Madera Subbasin with sufficient groundwater level data to evaluate perched groundwater conditions and the recognition that three of the five sites indicate the presence of perched groundwater, it is believed that perched groundwater is likely to exist in many other parts of the Subbasin.

Lower Aquifer

Contouring groundwater elevations in the Lower Aquifer is challenging because of combined limited availability of groundwater level data with well construction information and wells screened exclusively in the Lower Aquifer. In contouring groundwater levels in the Lower Aquifer, water levels from wells known to be constructed in the Lower Aquifer and any water levels below the Corcoran Clay (even if well construction is not known) were used for mapping groundwater elevations.

Table 2-6. Summary of Review of Groundwater Levels at Madera Subbasin Geotracker Regulated Facility Sites.

Site Name	Address	Surface Elevation	GW Level Date Range	MW Depth Range	Site Depth to GW	Site GW Elevation	Regional GW Elevation
Madera Airport	4020 Aviation Drive, Madera, CA	245-251	June 1998 to August 2009	160-220	139-207	44-107 (Regional)	60-120
Madera Cleaners	321 South C St., Madera, CA	273-274	Oct. 2006 to May 2010	119-122	100-106	167-174 (Perched)	100
Crop Production Services	24778 Avenue 13, Madera, CA	251-255	Feb. 1998 to Feb. 2018	195-220	116-173	78-139 (Regional)	70-135
MacGillis and Gibbs Pole Treating	Road 32 at Avenue 11, Madera, CA	282-286	Nov. 1998 to June 2015	15-27	3-27	260-280 (Perched)	120-180
		284-287	Nov. 1998 to June 2015	134-140	110-138	147-175 (Regional)	120-180
Fairmead Landfill	21739 Road 19, Fairmead, CA	243-244	Jan. 2005 to June 2018	114-128	105-130	113-139 (Perched)	-50 to 50
		239-252	Jan. 2005 to June 2018	134-210		100-127 (Shallow)	-50 to 50
		238-249	Jan. 2005 to June 2018	214-331		-58 to 53 (Regional)	-50 to 50

A combined dataset of Winter/Spring 1988 and Winter/Spring 1989 water level measurements was used to map Winter/Spring 1988 and 1989 groundwater elevation contours. The limited spatial representation of Lower Aquifer water level data is apparent in **Figure 2-51~~0~~** with only one water level datapoint available in the ~~Madera~~ Subbasin during the 1988 and 1989 time period. With this datapoint, groundwater elevation in the Lower Aquifer was estimated to be around 130 feet msl in Winter/Spring of 1988/1989. The pattern in Lower Aquifer groundwater elevations, including direction of groundwater flow, is difficult to interpret from the few datapoints and limited spatial representation.

More recent groundwater elevation contours for Winter/Spring 2014 and 2016 have greater spatial coverage than the 1988/1989 map, but still have relatively limited point control in the Lower Aquifer within the ~~Madera~~ Subbasin. The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer is presented as **Figure 2-52~~1~~** and indicates Lower Aquifer groundwater elevations of between -20 and 50 feet msl in a small area of the ~~Madera~~ Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 (**Figure 2-53~~2~~**) shows relatively lower groundwater elevations between -10 and -30 feet msl in the Lower Aquifer in the same area near Dry Creek and Fresno River. Farther south, groundwater elevations in the Lower Aquifer in 2016 are higher with elevations of about 60 feet msl. Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in the ~~Madera~~ Subbasin is challenging.

Groundwater Hydrographs

Hydrographs of time-series groundwater level data were reviewed to evaluate long-term trends in groundwater levels. Selected groundwater level hydrographs for unconfined groundwater, Lower Aquifer, and composite wells or wells with unknown construction are presented in **Figures 2-543 to 2-565** to illustrate temporal trends in groundwater levels across the Subbasin. Overall, long-term declines and very steep recent declines (between 2012 and 2016) were prevalent in the northwestern and northeastern portions of the Subbasin. More stable areas of the Subbasin include along the San Joaquin River in the southern portion of the Subbasin and an area extending northwest and across the Subbasin from the San Joaquin River in the western portion of the Subbasin.

Select hydrographs of water levels in the unconfined groundwater (outside the Corcoran Clay or above the Corcoran Clay) are displayed in **Figure 2-543**. All of the hydrographs displayed on **Figure 2-543** exhibit long-term water level declines, with wells in the more eastern parts of the Subbasin having the greatest water level declines. The hydrographs on **Figure 2-543** show groundwater levels with seasonal and year-to-year fluctuations and in some cases a slight downward trend prior to and through the mid-1980s. In contrast, all of the hydrographs on **Figure 2-543** exhibit substantially declining water levels from the late-1980s onward. The wells in the more eastern part of the Subbasin, outside the extent of the Corcoran Clay (10S16E25F002M, 11S17E28A001M, City of Madera 24, 11S20E31P001M, 12S18E13R001M) show groundwater level declines of between 2 and 6 feet per year over the period from the late-1980s through about 2015. The two wells in the more western part of the Subbasin (12S15E11R001M, 12S17E20P001M) have smaller groundwater level declines of between 1 and 2 feet per year over this period.

Select hydrographs of water levels in the Lower Aquifer (within the extent of the Corcoran Clay) are displayed in **Figure 2-554**. As discussed above, the availability of groundwater level data known to be specific to the Lower Aquifer is limited. Only one of the wells (11S16E22K001M) shown in **Figure 2-554** has a period of record sufficiently long to interpret trends in water levels. As with the unconfined groundwater, well 11S16E22K001M exhibits more stable water levels prior to the mid- or late-1980s but exhibits a substantial decline of approximately 150 feet from the late-1980s through 2015 representing an annual groundwater level decline of about 5 feet per year. ~~Although this decline in groundwater level is substantial, it is worth noting that groundwater in the Lower Aquifer can occur under confined conditions.~~

Because of limitations related to available well construction information, there are many wells with long periods of record for water levels but lacking well construction information. Select hydrographs of water levels in wells of unknown construction are presented in **Figure 2-565**. The hydrographs on **Figure 2-565** show groundwater level trends very consistent with those seen in the unconfined groundwater with substantial declines apparent over the time period between the late-1980s and 2015. Trends of more stable water levels, although slightly declining, prior to the mid-and late-1980s are apparent in most wells with greatly increased rates of groundwater level declines over the period from the late-1980s to 2015. The three northern most wells on **Figure 2-565** (11S16E03A001M, 10S18E09C001M, 11S17E16H001M) exhibit the most substantial groundwater level declines with between 100 and 150 feet of decline in groundwater levels between the mid-to late-1980s and 2015. These declines equate to annual rates of groundwater level decline between 3 and 5 feet per year. The groundwater level trends are generally similar in other parts of the Subbasin although the degree of decline is somewhat less.

Additional groundwater level hydrographs are presented in **Appendix 2.E**.

2.2.2.2 Groundwater Storage

Total Groundwater Storage

The total groundwater storage volume within the ~~Madera~~ Subbasin above the basement and base of freshwater is estimated to be between about 13 and 30 million AF based on an analysis using contouring of 2014 groundwater levels and an assumed average specific yield range of 5 to 12 percent. Table 2-7 summarizes the calculations of total groundwater storage in the Subbasin using a range of specific yield values, although recent groundwater modeling conducted to support development of the GSP suggests average specific yield values for the full saturated thickness in the Subbasin (i.e., from the regional water table to the base of fresh water) may be lower than previously estimated and closer to the lower end of the values listed in Table 2-7. In Bulletin 118, DWR previously estimated the total groundwater storage in the ~~Madera~~ Subbasin above the base of freshwater to be about 41 million AF using 1995 groundwater levels and a specific yield value of 10.4 percent. However, DWR's Bulletin 118 estimate was for a larger area of about 394,000 acres compared to the current ~~Madera~~ Subbasin area of a little under 348,000 acres.

Table 2-7. Estimates of Total Groundwater Storage Above Base of Freshwater (as of 2014).

Madera Subbasin Area (acres)	Specific Yield (percent)	Total Groundwater Storage (AF)	Notes on Specific Yield Basis
	5%	12,642,000	
	7%	17,699,00	
	8%	20,227,000	
347,667	10%	25,284,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	10.4%	26,295,000	DWR Bulletin 118
	12%	30,341,000	
	13%	32,869,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)

Change in Groundwater Storage

Based on a comparison of the contour maps of unconfined groundwater elevation for Winter/Spring 1988 and the two more recent contour maps for Winter/Spring 2014 and 2016, changes in groundwater elevation were calculated between 1988 and both 2014 and 2016. **Figure 2-57~~6~~** shows the calculated change in unconfined groundwater levels for 1988 to 2014 and **Figure 2-58~~7~~** presents the calculated change over the period 1988 to 2016. Unconfined groundwater levels declined substantially across much of the ~~Madera~~ Subbasin between 1988 and both 2014 and 2016. The greatest groundwater level declines were in the central and more northern parts of the Subbasin where declines exceeded 150 feet in areas. A majority of the areas within the Subbasin show declines of greater than 50 feet with somewhat larger declines indicated from the comparison of 1988 and 2016 water levels. The areas indicated in **Figures 2-57~~6~~ and 2-58~~7~~** to have increasing groundwater levels are primarily a result of differences in water level data availability between the different time periods and are unlikely to be an indication of actual rising groundwater levels.

The calculated changes in groundwater levels translate to changes in groundwater storage estimated to be about -2.5 million AF between 1988 and 2014 (-94,500 AFY) and about -3.6 million AF between 1988 and 2016 (-130,500 AFY), assuming ~~a range~~ of specific yield value~~s from 8 to 13~~ of 10.4 percent. This calculation, which represents the upper portion of the total saturated sediment thickness in the Subbasin, utilizes ~~a more representative higher range of specific yield values compared to the~~the DWR Bulletin 118 specific yield estimate, which yields the total Subbasin groundwater storage change calculations presented above. ~~These~~ Groundwater storage decreases for a range of specific yield values translate to annual decreases of about -73,000 to -118,000 AFY for 1988 to 2014 and -100,000 to -163,000 AFY for 1988 to 2016~~.~~, as summarized in Table 2-8~~summarizes the calculations of changes in groundwater storage from 1988 to 2014 and 1988 to 2016 under different specific yield values~~.

Table 2-8. Calculated Change in Groundwater Storage.

Analysis Time Period	Specific Yield (percent)	Total Groundwater Storage Change (AF)	Average Annual Groundwater Storage Change (AFY)	Notes on Specific Yield Basis
Change 1988 to 2014	8%	-1,891,308	-73,000	
	10%	-2,364,136	-91,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	10.4%	-2,458,701	-94,500	DWR Bulletin 118
	12%	-2,836,963	-109,000	
	13%	-3,073,376	-118,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)
Change 1988 to 2016	8%	-2,809,149	-100,000	
	10%	-3,511,437	-125,500	2002 AB3030 Madera County GMP value (Todd Engineers)
	10.4%	-3,651,894	-130,500	DWR Bulletin 118
	12%	-4,213,724	-150,500	
	13%	-4,564,868	-163,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)

Previous estimates of groundwater storage change for Madera County include DWR (1992), Todd (2002), and Provost & Pritchard (2014). DWR (1992) estimated groundwater storage decline from 1970 to 1990 to be 74,115 AFY. Todd (2002) calculated a groundwater storage decline of 68,338 AFY for the period from 1990 to 1998. The most recent of these evaluations of groundwater level and storage change is included in the 2014 Groundwater Management Plan (Provost & Pritchard, 2014), and covers the time period from 1980 to 2011. In general, groundwater levels declined between 30 and 150 feet throughout Madera County, or an average of 1 to 5 feet per year. Groundwater storage change was not quantified by subbasin. For the Madera County area included in the plan (not including areas of Root Creek Water District, Madera Water District, Aliso Water District, or Columbia Canal Company) studied in 2014 (plus the area of Merced County included in Chowchilla Water District), groundwater storage between 1980 and 2011 was estimated to have declined at an average rate of 143,000 AFY, which equates to a total decline of 4.4 million AF over the 31-year period.

2.2.2.3 Groundwater Quality

Maps of available groundwater quality data for a variety of constituents were prepared to characterize groundwater quality in the Subbasin. Key groundwater quality constituents discussed below include nitrate, total dissolved solids (TDS), and arsenic. These constituents have greater potential for presenting broader regional groundwater quality concerns extending beyond localized or site-specific contamination cases and are likely to reflect a range of potential contamination sources. A variety of maps of other groundwater quality constituents are included in **Appendix 2.E** and highlight local areas of groundwater quality contamination that are important for consideration when evaluating GSP-related PMAs and their potential to have adverse groundwater quality impacts.

Nitrate is one of the most common groundwater contaminants and is generally the water quality constituent of greatest concern in agricultural areas where application of fertilizers containing nitrogen can lead to elevated nitrate levels in groundwater. Additionally, nitrate is a constituent of concern in groundwater near dairy or other large-scale livestock operations. Natural concentrations of nitrate in groundwater are generally low, and elevated levels usually indicate impacts from land use activities. Nitrate presents health concerns at high concentrations and is regulated in public drinking water systems.

The U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) for nitrate (as nitrogen) of 10 mg/L under its National Primary Drinking Water Regulations; this MCL standard is established for public health reasons and is a requirement of all public drinking water systems. Total Dissolved Solids (TDS) is a general measure of salinity and overall water quality. Elevated salinity in groundwater can be a result of land use activities, but can also be naturally-occurring, especially in western parts of the San Joaquin Valley where subsurface geologic materials are derived from marine sediments. Arsenic is a naturally occurring chemical found in groundwater and has a primary MCL of 10 micrograms/liter (µg/L).

Additional maps of other groundwater quality constituents are presented in **Appendix 2.E** including maps of select chemicals typically found associated with point-source contamination including hydrocarbon products and pesticides. Several studies and maps of regional groundwater quality have also been prepared in recent years, and some of these maps are included in **Appendix 2.E**. Work for CV-SALTS (LSCE and LWA, 2016) evaluated ambient TDS and nitrate concentrations for the period 2000 to 2016 in the upper and lower zones within the Upper Aquifer. LSCE (2014) conducted groundwater quality mapping for the San Joaquin Valley for various constituents including TDS, nitrate, arsenic, vanadium, uranium, DBCP/fumigants, herbicides, solvents, and perchlorate. Maps of TDS and nitrate from the Groundwater Quality Assessment Report prepared for the East San Joaquin Water Quality Coalition (LSCE, 2014) presents groundwater quality data delineated by shallow and deep wells. Although the maps were not necessarily aquifer specific (shallow wells were distinguished from deeper wells for this study primarily based upon well use type), they do illustrate general concentrations in wells across the Subbasin. Other mapping of regional groundwater quality was included in the Regional Groundwater Management Plan (Provost & Pritchard, 2014). Typically, the major considerations for municipal/domestic and agricultural use with respect to groundwater quality include salinity (specific conductance, TDS), nutrients (nitrate), and metals (arsenic, manganese). For the purposes of their groundwater quality evaluation, Provost & Prichard (2014) defined shallow wells (0 to 400 feet), intermediate wells (400 to 600 feet), and deep wells (greater than 600 feet deep). This depth classification differs slightly from how groundwater conditions are represented in the HCM as defined in this Joint GSP, and is utilized only for the discussion of groundwater quality in this section. Groundwater quality maps from previous reports are provided in **Appendix 2.E.**

Groundwater quality data for other constituents as presented in published reports, particularly data from the USGS Groundwater Ambient Monitoring and Assessment (GAMA) Program investigations conducted for the area, are also presented in **Appendix 2.E.**

2.2.2.3.1 *Total Dissolved Solids*

Maps of maximum historical TDS concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) in the ~~Madera~~ Subbasin (**Figures 2-5~~9~~8 to 2-6~~1~~0**) indicate relatively low salinity groundwater quality across most of the Subbasin with maximum historical TDS concentrations less than 500 milligrams/liter (mg/L) in most places. Wells with maximum historical TDS concentrations greater than 750 mg/L exist scattered across the Subbasin and a relatively small number of wells with maximum TDS concentrations above 1,000 mg/L located mainly in the far western parts of the Subbasin. Higher TDS concentrations in the western part of the Subbasin may be caused by natural salinity present in groundwater occurring within Coast Range derived sediments of marine source material. Otherwise, there are no widely apparent and consistent spatial patterns in concentrations, although the wells exhibiting higher TDS concentrations above 1,000 mg/L are screened in the Upper Aquifer (**Figure 2-60~~59~~**).

Regional groundwater quality mapping of TDS concentrations was conducted for the CV-SALTS project (LSCE and LWA, 2016). These analyses for the upper zone (of the Upper Aquifer) showed generally increasing TDS from east to west across the Madera Subbasin. TDS concentrations ranged from less than 250 mg/L in the east to greater than 1,000 mg/L in the southwestern corner of the Subbasin. Analyses of the lower zone (of the Upper Aquifer) showed a similar pattern of increasing TDS from east to west, but with a smaller area of high TDS groundwater (**Appendix 2.E**).

2.2.2.3.2 *Nitrate*

Maps of maximum historical nitrate concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) are presented in by different well depth zone or other classification **Figures 2-621 to 2-643**. These maps highlight patterns in historical maximum nitrate concentrations across the Subbasin. A large percentage of the wells with nitrate data have maximum historical concentrations below 7.5 mg/L and many have concentrations below 5 mg/L. However, a number of areas of locally high maximum nitrate concentrations above 7.5 mg/L or above 10 mg/L are apparent across the Subbasin. The higher concentrations appear to be more common in the more western parts of the Subbasin. One particular area with a high density of wells with nitrate concentrations above the MCL of 10 mg/L (as N) is located in the western part of the Subbasin along Highway 145, directly south of where Dry Creek joins the Fresno River (**Figure 2-621**). Some of the clusters of wells with high nitrate concentrations are known to be associated with regulated facilities and contamination remediation sites. Most of the higher concentrations are from wells with unknown construction information, although maps of nitrate concentrations by depth zone indicate more wells known to be screened in the Upper Aquifer with higher concentrations than in the Lower Aquifer.

Regional mapping of nitrate concentrations in groundwater were also performed as part of the CV-SALTS project (LSCE and LWA, 2016). Maps of nitrate TDS concentrations in the upper zone (of the Upper Aquifer) showed a small area exceeding the MCL of 10 mg/L (as N) in the northwestern part of the Subbasin, while nitrate in the lower zone (of the Upper Aquifer) was indicated to exceed 10 mg/L in a similar but somewhat larger area in (compared to upper zone of Upper Aquifer) the northwest portion of the Subbasin (**Appendix 2.E**).

2.2.2.3.3 *Arsenic*

Maps of maximum historical arsenic concentrations in groundwater by principal aquifer (where screen intervals are known and limited to either Upper or Lower Aquifer) and overall (all wells including wells with unknown screen intervals and composite wells with well screens spanning both aquifers) are presented in **Figures 2-654 to 2-676**. Although there are wells with high arsenic concentrations scattered throughout the Subbasin, they are more common in the eastern part of the Subbasin. Most of the wells with maximum arsenic concentrations above the MCL of 10 µg/L are located northeast of Highway 99. Although a number of wells exhibit maximum concentrations above the MCL, the dominant fraction of wells with maximum arsenic concentrations are below 5 µg/L with many or most of these wells having concentrations below 2.5 µg/L. Few wells known to be screened in the Upper Aquifer (**Figure 2-665**) have elevated concentrations and a higher number of wells known to be constructed in the Lower Aquifer (**Figure 2-676**) have maximum concentrations above the MCL, although most wells of the identified Lower Aquifer wells have maximum concentrations below 5.

2.2.2.3.4 *Other Groundwater Quality Constituents*

Maps of a variety of other groundwater quality constituents are presented in **Appendix 2.E**. Many of these maps highlight distinct areas of local groundwater contamination or groundwater constituents that should be considered when evaluating potential groundwater quality impacts from implementation of PMAs to achieve sustainability. Wells with exceedances for a variety of constituents, including anthropogenic contaminants like pesticides, solvents, and petroleum-related chemicals, are displayed in maps in **Appendix 2.E**. Most notably, maps of DBCP, EDB, 1,2,3-TCP, perchlorate, PCE, and BTEX concentrations all indicate areas with wells exceeding the respective drinking water MCLs. Naturally occurring constituents such as uranium and manganese are also elevated in some wells with high uranium concentrations more apparent in the western part of the Subbasin and high manganese concentrations more common in the eastern parts of the Subbasin.

2.2.2.4 Land Subsidence

Recent land subsidence has been a major concern in the northwestern portion of Madera County, primarily impacting the western portion of the adjacent Chowchilla Subbasin. However, there has also been some recent subsidence occurring within the ~~Madera~~ Subbasin.

2.2.2.4.1 *Subsidence Mapping Data*

A map of subsidence that occurred between 1926 and 1970 shows a maximum of 1 to 2 feet of subsidence in the northwestern portion of the ~~Madera~~ Subbasin (**Figure 2-68~~7~~**). Subsidence mapping using InSAR data for the 2007 to 2011 time period (based on unpublished data from NASA-JPL, as published in LSCE~~,~~ et~~.~~ al., 2014) is shown in **Figure 2-69~~8~~**. A maximum subsidence of 0.5 to 1 foot for this time period occurred in the northwest part of the ~~Madera~~ Subbasin. ~~The most recent~~A map of subsidence that occurred between 2015 and 2017 (**Figure 2-70~~69~~**) shows 1.0 to 1.5 feet of subsidence adjacent to and north of the Fresno River in the northwestern portion of the Subbasin. Overall, the available subsidence maps for the three time periods show up to approximately three feet of subsidence in some areas of northwestern Madera Subbasin ~~since~~ from 1920 through 2017. Specific subsidence monitoring locations are shown in **Figure 2-71~~0~~**, which shows a relatively continuous monitoring record of subsidence at seven locations in the Subbasin between 2011 and 2017. Review of the subsidence monitoring location records (through 2017) indicate up to two feet of subsidence along the northwestern Subbasin boundary with Chowchilla Subbasin.

Other mapping of subsidence is included in **Appendix 2.D**. In northwest Madera Subbasin, subsidence from 2008 to 2010 was less than one foot. Mapping by USBR between July 2012 and December 2016 showed total subsidence ranging up to two feet in northwest Madera Subbasin. Various ongoing subsidence monitoring programs are being funded and/or conducted by DWR, USGS, USBR, and the National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA-JPL). Additional and post 2017 subsidence data are provided in Annual Reports and the Periodic Evaluation.

2.2.2.4.2 *Relationships Between Groundwater Levels and Subsidence*

Subsidence in the San Joaquin Valley has been attributed to groundwater level declines (and associated reduced pore pressure) within the groundwater system at depths below the Corcoran Clay in the Lower Aquifer. This association between conditions in the Lower Aquifer and subsidence has been observed nearby in the vicinity of Mendota in data from extensometer and continuous GPS monitoring coupled with groundwater level monitoring. This data suggests that most of the subsidence in the area is occurring at depths below the Corcoran Clay and correlates with declining groundwater levels in the Lower Aquifer (LSCE, 2015). This relationship has also been observed in other parts of the San Joaquin Valley (Lees et al., 2022) and has been attributed to a combination of the confined conditions in the Lower Aquifer in which small changes in storage can translate to large pressure changes along with the presence of a higher fraction of fine-grained sediments.

There is limited historical data available for the Subbasin with which to evaluate the relationship between subsidence and water levels. Spatial subsidence data are available from 2012 through present, but very limited data exist prior to 2012 in the Subbasin and most data for the period since 2012 are not available as continuous data. Most available time-series subsidence monitoring in the Subbasin started in 2012 as part of USBR monitoring associated with the SJRRP. InSAR data has been available from DWR since 2015 and is used in evaluating current and ongoing subsidence conditions in the Subbasin. Furthermore, long-term groundwater level data for comparing with subsidence monitoring data are also limited in availability and often have not occurred at or near the same locations as historical subsidence monitoring. Together, the limited availability of wells with long-term historical groundwater level monitoring data and the absence of known construction information in the vicinity of locations where historical subsidence monitoring has occurred, make comparisons between historical water levels and subsidence challenging.

Using the limited available data, to evaluate the relationship between groundwater levels and subsidence, time-series point data available from SJRRP benchmarks were compared with water levels in nearby wells with historical water level monitoring. **Figure 2-7210** presents a map with callout graphs illustrating time-series subsidence and water level data at paired SJRRP subsidence benchmark locations and nearby wells. Many wells have limited construction information for confirming their depth and screened interval, and there are a range of relationships between groundwater levels and subsidence are apparent in the graphs on **Figure 2-7210**, which vary by location and well depth. Some of the graphs in **Figure 2-7210** indicate groundwater levels declining in the Lower Aquifer and continued subsidence over the same period, suggesting that declining Lower Aquifer water levels may be related to ongoing subsidence. However, many other graphs indicate that subsidence has continued even during periods when water levels in the Lower Aquifer have remained stable or recovered, potentially indicating that ongoing subsidence is not a result of current declines in groundwater levels in the Lower Aquifer.

Additional comparison of water levels and subsidence were conducted by extracting time-series subsidence data from the InSAR dataset at points where existing historical water level monitoring has occurred, although the length of the historical monitoring record (only since 2016) and temporal resolution of the InSAR subsidence data are limited. Raster data from the InSAR data were extracted at points for selected wells chosen based on period of record, availability of construction data, and location within areas of interest for subsidence. **Figure 2-7210** presents a map of the locations where these comparisons were made with graphs comparing groundwater level and subsidence trends. Because of the limited period of record for these comparisons, it is difficult to identify any strong associations between water levels and subsidence. While some locations exhibit apparent relationships between declining water levels and the rate of subsidence, many other locations suggest there is no clear relationship between water levels and subsidence. Notably, subsidence continues even when water levels are stable or recovering at many locations. Such continued subsidence during periods when Lower Aquifer water levels remain stable may be a result of the delayed effects of residual subsidence caused by historically low groundwater levels that are not mitigated by the more recent stabilization or raising of groundwater levels. Residual subsidence resulting from historical conditions has been observed in many areas of the San Joaquin Valley and is discussed below.

2.2.2.4.3 *Residual Subsidence Resulting from Historical Conditions*

The theory of subsidence suggests that when regional groundwater levels reach a historical low point and subsidence occurs, future subsidence will not occur unless those historical lows are exceeded. However, it takes time for all the subsidence to occur in association with a low point in groundwater levels (often referred to as preconsolidation head), which is known as the subsidence lag time. The lag time may be several years to decades in some cases; therefore, it has often been observed that additional subsidence occurs even prior to the historical low point being exceeded. This is referred to as residual subsidence.

DWR defines active subsidence as being caused by, "…direct pumping and groundwater overdraft" and residual subsidence as, "…additional subsidence that occurs after the time of groundwater overdraft, as water pressures slowly reach equalization or drain in the clays that are being overdraft." (DWR, 2017). LSCE, et.al. (2014) notes that, "Residual compaction may continue long after water levels have stabilized in the aquifers." For example, in the Antelope Valley, residual compaction in thick low permeability clay layers was still occurring in the 1990s from large regional groundwater level declines that occurred between 1950 and 1975.

The 2017 DWR study notes that with construction of the California Aqueduct and delivery of surface water to replace groundwater pumping in the late 1960s, groundwater levels in some areas recovered as much as 200 feet (from up to 400 feet of decline) in the deep aquifer system. However, land subsidence continued to occur at a lesser rate than before the aqueduct went into service even though groundwater levels were recovering. This phenomenon was attributed to time delay in compaction of aquitards, which take more time to equilibrate their pore-fluid pressures with pressure changes occurring in aquifers. The lag time for equilibration of aquitard pore pressures depends on aquitard thickness and permeability (thicker and less permeable aquitards take longer to equilibrate). DWR notes it may take decades to centuries for some aquitards to equilibrate.

In terms of the relationship between groundwater level declines and subsidence (during the active subsidence phase), DWR notes the ratio varies from 8 to 25 feet of groundwater level decline being equal to one foot of subsidence throughout the San Joaquin Valley. The center of subsidence area west of Fresno had a ratio of one foot of subsidence per every 16 feet of groundwater level decline. A study cited by DWR (USBR, 1963) estimated residual subsidence rates to be 10 percent of active subsidence rates.

Subsidence data in the Subbasin indicated that rates of subsidence during the 2012 to 2015 drought ranged from 0.15 to 0.35 feet/year. In the years from 2017 to 2021, subsidence rates were approximately 0.1 to 0.25 feet/year in the northwest area, while subsidence rates in the central and southwest Subbasin were approximately 0.0 to 0.25 feet/year.

Based on review and comparison of available groundwater level and subsidence data in the Subbasin, establishing definitive relationships between groundwater levels and subsidence is challenging with the limitations of currently available data.

A study conducted by Lees et.al. (2022) provides some insights regarding overall subsidence and especially residual subsidence (referred to as deferred subsidence in this study) in the San Joaquin Valley over the past 65 years. The study uses a one-dimensional aquitard drainage model to evaluate the relationship between groundwater level fluctuations and subsidence over time near Hanford, California, including rates of subsidence during past time periods with declines in groundwater levels (i.e., periods of active subsidence) as well as rates of subsidence during times of stable to increasing groundwater levels (i.e., periods of residual subsidence). The study notes that while the modeling results reported in this study are specific to an area near Hanford, their modeling results can be generalized to evaluate subsidence at other locations within the San Joaquin Valley. The study also notes that significant subsidence occurred in San Joaquin Valley between the 1920s and 1970 with modeled subsidence rates of between 0.3 and 1.0 feet/year in the 1950s and 1960s. After 1970 the increased availability of surface water reduced rates of subsidence to near zero (0.03 feet/year) by 1987. However, another cycle of groundwater level declines occurred during the drought of 1987 to 1992 with subsidence rates increasing back up to 0.5 feet/year, followed by groundwater level recovery after 1992 with subsidence rates falling to 0.1 feet/year by 1999.

Additional cycles of declining groundwater levels and increasing subsidence occurred after 2000 as follows: 2001-2004 (subsidence rates up to 0.5 feet/year in 2004); 2007-2009 (subsidence rates up to 0.55 feet/year in 2009), and 2012-2015 (subsidence rates up to 1.2 feet/year in 2015). Intervening cycles of stable to increasing groundwater levels during 2005-2006 and 2010-2011 resulted in lower rates of subsidence, with a final cycle of groundwater level recovery in 2016-2017 that reduced subsidence rates to 0.45 feet/year in 2017. The study notes that the residual (deferred) subsidence rate of 0.45 feet/year in 2017 was as large as peak (active) subsidence rates during the 1987-92 and 2001-2004 periods of declining groundwater levels. The study suggests that the relatively high rate of residual subsidence observed in 2017 is due to the cumulative effect of repeated cycles of groundwater level declines (active subsidence) since the 1940s that resulted in incremental amounts/rates of residual subsidence being carried forward into the future from each cycle of groundwater level decline. Thus, the residual subsidence rate observed in 2017 encompasses a certain amount/rate of residual subsidence still remaining in the aquitard system from previous cycles of groundwater level decline that occurred in the 1950s/1960s, 1987-1992, 2001-2004, 2007-2009, and 2012-2015.– Overall, the modeled residual subsidence rates increased from 0.03 feet/year after 1970 to 0.16 feet/year after 2009 and then to 0.46 feet/year after 2015.

Modeling conducted for this study by Lees, et.al. (2022) also concluded that the proportional compaction of clay layers causing subsidence prior to 1980 was distributed approximately as follows: 70% in the Lower Aquifer, 20% in the Upper Aquifer, and 10% in the Corcoran Clay. The proportional distribution of compaction in clay layers changed after 1980 to approximately 90% in the Lower Aquifer and 5% each in the Upper Aquifer and Corcoran Clay. These study results indicate the great majority of subsidence is due to compaction of clay layers in the Lower Aquifer system and only small amounts of subsidence are due to compaction of the Corcoran Clay, which is consistent with previous extensometer and numerical modeling studies by others.

Another significant conclusion of Lees, et.al. (2022) was that the effective time constant that characterizes the time scale for head propagation through an aquitard (and hence aquitard compaction) ranges from 60 to 1,300 years. The authors concluded that given the thick aquitards and clay interbeds prevalent throughout the San Joaquin Valley, time scales on the order of decades to centuries are needed to characterize compaction and subsidence in this area.

It is useful to compare estimates of residual subsidence from the two studies by DWR (2017) and Lees et al. (2022) with subsidence data in the Subbasin since 2012. The residual subsidence rate of 10% of the active subsidence rate cited in the DWR study is consistent with the residual subsidence rate cited in the study by Lees et al. after the first cycle of active subsidence ended in 1970. However, the Lees et al. study includes more detailed evaluation of groundwater level and subsidence data since 2000 relative to characterizing residual subsidence rates than is included in the DWR study, and indicates that rates of residual subsidence (relative to active subsidence) have increased significantly since 2000. Comparison of the subsidence rates cited by Lees et al. in 2017 (0.46 feet/year) compared to 2012 to 2015 (1.2 feet/year) yield a residual subsidence rate of 38% of the active subsidence rate.

2.2.2.5 Groundwater - Surface Water Interaction

The primary surface water features in the ~~Madera~~ Subbasin are the Berenda Creek, Dry Creek, Fresno River, Cottonwood Creek, and San Joaquin River (**Figure 2-11**). Each of these streams is considered to be a source of recharge in the Subbasin, while also acting as conveyance features for local GSAs. A review of historical regional aquifer groundwater elevations compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study show groundwater elevations well below stream thalwegs (greater than 30 to 50 feet bgs) and indicate that surface water – groundwater interactions do not occur (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Berenda Creek, Dry Creek, the Fresno River, and Cottonwood Creek in the ~~Madera~~ Subbasin. However, comparison of historical groundwater and stream thalweg elevations suggest the San Joaquin River along the southern subbasin boundary was likely connected with groundwater over the period of available data from 1958 through 1984. Groundwater levels were generally below (and apparently disconnected from) the San Joaquin River by about 10 to 50 feet from 1989 through 2016 based on this analysis, which involved use of regional groundwater elevation contour maps for the "Unconfined Aquifer" prepared by DWR for the following years: Spring 1958, Spring 1962, Spring 1969, Spring 1970, Spring 1976, Spring 1984, and Spring 1989 through Spring 2011 (**Appendix 2.E**), and groundwater elevation contour maps for Spring 2014 and 2016 (**Figures 2-49~~8~~ and 2-50~~49~~**).

Maps of depths to shallow groundwater for 2014 and 2016 are displayed on **Figures 2-73~~1~~ and 2-74~~2~~**. These maps incorporate very shallow monitoring wells (i.e., less than 50 feet deep) not included in regional groundwater elevation contour mapping described above, including San Joaquin River Restoration Project (SJRRP) wells (many of which have well screens in the upper 30 feet) However, groundwater levels reflected in these very shallow wells may not be representative of conditions in the regional groundwater system. Depth to shallow groundwater maps were generated by contouring groundwater surface elevation and subtracting the contoured water surface from the ground surface elevation as represented by the USGS National Elevation Dataset Digital Elevation Model. Some of the areas on the southern and southwestern boundaries of the ~~Madera~~ Subbasin and along/adjacent to the San Joaquin River may be underlain by shallow clay layers that are above the principal aquifers in the area. Shallow groundwater in these areas can likely be considered mounded in that shallow clay layers help to maintain shallow groundwater levels regardless of whether or not an unsaturated zone exists beneath them as occurs in a truly perched groundwater condition as described above in Section 2.2.2.1 (Groundwater Levels). It is likely that seepage from the San Joaquin River is the source of water combined with presence of shallow clay layers, which serves to maintain shallow groundwater levels at these locations. While groundwater levels in this perched zone appear to be approximately 10 to 30 feet below ground surface, water levels in the underlying regional groundwater system are typically much deeper, in excess of 50 feet below ground surface.

Figures 2-73~~1~~ and **2-74~~2~~** illustrate how the San Joaquin River is disconnected from the shallow perched/mounded zone in most areas during these time periods. Shallow groundwater along uppermost reaches of the San Joaquin River is located to the east and northeast of a bedrock outcrop (**Figure 2-14**), and is somewhat isolated from the rest of the subbasin by the bedrock outcrop. The depth to bedrock beneath this portion of the San Joaquin River adjacent to the Sierra Nevada Mountains is relatively shallow. Review of the limited number of DWR well completion reports (WCR) that are available for this area indicate depth to bedrock ranging from 45 to 75 feet bgs from north to south along the San Joaquin River from just below Friant Dam to a point about four miles downstream of the dam. The combination of shallow depth to bedrock beneath the San Joaquin River (45 to 75 feet bgs), bedrock occurring at the surface one to two miles west/southwest of this area of relatively shallow groundwater, and seepage along the San Joaquin River of releases from Millerton Lake accounts for the shallow occurrence of groundwater at this location. Therefore, regional groundwater pumping is unlikely to have a significant effect on groundwater levels in this area. The presence of shallow groundwater at this location shown on **Figures 2-73~~1~~** and **2-74~~2~~** is inferred from groundwater levels in nearby areas, topographic slope, and groundwater model results. Review of the limited number of available DWR well logs for wells in this area indicated depths to water ranging from 22 to 39 feet bgs for dates ranging from May 1960 to September 1979 (at the time of well installation). Part of the GSP Implementation Plan will be to further investigate existing wells in this area for verifying presence of shallow groundwater (i.e., less than 30 feet bgs) and inclusion of a well as a RMS, if necessary. However, review of groundwater elevation hydrographs for wells screened in the Upper Aquifer (see Sections 3.2.5 and 3.3.5) indicate that there may be some connection between shallow groundwater levels and the San Joaquin River during certain time periods (e.g., wet season of wet years).

The relationship between stream seepage in the San Joaquin River along the southern boundary of the ~~Madera~~ Subbasin and groundwater pumping along this portion of the San Joaquin River within the ~~Madera~~ Subbasin (i.e., within approximately 0.75 miles of the San Joaquin River) is shown in **Figure 2-75~~3~~**. The relationship between groundwater pumping within five miles of the San Joaquin River and stream seepage is shown in **Figure 2-76~~4~~**. These figures suggest that at the highest end of the range of groundwater pumping (over 16,000 AFY in **Figure 2-75~~3~~** and over 200,000 AFY in **Figure 2-76~~4~~**), stream seepage increases with increased groundwater pumping. However, at the low to mid-range of groundwater pumping, the relationship is inconsistent. The highest amounts of groundwater pumping generally occur during drought periods when groundwater recharge is less, groundwater levels are lower, and groundwater would not be expected to be connected to the steam bed. In non-drought periods, when groundwater levels are higher and possibly connected to the streambed, there appears to be no strong relationship between groundwater pumping and stream seepage. Additional evaluation of this relationship in the field and in the groundwater model ~~will~~ may be conducted and reported in future Joint GSP Periodic Evaluations and associated Plan Amendments, as applicable. The relationship between streamflow entering the Subbasin at the upstream boundary of this river reach and stream seepage is shown in **Figure 2-77~~5~~**. As illustrated in **Figure 2-77~~5~~**, stream seepage (i.e., infiltration) occurs during Critical, Dry, and Below Normal Years. This indicates that the San Joaquin River is a losing reach and likely not connected to groundwater at these times. During Above Normal and Wet Years, both stream seepage and groundwater discharge to streams occurs. This indicates that the San Joaquin River is connected to groundwater for some duration during these times. **Figure 2-78~~6~~** displays the monthly stream seepage/groundwater discharge to streams by water year type along the San Joaquin River. This figure also indicates that the San Joaquin River is a losing reach during Critical, Dry, and Above Normal Years, but appears to have connection with groundwater during some periods during Above Normal and Wet Years. These relationships among various factors are discussed further in Sections 3.2.5 and 3.3.5.

Regardless of whether or not groundwater and surface water are interconnected along the San Joaquin River, there is at least some potential for regional groundwater pumping to impact groundwater dependent ecosystems (GDEs) with roots extending down 20 to 30 feet along the San Joaquin River. Thus, shallow groundwater areas adjacent to the San Joaquin River were further evaluated in regard to GDEs in the following section and in Chapter 3.

Further review of **Figures 2-73~~1~~ and 2-74~~2~~** indicates another area of shallow groundwater occurring at the eastern margin of the Plan Area adjacent to the Sierra Nevada Mountains in the area near where the Fresno River crosses the Madera Canal (Madera Canal Equalization Reservoir area)The hydrogeology in the vicinity of the Madera Canal Equalization Reservoir is characterized by shallow bedrock ranging from approximately 0 to 100 feet below ground surface. Given the extremely low permeability of fractured bedrock compared to the overlying unconsolidated alluvium, the underlying bedrock surface effectively operates as a perching layer for streamflow infiltrating down from the Fresno River/Madera Canal. The Fresno River flows through this area, with a dam/reservoir (Hensley Lake) upstream of this area. The Madera Canal also passes through this area, including the Equalization Reservoir, which is located on the Madera Canal. These man-made surface water features are the primary source of subsurface water in this area of the Subbasin adjacent to the Sierra Foothills. Because of the very steep hydraulic gradient in this area (in excess of 70 feet per mile) the nature of the hydraulic connection with the main regional groundwater system in the Subbasin is such that groundwater or infiltrating surface water in this area may flow down-gradient along the sloping bedrock surface into the main groundwater system. However, any groundwater pumping in the main groundwater basin aquifers is unlikely to impact shallow water levels in the Madera Canal Equalization Reservoir area.

Since late 2023 and as a result of individual comments received following submission of the 2020 Joint GSP, representatives from the Subbasin and Kings Subbasin have been meeting monthly with representatives from the USBR and FWA to better understand their issues and concerns related to ISW along the San Joaquin River (SJR) from Reach 1A to the Mendota Pool. Concurrent with meetings with USBR and FWA, representatives from both the Madera and Kings Subbasins have had extensive communication with representatives of the San Joaquin River Restoration Program (SJRRP). As of the date of this Plan Amendment, USBR and FWA are continuing to work to quantify total diversions, uses, and estimates of losses along the SJR. USBR is also working on a detailed analysis of the Holding Contracts and the groundwater pumping allowances and limitations that will need to be factored into any allowable groundwater pumping within proximity to the SJR. As a sign of their commitment to collaboratively working together to better understand ISW along the SJR, the Kings and Madera Subbasins have developed a MOU with USBR and FWA that includes a cooperative scope of work for further investigation of possible ISW from along the SJR from Reach 1A to Mendota Pool. A copy of the MOU between Kings, Madera, USBR, and FWA has been included in **Appendix 3.I**, along with updates to the ISW workplan as part of the January 2025 Plan Amendment.

In addition to development of the above noted ISW MOU and the resulting cooperatively developed work products, the GSAs plan to review the additional ISW white papers by DWR that were released in September 2024. In February 2024, DWR released the first of three papers on ISW. The remaining two papers were released in late September of 2024. In addition to the aforementioned papers, the GSAs understand that DWR plans to release an ISW guidance document in Winter 2024. During subsequent Plan Amendments, the GSAs may consider revisions to the current ISW SMC based on information gleaned from the collaborative work with USBR and FWA, in addition to the additional white papers released by DWR in 2024 and the ISW guidance document to be released by DWR in the future. Any potential revisions to SMC for ISW will be reported in Annual Reports, Periodic Evaluations, and/or Plan Amendments.

Based on review of available data, characterization of hydrogeologic conditions related to the potential for interconnected surface water is currently based on very limited data. Thus, additional data collection and analyses are needed to update and refine the understanding of how surface water and GDEs may (or may not) be connected to the regional aquifers where groundwater pumping occurs. Key elements of a workplan are described in Section 2.2.2.7.4. It is anticipated that some additional data to better characterize shallow stratigraphy, groundwater levels, and ~~interconnected surface water~~ISW will be available and incorporated into ~~the~~ future Joint GSP Periodic Evaluations and associated Plan Amendments, as applicable~~2025 GSP Update~~.

2.2.2.6 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined in California's Sustainable Groundwater Management Act (SGMA) as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (23 CCR § 351(m)). As described in The Nature Conservancy's guidance for GDE analysis (Rohde et al. 2018), a GDE's dependence on groundwater refers to reliance of GDE species and/or communities on groundwater for all or a portion of their water needs. Review of available groundwater level data from Winter/Spring 2014 and Winter/Spring 2016 indicates that shallow groundwater levels (i.e., within 30 feet of ground surface) exist in some portions of the Plan Area (Section 2.2.2.1). The depth to water (DTW) evaluation described in the above section for Groundwater – Surface Water Interaction also provides input for evaluation of GDEs.

A DTW of 30 feet was used as one of the primary criteria in the initial screening of potential GDEs. The use of a 30-foot DTW criterion to screen potential GDEs is based on reported maximum rooting depths of

California phreatophytes[48] and is consistent with guidance provided by The Nature Conservancy (Rohde et al. 2018) for identifying GDEs. Potential GDEs were retained for further analysis if the underlying DTW in either winter/spring 2014 or winter/spring 2016 was equal to or shallower than 30 feet. The 2014 and 2016 DTW data were the most accurate and recent DTW data available for the- Madera Subbasin. While the 2016 data represent conditions after the 2015 SGMA baseline, the use of shallow groundwater data from both years was deemed appropriate because it provided a more conservative (i.e., more inclusive) indicator of potential GDEs than the use of a data from a single year.

GDEs may also occur in areas where regional groundwater levels are deeper than 30 feet but shallower perched groundwater exists atop bedrock or another type of aquitard. Where DTW was greater than 30 feet, other criteria were used to determine whether potential GDEs should be subject to further analysis. For example, surface flow characteristics of rivers in the Madera Subbasin were also used to screen potential GDEs. Because the vast majority of rivers in the Subbasin are not perennial and all are in a net-losing hydrological condition (i.e., losing water to the groundwater system), this criterion excluded most of the smaller river channels and associated terrestrial vegetation from consideration as GDEs.

Four potential GDE units, the Fresno River Riparian, Friant Riparian, San Joaquin River Riparian, and Sumner Hill potential GDE units were identified in the Madera Subbasin (**Figure 2-797 through 3-820**, **Appendix 2.B**). The potential GDE units were identified using the California Department of Water Resources' (DWR) indicators of GDEs (iGDE) dataset, published online and referred to as the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (Klausmeyer et al. 2018), augmented with other relevant vegetation mapping data, aerial imagery, and hydrologic data. Field reconnaissance was conducted in portions of the unit in May 2019 to help characterize the vegetation composition and structure, document dominant plant species, and assess habitat characteristics to determine the potential for presence of special-status species.

Fresno River Riparian Potential GDE Unit

The Fresno River Riparian Potential GDE Unit is located at the eastern margin of the Madera Subbasin along the Fresno River. Approximately two-thirds of the unit is upstream of the Madera Canal along the Fresno River (**Figure 2-8078**). The Fresno River flows through this area and is impounded by Hidden Dam to form Hensley Lake approximately 2.5 miles upstream of the GDE unit. Since 1968, flow in the Fresno River has been controlled by Hidden Dam. Groundwater beneath the Fresno River Riparian Potential GDE Unit was approximately 10–30 feet deep in winter/spring 2014 (i.e., the upper 10–30 feet of the subsurface was unsaturated during this time). This is too deep for the Fresno River's surface flow to be connected to groundwater, but within the 30-foot maximum rooting depth of the dominant riparian plants in the unit. The Fresno River in the Madera Subbasin has been a net losing stream since at least the 1920s (TNC 2014), with infiltrating surface flow likely contributing directly to the shallow groundwater system that supports the vegetation in the Fresno River Riparian Potential GDE Unit. The Madera Canal also passes through the GDE unit, including the Equalization Reservoir which is located along the Madera Canal. Seepage or leaks from these man-made surface water features likely provide a portion of the subsurface water in this area of the Subbasin, but the magnitude of their contribution is unknown.

The hydrogeology in the vicinity of this GDE unit is characterized by shallow bedrock ranging from approximately 0 to 100 feet below ground surface. Because of the very steep hydraulic gradient in this area (in excess of 70 feet per mile the nature of the hydraulic connection with the main regional groundwater system in the Subbasin is such that groundwater or infiltrating surface water in this area

[48] A phreatophyte is a deep-rooted plant that obtains its water from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone (Rohde et al. 2018).

may flow down-gradient along the sloping bedrock surface into the main groundwater system, but any groundwater pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying this GDE unit.

The Fresno River Riparian Potential GDE Unit is composed of a mix of riparian forest, shrub, and herbaceous habitat types totaling approximately 40 acres. Analysis of existing vegetation mapping data, color aerial imagery, and May 2019 field reconnaissance conducted in representative portions of the unit determined the quality of riparian habitat in this unit to be high, with several areas of mature riparian forest along the river floodplain (Figure 2-8~~1~~3). Vegetation in the unit is over 80% native cover in the shrub and tree layer. Dominant vegetation included mature stands of Fremont cottonwood and Gooding's black willow (*Populus fremontii* and *Salix gooddingii*, respectively) with sandbar willow shrubs (*Salix exigua*) lining sections of the channel. The riverine, aquatic habitat of the Fresno River is not contained within the GDE unit because available hydrologic data indicates no connection of groundwater to the surface flow in the Fresno River in this area (i.e., this reach of the Fresno River loses water and is not connected to the groundwater system).

Figure 2-8~~1~~3. Riparian habitat in the Fresno River Riparian Potential GDE Unit, May 1, 2019. (Stillwater Sciences).

The Fresno River Riparian Potential GDE Unit provides habitat or ecosystem support for several special-status species. These species include special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE unit, or (3) directly observed during the May 2019 reconnaissance survey conducted by Stillwater Sciences (see **Appendix 2.B**).

The Fresno River Riparian Potential GDE Unit was determined to have **high ecological value** because of: (1) the known occurrence and presence of suitable habitat for several special-status species; and (2) the vulnerability of these species and their habitat to changes in groundwater levels (Rohde et al. 2018). The vegetation composing the GDE unit was determined to be more susceptible to changes in groundwater depth (i.e., DTW) than other groundwater conditions such as groundwater quality. Analysis of current and recent historical groundwater depth underlying the GDE unit indicates that current groundwater depth is within the range of recent historical fluctuations and future changes in groundwater management are unlikely to cause it to fall outside this baseline range. Consequently, the unit is characterized as having low susceptibility to changing groundwater conditions. Reconnaissance level biological assessments, aerial photograph analysis, and NDVI/NDMI data indicate adverse impacts are not likely occurring in the Fresno River Riparian Potential GDE Unit (**Appendix 2.B**).

Friant Riparian Potential GDE Unit

The Friant Riparian Potential GDE Unit is located in the uppermost reaches of the San Joaquin River below Friant Dam, extending along the San Joaquin River from the dam approximately 5.5 miles downstream (**Figure 2-8179**). Data from the limited number of DWR well completion reports that are available in this area indicate that depth to bedrock beneath the majority of the unit is relatively shallow, ranging from 45 to 75 feet bgs from north to south along the San Joaquin River. The San Joaquin River in the ~~Madera~~ Subbasin has been a net losing stream since at least the 1920s (TNC 2014), with infiltrating surface flow likely contributing directly to the shallow groundwater that supports the vegetation in the Friant Riparian Potential GDE Unit.

As described in Section 2.2.2.1 (Groundwater Levels), there is essentially no existing groundwater level data for the Friant Riparian Potential GDE area. This area was identified as a shallow groundwater area (DTW less than or equal to 30 feet) based on extrapolation of groundwater level data from further away. Thus, the actual depth to groundwater in this area is unknown. The combination of shallow depth to bedrock beneath the San Joaquin River in this unit and infiltration of surface flows from the San Joaquin River into the underlying alluvium largely accounts for the shallow occurrence of groundwater at this location. Therefore, groundwater pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying this GDE unit.

The Friant Riparian Potential GDE Unit is composed of a mix of riparian forest, shrub, and herbaceous habitat types totaling approximately 107 acres. Analysis of existing vegetation mapping data, color aerial imagery, and May 2019 field reconnaissance conducted in representative portions of the unit determined the quality of riparian habitat in this unit to be medium. This GDE unit is characterized by pockets of mature riparian forest associated with drainages and surrounded by grasslands on the floodplain of the San Joaquin River (Figure 2-842). The canopy is stratified with a moderately open understory. Vegetation in the observed portions of the unit was over 80% native cover in the shrub and tree layer and could be less than 50% native cover in the herbaceous ground layer, with the balance occupied by non-native species. Dominant vegetation in woody plant communities included Fremont cottonwood (*Populus fremontii*), Gooding's willow (*Salix gooddingii*), and valley oak (*Quercus lobata*) in the overstory and narrow-leaved willow (*Salix exigua*) in the shrub layer, interspersed with European grass-dominated herbaceous ground cover and emergent vegetation (tules, cattails) lining the channel edge.

Figure 2-842. Riparian corridor along the San Joaquin River in the Friant Riparian Potential GDE Unit, observed from Lost Lake Park, May 1, 2019 (Stillwater Sciences).

The Friant Riparian Potential GDE Unit provides habitat or ecosystem support for several special-status species. These species include special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE unit, or (3) directly observed during the May 2019 reconnaissance survey conducted by Stillwater Sciences (see **Appendix 2.B**).

The riverine, aquatic habitat of the San Joaquin River is not contained within the GDE unit because available hydrologic data indicates no groundwater connection to the surface flow in the San Joaquin River in this area (i.e., this reach of the San Joaquin River loses water to and is disconnected from the groundwater system). However, the riparian vegetation community of the Friant Riparian Potential GDE Unit fulfills several essential ecosystem functions or provides important habitat elements, such as large wood and riparian shade, on which both semi-aquatic species of the GDE unit and aquatic species of the San Joaquin River depend for completing essential life behaviors.

This unit contains or overlaps several known protected lands, including several parcels owned or managed by the San Joaquin River Parkway and Conservation Trust, and the State-owned San Joaquin River Ecological Reserve (CPAD 2018). In addition, the adjacent San Joaquin River contains Essential Fish Habitat (EFH) for Chinook salmon which is partially dependent on riparian inputs to provide important salmon habitat elements including shade, overhead cover, nutrients, and woody material for instream cover and habitat complexity (PFMC 2014).

The Friant Riparian Potential GDE Unit was determined to have **high ecological value** because of: (1) the likely occurrence of several special-status species and presence of suitable habitat for these species in the unit; (2) the presence of protected lands in the unit; and (3) the presence of species and ecological communities considered somewhat vulnerable to slight to moderate changes in groundwater levels

(Rohde et al. 2018). The vegetation composing the GDE unit was determined to be more susceptible to changes in groundwater depth (i.e., DTW) than other groundwater conditions such as groundwater quality. Its susceptibility to changing groundwater conditions is low because pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying this GDE unit and because shallow groundwater levels in this unit will be maintained in large part by continued restoration flows in the San Joaquin River under the SJRRP. Reconnaissance level biological assessments, aerial photograph analysis, and NDVI/NDMI data indicate adverse impacts are not likely occurring in the Friant Riparian Potential GDE Unit.

San Joaquin River Riparian Potential GDE Unit

The San Joaquin River Riparian Potential GDE Unit extends along the San Joaquin River from Highway 41 downstream to the point near Gravelly Ford where the San Joaquin River is no longer within the ~~Madera~~ Subbasin (**Figures 2-81~~79~~ and 2-82~~0~~**). Geologic cross sections show that the upper 60–80 ft under the San Joaquin River is sand and gravel/cobbles, with clay along the channel margins. The Corcoran Clay, a major aquiclude, does not occur under the San Joaquin River Riparian Potential GDE Unit. Beneath the San Joaquin River in the unit there is a perched/mounded aquifer near Gravelly Ford that occurs above the "A Clay" identified in the subsurface mapping, but there is no unsaturated zone between the perched/mounded aquifer and the underlying regional aquifer. Flow in the San Joaquin River is strongly controlled by releases from Friant Dam and water infiltrates from the channel bed into the disconnected aquifers below the reach. Groundwater elevation below the GDE is therefore strongly dependent on operations of Friant Dam.

Groundwater beneath the San Joaquin River Riparian Potential GDE Unit was approximately 20–30 feet deep in winter/spring 2014 and 2016 (i.e., the upper 20–30 feet of the subsurface was unsaturated during this time). This is too deep for the San Joaquin River's surface flow to be connected to groundwater, but within the 30-foot maximum rooting depth of the dominant riparian plants in the unit. Beneath the San Joaquin River, the groundwater is perched or mounded atop the shallow clay layer, but there is no unsaturated zone below the perched/mounded aquifer (Section 2.2.2.5). It is therefore possible that groundwater pumping in the regional aquifer could affect the shallower perched/mounded aquifer that maintains the GDE. The net-losing condition of the San Joaquin River in this area likely began in the 1920s or earlier (TNC 2014).

The San Joaquin River Riparian Potential GDE Unit is composed of several discontinuous areas of riparian vegetation along the San Joaquin River from Highway 41 to the point where the San Joaquin River leaves the Subbasin south of the intersection of Road 21 and Avenue 5 just downstream of Gravelly Ford. This unit includes portions of the riparian corridor of the San Joaquin River, supporting a mix of riparian forest, shrub, and herbaceous plant communities totaling approximately 156 acres. Analysis of existing vegetation mapping data, color aerial imagery, and May 2019 field reconnaissance conducted in representative portions of the unit determined the quality of riparian habitat in this unit to range from low to high, with overall quality considered moderately high. The reconnaissance survey of representative portions of the San Joaquin River Riparian Potential GDE Unit conducted in May 2019 identified areas of native riparian forest, riparian shrub, grassland (**Figures 2-81~~79~~ and 2-82~~0~~**). Vegetation in most of these units was over 80% native cover in the shrub and tree layer and less than 50% native cover in the herbaceous ground layer, with the balance occupied by non-native species. Dominant vegetation in woody plant communities included Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), and valley oak (*Quercus lobata*) in the overstory, narrow-leaved willow (*Salix exigua*) in the shrub layer, interspersed with European grass-dominated herbaceous ground cover. Non-native eucalyptus and arundo were observed throughout the unit.

The San Joaquin River Riparian Potential GDE Unit provides habitat or ecosystem support for several special-status species. These species include special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE unit, or (3) directly observed during the May 2019 reconnaissance survey conducted by Stillwater Sciences (see **Appendix 2.B**).

The riverine, aquatic habitat of the San Joaquin River is not contained within the GDE unit because available hydrologic data indicates no substantial groundwater connection to the surface flow in the San Joaquin River in this area (i.e., this reach of the San Joaquin River is disconnected from and loses water to the groundwater system). However, the riparian vegetation community of the San Joaquin River Riparian Potential GDE Unit fulfills several essential ecosystem functions or provides important habitat elements, such as large wood and riparian shade, on which both semi-aquatic species of the GDE unit and aquatic species of the San Joaquin River depend for completing essential life behaviors.

This GDE unit does not include any known protected lands (CPAD 2018) or critical habitat for federally listed species (USFWS 2019, NMFS 2016) but the adjacent San Joaquin River contains Essential Fish Habitat (EFH) for Chinook salmon which is partially dependent on riparian inputs to provide important salmon habitat elements including shade, overhead cover, nutrients, and woody material for instream cover and habitat complexity (PFMC 2014).

The San Joaquin River Riparian Potential GDE Unit was determined to have **moderate ecological value** because of: (1) the likely occurrence of several special-status species and presence of suitable habitat for these species in the unit; and (2) the presence of species and ecological communities considered somewhat vulnerable to slight to moderate changes in groundwater levels (Rohde et al. 2018). The vegetation composing the GDE unit was determined to be more susceptible to changes in groundwater depth (i.e., DTW) than other groundwater conditions such as groundwater quality. While the reconnaissance level biological assessments, aerial photograph analysis, and NDVI/NDMI data indicate that certain areas of the San Joaquin River Riparian Potential GDE Unit are relatively intact and within the range of natural variability, other areas of riparian vegetation show evidence of impaired function and condition (**Appendix 2.B.**). As a result, adverse impacts could be occurring in portions of the unit. Available evidence is insufficient, however, to determine whether adverse impacts are related to groundwater management.

Sumner Hill Potential GDE Unit

The Sumner Hill Potential GDE Unit is located in the eastern portion of the ~~Madera~~ Subbasin, west of the San Joaquin River in the vicinity of the Friant Riparian Potential GDE Unit (**Figure 2-81~~79~~**). This unit is classified as a potential GDE because its potential connection to groundwater is uncertain due to a lack of data on depth to groundwater, the source of surface water in the unit, and the connection between groundwater and surface water. The depth to bedrock immediately under the unit is not known, but the presence of the bedrock in adjacent hillslopes suggests that bedrock is directly beneath this site (i.e., there is effectively no unconsolidated alluvium beneath this GDE unit). There are no wells between Highway 41 and the San Joaquin River near Sumner Hill, so there is little data on groundwater depth. The paucity of wells also suggests that groundwater is limited at this site. Most of the unit is downstream of the Madera Canal, but the degree to which leakage from the canal contributes to the GDE in this unit is unknown. Approximately 0.8 acres of the GDE is upstream of the Madera Canal which suggests that the unit is not entirely dependent on leakage from the canal. Changes in hydraulic base level downslope (near the San Joaquin River) could potentially affect groundwater elevation near Sumner Hill if groundwater levels along the San Joaquin declined in the future.

The Sumner Hill Potential GDE Unit is located along an unnamed tributary to the San Joaquin River east of Sumner Hill in the ~~Madera~~ Subbasin and is composed of a mix of open water habitat, riparian forest, and emergent wetlands totaling approximately 45 acres. This site was noted during a reconnaissance visit to the Subbasin and is characterized as riparian vegetation and a freshwater emergent wetland on a high terrace fed by what is likely an intermittent drainage that connects to the San Joaquin River downstream of the unit. Analysis of existing vegetation mapping data, color aerial imagery, and May 2019 field reconnaissance conducted in representative portions of the unit determined the quality of wetland and riparian habitat in this unit to be generally good but with habitat patches ranging from somewhat degraded to excellent quality. The reconnaissance survey of representative portions of the Sumner Hill Potential GDE Unit conducted in May 2019 identified several areas of ponded water surrounded by mature wetland and riparian vegetation (**Figure 2-8179**). Vegetation in the unit was over 80% native cover in the shrub and tree layer and dominated by red willow (*Salix laevigata*), Goodding's black willow, Fremont cottonwood, rush and sedge species *(Juncus* spp. and *Carex* spp.), as well as cattails and tules (*Typha* spp. and *Schoenoplectus* spp.).

The Sumner Hill Potential GDE Unit provides habitat or ecosystem support for several special-status species. These species include special-status species that satisfy one or more of the following criteria: (1) known to occur in the region and suitable habitat present in the GDE unit, (2) documented occurrence within the GDE unit, or (3) directly observed during the May 2019 reconnaissance survey conducted by Stillwater Sciences (see **Appendix 2.B**).

The Sumner Hill Potential GDE Unit was determined to have **high ecological value** because of (1) the known occurrence of several special status species and presence of suitable habitat; and (2) the presence of species and ecological communities considered somewhat vulnerable to slight to moderate changes in groundwater levels (Rohde et al. 2018). The vegetation composing the GDE unit was determined to be more susceptible to changes in groundwater depth (i.e., DTW) than other groundwater conditions such as groundwater quality. Its susceptibility to changing groundwater conditions is low because pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying this GDE unit. Reconnaissance level biological assessments, aerial photograph analysis, and NDVI/NDMI data indicate adverse impacts are not likely occurring in the Sumner Hill potential GDE Unit (**Appendix 2.B**).

2.2.2.7 Uncertainty and Data Gaps in Hydrogeologic Conceptualization and Groundwater Conditions

Certain data gaps and associated uncertainty are described below. Additional information about assessment of data gaps and related improvements to the monitoring network is provided in Section 3.5.4.

2.2.2.7.1 Hydrogeologic Conceptual Model

Uncertainty in the HCM is related to limitations on the amount of available data (e.g., lithologic logs, borehole geophysical logs), reliability of those available data, and the reliability of correlations made from the available data. The amount of available data has been increasing over time and, in particular, nine dedicated multi-completion (nested) monitoring wells have been drilled and installed since 2019 with plans to install additional wells in the future. These GSA efforts result in very reliable data being collected with lithologic logs compiled by geologists using both drill cuttings samples and downhole geophysical logs. Additional data being collected over time includes lithologic logs included in water well reports prepared by drillers, although these logs are somewhat less reliable in that they generally do not benefit from incorporation of downhole geophysical logs and detailed logging by a geologist. The uncertainty in the HCM is expected to decrease in the future as such data are collected and incorporated into HCM updates. For example, drilling of dedicated monitoring wells since 2019 has already resulted in some refinement of the extent of the Corcoran Clay (**Figure 2-15**), which has also been incorporated into the recent MCSim Model update (**Appendix 6.D**).

2.2.2.7.2 Groundwater Levels and Storage

Uncertainty in the understanding of groundwater levels and storage is primarily a function of the location and frequency of groundwater level data. Groundwater storage has some additional uncertainty related to availability of data for specific yield and storage coefficient values. There is some uncertainty in both groundwater elevation contours and storage changes related to lack of data in some portions of the groundwater Subbasin (e.g., the far eastern portion of the Subbasin), which requires estimates to be prepared for those areas in Annual Reports. These data gaps and uncertainties are being addressed with the installation of dedicated monitoring wells in these areas, which has been ongoing since 2019. Relatively deep exploration drilling (up to 1,000 feet) has already been conducted at nine locations, with installation of up to three monitoring wells at each location screened in different depth zones. Each of these new dedicated monitoring wells provides continuous water level data (monitored by pressure transducers), which helps to fill data gaps and expands the coverage and understanding of groundwater levels and storage both horizontally (i.e., spatially) and vertically (i.e., different aquifers). This ongoing installation of dedicated monitoring wells will continue to reduce uncertainty and close data gaps in the future.

2.2.2.7.3 Groundwater Quality

Uncertainty in our understanding of groundwater quality is primarily a function of available well locations and the ability to obtain access to wells for collection of groundwater quality samples. Existing wells owned by others present challenges to obtaining well owner cooperation and coordination of site visits to collect samples when the pump is operating. These types of existing wells (typically agricultural production wells and, to a lesser extent, drinking water production wells) are being utilized to the extent possible. In addition, these data gaps and uncertainties are being addressed with the installation of dedicated monitoring wells, which has been ongoing since 2019. Relatively deep (up to 1,000 feet) exploration drilling has already been conducted at nine locations, with installation of up to three monitoring wells at each location screened in different depth zones. Each of these new dedicated monitoring wells provides groundwater quality sampling locations under the control of the GSAs, which helps to fill data gaps and expands the coverage and understanding of groundwater quality both horizontally (i.e., spatially) and vertically (i.e., different aquifers). This ongoing installation of dedicated monitoring wells will continue to reduce uncertainty and close data gaps in the future.

2.2.2.7.4 Land Subsidence

There is considerable uncertainty associated with the characterization of historical and future subsidence in the Subbasin. This uncertainty is related to a limited number of subsidence monitoring locations, limited data for correlations between groundwater levels and rate of subsidence, and limitations in understanding how total subsidence may be divided into active (i.e., associated with groundwater levels declining to new lows) and residual (i.e., subsidence that continues to occur in the absence of ongoing declines groundwater levels to new lows) subsidence components.

To address the need and interest in improving the understanding of subsidence in the Subbasin, the GSAs have developed a workplan outlining future activities related to monitoring and understanding conditions relating to subsidence in the Subbasin. The subsidence workplan is described in Section 4.9.5 ~~4.10.2~~ and included in **Appendix 3.H.**

2.2.2.7.5 Interconnected Surface Water

~~*Interconnected Surface Water*~~

There is considerable uncertainty associated with the characterization of interconnectivity between groundwater and surface water along the San Joaquin River in the Subbasin. The considerable depth to groundwater in most other areas of the Subbasin indicate no interconnectivity exists along other waterways. However, available shallow groundwater level data suggest that historically there likely have been some time periods and reaches where groundwater and surface water are directly connected along the San Joaquin River within the Subbasin. Because of the limited available data to directly relate stream stage and flow with groundwater levels along the San Joaquin River in the Subbasin, additional coordinated characterization of groundwater and surface water conditions in and along the San Joaquin River would improve the understanding of the nature of any connectivity between groundwater and surface water and inform evaluations of the extent to which groundwater pumping may influence seepage from the San Joaquin River.

One of the key considerations in understanding the groundwater and surface water connectivity along the San Joaquin River in the Subbasin relates to the subsurface sediments along the San Joaquin River. The presence of shallow clay layers beneath the San Joaquin River likely play a major role in how stream seepage interacts with the groundwater system and the extent to which these clay layers create perched/mounded groundwater conditions at shallow depths hydraulically separated from the deeper zones where groundwater pumping is occurring. Improving the characterization of these shallow subsurface sediments and identification and mapping of any perched groundwater conditions will inform the understanding of surface water and groundwater interactions along the San Joaquin River.

To address the need and interest in improving the understanding of the relationships between groundwater and surface water along the San Joaquin River in the Subbasin, the GSAs have developed a workplan outlining future activities related to monitoring and understanding conditions relating to groundwater and surface water connectivity along the San Joaquin River. One of the key objectives of the workplan is to develop an understanding of how groundwater pumping may influence streamflow in the San Joaquin River. An ~~interconnected surface water~~ISW workplan is included in **Appendix 3.I**. Key topics considered in the workplan include the following:

- Summary of existing surface water monitoring
- Overview of existing groundwater level monitoring in relation to surface water and surface water monitoring
- Review of groundwater pumping and monitoring
- Improvements to subsurface hydrogeologic characterization related to shallow clays and perched groundwater conditions including review of results from recently completed aerial electromagnetic surveys of the area
- Construction of shallow hydrogeologic cross-sections in the vicinity of the San Joaquin River
- Evaluation of groundwater levels at different depths and understanding of vertical hydraulic connections
- Identification of sites for additional characterization through lithologic borings, monitoring well construction, and aquifer testing activities
- Review of numerical modeling results and simulation approaches to evaluate stream seepage responses to groundwater management activities
- Recommendations and implementation plans for future surface water and groundwater monitoring

- Recommendations on future analytical activities and numerical model improvements and any associated field studies that may be needed, including thalweg surveys, rating curve development, or other activities
- Considerations related to coordination of monitoring for any new recharge projects in southern areas of the Subbasin

In addition to the GSAs' workplan described above, since late 2023 and as a result of individual comments received following submission of the 2020 Joint GSP, representatives from the Madera and Kings Subbasins have been meeting monthly with representatives from the USBR and FWA to better understand their issues and concerns related to ISW along the SJR from Reach 1A to the Mendota Pool, as well as with representatives of the SJRRP. This work has resulted in development of an MOU between the Madera and Kings Subbasins and USBR and FWA. It is described in more detail in Section 4.9.5.

2.2.3 Water Budget Information (23 CCR § 354.18)

This section presents the ~~historical and current~~ water budgets for the entire ~~Madera~~ Subbasin refined with information and knowledge gained during the assembly of individual water budgets for each GSA within the Subbasin. The work to refine the preliminary water budget and prepare individual GSA water budgets was enabled by a *Counties with Stressed Basins* Grant [49] from DWR to support preparation of the ~~Madera~~ Subbasin GSP.

The water budgets reported in this section are those developed for the 2020 GSP. All updates to the water budgets are documented and discussed in the Periodic Evaluation.

DWR has published guidance and Best Management Practice (BMP) documents related to the development of GSPs (DWR, 2016), including Water Budget BMPs. Consistent with these BMPs, this section presents the water budget development methodology and results according to the GSP regulations to describe the hydrologic systems within the study area, and includes estimates of uncertainty for various water budget components. An estimate of the sustainable yield of the ~~Madera~~ Subbasin is provided at the end of this section for (1) the reference historical period (1989-2014 hydrologic conditions and land use), (2) the current period (2015 land use with 1989-2014 average hydrologic conditions), and (3) the projected future period (2041-2090)[50] following the GSP implementation period (2020-2040) using projected future land use and historical 1965-2015 hydrologic data.

2.2.3.1 Water Budget Conceptual Model

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[51] over a specified period of time. When the water budget volume is an entire subbasin, the water budget facilitates assessment of the total volume of groundwater and surface water entering and leaving the subbasin over time, along with the change in the volume of water stored within the subbasin. When applied to a GSA, this method also facilitates assessment of the total volume of surface water entering and leaving a defined GSA boundary.

---

[49] Funded by the Water Quality, Supply, and Infrastructure Improvement Act of 204 (Proposition 1).

[50] The 2019-2090 projected water budget was used to provide a 50-year period to evaluate sustainability following the 2020-2040 project implementation period.

[51] Where 'volume' refers to a space with length, width and depth properties, which for purposes of the GSP means the defined aquifer and associated surface water system.

The conceptual model for the ~~Madera~~ Subbasin and GSA water budgets was developed during previous data collection and analysis efforts conducted by DE and LSCE (2017). This conceptual model is consistent with the GSP regulations, adhering to sound water budget principles and practices described in the Water Budget BMPs, including the use of defined water budget accounting centers covering the three-dimensional subbasin area and defined water budget components quantified according to best available information and science (DWR, 2016).

Water budgets were developed for the Subbasin to characterize historical, current, and projected water budget conditions. These water budgets were developed for the Subbasin and individual GSAs utilizing the data sources and procedures outlined in Section 2.2.3.3 below.

Study Area

The water budget study area is defined as the ~~Madera~~ Subbasin, described above in Section 2.1 (23 CCR § 354.8). The lateral and vertical extents of the study area are the same as those defined for the Plan Area.

Similar to the Plan Area, the vertical extent of the water budget study area is subdivided into a surface water system (SWS) and groundwater system (GWS). The SWS represents the land surface down to the bottom of plant root zone, within the lateral boundaries of the Subbasin. The GWS extends from the bottom of the root zone to the definable bottom of the Subbasin, within the lateral boundaries of the Subbasin.

During water budget development, the study area was also subdivided into seven subregions, each representing one GSA (Table 2-9). For each subregion, the SWS water budget was developed based on GSA-specific information describing land use, available surface water supplies, and other flow paths to facilitate estimation of groundwater extraction.

Table 2-9. Madera Subbasin GSAs and Water Budget Subregions.

GSA	Subregion	Subregion Abbreviation	Subregion Area, Acres
Madera County GSA	Madera County	MC	177,800
Madera Irrigation District GSA	Madera ID	MID	133,850
City of Madera GSA	City of Madera	COM	10,100
Root Creek Water District GSA	Root Creek WD	RCWD	9,550
Gravelly Ford Water District GSA	Gravelly Ford WD	GFWD	8,400
New Stone Water District GSA	New Stone WD	NSWD	4,200
Madera Water District GSA	Madera WD	MWD	3,700
		Total	347,600

General Water Budget Accounting Structure and Components

For accounting purposes, the water budget is divided into the Surface Water System (SWS) and Groundwater System (GWS), described above. These systems are referred to as *accounting centers*. Flows between accounting centers and storage within each accounting center represent water budget *components*. Separate but related water budgets were prepared for each accounting center that together represent the overall Subbasin water budget. A schematic of the general water budget accounting structure is provided in Figure 2-85~~3~~.

For accounting water in the SWS, interrelated water budgets were prepared individually for each subregion and for the entire Subbasin. For accounting water in the GWS, a Subbasin water budget was prepared integrating components in a numerical model of both the SWS and GWS, referred to as the MCSim model. The MCSim model was developed based on the fine-grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSim-FG).

A conceptual representation of the ~~Madera~~ Subbasin model water budget accounting centers and components is provided in Figure 2-86~~4~~. Required components for each accounting center are listed in Table 2-10, along with the corresponding section of the GSP regulations. Note that precipitation is not explicitly listed as a required water budget component, though it is needed to provide complete accounting of Subbasin inflows and outflows.

Subbasin boundary inflows and outflows must be quantified according to GSP regulations, as stated in 23 CCR § 354.18(b). Inflows and outflows may cross the Subbasin boundary or may represent exchanges of water between the SWS and the underlying GWS within the Subbasin.

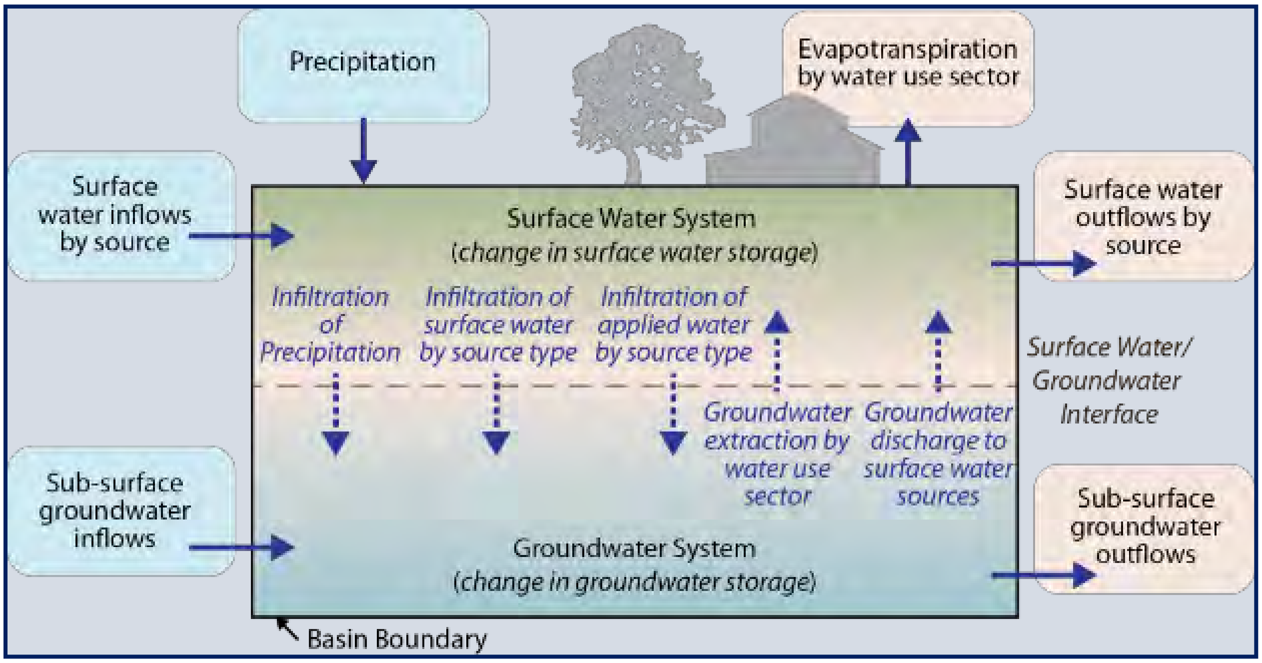


Figure 2-85~~3~~. Water Budget Accounting Structure (Source: DWR, 2016).

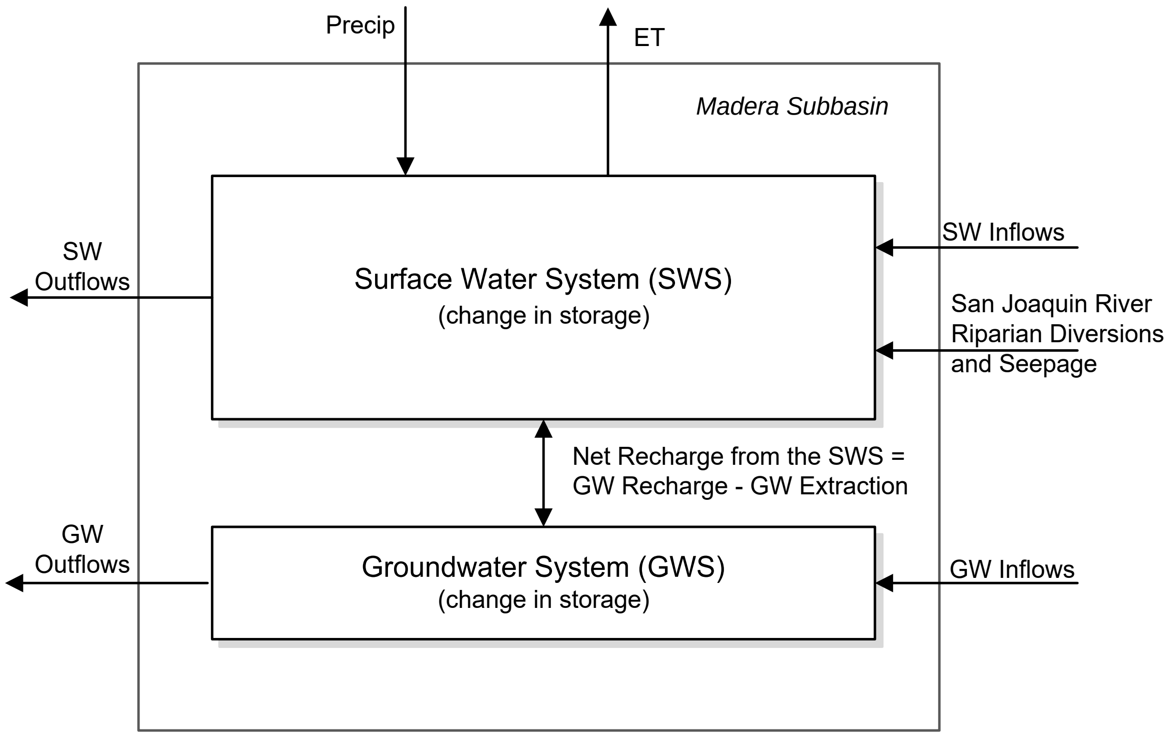


Figure 2-864. Madera Subbasin Boundary Water Budget Diagram.

Table 2-10. Water Budget Components by Accounting Center and Associated GSP Regulations.

Accounting Center	Water Budget Component (flow direction)	23 CCR Section[52]
Basin	Surface Water Inflow[1] (+)	§ 354.18(b)(1)
	Precipitation (+)	Implied
	Subsurface Groundwater Inflow (+)	§ 354.18(b)(2)
	Evapotranspiration[2] (-)	§ 354.18(b)(3)
	Surface Water Outflow[1] (-)	§ 354.18(b)(1)
	Subsurface Groundwater Outflow (-)	§ 354.18(b)(3)
	Change in Storage	§ 354.18(b)(4)
Surface Water System	Surface Water Inflow[1] (+)	§ 354.18(b)(1)
	Precipitation (+)	Implied
	Groundwater Extraction (+)	§ 354.18(b)(3)
	Groundwater Discharge (+)	§ 354.18(b)(3)
	Evapotranspiration[2] (-)	§ 354.18(b)(3)
	Surface Water Outflow[1] (-)	§ 354.18(b)(1)
	Infiltration of Applied Water[3,4] (-)	§ 354.18(b)(2)
	Infiltration of Surface Water[5] (-)	§ 354.18(b)(2)
	Infiltration of Precipitation[3] (-)	§ 354.18(b)(2)
	Change in Storage[6]	§ 354.18(a)
Groundwater System	Subsurface Groundwater Inflow (+)	§ 354.18(b)(2)
	Infiltration of Applied Water[3,4] (-)	§ 354.18(b)(2)
	Infiltration of Surface Water[5] (-)	§ 354.18(b)(2)
	Infiltration of Precipitation[4] (-)	§ 354.18(b)(2)
	Subsurface Groundwater Outflow (-)	§ 354.18(b)(3)
	Groundwater Extraction (-)	§ 354.18(b)(3)
	Groundwater Discharge (-)	§ 354.18(b)(3)
	Change in Storage	§ 354.18(b)(4)

1. By water source type.
2. By water use sector.
3. Synonymous with deep percolation.
4. Includes infiltration of applied surface water, groundwater, recycled water, and reused water.
5. Includes infiltration of lakes, streams, canals, drains, and springs. Synonymous with seepage.
6. Includes surface water streams and root zone (not groundwater system).

Boundary inflows include precipitation, surface water inflows (in various canals and streams), boundary watercourse seepage and groundwater inflows from adjoining subbasins. Outflows include evapotranspiration (ET), surface water outflows (in various canals and streams), and groundwater outflows. ET includes: ET of applied water (ET from soil and crop surfaces, of water that is derived from

[52] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5 Plan Contents

applied surface water, groundwater, recycled water, and reused water); ET of precipitation (ET from soil and crop surfaces, of water that is derived from precipitation); and evaporation from rivers, streams, canals, reservoirs, and other water bodies. ET of applied water (also identified as ET_{aw}) differs from applied water in that applied water is the volume of water that is directly applied to the land surface by irrigators (from all water sources), whereas ET_{aw} is the volume of that applied water that is consumptively used by crops, vegetation, and soil surfaces.

Also represented in Figures 2-853 and 2-864 are groundwater recharge and extraction, which are “internal” flows between the SWS and GWS. Net recharge from the SWS is defined as groundwater recharge minus groundwater extraction, and is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS. Subbasin boundary inflows and outflows are quantified on a monthly basis, including accounting for any changes in storage, such as changes is water stored in the root zone (**Equation 2-1**).

Inflows – Outflows = Change in Storage (monthly time step) [2-1]

Selection of the water budget analysis period is discussed in Section 2.2.3.2 below. The specific components of SWS inflows and outflows and the available data and calculation methodology for each component are summarized briefly in Section 2.2.3.3 below. Additional detail for inflows and outflows to each GSA is provided in **Appendix 2.F.** Inflows and outflows were calculated independently using measurements and other data or were calculated as the water budget closure term.

The Subbasin water budget was completed on a monthly time step and water year annual results are reported in Section 2.2.3.4 according to GSP regulations. Detailed SWS water budgets are reported for each individual GSA in **Appendix 2.F.a** through **Appendix 2.F.g.**

Quantification of GWS inflows and outflows is described below and in **Appendix 6.D.** The GWS water budget was completed for the entire Subbasin on a monthly time step. Some GSAs are small or are composed of noncontiguous small areas, making it difficult to accurately calculate the change in volume of groundwater stored. As a result, GWS water budgets were not calculated for individual GSAs.

Detailed Water Budget Accounting Centers and Components

To estimate the water budget components required by the GSP regulations, the SWS water budget accounting center is further subdivided into detailed accounting centers representing the Land Surface System (irrigated and non-irrigated lands), the Rivers and Streams System (natural waterways), and the Canal System.

Finally, the Land Surface System is subdivided into accounting centers representing water use sectors identified in the GSP regulations as “categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation” (23 CCR § 351(al)). Across the Madera Subbasin and within each subregion, the water use sector accounting centers include Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural), and Native Vegetation Land (NV). Industrial land covers only a small area of the Subbasin, so industrial water uses have been combined with urban and semi-agricultural uses in the Urban land use sector.

Detailed water budget components are defined for each detailed accounting center. Within the Land Use Sector accounting center, detailed water budget components are also defined for each water use sector accounting center. The addition of these detailed water budget accounting centers and components facilitates the development of water budgets based on the best available data and science by facilitating the incorporation of information from agricultural water management plans (AWMPs), urban water management plans (UWMPs) and other sources.

Water budget components for each detailed accounting center within the ~~Madera~~ Subbasin SWS are described in Tables 2-11 through 2-13. These water budget components were independently considered for each GSA to account for unique inflows and outflows to each GSA water budget presented in **Appendix 2.F.**

Table 2-11. Land Surface System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Land Surface System *Water Use Sectors: Agricultural Land, Native Vegetation Land, Urban Land*	Deliveries	Inflow	Deliveries from canal system to customers.
	Riparian Deliveries	Inflow	Deliveries from rivers and streams system to water rights users on lands adjacent to a river or stream.
	Groundwater Extraction	Inflow	Groundwater pumping to meet water demands.
	Precipitation	Inflow	Direct precipitation on the land surface.
	Reuse	Inflow	Reuse of percolated water from the unsaturated zone[53] (considered negligible in the Madera Subbasin).
	ET of Applied Water	Outflow	Consumptive use of applied irrigation water. In wetlands and riparian areas, may represent shallow groundwater uptake.
	ET of Precipitation	Outflow	Consumptive use of infiltrated precipitation.
	Runoff of Applied Water	Outflow	Direct runoff of applied irrigation water, includes tailwater and pond drainage for ponded crops (no ponded crops are grown in the Madera Subbasin).
	Runoff of Precipitation	Outflow	Direct runoff of precipitation.
	Infiltration of Applied Water	Outflow	Percolation of applied water below the root zone.
	Infiltration of Precipitation	Outflow	Percolation of precipitation below the root zone.
	Change in Storage	Storage	Change in storage of applied water within the root zone.

53 "The unsaturated zone is below the land surface system and represents the portion of the basin that receives percolated water from the root zone and either transmits it as deep percolation to the groundwater system or to reuse within the land surface system, or both." In *Water Budget BMP* (DWR, 2016).

Table 2-12. Rivers and Streams System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Rivers and Streams System	Surface Inflows	Inflow	Surface inflows at upper boundary of water budget area.
	Evaporation	Outflow	Direct evaporation from river and stream water surfaces.[54]
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from rivers and streams to the groundwater system during times of natural flow (during the times that rivers and streams serve as conveyance for irrigation releases, seepage is considered as part of the Canal System accounting center).
	Riparian Deliveries	Outflow	Deliveries from the Rivers and Streams system to water rights users on lands adjacent to a river or stream.
	Surface Outflows	Outflow	Surface outflows at lower boundary of water budget area.

Table 2-13. Canal System Water Budget Components.

Detailed Accounting Center	Detailed Component	Category	Description
Canal System	Diversions	Inflow	Diversions from Rivers and Streams System, including lakes and reservoirs in some cases.
	Evaporation	Outflow	Direct evaporation from canal water surfaces (unlined canals are generally maintained to be weed-free, so ET from bankside vegetation is not included).
	Infiltration of Surface Water (Seepage)	Outflow	Seepage from canals to the groundwater system and seepage from rivers and streams during the times that they serve as conveyance for irrigation releases.
	Spillage	Outflow	Spillage resulting from canal operations to the Rivers and Streams System.
	Deliveries	Outflow	Deliveries from the canal system to customers.

Characterization of Water Budget Components by Hydrologic Year Type

Surface water hydrology of the San Joaquin Valley is characterized by large variability in inter-annual precipitation and runoff resulting in both drought and flooding, sometimes in the same year. In contrast, relative differences in seasonal runoff are more predictable, with rainfall runoff occurring during the winter or snowfall forming snowpack in higher elevations that runs off as it melts in the spring and early summer.

[54] Does not include evapotranspiration of riparian vegetation (accounted in Land Surface System evapotranspiration).

A key indicator of seasonal variability in inter-annual hydrology is the San Joaquin Valley Water Year Index[55] (WYI), which is used to classify individual water years as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), or Critical (C) with respect to surface water runoff in the San Joaquin River Basin. These classifications are termed "water year types." A water year is defined as the period from October 1 of the preceding calendar year to September 30 of the current calendar year. For example, the 2000 water year represents the period from October 1, 1999, to September 30, 2000.

Rivers contributing to runoff from the San Joaquin Basin include, amongst others, the San Joaquin River itself, the Tuolumne River, the Stanislaus River, and the Merced River. The WYI for each year is weighted 80 percent based on unimpaired runoff from the San Joaquin Basin for the current year and 20 percent based on unimpaired runoff from the prior year (expressed in millions of acre-feet (maf)).[56] Unimpaired runoff represents the amount of runoff that would occur in the basin absent any diversions, storage, or inter-basin imports and exports.

The San Joaquin Valley WYI for the 51-year period from 1965 to 2015 is shown in Figure 2-875, along with corresponding water year type classifications. During this period, the WYI ranged from 0.81 maf in 2015 to 7.22 maf in 1983, representing a nine-fold difference. The average WYI over this period is 3.2 maf. Historical and recent drought periods are evident in the figure. Notably, only two above normal or wet years occurred between 2007 and 2015, and only four above normal or wet years have occurred between 2001 and 2015.

The distribution of water year types was considered in selecting water budget analysis periods that appropriately represent average historical hydrologic conditions. To support evaluation of differences in water budget components related to variable hydrology, the water year type associated with each year is also shown along with the SWS water budget results reported in section 2.2.3.4 of this report.

2.2.3.2 Water Budget Analysis Period

Criteria for Base Period Selection

In accordance with GSP regulations, a base period must be selected so that the analysis of sustainable yield is performed for a representative period with minimal bias that might result from the selection of an overly wet or dry period, while recognizing changes in other conditions including land use and water demands.

Per the GSP regulations, the historical base period must include a minimum of 10 years of surface water supply information, with 30 years recommended; the current base period must include a representative recent one-year period; and the projected base period must include a minimum of 50 years of historical precipitation, evapotranspiration, and stream flow data.

[55] California Department of Water Resources, California Cooperative Snow Surveys, *Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices* (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). Last accessed on 2/22/2019.

[56] California Environmental Protection Agency State Water Resources Control Board (SWRCB). 1995. *Water Quality Control Plan for the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary*, pg. 24.

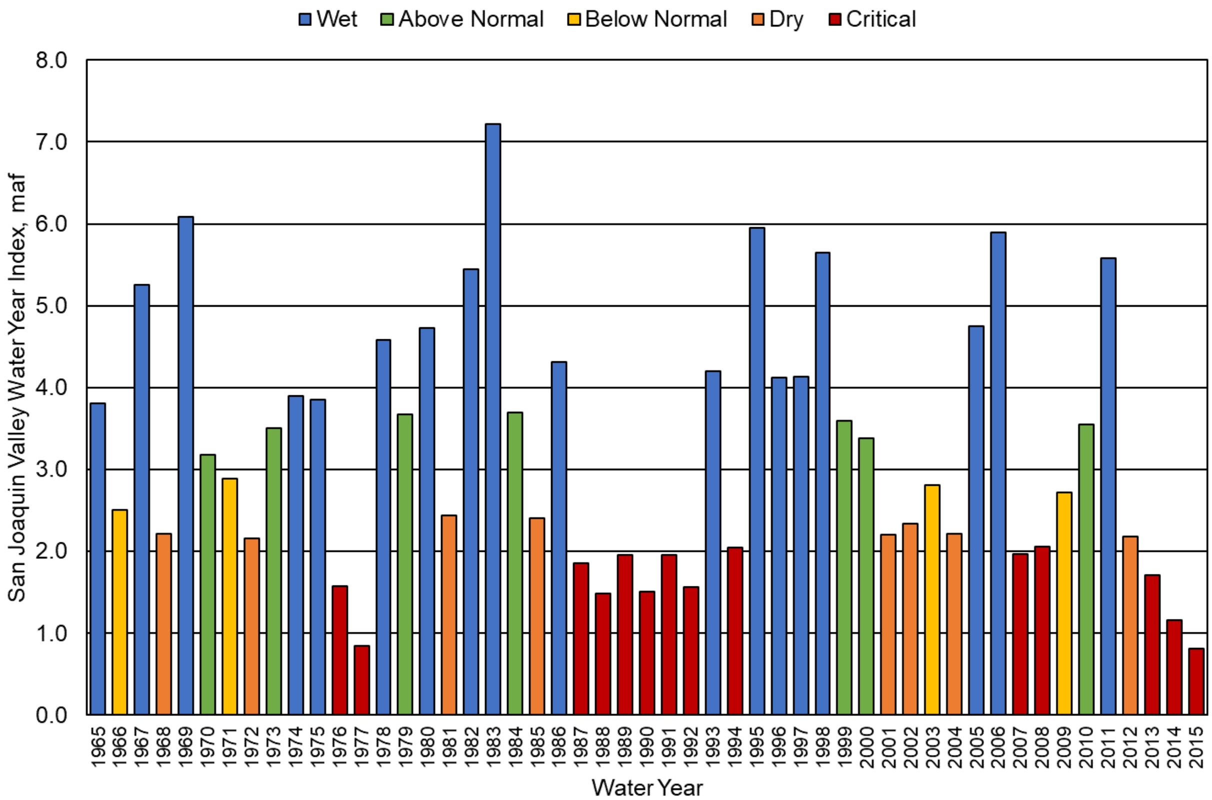


Figure 2-87~~5~~. San Joaquin Valley Water Year Index, 1965-2015.

The historical, current, and projected water budget base periods were selected on a water year basis considering the following criteria: San Joaquin Valley water year type; long-term mean annual water supply; inclusion of both wet and dry periods, antecedent dry conditions, adequate data availability; and inclusion of current hydrologic, cultural, and water management conditions in the Subbasin. Historical records of precipitation, unimpaired flows along the Fresno River, and USBR ~~Central Valley Project (~~CVP~~)~~ supplies served as an indicator of long-term mean water supply and potential for natural groundwater recharge during evaluation of proposed periods.

Historical Period

For the ~~Madera~~ Subbasin GSP, a 26-year historical water budget base period of water years 1989 through 2014 was selected.

As described in the Data Collection and Analysis Technical Memorandum for Madera County (DE and LSCE, 2017), available data was sufficient to develop a historical water budget for water years 1989 through 2015. However, the 1989 through 2014 period was found to be more representative of long-term average conditions as compared to the 1989 through 2015 following analysis of precipitation, unimpaired flows, and CVP supplies. Due to the comparative dryness of 2015 and corresponding low water supplies that year, including 2015 in the historical period would result in drier average hydrologic conditions than the long-term average.

Precipitation records in Madera, including annual precipitation, mean annual precipitation, and cumulative departure[57] from mean annual precipitation, are provided in Figure 2-886. As shown, a long-term average period between the late 1920s and the late 1970s (overall flat cumulative departure curve) was followed by alternating wet and dry periods, an average period between the late 1990s and 2011, and a dry period between 2012 and 2015.

In this context, 1989 to 2014 is a relatively balanced climatic period compared to the 1929 through 2015 period with a similar number of wet and dry years and some prolonged periods of wet, dry, and average conditions, representing a reasonable base period for conducting sustainability analyses.

Historical patterns of CVP supplies and unimpaired flows[58] along the Fresno River are shown in Figures 2-897 and 2-9088. Given the extremely low CVP supplies and unimpaired flows in 2015, a historical base period of water years 1989 through 2014 was selected.

This period begins in 1989, a critical year preceded by two critical years, and ends in 2014, a critical year with several prior critical or dry years, so that any water unaccounted for in the unsaturated zone is minimized[59]. Lastly, the proposed historical base period ends near the present time so that this period can also be used to assess groundwater conditions as they currently exist.

Thus, the historical base period of 1989 to 2014 provides an appropriate base period for assessing historical groundwater conditions with minimal bias from long-term land use changes or imbalances due to wet or dry conditions.

Current Period

For the current water budget, land use data from 2015 was used to calculate consumptive use and other root zone components in the Land Surface System water budget. This year was selected as most representative of current land use among years with available data at the initiation of SGMA data collection and analysis work in early 2017. To complete the current water budget, the 2015 root zone water budget components were combined with meteorological and surface water components representing average hydrologic conditions during the 1989 through 2014 historical base period, assuming the 2015 land use occurred in all years. This was considered a more accurate representation of current inflows and outflows from the Subbasin and each GSA as compared to evaluating hydrologic conditions in a single year.

[57] Cumulative departure curves are useful to illustrate long-term hydrologic characteristics and trends during drier or wetter periods relative to the mean annual precipitation or streamflow. Downward slopes of the cumulative departure curve represent drier periods relative to the mean, while upward slopes represent wetter periods relative to the mean. A steep slope indicates a drastic change in dryness or wetness during that period, whereas a flat slope indicates average conditions during that period, regardless of whether the total cumulative departure falls above or below zero.

[58] Unimpaired flow is defined as flow “that would have occurred had water flow remained unaltered in rivers and streams instead of stored in reservoirs, imported, exported, or diverted.” (DWR, 2007).

[59] Antecedent (i.e., prior or left-over year) dry conditions minimize differences in groundwater in the unsaturated zone at the beginning and at the end of a study period. Given that the volume of water in the unsaturated zone is difficult to determine, particularly at the scale of a groundwater subbasin, selection of a base period with relatively dry conditions antecedent to the beginning and end of the period of record is preferable.

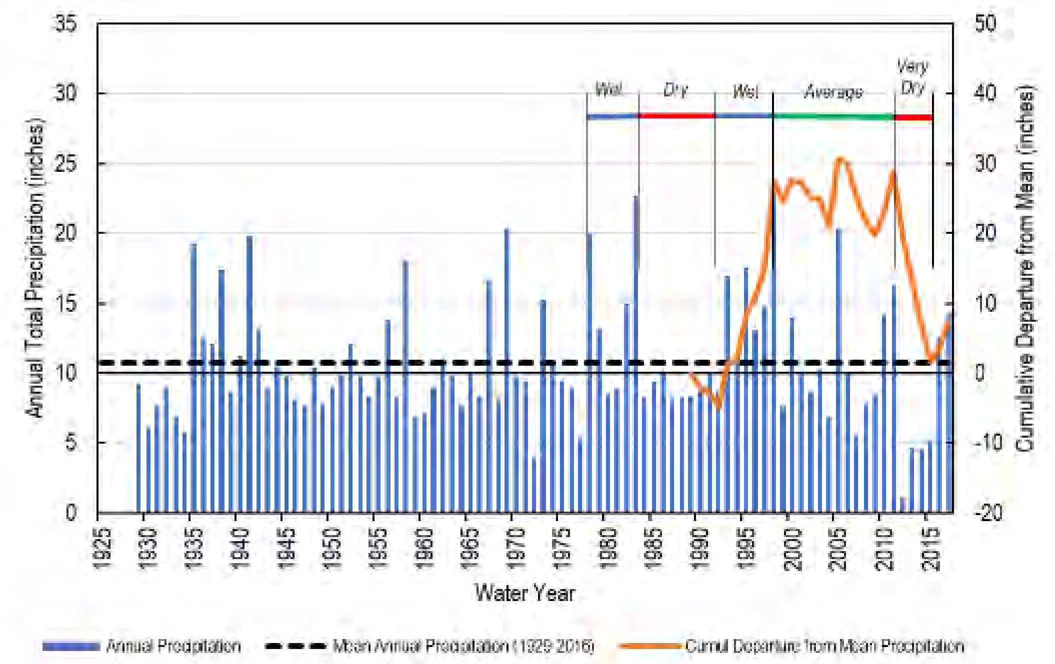


Figure 2-88~~6~~. Annual Precipitation and Cumulative Departure from Mean Precipitation in Madera, CA.[60]

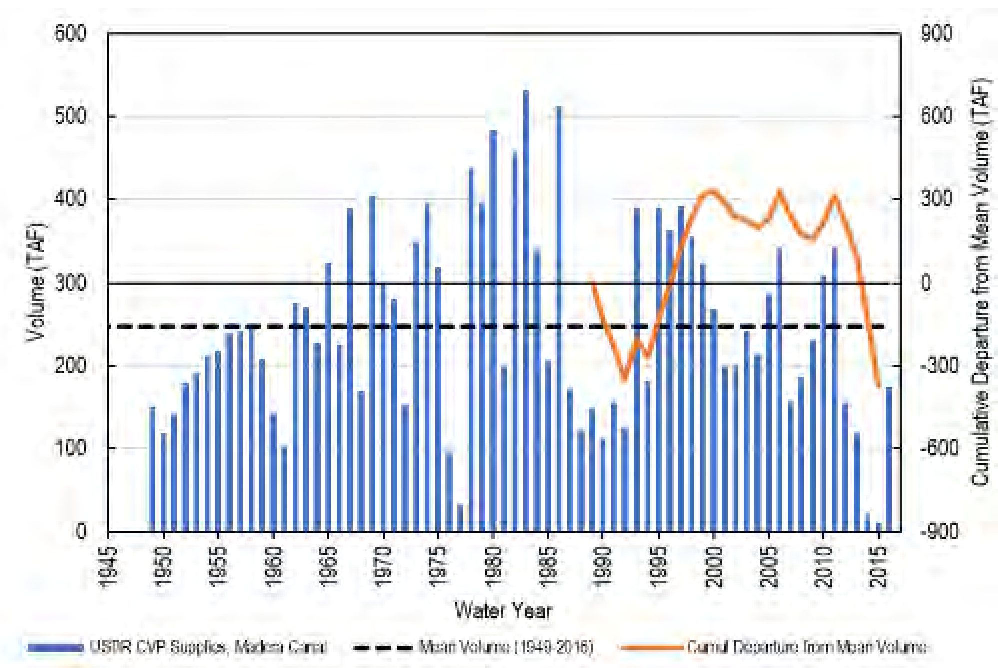


Figure 2-89~~7~~. Annual CVP Supplies and Cumulative Departure from Mean CVP Supplies along Madera Canal.[61]

[60] Precipitation data from National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI) Station 045233.

[61] Madera Canal inflows from U.S. Geologic Survey (USGS) Site 11249500 (MADERA CN A FRIANT CA).

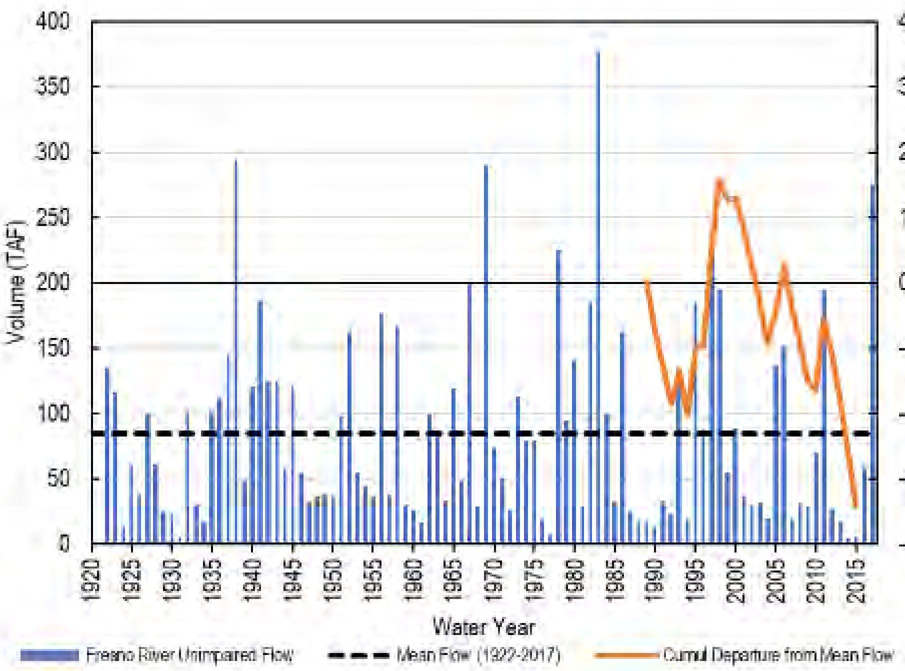


Figure 2-9088. Annual Flow and Cumulative Departure from Mean Flow along Fresno River near Daulton, CA.[62]

Projected Period

For the projected water budgets used to evaluate projects, a 72-year projected period was chosen to provide a 22-year project implementation period from 2019-2040 and a 50-year period to evaluate sustainability from 2041-2090. Time series data for water years 2019-2090 were developed using:

1. Historical hydrologic data from water years 1965-2015
2. Historical water supply data from 1989-2015, with adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program[63]
3. 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090)[64]

The years that were used for developing the projected period hydrologic and water supply data were chosen because (1) they mostly closely matched long-term mean annual water supply, based on

[62] Fresno River unimpaired flows compiled from: 2016 Department of Water Resources, Bay-Delta Office, Natural and Unimpaired Flows for the Central Valley of California (1922-2014); California Data Exchange Center, U.S. Army Corps of Engineers (USACE) Station FHL (FRESNO R ABV HENLEY LAKE) (2015-2017).

[63] Estimated by the Friant Water Authority Report (or Friant Report): "Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California" (2018). Although the Friant Report accounts for climate change, it is considered the best available estimate of projected Madera Canal deliveries under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Steiner Report Kondolf Hydrograph (Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

[64] Land use adjustment for urban area projected growth also accounts for changes in agricultural and municipal water use. See Section 2.2.3.3, "Crop Water Use" and "Urban Water Use."

comparative analysis with all available historical data for Madera Canal and Fresno River; (2) they included both wet and dry periods; and (3) because of data availability for a 50-year time period. In particular, the implementation period was simulated with hydrologic and water supply data from 2000-2010. This period was chosen because it represents a recent 10-year period of relatively average annual water supply (compared to the long-term mean annual water supply), with a relatively uniform distribution of water year types that begins and ends with a drier period, such that any water unaccounted for in the unsaturated zone is minimized. Other years were simulated with hydrologic and water supply data matched to each year based on expected similarities in water year indices.

To evaluate sensitivity to climate change, projected water budgets were also developed using:

1. Historical hydrologic data from water years 1965-2015 adjusted by DWR-provided 2030 mean climate change factors
2. Historical water supply data from 1989-2015 adjusted similarly by climate change factors, with additional adjustment of CVP supply based on projected alteration of available Friant Releases by the San Joaquin River Restoration Program
3. 2017 land use adjusted for urban area projected growth from 2017 through 2070 (areas were held constant from 2071 through 2090)

Water Budget Time Step

The GSP regulations specify that sustainability analyses be conducted on at least an annual time step. However, a monthly time step is recommended to support evaluation of sustainability indicators and potential PMAs. These sustainability evaluations, which may include analyses involving hydrologic modeling, require data and analyses at a time step sufficient to assess seasonal conditions and trends within an annual interval in addition to long-term trends spanning years.

Water budget calculations were performed on a monthly time step, although certain water budget components identified in Section 2.2.3.3 (e.g. runoff of precipitation) were calculated on a daily basis before being summed to monthly values. For reporting purposes, water budget results are summarized by water year.

Water Budget Reporting by Analysis Period

The historical and current water budgets were completed for the SWS outside of the MCSim model. The historical budget was used to develop model inputs and to confirm and calibrate model outputs. The current budget was used to estimate the net recharge from the SWS (net recharge), defined as the average annual sum of all groundwater extraction (negative) and groundwater recharge (positive) to and from the surface and root zone overlying the ~~Madera~~ Subbasin. "Shortage" was also calculated from the water budget as the inverse of net recharge (sum of all groundwater extraction (positive) and groundwater recharge (negative) to and from the surface and root zone overlying the ~~Madera~~ Subbasin). This "shortage" was used to inform stakeholders regarding the Subbasin status and to determine the extent of projects and/or demand management required for the Subbasin to reach sustainability.

The projected water budget was completed only in the MCSim model. The projected water budget in the MCSim model was first developed without projects. Then, the projects and/or demand reduction actions developed to bring the Subbasin to sustainability were added to the projected water budget to confirm that these projects and/or demand reduction actions were sufficient to reach sustainability by 2040.

2.2.3.3 Water Budget Components and Uncertainties

This section provides a summary of the data sources and calculations used to develop time series datasets for each component in the Subbasin SWS water budget. The datasets include surface water inflows and outflows, meteorological data used to compute reference crop evapotranspiration (ET_{ref}), land use and cropping patterns, crop water use (evapotranspiration, or ET), surface water diversions, applied surface water volumes, and groundwater pumping volumes. Each of these datasets is summarized below by accounting center.

Land Surface System

In the Madera Subbasin, the Land Surface System encompasses all land surface area apart from rivers, streams, and canal systems. As required by the GSP regulations, the total Land Surface System is subdivided into three water budget accounting centers representing Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural land), and Native Vegetation Land (NV) water use sectors. Water budgets for each water use sector accounting center are developed with distinct, but similar, inflow and outflow components. Water budgets for each water use sector accounting center were developed uniquely for each Madera Subbasin GSA, as described in **Appendix 2.F.**

Detailed Land Surface System water budget components are summarized in Table 2-14, including general components included in every water use sector water budget and specific components unique to individual water use sectors. This table also includes a brief description of the estimation methods and information sources for each component. Details for each component are provided in **Appendix 2.F.** for each data type used in the water budgets.

Meteorological Data

In the Land Surface System water budgets, meteorological data is used directly in calculating precipitation inflows and indirectly for estimating crop consumptive use, or evapotranspiration, and for simulating root zone characteristics over time using a root zone model (described below).

All weather data time series required for developing the Land Surface System water budget components were derived from weather station data reported by the California Irrigation Management Information System (CIMIS) and National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI). CIMIS and NOAA NCEI data were obtained and quality controlled following the procedure described in **Appendix 2.F.h.** Table 2-15 lists the stations and periods of record used for each station. Between 1988 and 2015, CIMIS data from various stations in and around the Subbasin were used to calculate daily reference crop evapotranspiration (ET_{ref}) and develop precipitation time series for the Madera Subbasin. These stations are preferred due to their siting specifically in agricultural areas. During years in the water budget analysis periods when CIMIS data was not available, data from the Madera NOAA NCEI station was used to estimate ET_{ref} and to develop precipitation time series.

Precipitation

Daily precipitation inflows to each Land Surface System water use sector were calculated as the daily precipitation depth derived from weather station data (in feet) applied over the total area of each water use sector within the Subbasin (in acres). Daily precipitation volumes were summarized to monthly and annual volumes for water budget development. Daily precipitation depths were also provided as inputs to the root zone model to simulate precipitation availability for consumptive use, infiltration, and runoff.

Reference Evapotranspiration

Daily reference crop evapotranspiration (ET_{ref}) was determined by following the scientifically sound and widely accepted standardized Penman-Monteith (PM) method, as described by the ASCE Task Committee Report on the Standardized Reference Evapotranspiration Equation (ASCE-EWRI, 2005). The Task Committee Report standardizes the ASCE PM method for application to a full-cover alfalfa reference (ET_r) and to a clipped cool season grass reference (ET_o). The clipped cool season grass reference was selected for this application, as it is widely used throughout California. Daily ET_o values were provided as inputs to the root zone model for simulating crop consumptive use requirements.

Root Zone Model

A daily root zone water budget model was used to develop an accurate and consistent calculation of historical crop ET (ET_c) and other water budget components that must be reported for the Land Surface System water use sectors, per the GSP regulations. A daily root zone water budget is a generally accepted and widely used method to estimate the portion of evapotranspiration attributable to rainfall (effective rainfall), versus irrigation (ASCE, 2016 and ASABE, 2007).

Flows through the root zone and plant surfaces of irrigated lands were modeled using a stand-alone tool, that can also be linked to the Integrated Water Flow Model (IWFM), known as the IWFM Demand Calculator (IDC). The physically-based IDC version 2015.0.0036 (DWR, 2015) is developed and maintained by the California Department of Water Resources (DWR). IDC uses weather data and information regarding crops, soil properties, and irrigation methods to compute the balance of inflows and outflows from the Land Surface System.

For developing SWS water budgets, a daily IDC was used as a stand-alone root zone model independent of IWFM. For developing the integrated SWS and GWS water budgets in the MCSim model, this daily IDC application was converted to a monthly application, recalibrated to match the monthly inflows and outflows in the SWS water budgets, and then integrated with the remaining components of MCSim. The IDC application thus served as the foundation for coupling the SWS water budget to the groundwater model used in GSP development.

IDC was used to develop time series estimates for the following water budget components:

- ET of applied water
- ET of precipitation
- Infiltration of applied water
- Infiltration of precipitation
- Uncollected surface runoff of applied water (estimated as negligible in the ~~Madera~~ Subbasin)
- Uncollected surface runoff of precipitation
- Change in root zone storage

Details regarding the improved crop coefficients used by IDC for estimating ET are described in the Crop Water Use section below. Additional details regarding development of the full IDC root zone water budget, including major inputs, are provided in **Appendix 2.F.i.**

Land Use Data

Accurate land use areas are required for determining crop consumptive use (ET) and for developing an accurate root zone model. For this Joint GSP, a land use analysis was performed to develop a Madera County-wide annual spatial crop acreage dataset from which annual crop areas in the ~~Madera~~ Subbasin and each GSA were derived. The detailed procedure used for land use data development is described in **Appendix 2.A.**

Table 2-14. Land Surface System Water Budget General Detailed Components and Estimation Techniques.

Detailed Component	Category	Water Use Sector	Subregion	Data Type	Calculation/Estimation Technique	Information Sources
Precipitation	Inflow	AG, UR, NV	All	Meteorological Data	Calculated as the precipitation depth over the total land area by Water Use Sector	Madera NCEI, Fresno/Madera/Madera II CIMIS, land use data
Groundwater Extraction/Upflux	Inflow	AG, UR, NV	All (except MWD AG)	Closure Term	Calculated as the difference of total inflows and total outflows from the Water Use Sector water balance	Closure Term
	Inflow	AG	MWD	Groundwater Data	Reported by historical MWD records	MWD Groundwater Management Plan (GMP)
Surface Water Deliveries	Inflow	AG	MID, MWD, GFWD	Surface Water Data	Measured by water suppliers	MID STORM delivery database, GFWD delivery records, MWD delivery records
Riparian Deliveries	Inflow	AG	MC, MID, RCWD	Surface Water Data	Reported by historical water rights and statements of diversion, estimated from streamflow and crop ET when records not available	eWRIMS, Holding Contracts
Evapotranspiration (ET) of Applied Water	Outflow	AG, UR	All	Meteorological Data, Crop Water Use (Root Zone Model)	Estimated by IDC root zone water budget using CIMIS reference ET, precipitation, estimated crop coefficients from energy balance (SEBAL) analysis, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data
Evapotranspiration (ET) of Precipitation	Outflow	AG, UR, NV	All	Meteorological Data, Crop Water Use (Root Zone Model)	Estimated by IDC root zone water budget using CIMIS reference ET, CIMIS precipitation, estimated crop coefficients from energy balance (SEBAL) analysis, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data
Infiltration of Applied Water	Outflow	AG, UR	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Infiltration of Precipitation	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Runoff of Applied Water	Outflow	AG, UR	All	Root Zone Model	Estimated as negligible in the Madera Subbasin	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Runoff of Precipitation	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget using CIMIS precipitation, NRCS soils characteristics, cropped area by crop type	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey
Change in Storage	Outflow	AG, UR, NV	All	Root Zone Model	Estimated by IDC root zone water budget as net change in root zone water due to consumption or infiltration.	Fresno/Madera/Madera II CIMIS, land use data, NRCS soil survey

Table 2-15. Madera Subbasin Weather Data Time Series Summary.

Weather Station	Station Type	Start Date	End Date	Comment
Fresno State	CIMIS	Oct. 2, 1988	May 12, 1998	Used before Madera CIMIS station was installed.
Madera	CIMIS	May 13, 1998	Apr. 2, 2013	Moved eastward 2 miles in 2013 and renamed "Madera II."
Madera II	CIMIS	Apr. 3, 2013	Dec. 31, 2015	
Madera	NOAA NCEI	Jan. 1, 1928	Dec. 31, 2017	Used for developing ET_{ref} time series for projected water budget period before CIMIS station data was available.

Land use estimates for 1989 through 2015 corresponding to water use sectors (as defined by the GSP regulations) are summarized above in Section 2.1 Description of the Plan Area (Figure 2-3 and Table 2-1). The Urban land use category includes urban, industrial, and semi-agricultural lands. Industrial land use in the Subbasin covers only a small area, so these lands were included in the Urban water use sector. Between 1989 and 2015, the expansion of agricultural and urban lands has coincided with a reduction in native vegetation across the Subbasin.

Agricultural land uses are also detailed in Section 2.1 above (Figure 2-4 and Table 2-2). Across the Subbasin, agriculture has historically been dominated by permanent crops, including grapes and orchards. In particular, orchard acreage has more than doubled since 1989. As these crops have higher consumptive water use requirements than many other commodities grown in the Subbasin, agricultural water demand has increased in recent years. Dairy land use and water use are included in the agricultural land water balance in the– Madera Subbasin, as the majority of water used by dairies is applied to crops (approximately 90%).

Detailed land use summaries are provided for each GSA in **Appendix 2.F.**

Crop Water Use

The daily IDC root zone water budget application described above was used to develop an accurate and consistent calculation of historical crop ET (ET_c) using the widely accepted crop coefficient – reference crop ET" methodology following standardized conventions established in the American Society of Civil Engineers (ASCE) Manual 70: Evaporation Evapotranspiration, and Irrigation Water Requirement (2016), and in the Food and Agriculture Organization of the United Nations (FAO) Irrigation and Drainage Paper 56 (FAO-56) (Allen, et al., 1998). In this methodology, daily evapotranspiration of a reference crop (ET_{ref}) is calculated based on local weather and climate conditions specific to the Subbasin and analysis period. Daily ET_{ref} is then adjusted to estimate daily ET_c for other crops by a specific crop coefficient (K_c) curve unique to the crop type and its development stage, growth conditions, and health.

Daily ET_o was calculated for the Madera Subbasin from weather station data, as described above. Crop coefficients were derived from actual ET (ET_a) estimated by the Surface Energy Balance Algorithm for Land (SEBAL) for 2009. Remotely sensed energy balance ET results account for soil salinity, deficit irrigation, disease, poor plant stands, and other stress factors that affect crop ET. Studies by Bastiaanssen, et al. (2005), Allen, et al. (2007 and 2011), Thoreson, et al. (2009) and others have found that when performed by an expert analyst, seasonal ET_a estimates produced by SEBAL are within plus or minus five percent of actual crop ET.

For crops grown in theee Madera Subbasin, annual historic ET_c was computed by the IDC application using the quality controlled CIMIS ET_o and these local, remote sensing derived crop coefficients. The aforementioned IDC root zone model parsed these ET_c estimates into the ET of applied water and ET of precipitation estimates used in the ~~Madera~~ Subbasin water budgets.

Urban Water Use

Urban water use was computed in the IDC application through the urban land use module. This module simulates demands of municipal water users, including domestic well users, state small water systems, small community water systems, medium and large community water systems, and non-community water systems. Inputs to the urban module include: annual population estimates for urban and residential areas in the Subbasin; groundwater pumping records from City of Madera, when available, or estimates based on annual population records and average per capita water use; fraction of total water used indoors versus outdoors; and parameters dictating runoff, evapotranspiration, and infiltration. Urban water use was calculated from these inputs over the area in the Subbasin representing the urban water use sector (urban, industrial, and semi-agricultural land).

Surface Water Data

In the Land Surface System, surface water inflows primarily include surface water deliveries and riparian deliveries to agricultural lands.

Surface water deliveries are reported by each GSA that distributes water for deliveries to agricultural lands. When monthly records are unavailable, annual records are distributed to monthly values in proportion to the monthly pattern of ET of applied water provided by the root zone model during the irrigation season. Missing records are estimated based on the average monthly deliveries by water year type.

Riparian deliveries are diverted directly to riparian parcels from adjacent waterways. For water budget accounting, riparian deliveries include water diverted under both appropriative water rights and riparian claims. Appropriative water rights and riparian claims along the San Joaquin River are reported by the State Water Resources Control Board's Electronic Water Rights Information Management System (eWRIMS). Riparian deliveries along Fresno River are included in the MID GSA Canal System water budget (described below) within the water budget component "Diversions from Fresno River." In the water budget, reported water rights diversions are subtracted from the total flows along their respective waterways.

Groundwater Extraction

Groundwater extraction was calculated as the Land Surface System water budget "closure" term – the difference between all other estimated or measured inflows and outflows from each water use sector. Groundwater extraction was selected as the closure term because groundwater pumping data is generally unavailable across the Subbasin (except for MWD in recent years). Also, groundwater extraction serves as a relatively large inflow to the Land Surface System, resulting in lower relative uncertainty when calculated as a closure term compared to smaller flow paths following the procedure outlined by Clemmens and Burt (1997).

Groundwater pumping was calculated as the water budget closure term for all water use sectors in all subregions with the exception of MWD agricultural lands between water years 1993 and 2014. During this period, groundwater pumping data reported in the MWD Groundwater Management Plan were used and infiltration of applied water was the closure term.

Rivers and Streams System

At the Subbasin level, the Rivers and Streams System includes all inflows and outflows from natural waterways that cross a portion of the Subbasin, including intermittent and ephemeral streams. The San

Joaquin River, a perennial waterway flowing along the Subbasin boundary, was not explicitly included in the water budgets[65], although estimates of boundary seepage were included in the Subbasin and subregion estimates of net recharge from the SWS.

Detailed Rivers and Streams System water budget components are summarized for the entire ~~Madera~~ Subbasin in Table 2-16 along with a brief description of the estimation technique and information sources for each. Additional detailed components unique to individual subregion water balances are summarized in **Appendix 2.F.**

Surface Water Data

Surface water data includes primarily surface water inflows and surface water outflows for each of the major waterways within the ~~Madera~~ Subbasin. A surface hydrology map summarizing the ~~Madera~~ Subbasin inflows, outflows, and available data sources is provided in Figure 2-91~~89~~. Surface water diverted under the surface water rights of MID and GFWD is included in those agencies' GSA water budgets found in **Appendix 2.F.**

Inflow and outflow data sources and estimation procedures are described for each waterway below. Additional detail and a description of quality control procedures can be found in **Appendix 2.F.** These procedures were used to determine the waterway inflows and outflows from the ~~Madera~~ Subbasin.

Berenda Creek

Inflow and outflow data for Berenda Creek were assembled from records provided by MID. MID has installed a number of recorders that record flows at key inflow and outflow points, including "Recorder 13: Berenda Creek Head" and "Recorder 2: Berenda Creek Spill." Recorder 13 is located along Berenda Creek approximately 7.5 miles north of the City of Madera and approximately 13 miles inside the Subbasin boundary. Recorder 2 is located approximately 8.5 miles south of the City of Chowchilla and just over 3 miles upstream of the Subbasin boundary. Average daily flow values were provided by MID for the years 1970-2017 (Recorder 13) and 1966-2018 (Recorder 2) and summarized into monthly and annual flow volumes.

Subbasin inflows and outflows were estimated by adjusting the associated recorder data for estimated seepage and evaporation along the portion of the creek within the Subbasin but upstream or downstream of the inflow or outflow measurement point, respectively.

[65] The San Joaquin River does not cross the lateral boundaries of the Madera Subbasin, as defined above, and San Joaquin River flows are thus not considered surface water inflows to the subbasin within this water budget. A portion of infiltration of surface water from the San Joaquin River is considered to cross the subbasin boundaries into the groundwater system and is included in the calculation of the subbasin estimates of overdraft and net recharge from SWS.

Table 2-16. Subbasin Rivers and Streams System Water Budget Detailed Components and Estimation Techniques.

Detailed Component	Category	Data Type	Waterway	Calculation/Estimation Technique	Information Sources
Surface Inflows	Inflow	Surface Water Data	Berenda Creek	Calculated from MID recorder measurements adjusted upstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 13, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Cottonwood Creek	Calculated from MID recorder measurements adjusted upstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 14, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Chowchilla Bypass	Calculated from SLDMWA CBP station measurements adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	SLDMWA CBP station, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Dry Creek	Estimated as equal to Berenda Creek recorder measurements adjusted upstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 13, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Fresno River	Estimated as equal to USGS measurement site along Fresno River below Hidden Dam	USGS Site 11258000 (FRESNO R BL HIDDEN DAM NR DAULTON CA)
Runoff of Precipitation	Inflow	Meteorological Data	All	Calculated in IDC root zone water budget as daily rainfall runoff using SCS curve number analysis.	Root zone simulation model, NRCS soils characteristics, CIMIS precipitation data
Evaporation	Outflow	Meteorological Data	All	Estimated from reference ET, evaporation coefficient, and estimated water surface area.	Fresno State/Madera/Madera II CIMIS Stations
Infiltration of Surface Water	Outflow	Closure Term (MC, MID), Soils Data (other GSAs)	All	Estimated from wetted area and estimated seepage coefficient by soil type	NRCS soil survey, GIS waterway attributes analysis
Riparian Deliveries[1]	Outflow	Surface Water Data	San Joaquin River	Reported riparian deliveries and estimated riparian deliveries based on estimated consumptive use of riparian parcels during streamflow	eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Surface Outflows	Outflow	Surface Water Data (MC, MID), Closure Term (other GSAs)	Berenda Creek	Calculated from MID recorder measurements adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 2, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Cottonwood Creek	Calculated from MID recorder measurements adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 10, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Chowchilla Bypass	Calculated from SLDMWA CBP station measurements adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	SLDMWA CBP station, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations
			Fresno River	Calculated from MID recorder measurements (downstream of convergence with Dry Creek) adjusted downstream to the Subbasin boundary for estimated seepage and evaporation	MID Recorder 4, NRCS soil survey, Fresno State/Madera/Madera II CIMIS Stations

[1] Riparian deliveries along Fresno River within the Madera Subbasin are included in the MID GSA Canal System water budget within "Diversions from Fresno River."

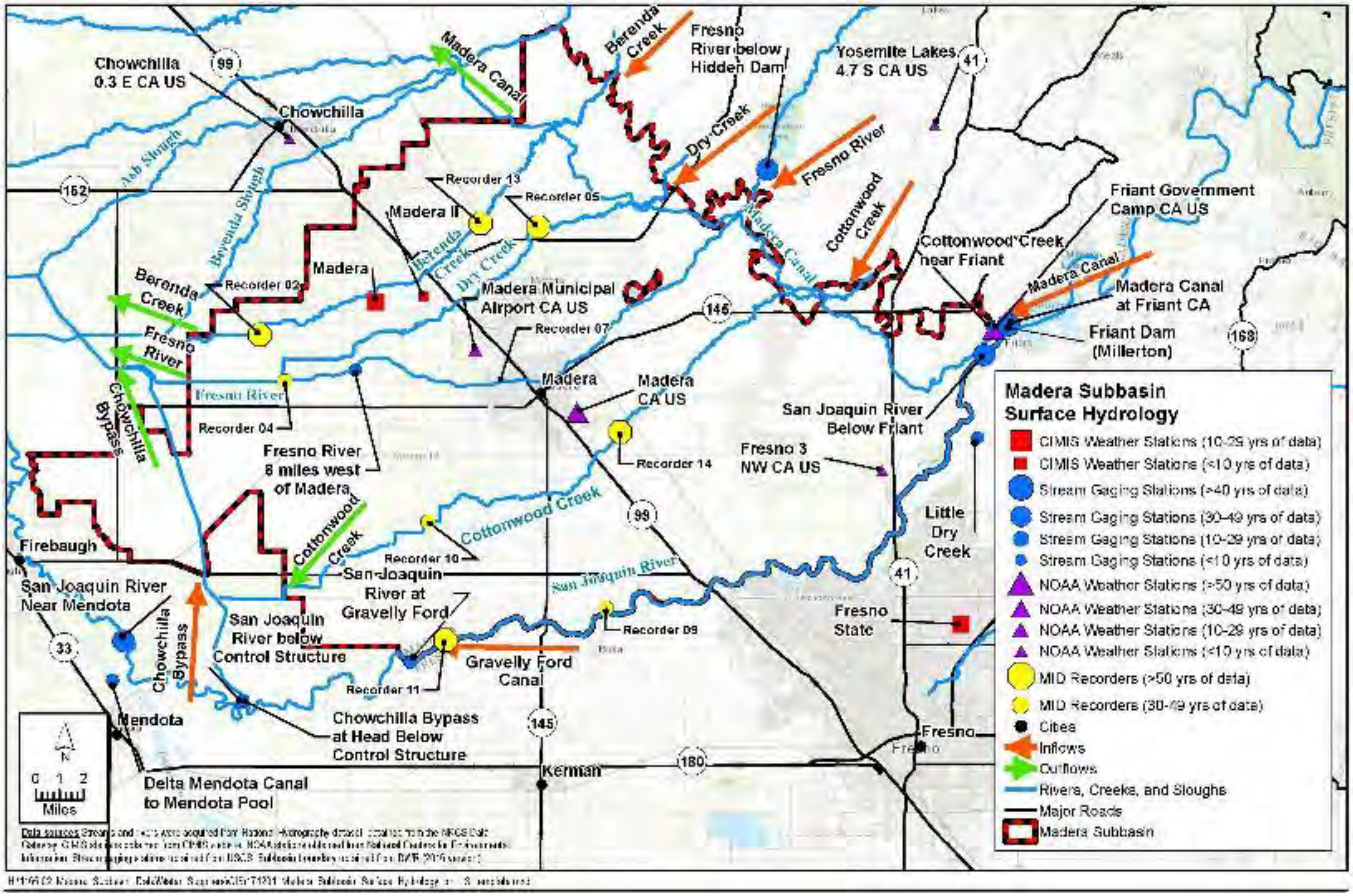


Figure 2-91~~89~~. Madera Subbasin Inflows and Outflows.

Cottonwood Creek

Inflow and outflow data for Cottonwood Creek were also assembled from MID records. “Recorder 14: Cottonwood Creek Head” records historical inflows to MID on Cottonwood Creek and is located just a few miles southeast of City of Madera and approximately 11 miles from the eastern Subbasin boundary. “Recorder 10: Cottonwood Creek Spill” records outflows from MID and is located approximately 7 miles upstream of the Subbasin boundary. During the irrigation season, just over 18 miles of the creek are sometimes used as part of the MID and GFWD irrigation distribution systems. GFWD extracts water for irrigation downstream of Recorder 14. Average daily flow volumes were provided by MID for the years 1970-2016 and summarized into monthly and annual volumes.

Subbasin inflows were estimated by adjusting the Recorder 14 records for estimated seepage and evaporation along the portion of the creek within the Subbasin but upstream of the inflow measurement point. Subbasin outflows were estimated as the Recorder 10 records adjusted for GFWD diversions and estimated seepage and evaporation.

Chowchilla Bypass

The Chowchilla Bypass is located in the southwestern part of the ~~Madera~~ Subbasin, serving as a flood control channel operated via gates along the San Joaquin River during times when flows would exceed the San Joaquin River’s downstream capacity. Inflow data for Chowchilla Bypass at its head below the control structure were assembled using a combination of DWR’s Water Data Library (WDL) records (1982-1991) and California Data Exchange Center (CDEC) records (1997-2017). Daily average flow values were summarized as monthly and annual volumes. Missing data were estimated on a monthly basis based on available historical records.

Subbasin inflows were estimated by adjusting the CDEC and WDL records for estimated seepage and evaporation from the measurement point to the ~~Madera~~ Subbasin boundary inflow point, and Subbasin outflows were similarly estimated by adjusting inflows from the measurement point to the ~~Madera~~ Subbasin boundary outflow point.

Dry Creek

Inflow data for Dry Creek were assembled from MID records. “Recorder 5: Dry Creek Head Flood Water” is located along Dry Creek approximately 7 miles north of the City of Madera and approximately 8.5 miles from the eastern boundary of the Subbasin. Average daily flow values were provided for years 1966-2018, which were summarized into monthly and annual flow volumes.

Subbasin inflows were estimated by adjusting the Recorder 5 records for estimated seepage and evaporation along the portion of the creek within the Subbasin but upstream of the inflow measurement point. Dry Creek joins the Fresno River upstream of MID Recorder 4. Therefore, Dry Creek outflow is measured as part of the Fresno River outflow.

Fresno River

Inflow data for the Fresno River were assembled from records provided by both the USGS and CDEC. The USGS site number 11258000 (“FRESNO R BL HIDDEN DAM NR DAULTON CA”) is located along the Fresno River near Daulton, CA, in Madera County, approximately 1 mile downstream of Hidden Dam on the Fresno River. The CDEC site, Hidden Dam (Hensley), is also located near Daulton, CA in Madera County just downstream of Hidden Dam. Both sites measure reservoir discharge into the Fresno River. Subbasin inflows were assembled from USGS (1941-1990) and CDEC (1993-2018) and summarized into monthly and annual volumes. Missing data were estimated by average monthly volumes by water year type.

During the irrigation season, approximately 10 miles of the Fresno River are used as part of the MID irrigation water distribution system. Some CVP supplies in the Madera Canal are diverted into Fresno River, serving as additional inflows to the Rivers and Streams System (described below).

Outflow data for the Fresno River was estimated from records provided by MID for "Recorder 4: Fresno River Rd. 16" for years 1951-2018. This recorder measures flow in the Fresno River where it exits the MID service area, downstream of the location where Dry Creek joins the Fresno River and approximately 4 miles upstream of the Subbasin boundary. Thus, Dry Creek outflow is measured as part of the Fresno River outflow. Surface outflows were estimated from these records with adjustment for estimated seepage and evaporation from the portion of the Fresno River inside the Subbasin but downstream of the Recorder 4 measurement site.

Madera Canal Diversions to Rivers and Streams System

The Madera Canal enters the ~~Madera~~ Subbasin at its southeastern corner, runs northwesterly generally along the eastern Subbasin boundary, and leaves the Subbasin almost 32 miles to the northwest. Located along the canal are delivery points to irrigation distribution infrastructure, irrigated lands, and the Fresno River.

Data for Madera Canal diversions and flood diversions to Fresno River were assembled from USBR CVP recorded irrigation deliveries and flood deliveries, respectively, at Madera Canal Mile 18.8. Daily records of irrigation deliveries and flood deliveries in cubic feet per second (cfs) were provided by MID for 1988-2018.

Riparian Deliveries

Riparian deliveries are described above in the Land Surface System components descriptions.

Spillage from MID

Excess flows in the MID conveyance system are released at spill sites into the Fresno River. Monthly spillage volumes were assembled from MID recorder data from Recorders 15 (24.2 Spill), 16 (17.0 Spill), 17 (24.2-13.2 Spill), 18 (Dry Creek Lat. Spill), 19 (24.2-17.0 End), and 20 (24.2-14.2 Spill). Recorders 9 (6.2 Spill) and 11 (16.9 - 18.4 - 6.2 Spill) record spillage from the MID conveyance system to the San Joaquin River. Monthly recorder data was available between 1972-1974 and 2003, and daily recorder data was available between 2005 and 2018.

MID Conveyance System to Cottonwood Creek

In addition to the spillage sites identified above, water is also released from the MID conveyance system into Cottonwood Creek for delivery to GFWD. Annual volumes were estimated based on MID Recorder 10 records and GFWD delivery records extracted from GFWD's 1996 Agricultural Water Management Plan for the period 1985 through 1996, and from GFWD's Water Source Summary records for the period 2004 through 2017. Monthly volumes were estimated based on the monthly pattern of agricultural ET of applied water in GFWD, assuming that MID conveyance system releases to GFWD via Cottonwood Creek only occur primarily within the irrigation season.

San Joaquin River

The San Joaquin River flows along the southern Subbasin boundary but does not cross the lateral boundaries of the ~~Madera~~ Subbasin. Thus, flow along the San Joaquin River was not explicitly included in surface water inflows to the Subbasin water budget. Only surface water that is diverted from the San Joaquin River to users in the Subbasin, such as riparian diversions and diversions to Gravelly Ford Water

District, is included as surface water inflows. A portion of infiltration of surface water from the San Joaquin River is also considered to cross the Subbasin boundaries into the groundwater system and is included in the Subbasin estimates of overdraft and net recharge from SWS.

To develop these seepage estimates, a San Joaquin River boundary balance was developed using measured inflows to the San Joaquin River from Friant Dam and Little Dry Creek, as well as measured outflows along the San Joaquin River near GFWD. Inflow data from Friant Dam were assembled for 1911-2018 from USGS records at Site 11251000 ("SAN JOAQUIN R BL FRIANT CA") located near the town of Friant in Fresno County, approximately 2 miles downstream of the Friant Dam. Inflow data from Little Dry Creek were assembled for 1997-2018 from CDEC records at site "Little Dry Creek (LDC)." Outflow data were assembled for 1997-2018 from CDEC records at site "San Joaquin River at Gravelly Ford (GRF)," which is located in Madera County approximately 7.5 miles northwest of the town of Kerman. Missing data was estimated as the average monthly volume by water year type. In each month, the difference between these inflows and outflows was estimated to be the total seepage along the ~~Madera~~ Subbasin boundary during that month. These seepage estimates were found to be consistent with San Joaquin River Restoration Study values.[66] For sections of the San Joaquin River bordering the ~~Madera~~ Subbasin, half of the total estimated seepage was assigned to the Subbasin.

Meteorological Data

As in the Land Surface System water budgets, meteorological data from CIMIS and NOAA NCEI weather stations was used in calculating weather-related inflows and outflows to the Rivers and Streams system. These components are summarized below.

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified in Table 2-15 multiplied by the waterway surface area and a free water surface evaporation coefficient of 1.05 from UCCE (1989) and ASCE (2016). When, based on streamflow records and related water balances, water was estimated to be in the waterway reach, evaporation was estimated. Evaporation was calculated on a reach-by-reach basis along each waterway and summed for all waterway reaches within the Subbasin and for each GSA.

Runoff of Precipitation

Runoff of precipitation was calculated by the IDC root zone water budget as the component of total uncollected runoff attributed to precipitation. The IDC application uses a modified version of the SCS curve number (SCS-CN) method to estimate runoff of precipitation. Curve numbers are used as described in the National Engineering Handbook Part 630[67] (USDA, 2004, 2007) based on land use or cover type, surface treatments (e.g. straight rows, bare soil), hydrologic condition, and hydrologic soil group. Additional details regarding IDC root zone water budget development are provided in **Appendix 2.F.i.**

Soils Data

As in the Land Surface System water budget, soils data from SSURGO was used in calculating infiltration from the Rivers and Streams System.

[66] Friant Water Users Authority Natural Resources Defense Council. 2002. *San Joaquin River Restoration Study Background Report,* Chapter 2: Surface Water Hydrology.

[67] Table 1. Runoff curve numbers for agricultural lands.

Infiltration of Surface Water

Infiltration of surface water (seepage) was calculated based on the wetted area and seepage characteristics of each waterway reach, as determined from a detailed waterway analysis to identify reach dimensions, soil types, soil distribution, and associated seepage characteristics based on NRCS soils data. Seepage was first calculated on a reach-by-reach basis along each waterway and summed for all reaches in CM GSA, GFWD GSA, MWD GSA, NSWD GSA, and RCWD GSA. For MC GSA and MID GSA, seepage was calculated as the Subbasin Rivers and Streams System closure term, after accounting for seepage from other GSAs, and was then apportioned between MC and MID based on relative waterway wetted areas. Total Subbasin seepage was calculated as the sum of seepage from all GSAs.

Canal System

In the ~~Madera~~ Subbasin, the Canal System includes all canals in the MID and GFWD conveyance systems. All other GSAs either do not contain subregion-wide irrigation water distribution systems (MC, COM, NSWD) or have a piped distribution system (MWD and RCWD).

Detailed Canal System water budget components are summarized in Tables 2-17 and 2-18 for MID GSA and GFWD GSA, respectively. These tables also include brief descriptions of the estimation techniques and information sources for each component. Details for each component are briefly summarized below and are provided in detail for each GSA in **Appendix 2.F.**

Surface Water Data

Surface water data includes diversions of irrigation and flood releases from various sources and surface water outflows from canals, including spillage and deliveries.

Inflow and outflow data sources and estimation procedures are briefly described for each GSA below.

Diversions to MID

Diversions to the MID distribution system are largely from the Madera Canal downstream of the diversion point from Millerton Lake. Most diversions from the Madera Canal go directly to the MID conveyance system. At Madera Canal Mile 18.8, some water enters the Fresno River, which serves as part of the MID Canal System during the irrigation season, and is diverted into the MID canal system. These inflow data sources and calculation procedures are described below.

Diversions from Madera Canal and Flood Diversions

Data for MID's Diversions from Madera Canal and Flood Diversions were assembled from USBR CVP records of total irrigation and flood deliveries, respectively, at Madera Canal Miles 6.1, 13.06, 22.95, 24.1, 26.8, 27.5, 28.38, 28.39, 28.64, 30.4, 30.5, and 32.2. These mile markers span the Madera Canal from south to north within the ~~Madera~~ Subbasin and provide diversions directly to MID. Daily records in cubic feet per second (cfs) were provided by MID for 1988-2018.

Table 2-17. Madera Irrigation District Canal System Water Budget General Detailed Components and Estimation Techniques.

Detailed Component	Category	Data Type	Calculation/Estimation Technique	Information Sources
Diversions from Madera Canal	Inflow	Surface Water Data	Reported in USBR CVP irrigation delivery records at Madera Canal Miles 6.1, 13.06, 22.95, 24.1, 26.8, 27.5, 28.38, 28.39, 28.64, 30.4, 30.5, 32.2	USBR CVP delivery records
Diversions from Fresno River[1]	Inflow	Surface Water Data	Closure of Fresno River Balance	USGS Site 11258000 (FRESNO R BL HIDDEN DAM NR DAULTON CA), USBR CVP delivery records, IDC root zone water budget, NRCS soils characteristics, CIMIS precipitation data, MID recorders
Flood Diversions from Madera Canal	Inflow	Surface Water Data	Reported in USBR CVP flood delivery records at Madera Canal Miles 6.1, 13.06, 22.95, 24.1, 26.8, 27.5, 28.38, 28.39, 28.64, 30.4, 30.5, 32.2	USBR CVP delivery records
Infiltration of Surface Water (Seepage)	Outflow	Closure Term	Calculated as the difference of total inflows and total outflows from the Canal System water budget	Closure Term
Evaporation	Outflow	Meteorological Data	Estimated from reference ET, evaporation coefficient, and estimated canal surface area.	Fresno State/Madera/Madera II CIMIS Stations
Spillage	Outflow	Surface Water Data	Measured by MID recorders at spillage sites	MID Recorders 9, 11, 15-20
MID Conveyance System to Cottonwood Creek	Outflow	Surface Water Data	Measured by MID recorders	MID Recorder
Surface Water Deliveries to MID growers	Outflow	Surface Water Data	Measured by MID	MID STORM[2] delivery database
Deliveries to CWD	Outflow	Surface Water Data	Measured by MID	MID STORM delivery database
Surface Water Deliveries to GFWD	Outflow	Surface Water Data	Measured by GFWD	GFWD delivery records
Surface Water Deliveries to MWD	Outflow	Surface Water Data	Measured by MID, MWD	MID STORM delivery database, MWD delivery records
Surface Water Deliveries to RCWD	Outflow	Surface Water Data	No deliveries during historical baseline period (deliveries began in 2017).	MID STORM delivery database, RCWD delivery records

[1] Total diversions from Fresno River includes riparian deliveries from Fresno River.
[2] The water ordering and delivery management software used by Madera Irrigation District.

Table 2-18. Gravelly Ford Water District Canal System Water Budget General Detailed Components and Estimation Techniques.

Detailed Component	Category	Data Type	Calculation/Estimation Technique	Information Sources
Diversions from San Joaquin River	Inflow	Surface Water Data	Reported by GFWD	Gravelly Ford WD reports
Diversions from MID Conveyance System	Inflow	Surface Water Data	Reported by GFWD	Gravelly Ford WD reports
Diversions from Cottonwood Creek via MID	Inflow	Surface Water Data	Reported by GFWD	Gravelly Ford WD reports
Diversions from Cottonwood Creek (Natural Flow)	Inflow	Surface Water Data	Reported by GFWD	Gravelly Ford WD reports
Infiltration of Surface Water (Seepage)	Outflow	Closure Term	Calculated as the difference of total inflows and total outflows from the Canal System water budget	Closure Term
Evaporation	Outflow	Meteorological Data	Estimated from reference ET, evaporation coefficient, and estimated canal surface area.	Fresno State/Madera/Madera II CIMIS Stations
Spillage	Outflow	Surface Water Data	Estimated as zero	Gravelly Ford WD reports
Surface Water Deliveries	Outflow	Surface Water Data	Reported by GFWD	Gravelly Ford WD reports

Diversions from Fresno River

Data for MID's Diversions from Fresno River were computed as the irrigation season closure term of a monthly Fresno River boundary balance. The balance was computed for 1989 through 2018 and encompassed the extent of the waterway from the Subbasin boundary near Hidden Dam to Recorder 4 at the waterway outflow from MID. Inflows included measured Hidden Dam releases, measured diversions to Fresno River from Madera Canal Mile 18.8, runoff of precipitation estimated from the IDC root zone water budget, measured spillage from the MID conveyance system, and measured inflows from Dry Creek. Outflows included calculated seepage and evaporation following the procedures described above, and measured streamflow at MID Recorder 4, with diversions from Fresno River to MID calculated as the balance closure term. The total diversions from Fresno River to MID includes Pre-1914 water rights and riparian claims exercised by irrigators along Fresno River.

Diversions to GFWD

GFWD diverts natural flows from two waterways, the San Joaquin River and Cottonwood Creek, and also receives diversions from the Madera Canal via MID either through MID's conveyance system or through releases that MID makes into Cottonwood Creek for GFWD.

Annual volumes for all four diversions were estimated based on records obtained from GFWD's 1996 Agricultural Water Management Plan for the period 1985 through 1996, and from GFWD's Water Source Summary records for the period 2004 through 2017. Other years were estimated based on available data and agricultural ET of applied water requirements. Monthly volumes were estimated by distributing annual volumes following the monthly pattern of agricultural ET of applied water in GFWD during months with sufficient flows in the associated waterways, as determined by waterway boundary balances.

Surface Water Deliveries from MID

MID's distribution system primarily provides deliveries to MID customers. However, MID also makes deliveries to MWD along Dry Creek, deliveries to RCWD, deliveries to GFWD, and deliveries to individual customers in CWD. All deliveries since 1999 are recorded in MID's STORM delivery database with a delivery ID number, reading date, and relevant information related to the location in the system, turnout, and parcel that received the delivery. These turnout and parcel information are linked to growers in MID and other GSAs. Monthly deliveries to each GSA were summarized from STORM data for 1999 through 2017.

For 1989 through 1998, annual deliveries to MID and GFWD were summarized from MID's Water Supply and Grower Use History records. Annual deliveries to MWD were extracted from the 2014 Update to MWD's Groundwater Management Plan or estimated by the average annual deliveries during the available record period. Annual deliveries to CWD were estimated as zero prior to 1998. All annual deliveries were distributed monthly following the pattern of agricultural ET of applied water for irrigation season months in each subregion.

Surface Water Deliveries from GFWD

Unlike MID, GFWD's distribution system provides deliveries only to GFWD customers. For 1982-2006, monthly deliveries were extracted from GFWD's Summary of Water Sold from District. For 2007-2017, annual deliveries were extracted from GFWD's Water Source Summary records. During this period, monthly volumes were estimated by distributing annual volumes based on the monthly pattern of agricultural ET of applied water in GFWD.

Spillage from MID

As described above, excess flows in the MID conveyance system are released at spill sites into the Fresno River and the San Joaquin River. Monthly spillage volumes were assembled from MID records from Recorders 9, 11, and 15 through 20. Monthly recorder data was available between 1972-1974 and 2003, and daily recorder data was available between 2005-2018.

Meteorological Data

As in the Land Surface System and Rivers and Stream System water budgets, meteorological data from CIMIS and NOAA NCEI weather stations was used in calculating evaporation from the Canal Systems.

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified in Table 2-15 multiplied by the total conveyance system surface area in each GSA and a free water surface evaporation coefficient of 1.05 from UCCE (1989) and ASCE (2016) to compute evaporation.

Soils Data

As in the Land Surface System and Rivers and Stream System water budgets, soils data from SSURGO was used in calculating seepage from the Canal Systems.

Infiltration of Surface Water

Similar to the Rivers and Streams System water budgets, infiltration of surface water (seepage) can be calculated based on the wetted area and seepage characteristics of each subregion's conveyance system. However, due to the relative uncertainty of canal wetted area characteristics and soil conditions combined with higher certainty of diversions to the canal system and deliveries from the canal system, seepage was instead calculated as the Canal System closure term.

Inflow and Outflow Data Quality Control

Quality control procedures were applied to identify data gaps and data values outside of plausible ranges. Data gaps were filled with monthly estimates based on available daily, monthly, or annual data and historical average monthly patterns of streamflow and crop water demand by hydrologic water year type according to the San Joaquin Valley WYI described in Section 2.2.3.1 above.

Surface Water Data

For months with missing surface water data, the monthly volume was estimated as the average volume of that same month calculated across all years of the same water year type. When the number of years with available data for developing water year type monthly averages was less than five, the five water year types were grouped into simply "Wet" and "Dry" years. "Wet" years were defined as wet or above normal, and the "Dry" years were defined as below normal, dry, or critical.

For years with annual stream inflow/outflow data, monthly volumes were estimated as a portion of the measured annual volume distributed by the average monthly pattern of flow observed during water years of the same type.

For years with annual deliveries or diversions data, monthly volumes were estimated as a portion of the measured annual volume distributed by the average monthly pattern of crop water demand as calculated by the IDC root zone water budget for lands receiving those deliveries.

Meteorological Data, Soils Data, and Root Zone Water Budget Inputs

Quality control procedures used applied to meteorological data, soils data, and other data prepared for IDC root zone water budget development are described in **Appendix 2.F.i.**

Uncertainties in Water Budget Components

Uncertainties associated with each water budget component have been estimated as described by Clemmens and Burt (1997) as follows:

1. The uncertainty in each independently estimated water budget component is estimated as a percentage representing approximately a 95% confidence interval. These uncertainties are estimated based on professional judgement.
2. Assuming random, normally distributed error, the standard deviation is estimated as the confidence interval divided by 2 for each independently estimated component.
3. The variance is estimated for each component as the square of the standard deviation for each independently estimated component.
4. The variance in the closure term is estimated as the sum of variances for each independently estimated component.
5. The standard deviation in the closure term is estimated as the square root of the sum of variances.
6. The 95% confidence interval in the closure term is estimated as twice the estimated standard deviation.

Estimated uncertainties were calculated following the above procedure for the Subbasin water budgets as well as all GSA water budgets. Table 2-19 provides a summary of typical uncertainty values associated with major SWS inflows and outflows. These uncertainties provide a basis for evaluating confidence in water budget results and help to identify data needs that may be addressed during GSP implementation.

2.2.3.4 Water Budget Analysis

The conceptual water budget model for the ~~Madera~~ Subbasin and the GSAs identified in Table 2-10 was previously presented and discussed in Section 2.2.3.1. It is structured to include separate but related water budgets for the SWS and for the underlying GWS.

This section presents SWS water budget components within the ~~Madera~~ Subbasin as per GSP regulations for the historical base period (1989 through 2014) and 2015. These are followed by a summary of the water budget results by accounting center. The historical water budgets for each GSA are presented and discussed in **Appendix 2.F.** along with summaries of GSA land use data relevant to water budget development.

Surface Water Inflows

Surface water inflows include surface water flowing into the Subbasin across the Subbasin boundary. Per the Regulations, surface inflows must be reported by water source type. According to the Regulations:

> *"Water source type" represents the source from which water is derived to meet the applied beneficial uses, including groundwater, recycled water, reused water, and surface water sources identified as Central Valley Project, the State Water Project, the Colorado River Project, local supplies, and local imported supplies.*

Additionally, runoff of precipitation from upgradient areas adjacent to the subregion represents a potential source of surface water inflow.

Table 2-19. Estimated Uncertainty of Subbasin Water Budget Components.

Flowpath Direction (relative to SWS)	Water Budget Component	Data Source	Estimated Uncertainty (%)	Source
Inflows	Surface Water Inflows	Measurement	5%	Estimated streamflow measurement accuracy
	Deliveries	Measurement	6%	Estimated delivery measurement accuracy (accuracy required for Reclamation contractors)
	Precipitation	Calculation	30%	Clemmens, A.J. and C.M. Burt, 1997.
	Groundwater Extraction	Calculation	20%	Typical uncertainty when calculated for Land Surface System water balance closure;
Outflows	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and measured streamflow data compared to field measurements.
	Infiltration of Applied Water	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use and NRCS soils characteristics.
	Infiltration of Precipitation	Calculation	20%	Estimated accuracy of daily IDC root zone water budget based on annual land use, NRCS soils characteristics, and CIMIS precipitation.
	Surface Water Outflows	Measurement	15%	Estimated streamflow measurement accuracy with adjustment for infiltration and evaporation.
Net Recharge from SWS		Calculation	20%	Estimated water budget accuracy; typical value calculated for Subbasin-level net recharge from SWS.

Local Supplies

Local supply inflows to the ~~Madera~~ Subbasin include surface water inflows along Berenda Creek, Dry Creek, Cottonwood Creek, and Chowchilla Bypass, as well as riparian deliveries from the San Joaquin River. Water is diverted from these surface water inflows under the water rights held by certain GSAs.

Local Imported Supplies

~~Madera~~The Subbasin does not receive local imported supplies.

CVP Supplies

Agencies with CVP contracts can receive CVP supplies in the ~~Madera~~ Subbasin. CVP supplies received via Madera Canal include Millerton irrigation releases and flood releases. CVP supplies are also received from Hidden Dam releases along Fresno River. Additionally, GFWD can receive CVP supplies diverted from the San Joaquin River.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within the ~~Madera~~ Subbasin.

Other Surface Inflows

For the water budgets presented herein, precipitation runoff from outside the Subbasin is considered relatively minimal and is expected to enter the Subbasin along the waterways above as natural flows following relatively large storm events and are accounted as part of local supplies. Precipitation runoff from lands inside the Subbasin is internal to the surface water system and is thus not considered as surface inflows to the Subbasin boundary.

Summary of Surface Inflows

Surface water inflows by water year type are summarized in Figure 2-92~~0~~ and Table 2-20. During the study period, surface water supplies vary greatly with water year type, with substantial local supply inflows during wet years that are reduced in above normal years and remain relatively constant during all other year types. CVP supplies remain more consistent between years. Total surface water inflows range from approximately 120 thousand acre-feet (TAF) during average critical years to over 1,000 TAF during average wet years.

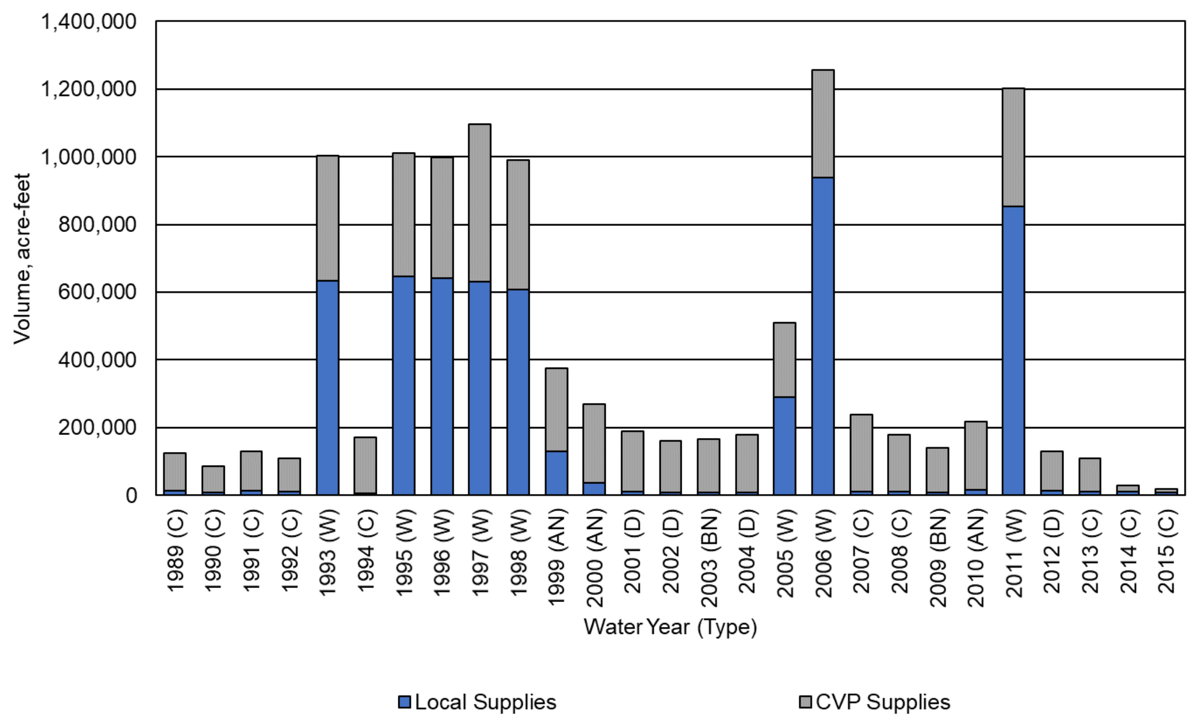


Figure 2-92~~0~~. Madera Subbasin Surface Water Inflows by Water Source Type.

Table 2-20. Madera Subbasin Surface Water Inflows by Water Source Type (Acre-Feet) (23 CCR § 354.18(b)(1)).

Water year (Type)	Local Supplies					CVP Supplies			Surface Water Inflows Total
	Berenda Creek	Chowchilla Bypass	Cotton-wood Creek	Dry Creek	Riparian Deliveries from San Joaquin River[1]	Madera Canal (diversions to MID and Fresno River)	Fresno River (Hidden Dam)	Diversions from San Joaquin River	
1989 (C)	1,230	0	2,553	1,230	7,500	94,921	16,408	0	123,841
1990 (C)	0	0	0	0	7,500	68,119	9,604	0	85,223
1991 (C)	1,125	0	3,535	1,125	8,200	93,362	20,389	2,225	129,961
1992 (C)	851	0	1,414	851	7,300	79,162	20,389	0	109,967
1993 (W)	7,100	588,832	24,077	7,100	7,300	216,724	140,795	10,999	1,002,926
1994 (C)	0	0	0	0	7,300	113,868	38,847	11,729	171,744
1995 (W)	10,056	589,328	30,486	10,056	7,500	218,728	134,717	10,789	1,011,660
1996 (W)	3,665	609,534	16,017	3,665	7,500	238,464	106,175	12,569	997,588
1997 (W)	13,661	561,559	35,983	13,661	7,500	224,541	226,611	11,871	1,095,387
1998 (W)	15,729	538,633	30,290	15,729	7,500	216,061	155,719	9,969	989,630
1999 (AN)	0	118,845	2,365	0	7,500	156,622	83,494	7,174	376,000
2000 (AN)	3,016	6,346	17,793	3,016	7,500	141,623	82,040	8,864	270,198
2001 (D)	542	0	1,819	542	7,500	128,939	46,313	3,707	189,361
2002 (D)	619	0	743	619	7,500	122,363	24,008	5,732	161,585
2003 (BN)	0	0	0	0	7,500	126,341	25,770	7,509	167,119
2004 (D)	0	0	0	0	7,500	137,290	23,729	11,472	179,991
2005 (W)	10,745	249,214	11,466	10,745	7,500	131,358	80,215	9,562	510,803
2006 (W)	12,159	901,256	6,542	12,159	7,500	170,396	135,179	9,730	1,254,921
2007 (C)	2,281	0	0	2,281	7,500	110,062	108,519	7,940	238,583
2008 (C)	878	0	2,512	878	7,500	106,030	52,440	7,854	178,093
2009 (BN)	0	0	0	0	7,872	117,306	12,835	2,556	140,570
2010 (AN)	2,869	0	3,919	2,869	7,723	143,035	50,684	5,965	217,066
2011 (W)	10,714	803,187	19,870	10,714	8,504	150,233	191,949	6,302	1,201,473
2012 (D)	2,697	0	0	2,697	7,723	80,897	34,364	823	129,200
2013 (C)	880	0	0	880	8,934	71,083	26,587	0	108,363
2014 (C)	875	0	0	875	8,356	15,966	3,451	0	29,524
2015 (C)	883	0	0	883	6,995	7,984	1,621	0	18,365
Average (1989-2014)	3,911	191,028	8,130	3,911	7,662	133,596	71,201	6,359	425,799
Average (1989-2014) W	10,478	605,193	21,841	10,478	7,600	195,813	146,420	10,224	1,008,049
Average (1989-2014) AN	1,962	41,730	8,026	1,962	7,574	147,093	72,073	7,334	287,754
Average (1989-2014) BN	0	0	0	0	7,686	121,824	19,302	5,032	153,844
Average (1989-2014) D	965	0	640	965	7,556	117,372	32,103	5,434	165,035
Average (1989-2014) C	900	0	1,001	900	7,708	76,056	29,825	2,975	119,366

Surface Water Outflows

Surface water outflows are summarized in Figure 2-931 and Table 2-21. These include natural flows along waterways, runoff of precipitation, and flood releases or spillage of USBR CVP deliveries. Surface outflows along Fresno River include a mixture of both local supplies and CVP supplies, while surface outflows along all other waterways include only local supplies. Overall, surface outflows are significantly higher in wet years, averaging approximately 711TAF overall.

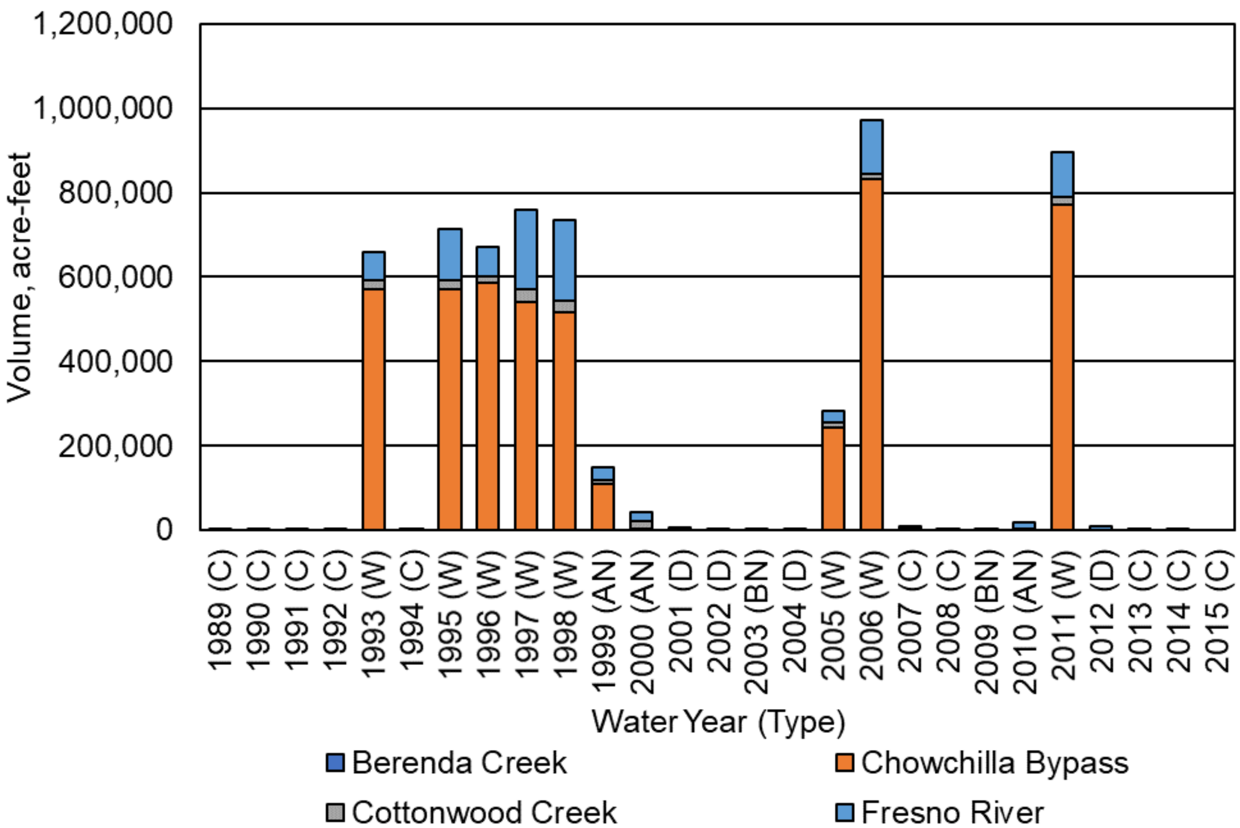


Figure 2-931. Madera Subbasin Surface Outflows by Waterway.

Table 2-21. Madera Subbasin Surface Outflows by Water Source Type (Acre-Feet) (23 CCR § 354.18(b)(1)).

Water Year (Type)	Local Supplies			CVP Supplies	Surface Water Outflows Total
	Berenda Creek	Chowchilla Bypass	Cottonwood Creek	Fresno River	
1989 (C)	0	0	1,642	0	1,642
1990 (C)	0	0	426	0	426
1991 (C)	0	0	2,472	0	2,472
1992 (C)	0	0	660	0	660
1993 (W)	0	571,205	19,816	66,924	657,945
1994 (C)	0	0	1,179	174	1,353
1995 (W)	0	572,197	19,402	120,760	712,359
1996 (W)	0	587,638	12,570	71,327	671,535
1997 (W)	0	541,011	29,319	188,130	758,460
1998 (W)	0	517,240	26,913	192,104	736,257
1999 (AN)	0	108,794	10,379	30,305	149,478
2000 (AN)	0	4,238	17,518	22,011	43,767
2001 (D)	0	0	4,381	330	4,711
2002 (D)	0	0	1,975	0	1,975
2003 (BN)	0	0	3,060	0	3,060
2004 (D)	0	0	2,779	0	2,779
2005 (W)	0	244,628	12,018	27,134	283,779
2006 (W)	0	831,930	13,408	126,759	972,098
2007 (C)	0	0	4,687	4,642	9,328
2008 (C)	0	0	1,444	0	1,444
2009 (BN)	0	0	1,882	0	1,882
2010 (AN)	0	0	4,520	13,936	18,456
2011 (W)	0	771,095	18,095	106,808	895,998
2012 (D)	0	0	1,781	8,143	9,924
2013 (C)	0	0	520	1,696	2,215
2014 (C)	0	0	528	0	528
2015 (C)	0	0	0	0	0
Average (1989-2014)	0	182,691	8,207	37,738	228,636
Average (1989-2014) W	0	579,618	18,943	112,493	711,054
Average (1989-2014) AN	0	37,677	10,806	22,084	70,567
Average (1989-2014) BN	0	0	2,471	0	2,471
Average (1989-2014) D	0	0	2,729	2,118	4,847
Average (1989-2014) C	0	0	1,506	724	2,230

Groundwater System Inflows

Estimates of groundwater system inflows are provided in Figure 2-942 and Table 2-22. These inflows include calculated inflows from the SWS and subsurface groundwater inflows from adjacent subbasins[68]. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, while infiltration of applied water has remained comparatively steady over time. Infiltration of surface water (seepage) also exhibits substantial variability, particularly from the Rivers and Streams system, matching the annual variability of surface water inflows. Although the San Joaquin River passes along the Subbasin boundary, it provides significant infiltration to the groundwater system.

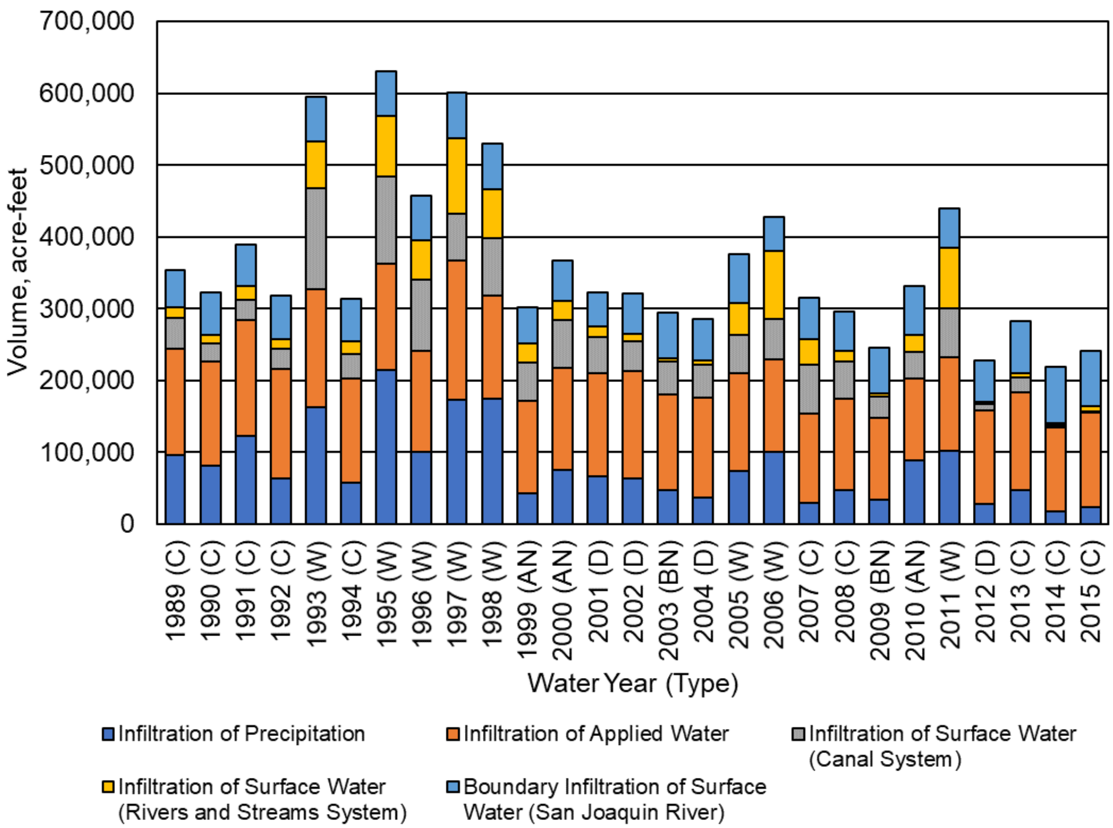


Figure 2-942. Madera Subbasin Groundwater System Inflows.

68 Subsurface groundwater inflows to Madera Subbasin include simulated inflows from the Kings, Delta-Mendota, and Chowchilla Subbasins.

Table 2-22. Madera Subbasin Groundwater System Inflows (Acre-Feet) (23 CCR § 354.18(b)(2)).

Water Year (Type)	Net Subsurface Groundwater Inflow*	Infiltration of Precipitation	Infiltration of Applied Water	Infiltration of Surface Water (Canal System)	Infiltration of Surface Water (Rivers and Streams	Boundary Infiltration of Surface Water (San Joaquin River)[1]
1989 (C)	*	96,351	148,296	42,071	14,964	52,497
1990 (C)	*	81,088	145,011	25,400	12,320	58,752
1991 (C)	*	123,511	160,316	27,970	20,263	57,288
1992 (C)	*	62,969	152,795	27,828	14,654	60,041
1993 (W)	*	162,741	164,801	140,343	65,111	62,817
1994 (C)	*	58,348	144,914	34,166	12,659	59,956
1995 (W)	*	214,231	148,228	121,657	83,646	62,817
1996 (W)	*	101,102	140,025	99,251	55,332	62,255
1997 (W)	*	173,094	193,912	65,431	105,229	62,817
1998 (W)	*	174,199	144,228	79,813	68,549	62,817
1999 (AN)	*	43,408	128,597	53,130	26,357	50,906
2000 (AN)	*	76,027	142,023	66,008	26,911	55,502
2001 (D)	*	67,345	142,660	50,232	14,993	48,148
2002 (D)	*	63,264	150,000	41,117	10,666	55,815
2003 (BN)	*	47,327	133,158	45,860	4,759	63,273
2004 (D)	*	36,813	139,987	45,875	5,390	57,377
2005 (W)	*	74,179	136,476	52,826	43,921	68,614
2006 (W)	*	100,804	128,548	56,357	94,406	47,623
2007 (C)	*	29,108	124,966	68,377	36,035	58,246
2008 (C)	*	46,943	127,820	52,292	13,618	55,176
2009 (BN)	*	34,229	113,925	30,106	3,610	64,000
2010 (AN)	*	89,286	113,681	37,431	23,258	67,546
2011 (W)	*	102,145	130,134	68,128	83,880	54,998
2012 (D)	*	28,501	130,087	8,543	3,596	58,013
2013 (C)	*	47,652	136,294	19,824	5,984	72,669
2014 (C)	*	18,289	117,058	2,982	2,710	78,643
2015 (C)	*	24,117	129,834	1,026	7,006	77,442
Average (1989-2014)	69,435	82,806	139,921	52,424	32,801	59,946
Average (1989-2014) W	*	137,812	148,294	85,476	75,009	60,595
Average (1989-2014) AN	*	69,574	128,100	52,190	25,509	57,985
Average (1989-2014) BN	*	40,778	123,542	37,983	4,184	63,636
Average (1989-2014) D	*	48,981	140,684	36,442	8,661	54,838
Average (1989-2014) C	*	62,695 [2]	139,719	33,434	14,801	61,474

*Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.

[1] Boundary infiltration of surface water estimated as closure of San Joaquin River boundary balance during years with available data.

[2] Average infiltration of precipitation higher in critical years due to relatively higher amounts of precipitation in 1989-1992.

Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in Figure 2-953 and Table 2-23. For agricultural and urban (urban, industrial, and semi-agricultural) lands, groundwater extraction represents pumping, while for native lands, groundwater extraction by riparian vegetation was considered to be minimal[69] because of the depth to groundwater in the Subbasin. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability in surface water supplies and crop water demands.

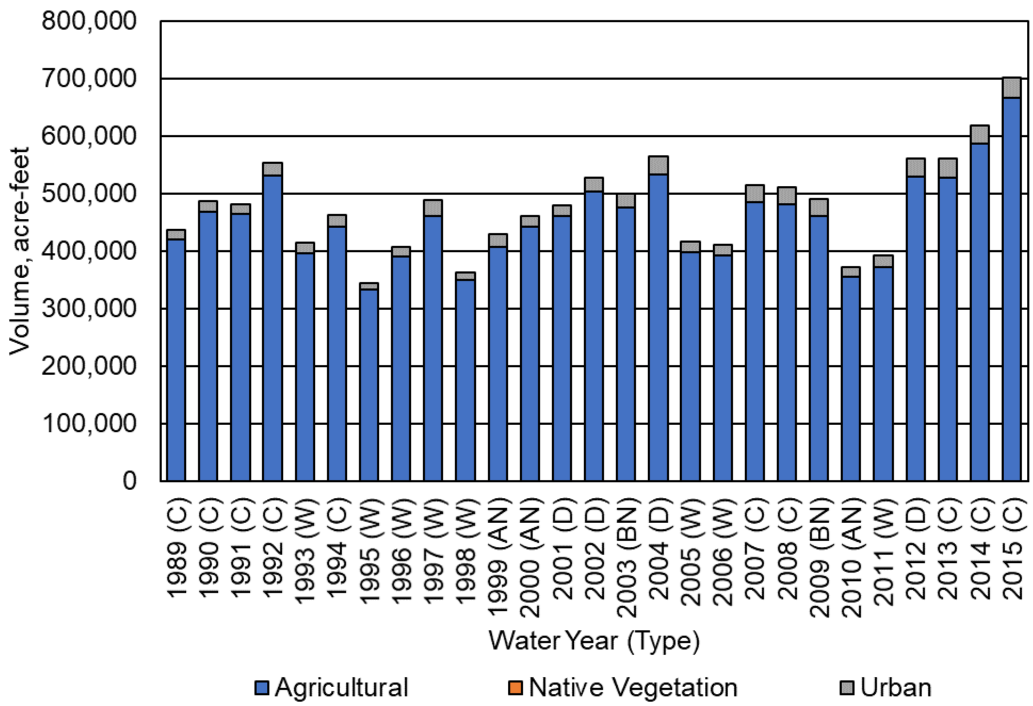


Figure 2-953. Madera Subbasin Groundwater Extraction by Water Use Sector.

[69] Groundwater extraction of native vegetation estimated by ET_{aw} from the Madera IDC application is less than 100 AF/yr.

Table 2-23. Madera Subbasin Groundwater Extraction by Water Use Sector (Acre-Feet) (23 CCR § 354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Total
1989 (C)	420,304	0	17,047	437,350
1990 (C)	469,254	0	18,082	487,336
1991 (C)	464,476	0	17,005	481,484
1992 (C)	530,866	0	22,565	553,433
1993 (W)	396,671	0	17,788	414,458
1994 (C)	443,027	0	20,740	463,764
1995 (W)	333,246	0	11,123	344,367
1996 (W)	391,387	0	16,902	408,296
1997 (W)	461,009	0	27,067	488,076
1998 (W)	349,190	0	14,575	363,761
1999 (AN)	407,530	0	21,324	428,850
2000 (AN)	441,735	0	20,179	461,915
2001 (D)	461,191	0	18,700	479,886
2002 (D)	503,340	0	24,419	527,750
2003 (BN)	476,326	0	23,949	500,270
2004 (D)	533,786	0	31,017	564,795
2005 (W)	397,369	0	19,653	417,023
2006 (W)	391,981	0	19,106	411,093
2007 (C)	484,945	0	30,451	515,403
2008 (C)	480,879	0	30,465	511,343
2009 (BN)	461,512	0	29,792	491,300
2010 (AN)	355,071	0	17,574	372,645
2011 (W)	372,938	0	19,958	392,898
2012 (D)	529,719	0	31,461	561,171
2013 (C)	528,180	0	33,185	561,363
2014 (C)	586,962	0	32,286	619,252
2015 (C)	666,437	0	36,168	702,611
Average (1989-2014)	448,958	0	22,554	471,512
Average (1989-2014) W	386,724	0	18,272	404,996
Average (1989-2014) AN	401,445	0	19,692	421,138
Average (1989-2014) BN	468,919	0	26,871	495,790
Average (1989-2014) D	507,009	0	26,399	533,408
Average (1989-2014) C	489,877	0	24,647	514,524

Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the ~~Madera~~ Subbasin. Given the substantial depth to the water table, groundwater discharge to surface water sources is negligible.

Evapotranspiration by Water Use Sector

Total evapotranspiration (ET) by water use sector is reported in Figure 2-964 and Table 2-24. Total ET varies between years, with the lowest observed in 1989, at approximately 593TAF, and greatest in 2004, at approximately 714TAF. Agricultural ET tends to increase in drier years, while native ET decreases. Total ET has remained relatively steady over time.

ET of applied groundwater is included in the total ET of applied water reported in the SWS water budget for each GSP (**Appendix 2.F**). For irrigators without access to surface water, ET of applied water is equal to ET of applied groundwater.

In addition to total ET from land surfaces, estimates of evaporation from rivers and streams are reported in Figure 2-975 and Table 2-25. Evaporation is highest in wet years when surface water inflows are typically higher, averaging approximately 10TAF overall.

Change in Storage

Estimates of average annual change in storage within the GWS are summarized for each water budget scenario in Table 2-26.

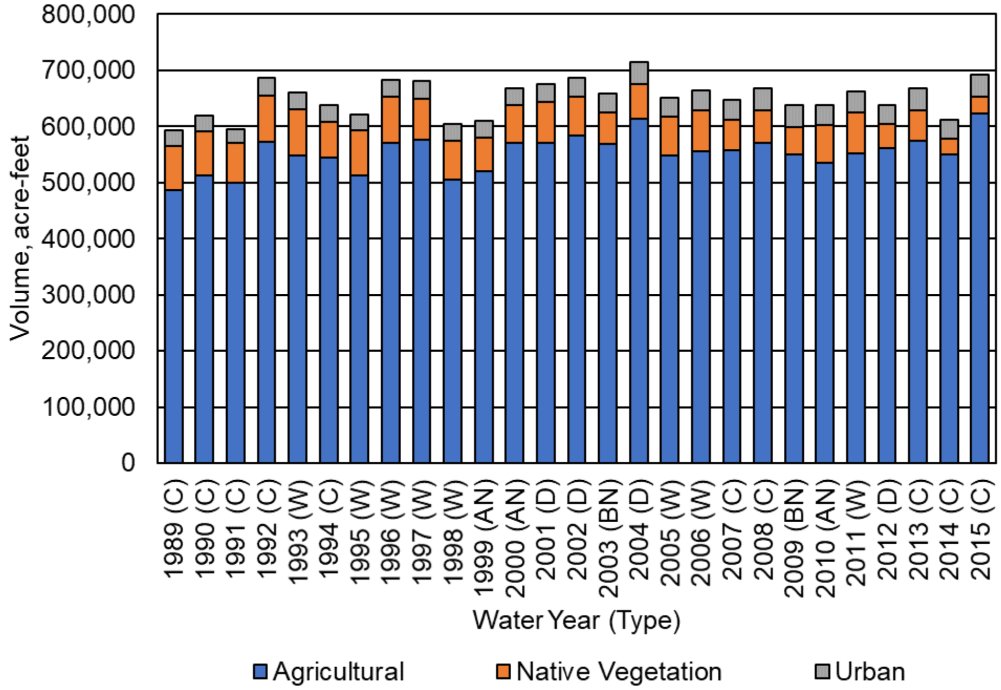


Figure 2-964. Madera Subbasin Total Evapotranspiration by Water Use Sector.

Table 2-24. Madera Subbasin Total Evapotranspiration by Water Use Sector (Acre-Feet) (23 CCR § 354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Total
1989 (C)	485,824	79,935	27,122	592,881
1990 (C)	513,276	77,560	28,514	619,350
1991 (C)	500,398	69,647	25,086	595,131
1992 (C)	572,303	83,293	30,974	686,570
1993 (W)	547,892	82,461	30,067	660,420
1994 (C)	543,943	64,741	29,603	638,287
1995 (W)	512,822	79,972	27,620	620,414
1996 (W)	570,200	82,951	29,831	682,982
1997 (W)	576,285	72,430	32,057	680,772
1998 (W)	505,935	69,393	28,179	603,507
1999 (AN)	520,964	59,990	28,388	609,342
2000 (AN)	569,938	68,233	30,764	668,935
2001 (D)	571,037	73,403	30,382	674,822
2002 (D)	583,612	69,419	33,687	686,718
2003 (BN)	569,156	55,844	33,185	658,185
2004 (D)	614,494	61,530	37,972	713,996
2005 (W)	548,046	68,905	33,789	650,740
2006 (W)	554,996	74,383	34,958	664,337
2007 (C)	557,417	55,271	35,494	648,182
2008 (C)	570,515	58,525	39,372	668,412
2009 (BN)	551,063	48,169	39,169	638,401
2010 (AN)	534,575	67,984	35,739	638,298
2011 (W)	552,037	73,776	36,889	662,702
2012 (D)	562,080	42,034	34,077	638,191
2013 (C)	574,904	52,989	40,775	668,668
2014 (C)	550,832	27,370	34,438	612,640
2015 (C)	623,042	30,495	39,270	692,807
Average (1989-2014)	550,559	66,162	32,620	649,342
Average (1989-2014) W	546,027	75,534	31,674	653,234
Average (1989-2014) AN	541,826	65,402	31,630	638,858
Average (1989-2014) BN	560,110	52,007	36,177	648,293
Average (1989-2014) D	582,806	61,597	34,030	678,432
Average (1989-2014) C	541,046	63,259	32,375	636,680

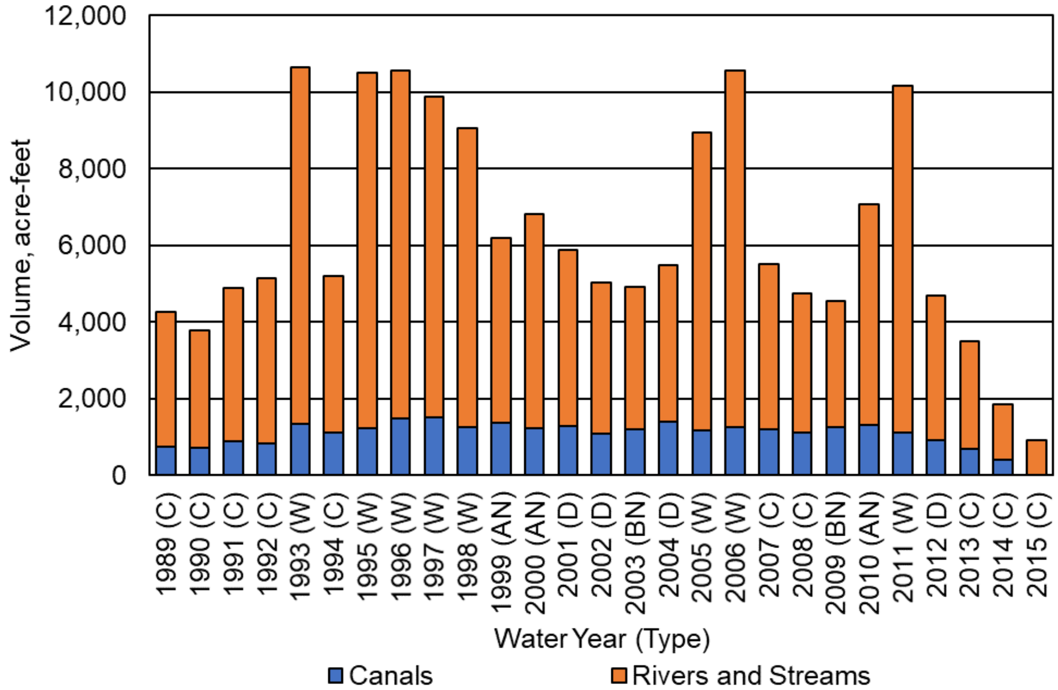


Figure 2-9~~5~~7. Madera Subbasin Evaporation from the Surface Water System.

Table 2-25. Madera Subbasin Evaporation from the Surface Water System (Acre-Feet) (23 CCR § 354.18(b)(3)).

Water Year	Canals	Rivers and Streams
1989 (C)	754	3,511
1990 (C)	726	3,058
1991 (C)	880	4,022
1992 (C)	834	4,324
1993 (W)	1,330	9,322
1994 (C)	1,125	4,089
1995 (W)	1,230	9,283
1996 (W)	1,482	9,091
1997 (W)	1,509	8,365
1998 (W)	1,255	7,803
1999 (AN)	1,355	4,833
2000 (AN)	1,237	5,569
2001 (D)	1,278	4,607
2002 (D)	1,084	3,943
2003 (BN)	1,212	3,694
2004 (D)	1,383	4,096
2005 (W)	1,168	7,776
2006 (W)	1,254	9,322
2007 (C)	1,191	4,323
2008 (C)	1,105	3,648
2009 (BN)	1,241	3,302
2010 (AN)	1,316	5,755
2011 (W)	1,120	9,045
2012 (D)	902	3,780
2013 (C)	686	2,809
2014 (C)	397	1,461
2015 (C)	0	910
Average (1989-2014)	1,117	5,417
Average (1989-2014) W	1,294	8,751
Average (1989-2014) AN	1,303	5,386
Average (1989-2014) BN	1,227	3,498
Average (1989-2014) D	1,162	4,106
Average (1989-2014) C	855	3,472

Historical Water Budget Summary

Annual inflows, outflows, and change in storage for the ~~Madera~~ Subbasin SWS are summarized in Figure 2-9~~6~~8. Inflows are shown as positive values, while outflows and change in storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget and opportunities for projects to increase groundwater recharge and the Subbasin sustainable yield.

Detailed historical water budget components in each GSA are summarized in detail in **Appendix 2.F.**

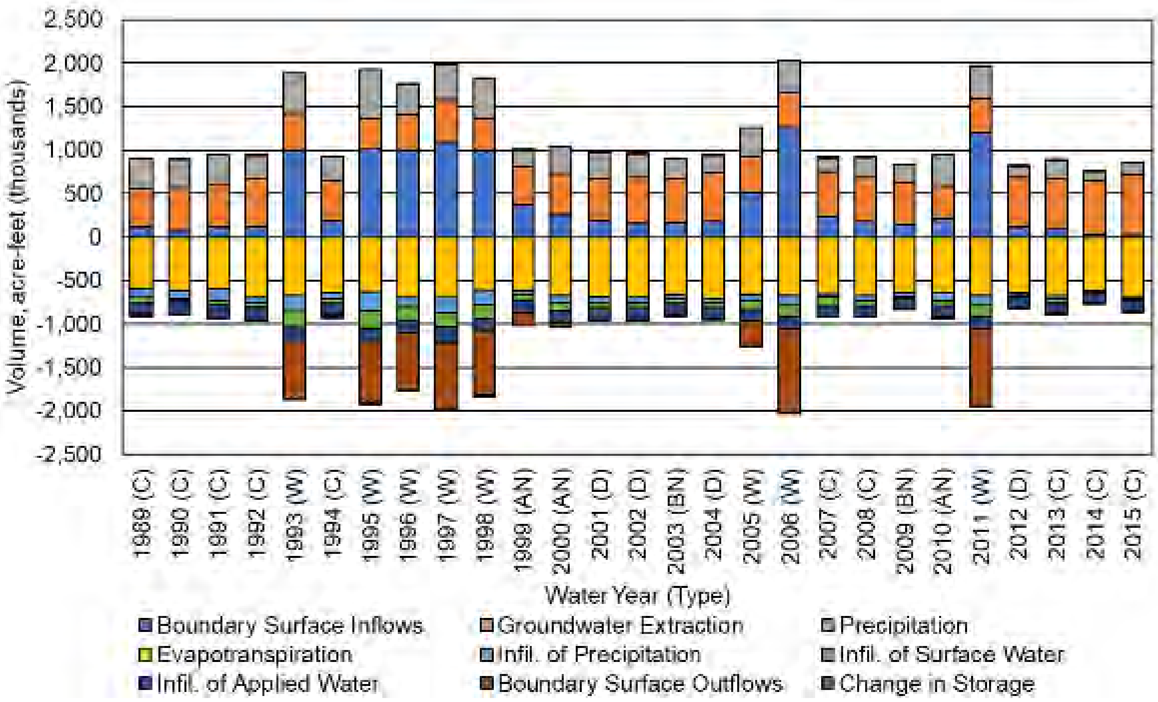


Figure 2-986. Madera Subbasin Surface Water System Historical Water Budget.

Current Water Budget Summary

Annual inflows, outflows, and change in SWS storage under current land use conditions in the Madera Subbasin SWS are summarized in Figure 2-997. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of current land use on SWS inflows and outflows over time.

Detailed current water budget components in each subregion are summarized in detail in **Appendix 2.F.**

Projected Water Budget Development

Water budgets were projected into the future to estimate future water demands under different future scenarios and to evaluate the potential effects of different management actions and implementation of different projects.

Two primary projected water budget scenarios were considered: a projected without projects (no action) scenario, and a projected with projects scenario. Both these projected scenarios were also considered in the context of potential climate change effects on surface water supply and weather parameters.

Two major time periods exist in the future projected model: the GSP implementation period (2020-2039), during which PMAs are implemented to bring the Subbasin into sustainability, and the sustainability period (2040-2090), after which PMAs have been fully implemented.

The development of the projected future scenarios is described in detail in **Appendix 6.D**, Groundwater Model Documentation. The development of projected time series for precipitation, evapotranspiration, and surface water flows are briefly summarized in Tables 2-27 and 2-28 below.

Comparison of Water Budget Scenarios

Table 2-26 provides a summary of the average annual inflows, outflows, change in groundwater storage, and overdraft estimated at the Subbasin-level in the historical, current, projected without projects, and projected with projects water budgets.

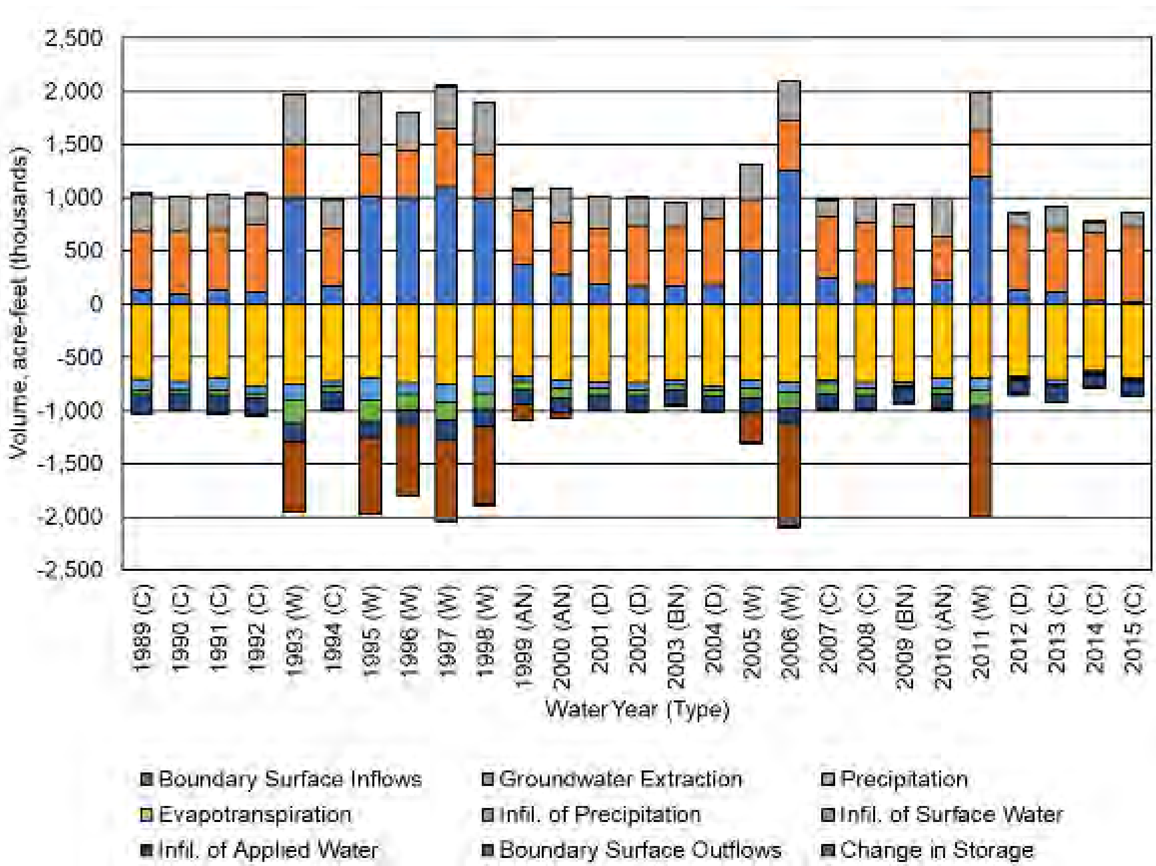


Figure 2-997. Madera Subbasin Surface Water System Current Water Budget.

Table 2-26. Comparative Summary of all Water Budget Scenarios, Annual Average Volumes by Flow Path (Acre-Feet).

23 CCR Section	Flow Path Direction (Relative to GWS)	Flow Path	Water Budget Period				Reason for Difference from Historical
			Historical	Current	Projected, No Action	Projected, With Projects	
			1989-2014	2015 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090	
354.18(b)(1)	N/A (SWS flow path)	Surface Water Inflows	425,800	425,800	374,200	377,800	Decrease due to SJRRP (Projected)
		Local Supplies	*214,600*	*214,600*	*164,300*	*167,800*	Decrease in Chowchilla Bypass flows with SJRRP (Projected)
		CVP Supplies	*211,200*	*211,200*	*210,000*	*210,000*	Decrease in CVP deliveries with SJRRP (Projected)
354.18(b)(1)	N/A (SWS flow path)	Surface Water Outflows	228,600	228,600	174,000	154,700	Decrease due to decreased surface water inflows described above (Projected), GSP project diversions (With Projects)
		Local Supplies	*190,900*	*190,900*	*144,600*	*124,300*	
		CVP Supplies	*37,700*	*37,700*	*29,400*	*30,400*	
Implied	N/A (SWS flow path)	Precipitation	298,500	298,500	346,100	346,100	Increase due to higher proportion of water years anticipated in projected period (35% of years, versus 31% in historical period)
354.18(b)(2)	Inflow	Infiltration of Surface Water	145,200	144,900	162,000	217,100	Increase due to infiltration of GSP projects (With Projects)
354.18(b)(2)	Inflow	Infiltration of Applied Water	139,900	145,100	133,700	130,700	Decrease due to urban growth (Projected), demand management (with Projects)
354.18(b)(2)	Inflow	Infiltration of Precipitation	82,800	80,400	83,400	88,400	N/A
354.18(b)(3)	N/A (SWS flow path)	Evapotranspiration	655,900	715,800	704,800	638,800	Increase due to cropping (Current; Projected, No Action); Decrease due to demand management (Projected, With Projects)

23 CCR Section	Flow Path Direction (Relative to GWS)	Flow Path	Water Budget Period				Reason for Difference from Historical
			Historical	Current	Projected, No Action	Projected, With Projects	
			1989-2014	2015 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090	
354.18(b)(3)	Outflow	GW Pumping	471,500	533,100	548,000	447,400	Increase due to cropping (Current; Projected, No Action); Decrease due to demand management (Projected, With Projects)
354.18(b)(3)	Outflow	GW Discharge to Surface Water Sources	0	0	0	0	Low groundwater levels
354.18(b)(2),(3)	Inflow (Net)	Net Subsurface Inflow	69,400	N/A	108,200	21,400	Increase due to low groundwater levels (Projected, No Action); Decrease due to GSP projects and management actions used to achieve sustainability (Projected, With Projects)
354.18(b)(4)	Inflows - Outflows	Average Annual Change in Groundwater Storage	-34,200	N/A	-60,700	10,200	Decrease due to cropping and related groundwater extraction (Current; Projected, No Action); Increase due to GSP projects and management actions used to achieve sustainability (Projected, With Projects)
354.18(b)(5)	Inflows - Outflows	Average Overdraft	-34,200	N/A	-60,700	10,200	Changes due to reasons above.

[1]Net subsurface inflow not estimated for current water budget due to uncertainties in adjacent Subbasin groundwater conditions.

Table 2-27. Development of Projected Future Precipitation and Evapotranspiration Time Series.

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Precipitation	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly change factors by water year type	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly change factors by water year type
Evapotranspiration	2001-2010 historical data (2020-2029 and 2030-2039), assuming 2017 land use adjusted for projected urban area growth from 2017-2039	1965-2015 historical data, assuming 2017 land use adjusted for projected urban area growth from 2017-2070 (urban area constant from 2071-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly change factors by water year type, assuming 2017 land use adjusted for projected urban area growth from 2017-2039	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly change factors by water year type, assuming 2017 land use adjusted for projected urban area growth from 2017-2070 (urban area constant from 2071-2090)

Table 2-28. Development of Projected Future Surface Water Supply Time Series.

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Surface Water Inflow - Unimpaired Streams	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly streamflow change factors by water year type	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly streamflow change factors by water year type
Surface Water Inflow - Fresno River (Hidden Dam Releases)	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 historical data adjusted by CalSim II 2030 climate change projections for Hensley Lake; 2004-2010 data estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type	1965-2003 historical data (2040-2078) adjusted by CalSim II 2030 climate change projections for Hensley Lake; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Surface Water Inflow - San Joaquin River (Friant Dam Releases)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 data provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010 data estimated as the historical volume adjusted by the average Friant Report volume by month and water year type	1965-2003 data (2040-2078) provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average Friant Report volume by month and water year type
Surface Water Inflow - Chowchilla Bypass	Estimated based on the historical monthly ratio of Chowchilla Bypass (CBP) and San Joaquin River (SJR) flows, with projected SJR inflow data provided by the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the historical monthly ratio of CBP and SJR flows, with projected SJR inflow data provided by the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003: estimated based on the historical monthly ratio of CBP and SJR flows by water year type, with projected SJR inflow data provided by the Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010: estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with average projected SJR inflows calculated from 1921-2003 by month and water year type	1965-2003 (2040-2078): estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with projected SJR inflow data provided by the Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 (2079-2090): estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with average projected SJR inflows calculated by month and water year type
Diversions from Madera Canal	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 data provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010 data estimated as the historical volume adjusted by the average Friant Report climate change volume by month and water year type	1965-2003 data (2040-2078) provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average Friant Report climate change volume by month and water year type

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Other Diversions/ Bypasses	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039)***	1965-2015 historical data (2040-2090)***

* "Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018.

** Although the Friant Water Authority Report (or Friant Report) accounts for climate change, it is considered the best available estimate of projected Madera Canal deliveries under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Steiner Report Kondolf Hydrograph (Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

*** Historical volumes specified in the model to ensure that GSAs can use as much surface water as is available in a given time step up to the maximum historical surface water used.

Overdraft Conditions

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR, 2003). The Madera Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR § 354.18(b)(5), the Subbasin overdraft has been quantified for this period. Overdraft is calculated as the sum of all outflows from the groundwater system, including groundwater extraction and subsurface outflow, minus the sum of all inflows to the groundwater system, including infiltration from all sources and subsurface inflow.

The average Subbasin overdraft is presented below for 1989-2014 based on the historical water budget (Table 2-29) and current land use water budget (Table 2-30).

Net Recharge from SWS

For estimates of the SWS contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage (when negative) of recharge from the SWS based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage based on current cropping, land use practices, and average hydrologic conditions.

Table 2-29. Historical Water Budget: Average Overdraft by Water Year Type, 1989-2014 (Acre-Feet) (23 CCR § 354.18(b)(5)).

Year Type	Number of Years	Net Subsurface Groundwater Inflow (a)	Infiltration of Applied Water (b)	Infiltration of Precipitation (c)	Infiltration of Surface Water (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	148,294	137,812	221,080	404,997	*
AN	3	*	128,100	69,574	135,683	421,137	*
BN	2	*	123,542	40,778	105,804	495,785	*
D	4	*	140,684	48,981	99,941	533,401	*
C	9	*	139,720	62,695	109,709	514,525	*
Annual Average (1989-2014)	26	69,435	139,921	82,806	145,171	471,511	-34,178

* Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.

Table 2-30. Current Land Use Water Budget: Average Overdraft by Water Year Type, 1989-2014 (Acre-Feet) (23 CCR § 354.18(b)(5)).

Year Type	Number of Years	Net Subsurface Groundwater Inflow (a)	Infiltration of Applied Water (b)	Infiltration of Precipitation (c)	Infiltration of Surface Water (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	152,925	134,397	220,640	459,807	*
AN	3	*	132,331	67,635	136,545	475,307	*
BN	2	*	131,545	39,703	105,633	569,873	*
D	4	*	139,461	46,865	100,009	576,028	*
C	9	*	147,842	60,510	109,121	590,203	*
Annual Average (1989-2014)	26	69,435	145,073	80,367	144,929	533,079	-93,276

* Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.

Average net recharge from the SWS is presented below for 1989-2014 based on the historical water budget (Table 2-31) and current land use water budget (Table 2-32). Historically, average annual overdraft from the ~~Madera~~ Subbasin was approximately 104TAF between 1989 and 2014. Under current land use conditions, average annual overdraft from the ~~Madera~~ Subbasin has increased to approximately 163TAF.

Annual Supply, Demand, and Change in Groundwater Stored by Water Year Type

Annual supply, demand, and change in groundwater stored is summarized by water year type in Table 2-33 for historical, current, projected without projects (no action), and projected with projects conditions.

Table 2-31. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	148,294	137,812	221,080	404,997	102,189
AN	3	128,100	69,574	135,683	421,137	-87,779
BN	2	123,542	40,778	105,804	495,785	-225,662
D	4	140,684	48,981	99,941	533,401	-243,795
C	9	139,720	62,695	109,709	514,525	-202,401
Annual Average (1989-2014)	26	139,921	82,806	145,171	471,511	-103,613

Table 2-32. Current Land Use Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (Acre-Feet).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	152,925	134,397	220,640	459,807	48,154
AN	3	132,331	67,635	136,545	475,307	-138,796
BN	2	131,545	39,703	105,633	569,873	-292,992
D	4	139,461	46,865	100,009	576,028	-289,693
C	9	147,842	60,510	109,121	590,203	-272,730
Annual Average (1989-2014)	26	145,073	80,367	144,929	533,079	-162,711

Table 2-33. Comparative Summary of Annual Supply, Demand, and Change in Storage by Water Year Type (Acre-Feet per Year) (23 CCR § 354.18(b)(6)).

Water Year Type	Water Budget Element	Water Budget Flow Paths	Water Budget Period			
			Historical	Current	Projected, No Action	Projected, With Projects
			1989-2014	2015 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090
W	Supply	Surface Water Inflows	1,008,000	1,008,000	761,400	767,700
	Supply	Precipitation	416,700	416,700	490,100	490,100
	Demand	Evapotranspiration	663,300	718,400	709,100	645,300
	Change in Storage	Change in Groundwater Storage	177,000	122,900	197,200	417,400
AN	Supply	Surface Water Inflows	287,700	287,700	281,700	289,800
	Supply	Precipitation	287,500	287,500	347,100	347,100
	Demand	Evapotranspiration	645,500	697,800	718,300	649,700
	Change in Storage	Change in Groundwater Storage	-31,700	-82,700	-60,800	-36,100
BN	Supply	Surface Water Inflows	153,800	153,800	156,500	156,300
	Supply	Precipitation	220,300	220,300	272,300	272,300
	Demand	Evapotranspiration	653,000	721,400	711,200	643,200
	Change in Storage	Change in Groundwater Storage	-163,100	-230,400	-198,500	-191,000
D	Supply	Surface Water Inflows	165,000	165,000	157,800	159,100
	Supply	Precipitation	220,600	220,600	250,500	250,500
	Demand	Evapotranspiration	683,700	729,400	722,000	650,500
	Change in Storage	Change in Groundwater Storage	-181,300	-227,200	-220,200	-248,700
C	Supply	Surface Water Inflows	119,400	119,400	108,600	108,800
	Supply	Precipitation	238,400	238,400	236,200	236,200
	Demand	Evapotranspiration	646,300	710,500	680,700	617,100
	Change in Storage	Change in Groundwater Storage	-154,600	-217,700	-261,600	-284,600

Subbasin Sustainable Yield Estimate.

The sustainable yield assessment is largely based on the balance of recharge versus discharge components in conjunction with groundwater storage change estimates for the Subbasin as a whole. In other words, undesirable results for sustainability indicators not accounted for in this preliminary analysis may lead to a lower sustainable yield estimate. While preliminary, this sustainable yield assessment does provide important insights regarding the magnitude of existing groundwater overdraft, the scale of potential projects needed to ultimately achieve sustainable Subbasin operations, and the groundwater available for extraction under sustainable Subbasin operations.

The GSP regulations require the water budget to quantify the sustainable yield for the Subbasin. Sustainable yield is defined as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC §10721(w)). The sustainability goal for the ~~Madera~~ Subbasin is to implement a package of PMAs that will, by 2040, balance long-term groundwater system inflows with outflows based on a 50-year period representative of average historical hydrologic conditions. Therefore, the maximum quantity of water that can be withdrawn following GSP implementation is equal to the average total inflows to the groundwater system, assuming that net subsurface flows have stabilized. In addition, model results show that the schedule for project implementation together with the Domestic Well Mitigation Program (during the GSP implementation period, prior to 2040) results in MOs and related values for the sustainability indicators that avoid MTs and associated undesirable results for the 2040-2090 projected period.

In alignment with the GSP regulations and DWR's Sustainable Management Criteria BMP (DWR, 2017), sustainable yield has been estimated as part of the Subbasin historical water budget (1989-2014) and the Subbasin projected with projects water budget (2040-2090). A single value of sustainable yield has been estimated for the Subbasin as a whole during each of these analysis periods, which have been shown to be representative of long-term average hydrologic conditions. (DWR, 2017).

Preliminary sustainable yield, not accounting for undesirable results, was calculated for the 1989-2014 historical water budget using three methods, resulting in estimates of similar magnitude with differing confidence intervals (Table 2-34). The first method estimates sustainable yield as the average annual groundwater extraction minus the average annual change in groundwater storage during the 1989-2014 historical period. The second method calculates sustainable yield as the sum of the average annual inflows to the groundwater system (infiltration of applied water, infiltration of precipitation, infiltration of surface water, and subsurface groundwater inflow) during the 1989-2014 historical period. The third method calculates sustainable yield as the groundwater extraction required to achieve approximately zero overdraft following iterative reduction of ET of applied water, reducing demand. The reduction in ET of applied water results in lower demand for groundwater extraction and an associated reduction in infiltration of applied water, which both affect overdraft. The sustainable yield estimates derived from analysis of the historic water budget should be considered preliminary, as they do not fully account for all undesirable results, such as effects on groundwater dependent ecosystems (GDEs), and other SGMA-required components in the sustainable yield assessment.

Table 2-34. Summary of Sustainable Yield Estimates from Historical Water Budget (23 CCR § 354.18(b)(7)).

Quantification Method	Average Volume, 1989-2014 (AF)	Estimated Confidence Interval (percent)	Confidence Interval Source	Average minus CI (AF)	Average plus CI (AF)
Groundwater Extraction and GWS Change in Storage	437,300	25%	Calculation.	328,000	564,600
Total Inflows to GWS	437,300	19%	Calculation.	354,200	520,400
"Simulation" of Reduced Demand	423,300	25%	Professional Judgment.	317,500	529,100

Sustainable yield was also calculated for the projected period, with a specific focus on the 2040-2090 evaluation period following implementation of GSP PMAs.

Sustainable yield is dependent upon conditions in existence at the time, and therefore changes during the GSP implementation period as projects are completed, increasing recharge or leading to reductions in demand. As such, sustainable yield was only calculated for the sustainability period during which all identified projects would be fully operational (2040-2090).

For the 2040-2090 period, model results demonstrate that sustainability indicator MTs and associated undesirable results are avoided by the combined effects of the project implementation schedule and the mitigation program for domestic wells described in this Joint GSP. Thus, the sustainable yield for this 2040-2090 projected period is the quantity of groundwater "…that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC § 10721(w)).

Sustainable yield was calculated for the 2040-2090 projected period (Table 2-35) with a single value of a sustainable yield for the Subbasin as a whole (DWR, 2017). The sustainable yield is estimated as the average annual groundwater extraction during the projected 2040-2090 period. This projected groundwater extraction equals the sum of the average annual recharge without projects and the average annual net project infiltration during the projected period. Since average groundwater inflows approximately equal outflows during the 2040-2090 period, the average annual change in the groundwater storage would be close to zero over this 50-year period. By this method, sustainable yield is estimated to be 439,300 AFY. Accounting for all uncertainties in GWS inflows and outflows, the sustainable yield is estimated to range between 329,500 AFY and 549,100 AFY.

Table 2-35. Summary of Sustainable Yield Estimates from Projected With Projects Water Budget (23 CCR § 354.18(b)(7)).

Quantification Method	Average Volume, 2040-2090 (AF)	Estimated Confidence Interval[1] (percent)	Average minus CI (AF)	Average plus CI (AF)
Groundwater Extraction and GWS Change in Storage	439,300	25%	329,500	549,100

[1] Confidence interval source: Professional judgment based on historical calculations.

Surface Water Available for Groundwater Recharge

Implementation of the GSP will require the- Madera Subbasin to be operated within its sustainable yield by 2040. To achieve this, GSAs may implement projects to restrict groundwater pumping or to increase groundwater recharge (Figure 2-10098).

Figure 2-10098. On-farm Recharge in Madera Irrigation District.

There are five potential sources of water available for groundwater recharge projects: Fresno River flood releases, Millerton flood releases, Chowchilla Bypass flows, additional CVP diversions, and water purchased from outside the Subbasin.

Fresno River flood releases include releases from Hidden Dam and releases from Millerton Reservoir (including Section 215 water[70] or other sources of CVP yield determined by Reclamation to be available to its contractors) that enter Fresno River at Madera Canal Mile 18.8. Available Fresno River flood releases exclude water diverted to the MID conveyance system from Fresno River at Franchi Diversion Dam. During the historical base period (1989-2014), Fresno River flood releases occurred in all eight years classified as wet by DWR's San Joaquin River Water Index. In wet years, surface water was available from Fresno River for groundwater recharge. Across the 2019-2090 projected period (using historical hydrologic and water supply data, as described in Section 2.2.3.2), surface water in Fresno River is also expected to be available for groundwater recharge during wet years.

Millerton flood releases include flood releases to the Madera Subbasin (including 16(b) water[71]) along Madera Canal and exclude releases to Fresno River at Madera Canal Mile 18.8. During the historical base

[70] Reclamation Reform Act of 1982, Section 215 allows delivery of large, temporary, and non-storable water supplies to land that is otherwise ineligible to receive federal water.

[71] San Joaquin River Restoration Settlement, Paragraph 16(b): Recovered Water Account.

period, Millerton flood releases occurred in 8 of 26 years and averaged 34TAF per year when there was a release. Seven of these years were classified as wet years (36TAF per year on average), while the remaining year was classified as above normal (15TAF). Millerton flood releases are projected to occur in an estimated 18 years out of 51 years of the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets.

Chowchilla Bypass flows include all water entering the Subbasin along Chowchilla Bypass downstream of the heading along San Joaquin River below the control structure. During the historical base period, Chowchilla Bypass flows occurred in 11 of 26 years and averaged 453TAF per year with flow. Among these years, Chowchilla Bypass flows occurred in all eight years classified as wet by DWR's San Joaquin River Water Index, averaging 605TAF per wet year. Flows also occurred in above normal years, averaging 63TAF per year. Chowchilla Bypass flows are projected to occur in 25 years out of 51 years of the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets. It is important to note that when water historically flows in the Chowchilla Bypass, the duration averages approximately 40 days.

The remaining potential sources of water available for groundwater recharge – additional CVP diversions and purchased water – are new sources of water that would be brought into the Subbasin as part of GSP projects.

2.2.4 Management Areas (23 CCR § 354.20)

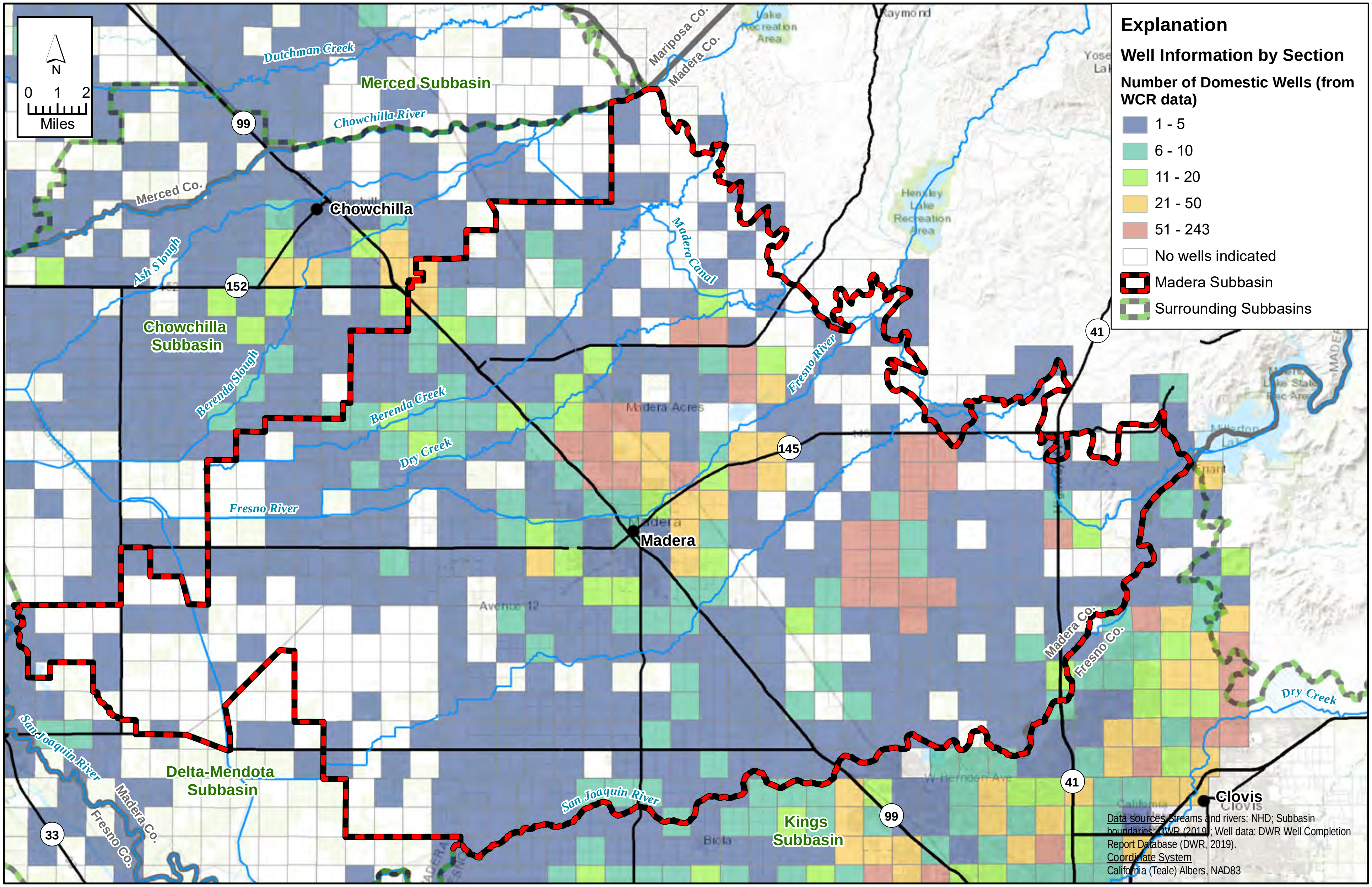
SGMA regulations allow for a GSA or group of GSAs in a Subbasin to decide if designation of management areas will help facilitate implementation of the GSP. Options for use of management areas were discussed among GSA representatives and the GSP consultant team and in public meetings. The four Joint GSP GSAs preparing this joint GSP decided not to designate any management areas in the Plan Area. This decision was based upon review of the Subbasin hydrogeologic conceptual model, groundwater conditions, and water budget analyses. It was determined that there were not sufficient differences in hydrogeologic or groundwater conditions across the Subbasin to warrant designation of management areas. Water budgets are already calculated at both the Subbasin scale and for each of the four Joint GSP GSAs preparing this Joint GSP. In addition, water budgets were prepared for the three GSAs not included in this joint GSP.

The sustainable management criteria and projects/management actions for the Subbasin and each GSA are described in Sections 3 and 4, respectively. Although management areas are not used in the GSP, sustainable management criteria are specific to each RMS location as described in more detail in Section 3.

CHAPTER 2 PLAN AREA AND BASIN SETTING

Selected Figures

The following figures can be found after this page: Figures 2-5 to 2-7, Figures 2-10 to 2-820



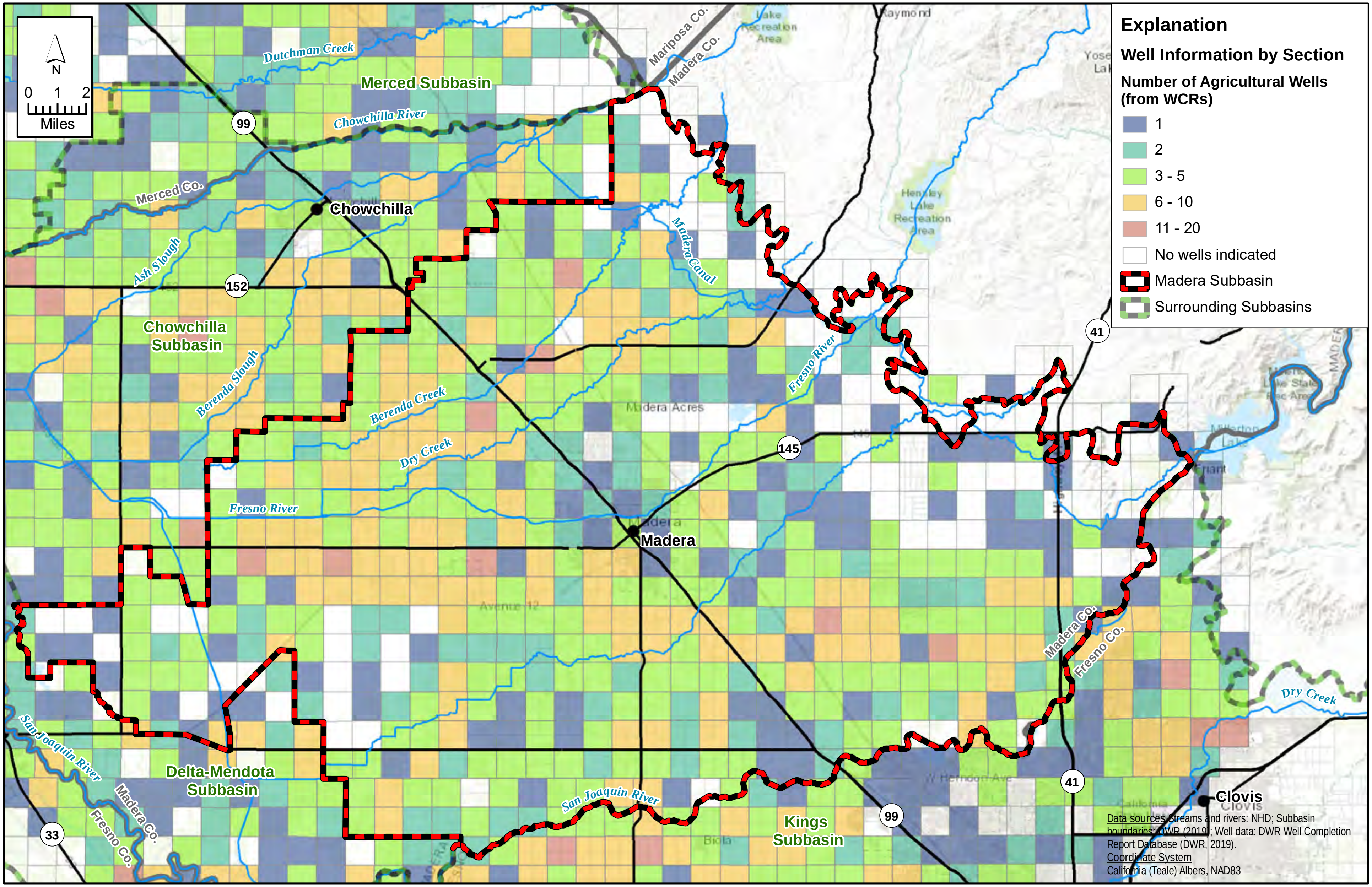
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-5 Madera Subbasin Wells By Section Dom Well Count.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-5
Map of Well Information by Section: Number of Domestic Wells (from WCR data)

Madera Subbasin
Groundwater Sustainability Plan



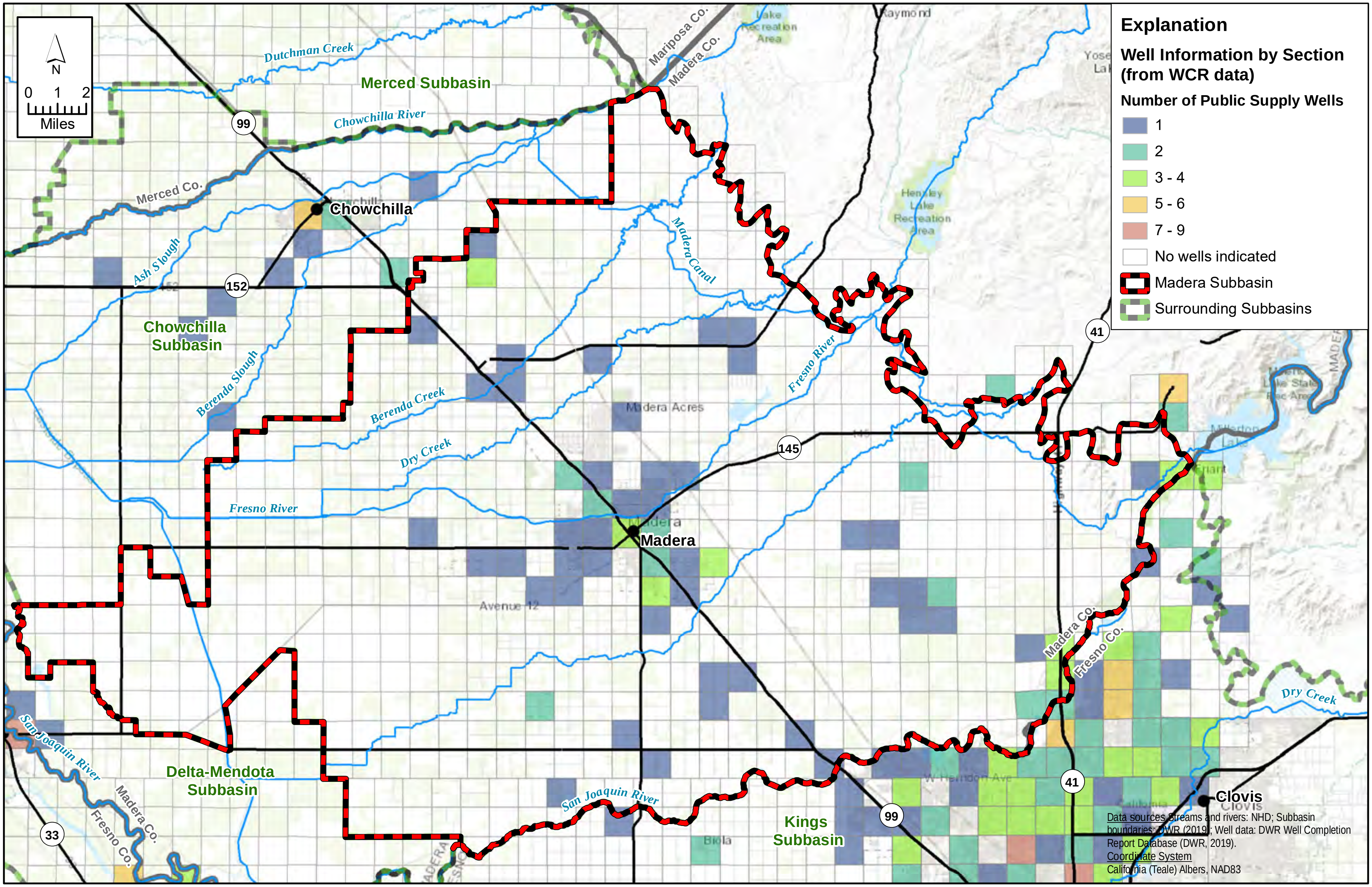
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-6 Madera Subbasin Wells By Section Ag Well Count.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-6
Map of Well Information by Section: Number of Agricultural Wells (from WCR data)

Madera Subbasin
Groundwater Sustainability Plan



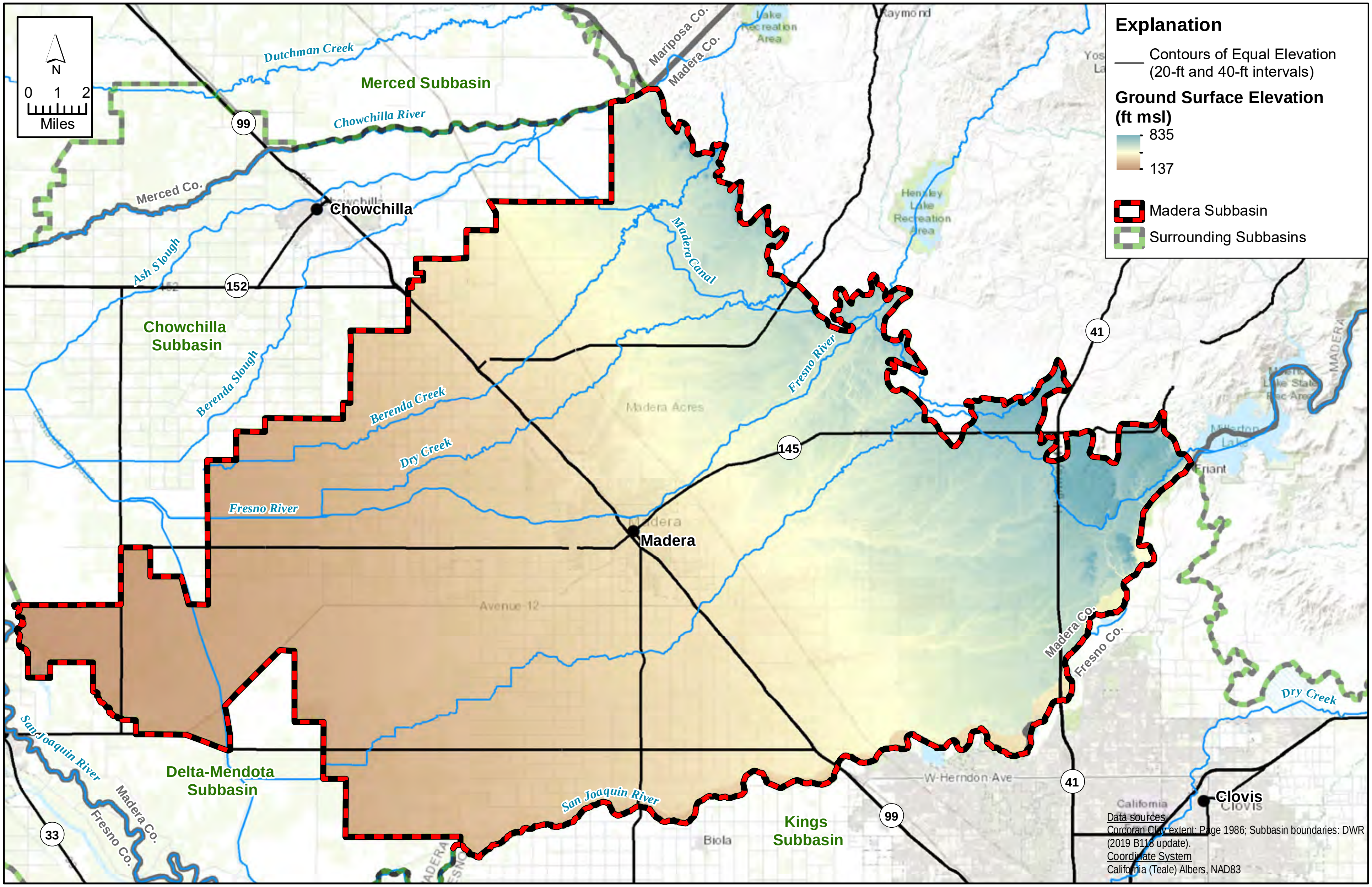
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-7 Madera Subbasin Wells By Section PWS Well Count.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-7
Map of Well Information by Section: Number of Public Supply Wells (from WCR data)

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-10 Madera Subbasin Topographic Map.mxd

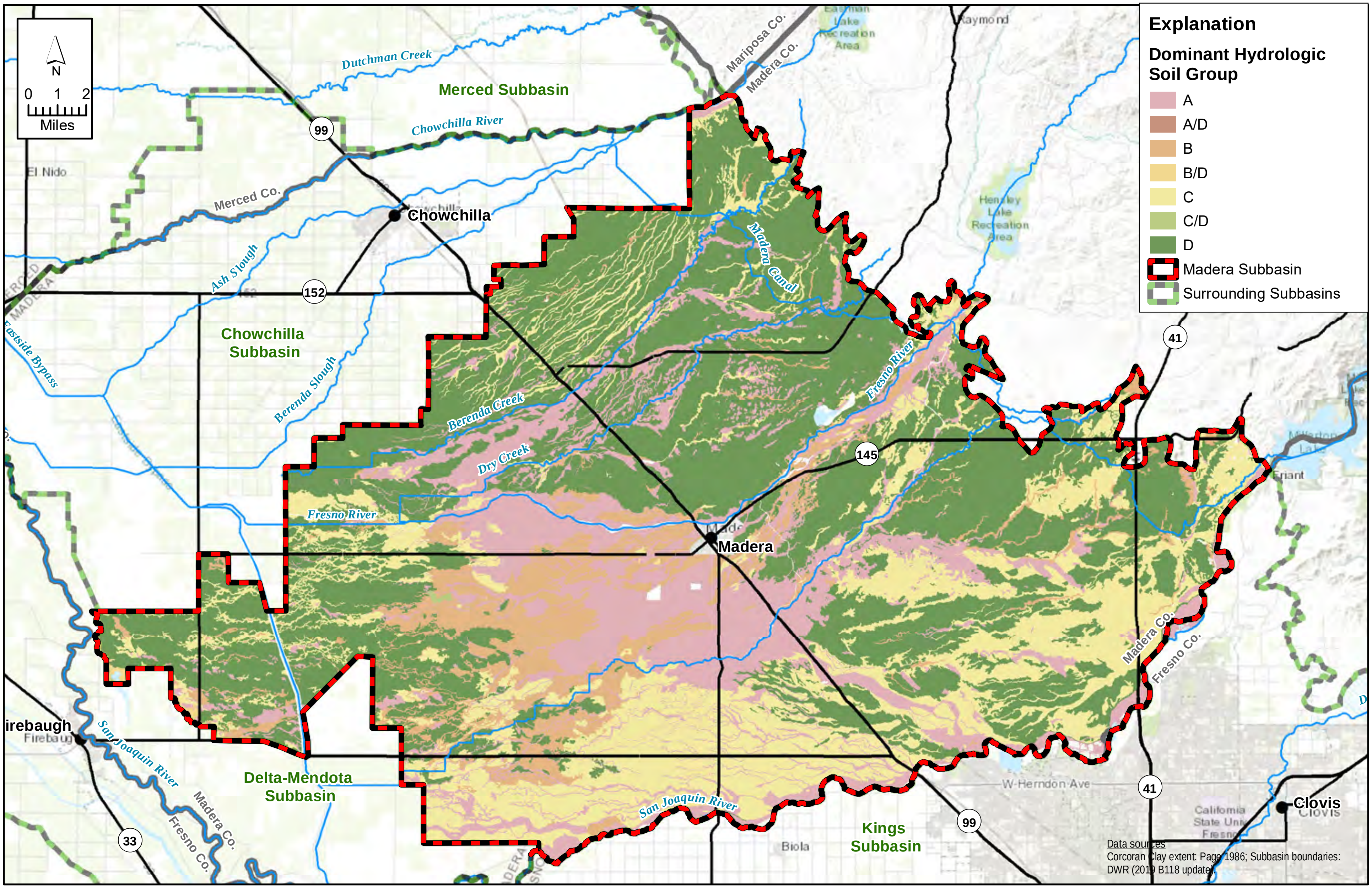
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-10

Topographic Map

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-X Madera Subbasin Soil Unit Map.mxd

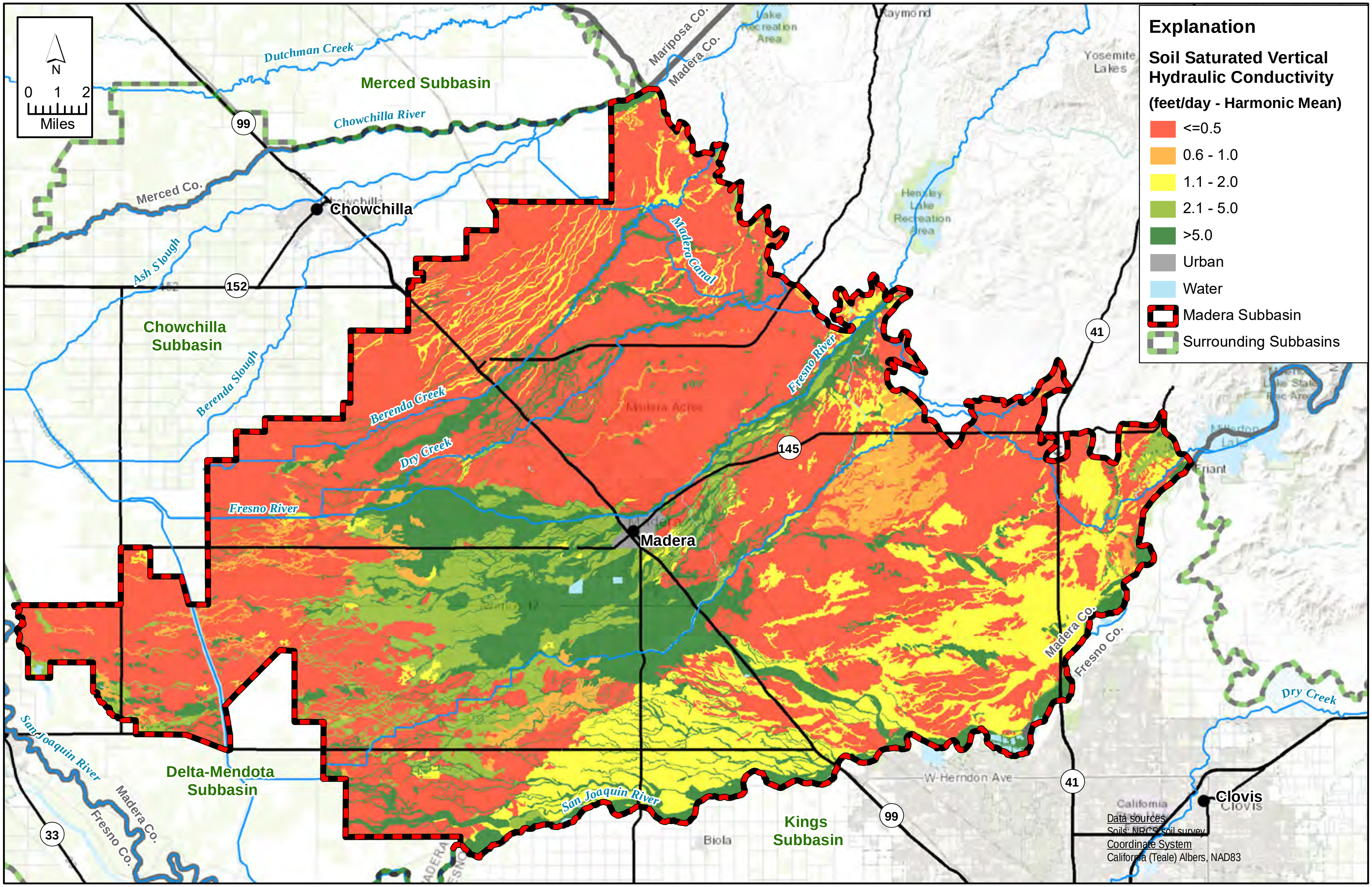
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-11

Soil Hydrologic Units Map

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-12 Madera Subbasin Soil Hydraulic Conductivity Map.mxd

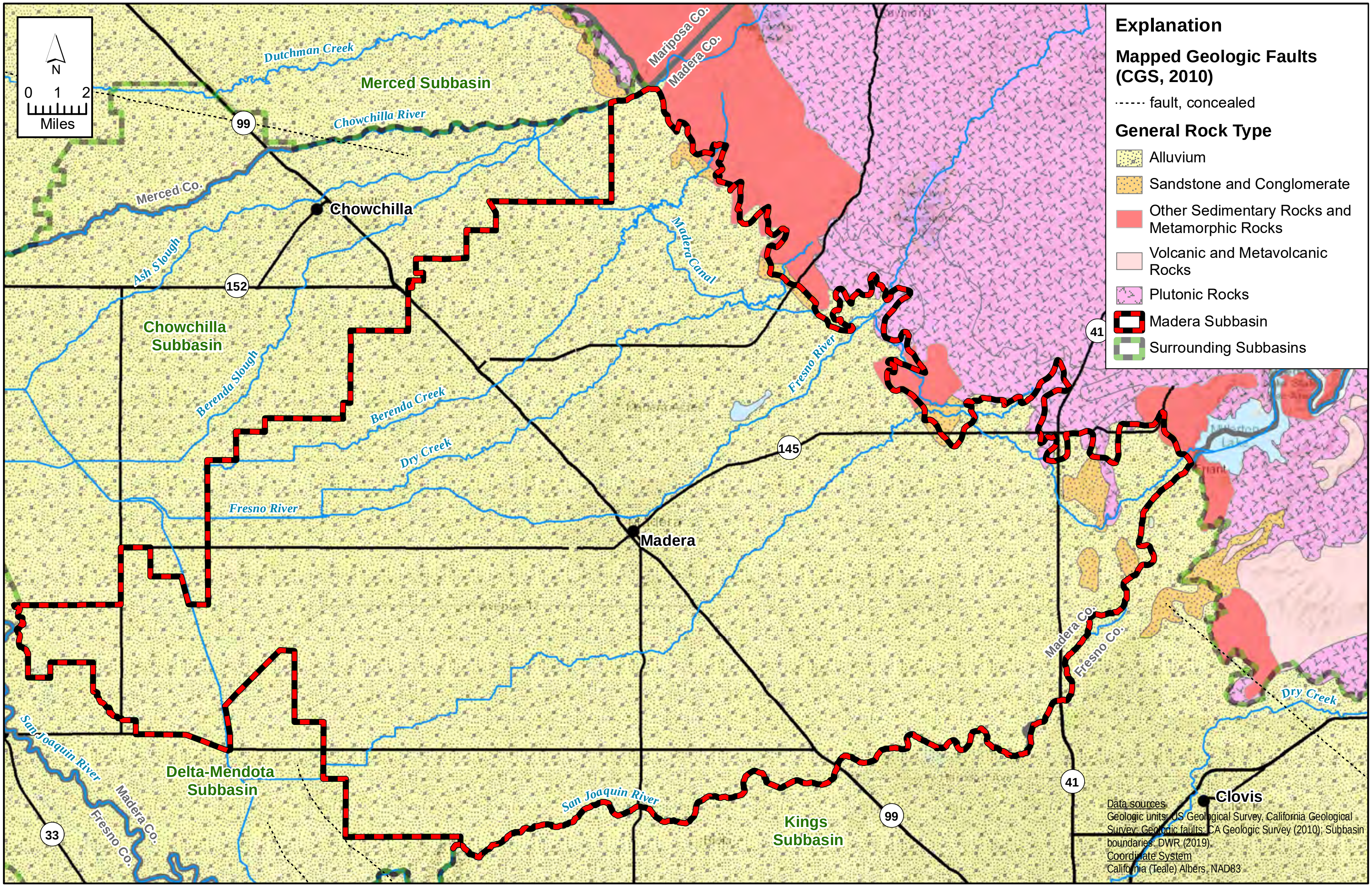
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-12

Soil Hydraulic Conductivity Map

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-13 Madera Subbasin General Geologic Map.mxd

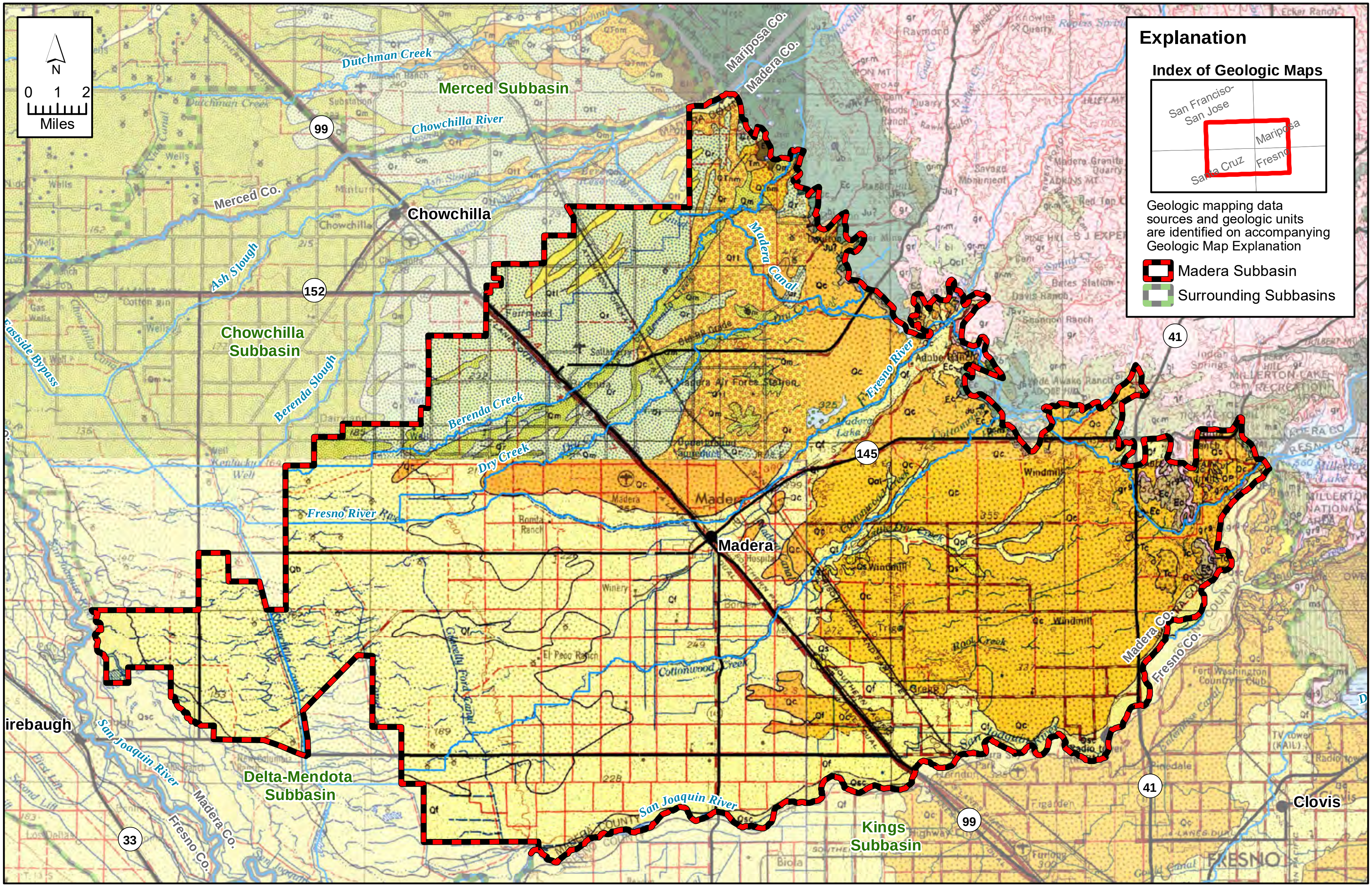
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-13

General Geologic Map

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-X Madera Subbasin Surficial Geology Map.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-14

Surficial Geology Map

Madera Subbasin
Groundwater Sustainability Plan

Compiled Geologic Map Explanation

San Francisco - San Jose Quadrangle

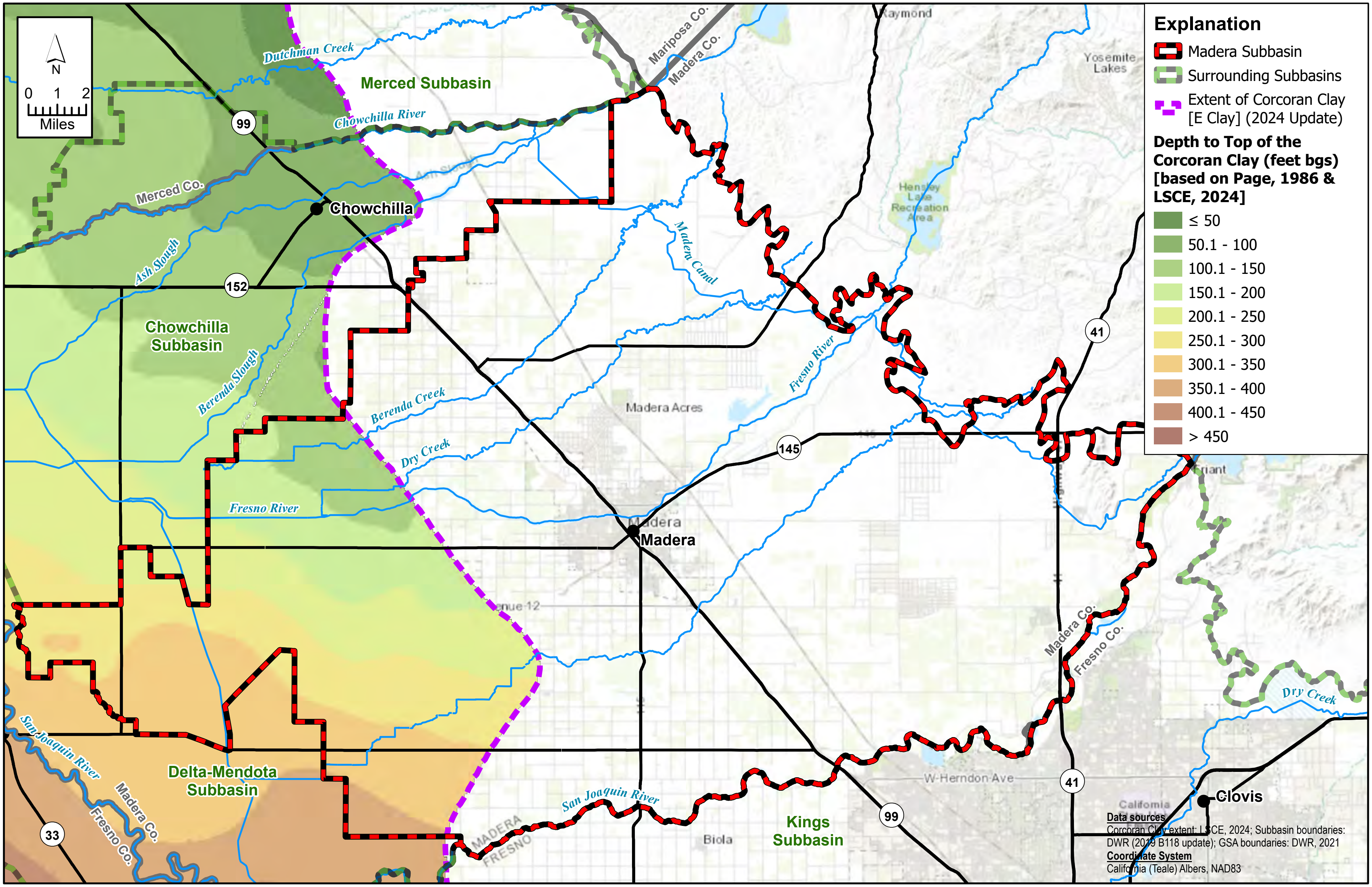
Q	Alluvium
Qdp	Dos Palos Alluvium
Qf	Alluvial fan deposits
Qsl	San Luis Ranch Alluvium
Qp	Patterson Alluvium
Qtl	Turlock Lake Formation *(Nonmarine sand, silt, and gravel)*
Pl	Laguna Formation *(Consolidated alluvium)*
Qm	Modesto Formation
Qr	Riverbank Formation
Qlb	Los Banos Alluvium
QTnm	North Merced Gravel *(Thin pediment veneer)*
Jjp	Jasper Point Formation *(Chert, tuff, pillow basalt; marine)*
ms	Metasedimentary rocks*
ls	Crystalline limestone and dolomite*
Pzcc	Calaveras Complex *(Metasedimentary rocks)*
mv	Metavolcanic rocks*
Mtm	Table Mountain Latite
Tm	Mehrten Formation *(Andesitic conglomerate)*
Tvs	Valley Springs Formation *(Rhyolitic tuff and sedimentary rocks)*
Ei	Ione Formation *(Quartzose sandstone and kaolinitic clay; mostly nonmarine)*
Tg	"Auriferous" Gravels
Pl	Locatelli Formation *(Marine sandstone and conglomerate)*
Kl	Lower Cretaceous marine sandstone and shale
Mzg	Granitic rocks
Mzgb	Gabbroic rocks
um	Ultramafic rocks
Jm	Mariposa Formation *(Slate, graywacke, and conglomerate; marine)*
Jsm	Salt Springs and Merced Falls Slates
Jms	Jurassic(?) metasedimentary rocks
Jch	Copper Hill Volcanics
Jlr	Logtown Ridge Volcanics
Jgo	Gopher Ridge Volcanics
Jpb	Penon Blanco Volcanics
Jmv	Jurassic metavolcanic rocks

Santa Cruz, Mariposa, and Fresno Quadrangles

Qal	Alluvium
Qsc	Stream channel deposits (GREAT VALLEY)
Qf	Fan deposits (GREAT VALLEY)
Qb	Basin deposits (GREAT VALLEY)
Qc	Pleistocene nonmarine
QP	Plio-Pleistocene nonmarine
Qpv	Pleistocene volcanic: Qpv[r] —rhyolite; Qpv[a]—andesite; Qpv[b] —basalt; Qpv[p] —pyroclastic rocks
Tc	Tertiary nonmarine
Pv	Permian metavolcanic rocks
Ec	Eocene nonmarine
E	Eocene marine
Tv	Tertiary volcanic: Tv[r] —rhyolite; Tv[a] —andesite; Tv[b] —basalt; Tv[p] —pyroclastic rocks
Ju	Upper Jurassic marine
m / ls	Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)
ms	Pre-Cretaceous metasedimentary rocks
gr-m	Pre-Cenozoic granitic and metamorphic rocks
IPv	Paleozoic metavolcanic rocks
Cv	Carboniferous metavolcanic rocks

Geologic Map compiled from:

1. Wagner, D.L., Bortugno, E.J., and Mc Junkin, R.D., 1991, Geologic Map of the San Francisco - San Jose Quadrangle, California Geological Survey, Regional Geologic Map No. 5A, 1:250,000 scale.
2. Jennings, C.W. and Strand, R.G., 1958, Geologic Atlas of California - Santa Cruz Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 020, 1:250,000 scale.
3. Strand, R.G., 1967, Geologic Atlas of California - Mariposa Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 009, 1:250,000 scale.
4. Matthews, R.A. and Burnett, J.L., 1965, Geologic Atlas of California - Fresno Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 005, 1:250,000 scale.



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Corcoran Clay_DepthTop

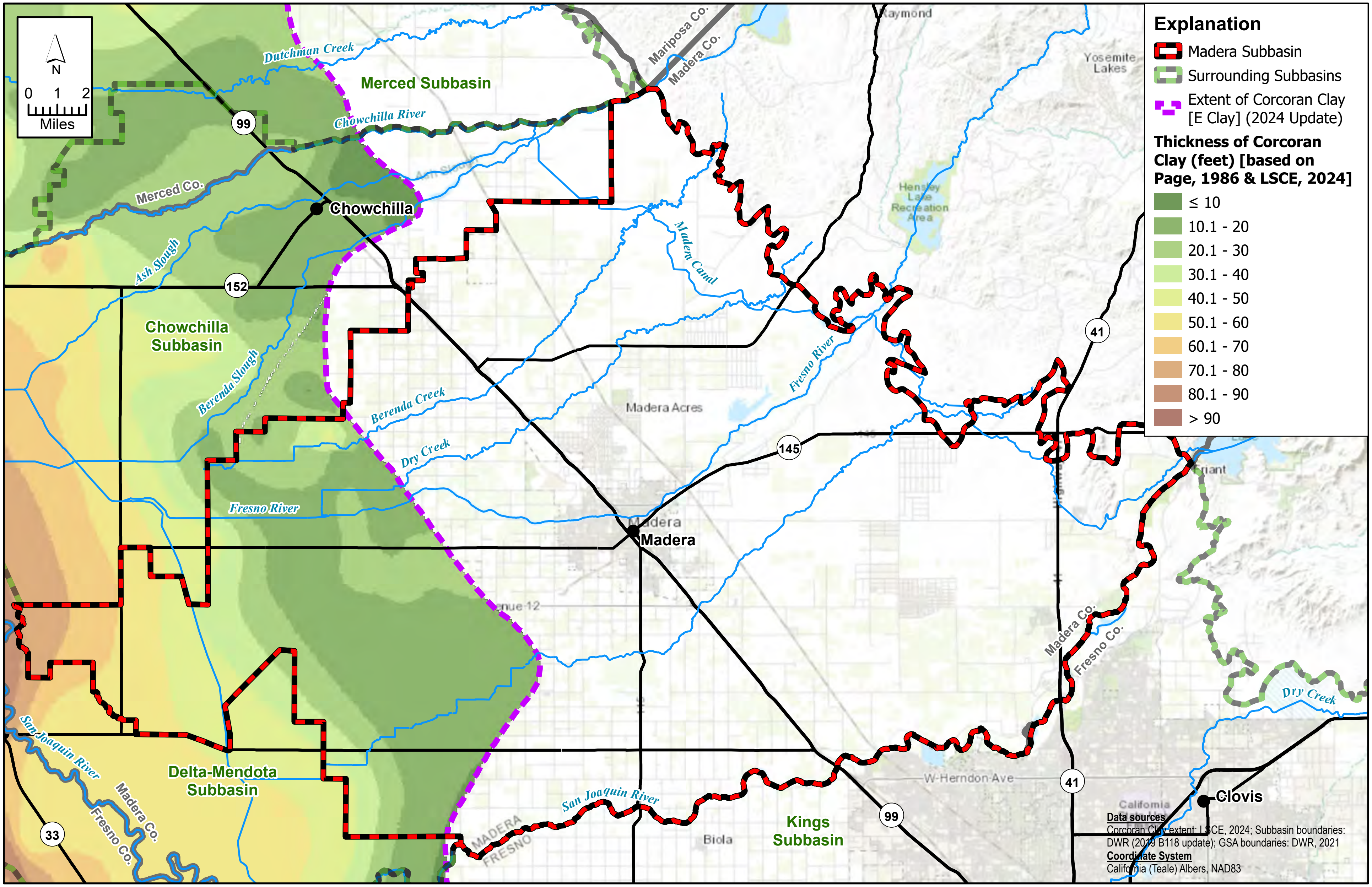
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-15

Extent and Depth to the Top of the Corcoran Clay

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Corcoran Clay_Thickness

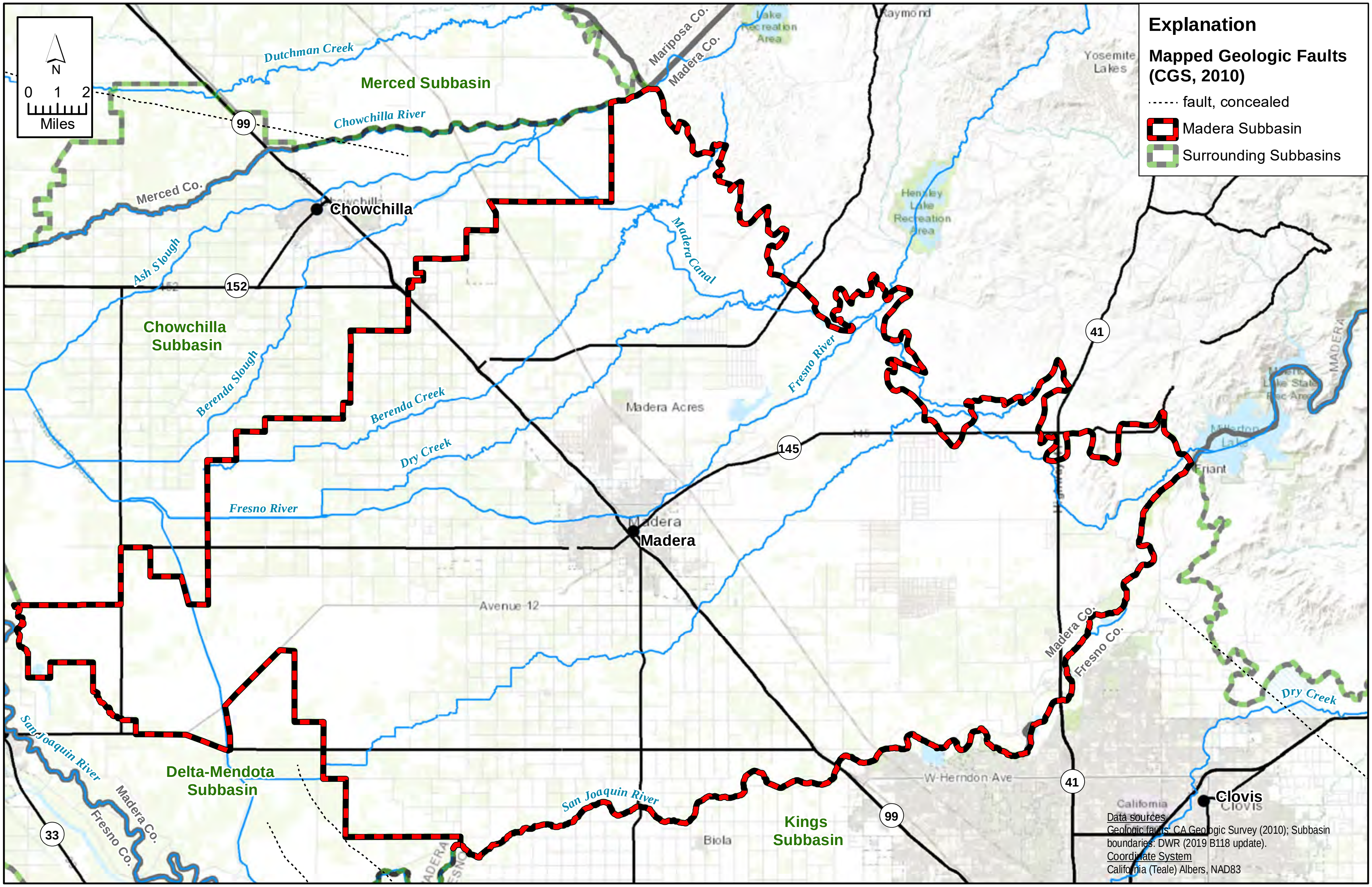
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-16

Thickness of the Corcoran Clay

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-17 Madera Subbasin Geologic Fault Map.mxd

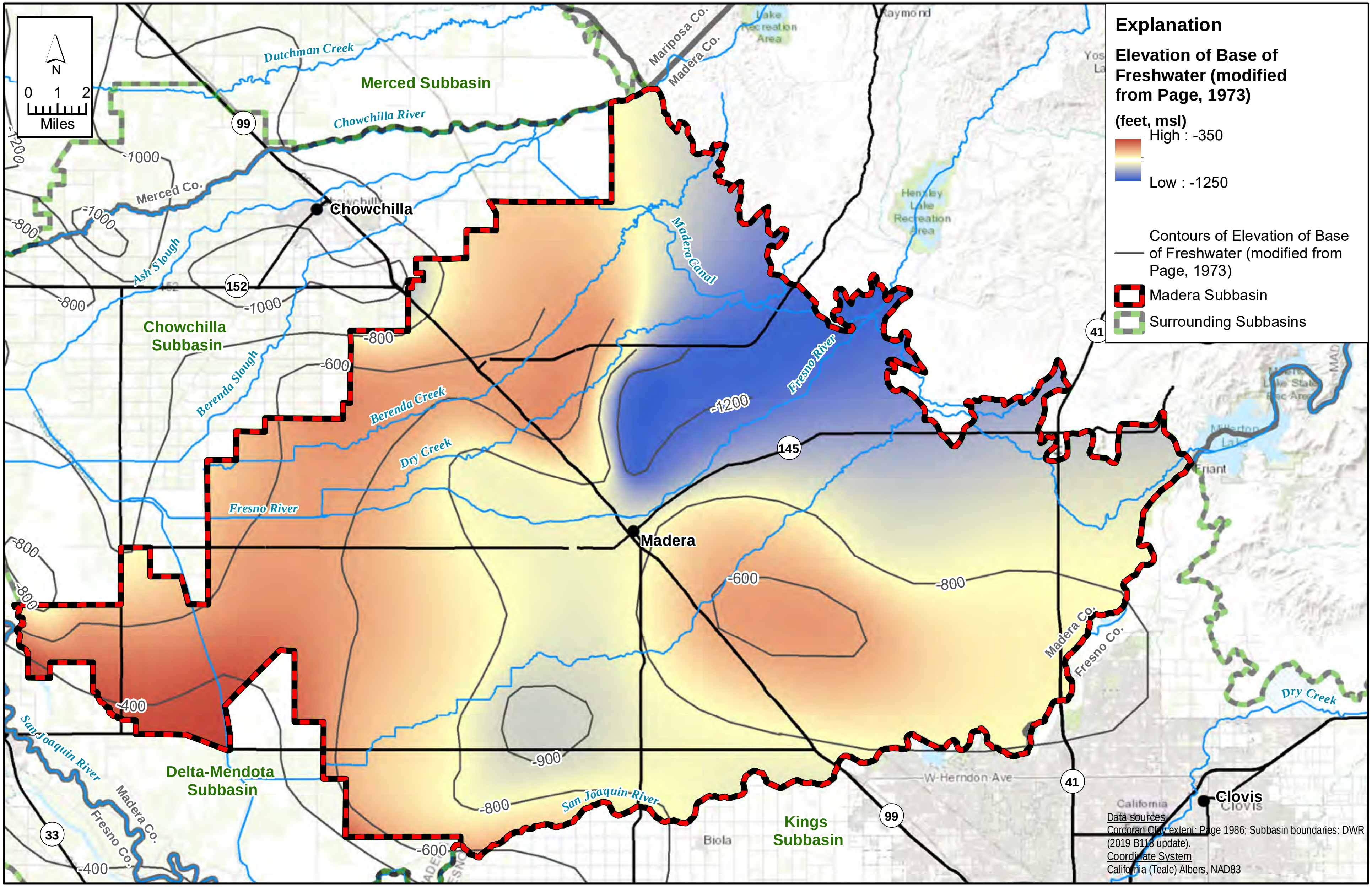
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-17

Geologic Fault Map

Madera Subbasin
Groundwater Sustainability Plan



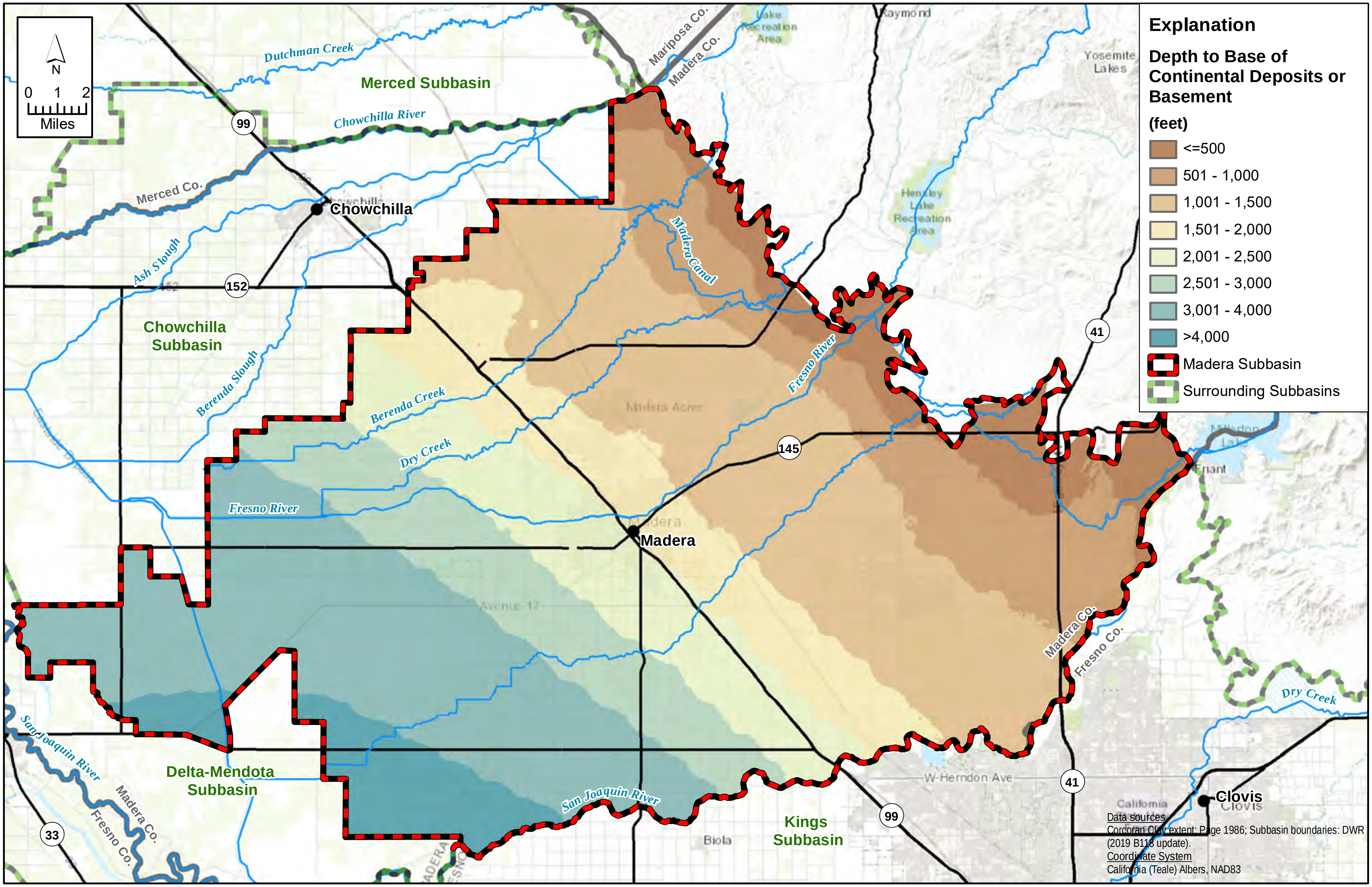
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-18 Madera Subbasin Base of Freshwater Map.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-18
Elevation of Base of Freshwater: Modified from Page (1973)

Madera Subbasin
Groundwater Sustainability Plan



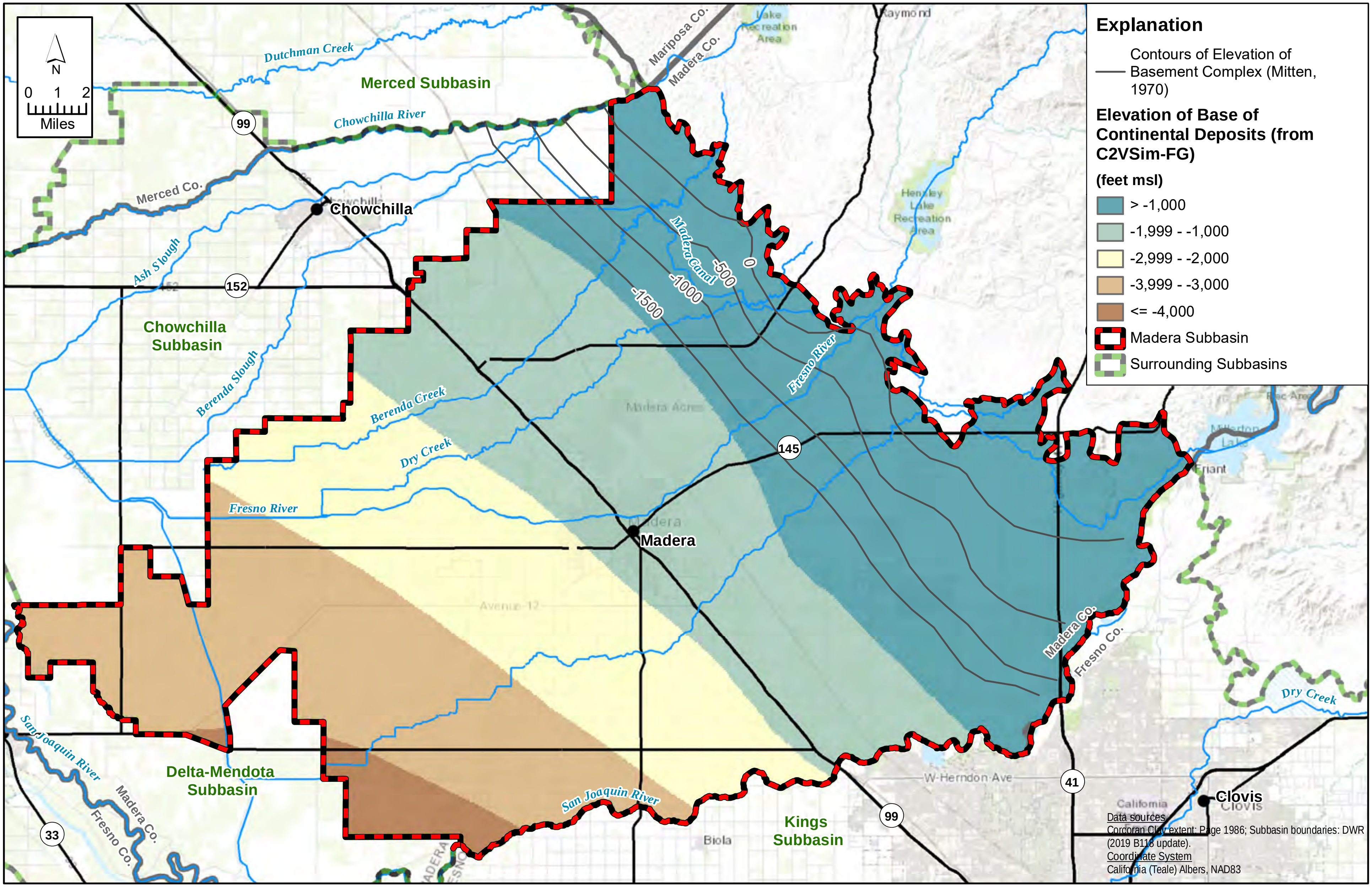
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-19 Madera Subbasin Depth to Basement Map.mxd

DAVIDS ENGINEERING, INC — Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-19

Depth to Base of Continental Deposits or Basement Complex

Madera Subbasin
Groundwater Sustainability Plan

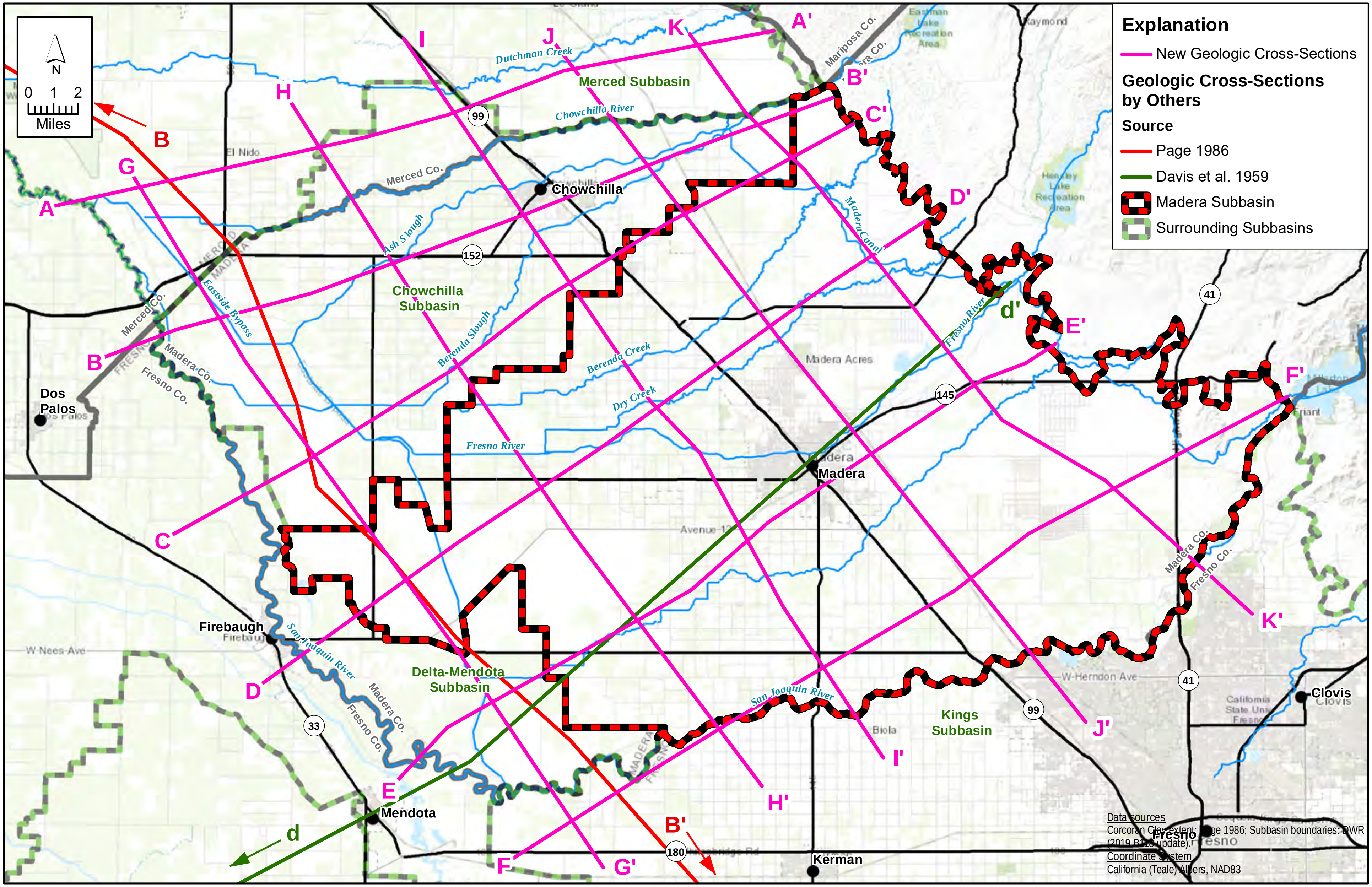


X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-20 Madera Subbasin Elevation of Basement Complex Map.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-20
Elevation of Top of Basement Complex (from Mitten, 1970) and Bottom of Continental Deposits (from C2VSim-FG, 2018)

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-21 Madera Subbasin Cross Section Location Map.mxd

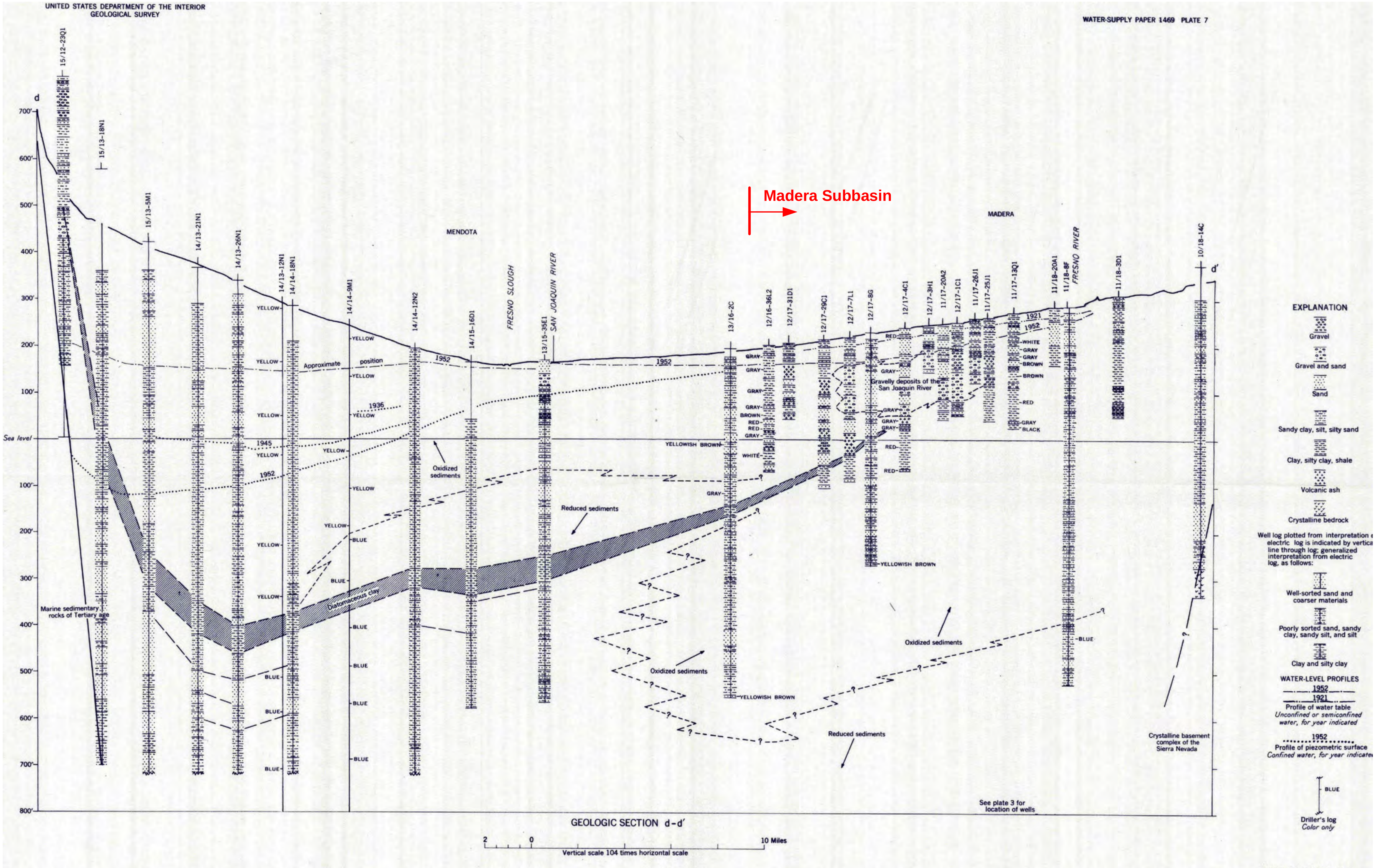
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-21

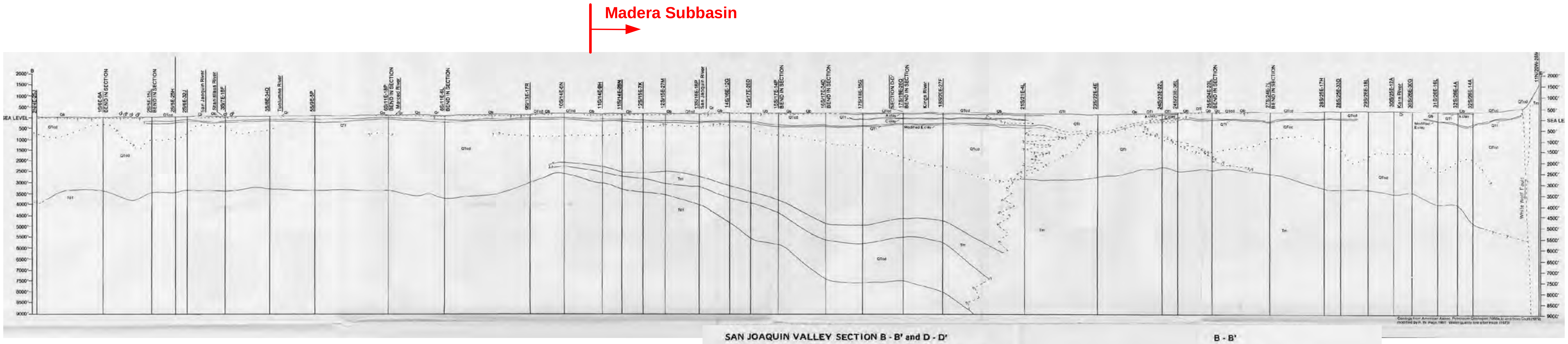
Geologic Cross-Section Location Map

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-22 CrossSection_Davis1959_d.mxd

FIGURE 2-22
Geologic Cross-Section: Davis et al. (1959) Section D-D'



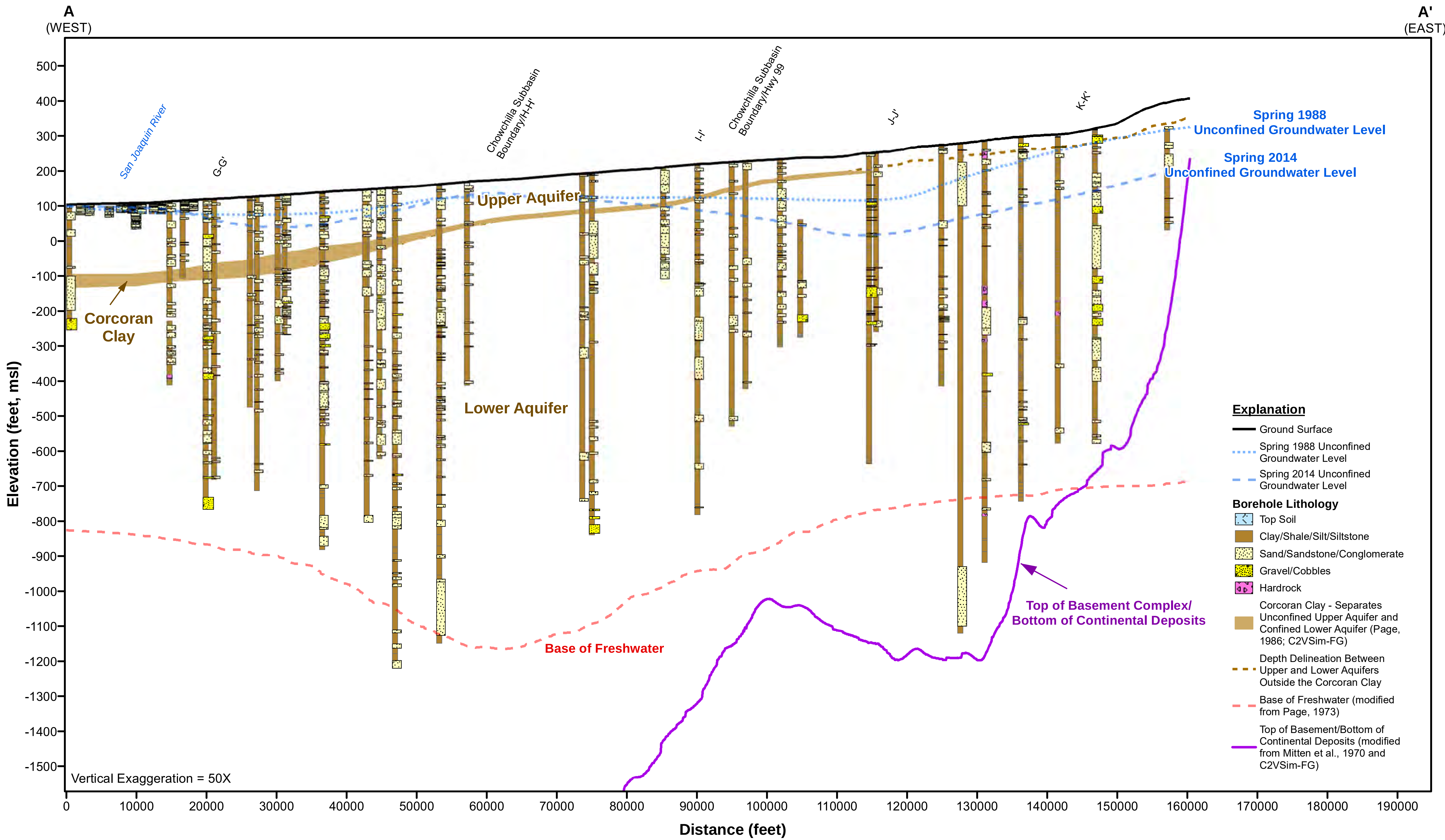
SAN JOAQUIN VALLEY SECTION B - B' and D - D'

		B - B'
Qs	**Sand dunes (Holocene)** Windblown sand and dune sand	Description at left
Qb	**Flood-basin deposits (Holocene)** Clay, silt, and some sand;	Near northern end of section consist of muck, peat, and other organic soils
Qr	**River deposits (Holocene)** Gravel, sand, silt, and minor amounts of clay; deposited along channels, flood plains, and natural levees of main streams.	Description at left
QTl	**Lacustrine and marsh deposits (Pliocene to Holocene)** Clay, silt, and some sand; in subsurface include three widespread clays: A clay (Pleistocene and Holocene?), C clay (Pleistocene); and modified E clay (Pleistocene), includes Corcoran Clay Member of Tulare Formation	Description at left
QTcd	**Continental rocks and deposits (Oligocene to Holocene)** Heterogenerous mix of generally poorly sorted clay, silt, sand, and gravel, some beds of claystone, siltstone, sandstone, and conglomerate...	On this section, principal unit, continental rocks and deposits (Miocene to Holocene): in northern part of section may include continental rocks and deposits (Miocene and Pliocene)--mostly Mehrten Formation or an equivalent, and continental rocks and deposits (Oligocene and Miocene) -mostly Valley Springs Formation or an equivalent. Include continental rocks and deposits (Miocene and Pliocene)--chiefly the Chanac Formation (Miocene) at extreme southern end of section, and the Zilch Formation of informal subsurface usage, which is considered to be the continental equivalent of the Marine Temblor Formation (Oligocene and Miocene)
Tm	**Marine rocks and deposits (Eocene, Oligocene, Miocene, and Pliocene)** Sand, clay, silt, sandstone, shale, mudstone, and siltstone. On these section include marine rocks and deposits of Miocene and Pliocene age only	Description at left
TpT	**Continental and marine rocks and deposits (Pre-Tertiary to Oligocene)** Continental rocks and deposits of clay, shale, sand, sandstone and conglomerate; marine rocks and deposits of clay, shale, sandstone, and conglomerate...	On this section include marine rocks and deposits of Eocene and Oligocene age, also include some Paleocene marine rocks. Include continental rocks and deposits (Eocene to Miocene)-- chiefly Walker Formation (Eocene to Miocene) at depths off the section - greater than 13,000ft, where the Walker Formation underlies Eocene, marine sediments. Include marine rocks (Pre-Tertiary)
pTgm	**Granitic and metamorphic rocks (Pre-Tertiary)** Granitic rocks with some mafic intrusive rocks, and metasedimentary and metavolcanic rocks. Include granitic rocks (Pre-Tertiary) and metamorphic rocks (Pre-Tertiary)	Not present

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-23
Geologic Cross-Section: Page (1986) Section B-B'

Madera Subbasin
Groundwater Sustainability Plan



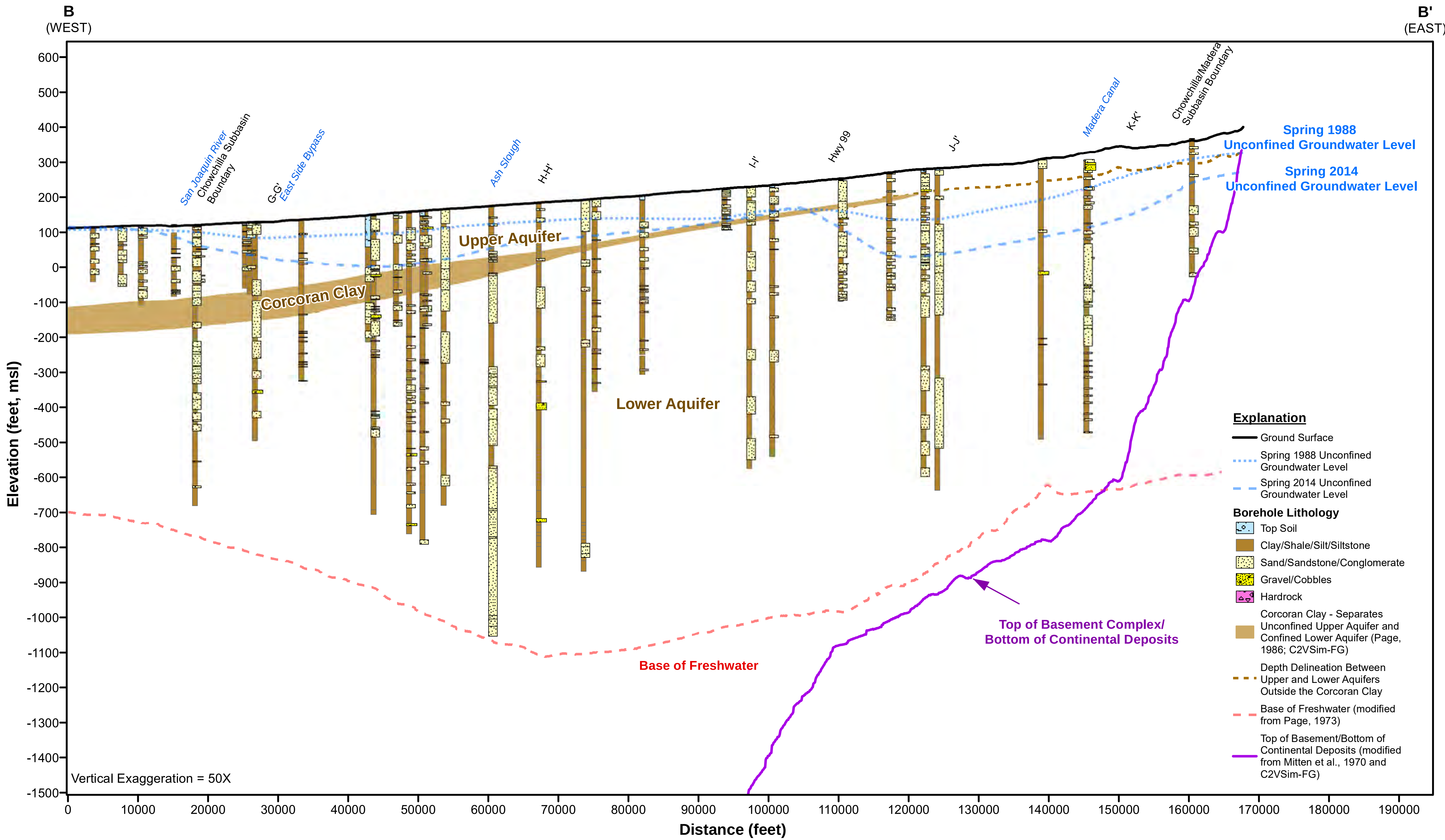
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-24 CrossSection_LSCE_A.mxd

DAVIDS ENGINEERING, INC Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-24

Madera County Geologic Cross-Section A

Madera Subbasin
Groundwater Sustainability Plan



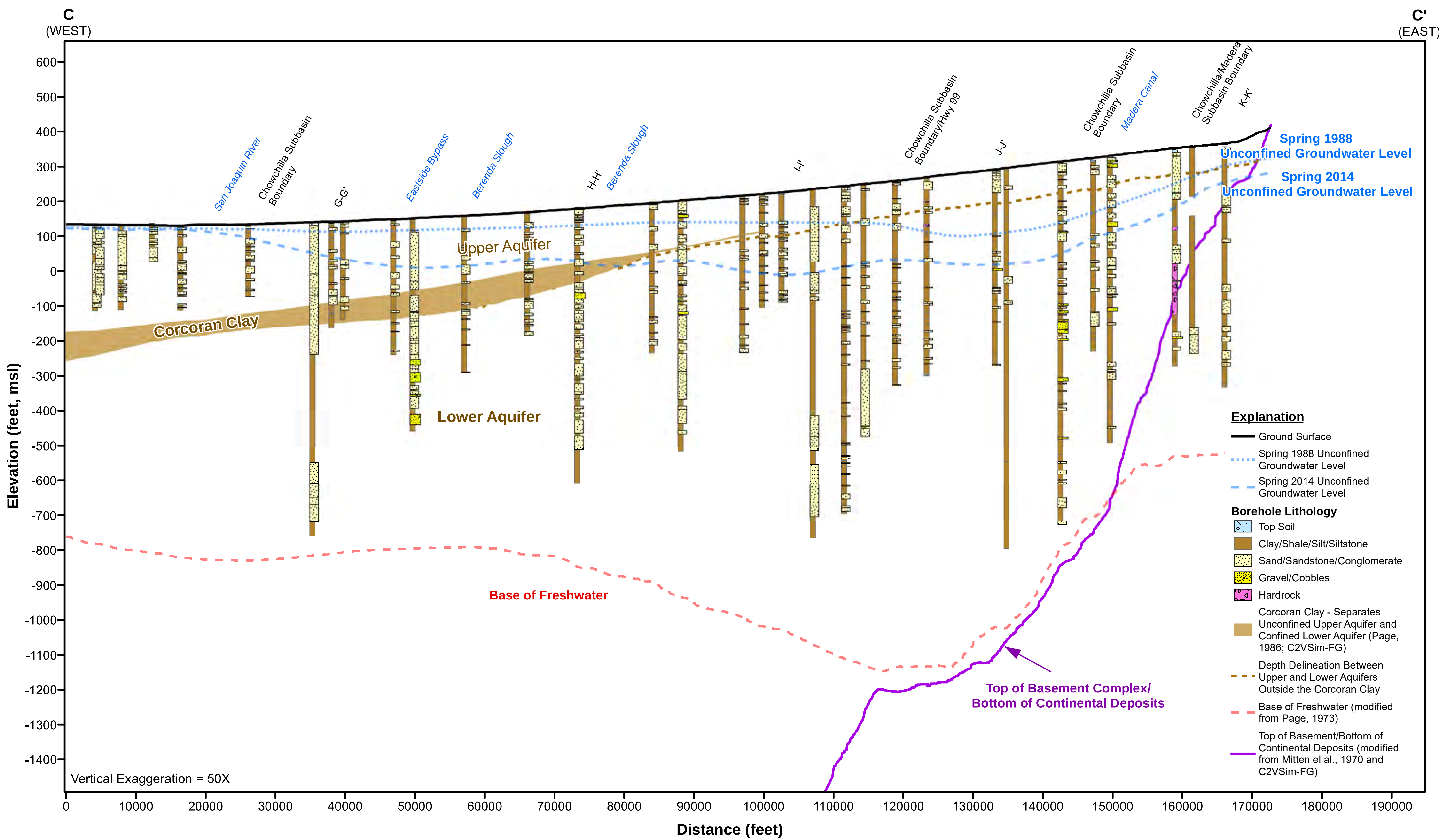
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-25 CrossSection_LSCE_B.mxd

DAVIDS ENGINEERING, INC   Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-25

Madera County Geologic Cross-Section B

Madera Subbasin
Groundwater Sustainability Plan



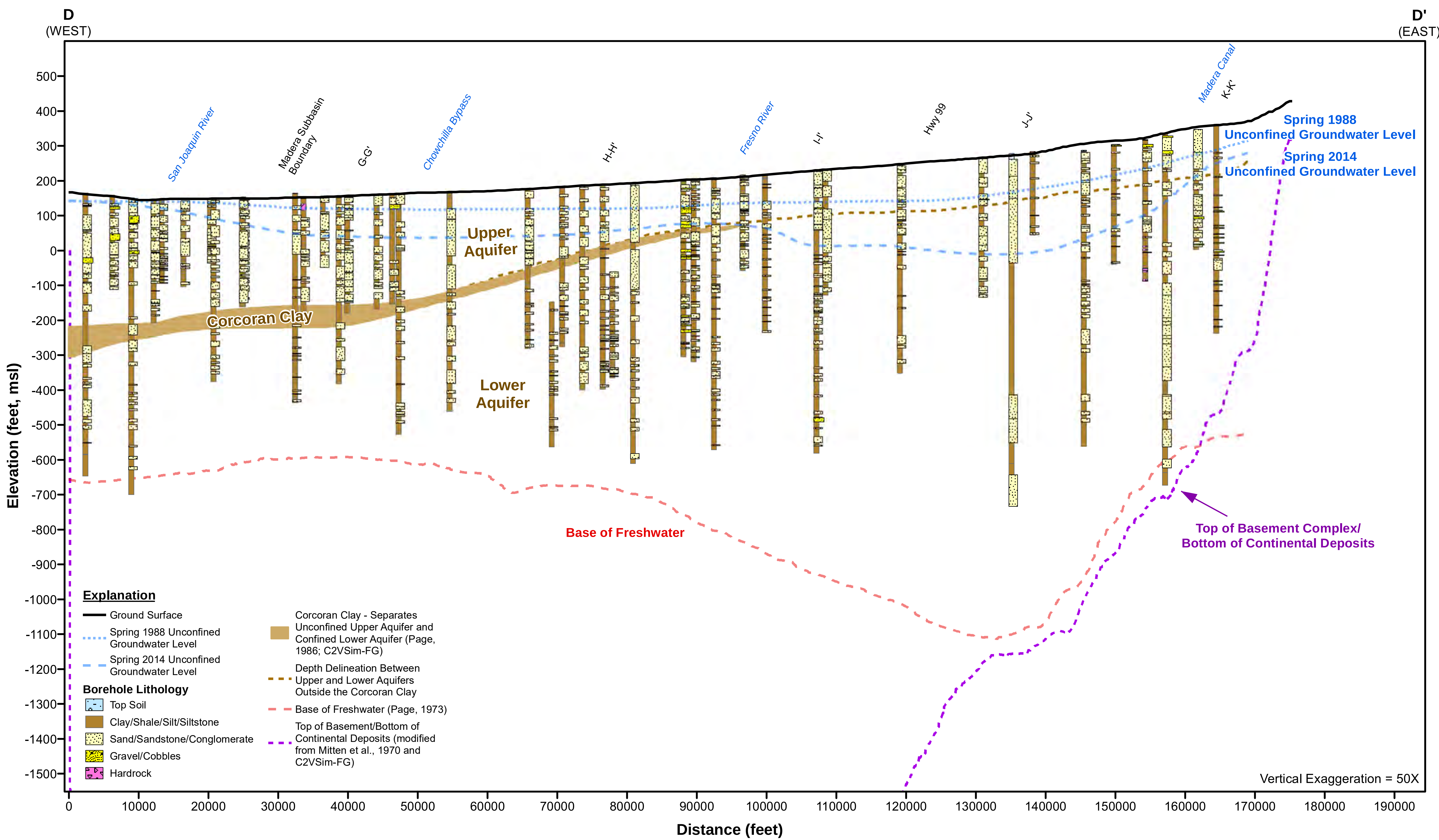
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-26 CrossSection_LSCE_C.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-26

Madera County Geologic Cross-Section C

Madera Subbasin
Groundwater Sustainability Plan



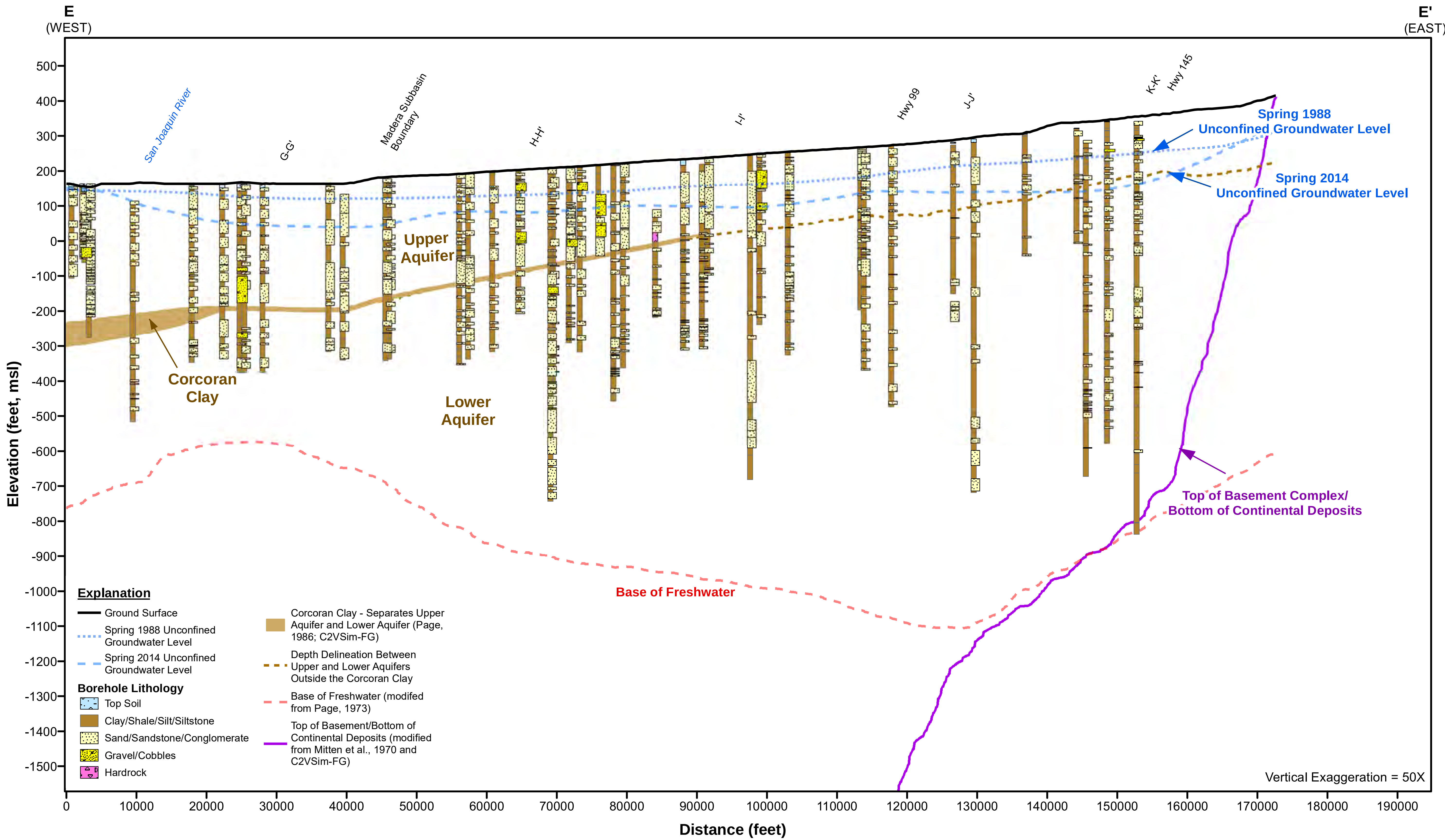
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-27 CrossSection_LSCE_D.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-27

Madera County Geologic Cross-Section D

Madera Subbasin Groundwater Sustainability Plan



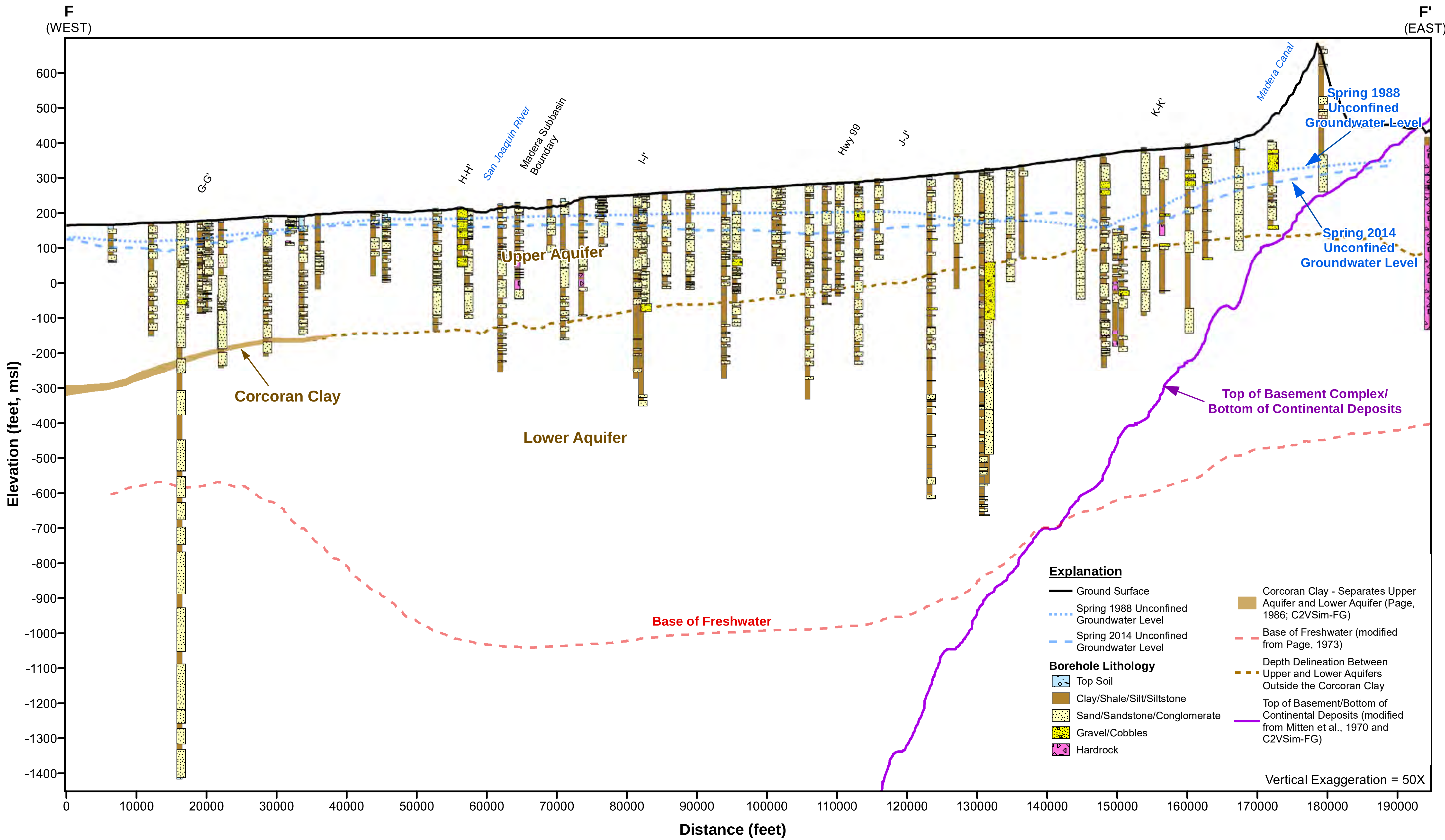
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-28 CrossSection_LSCE_E.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-28

Madera County Geologic Cross-Section E

Madera Subbasin
Groundwater Sustainability Plan



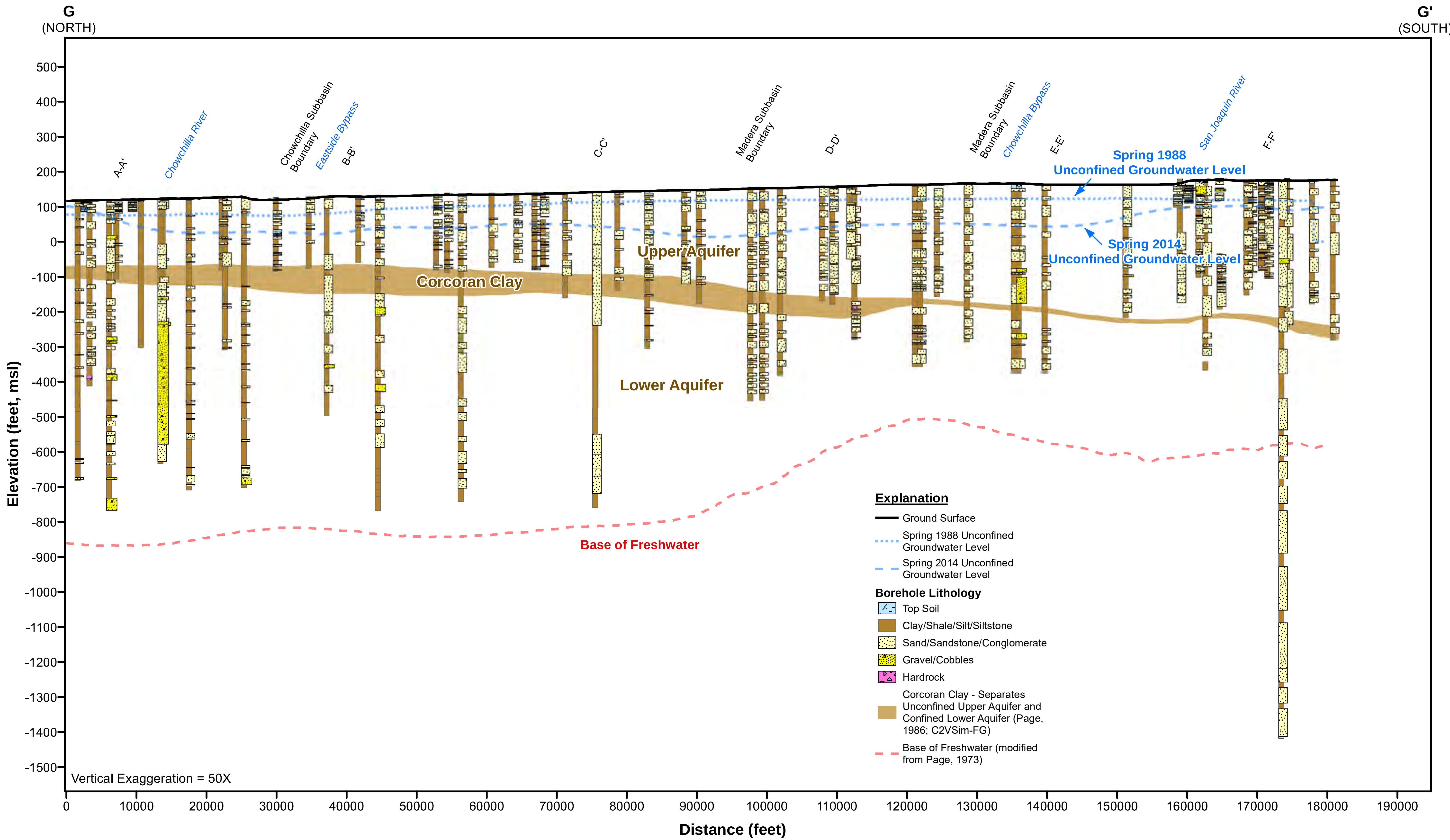
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-29 CrossSection_LSCE_F.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-29

Madera County Geologic Cross-Section F

Madera Subbasin
Groundwater Sustainability Plan



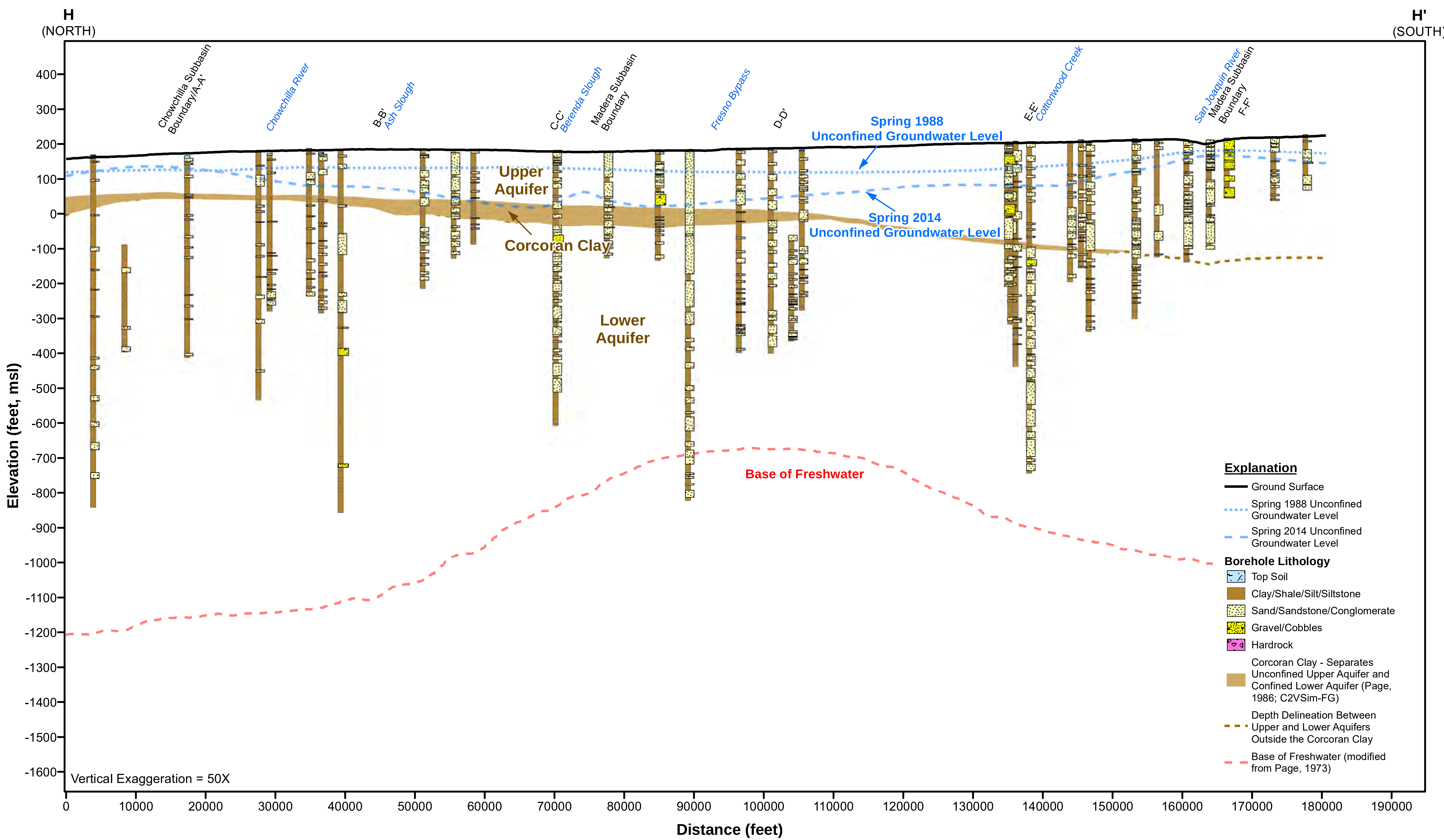
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-30 CrossSection_LSCE_G.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-30

Madera County Geologic Cross-Section G

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-31 CrossSection_LSCE_H.mxd

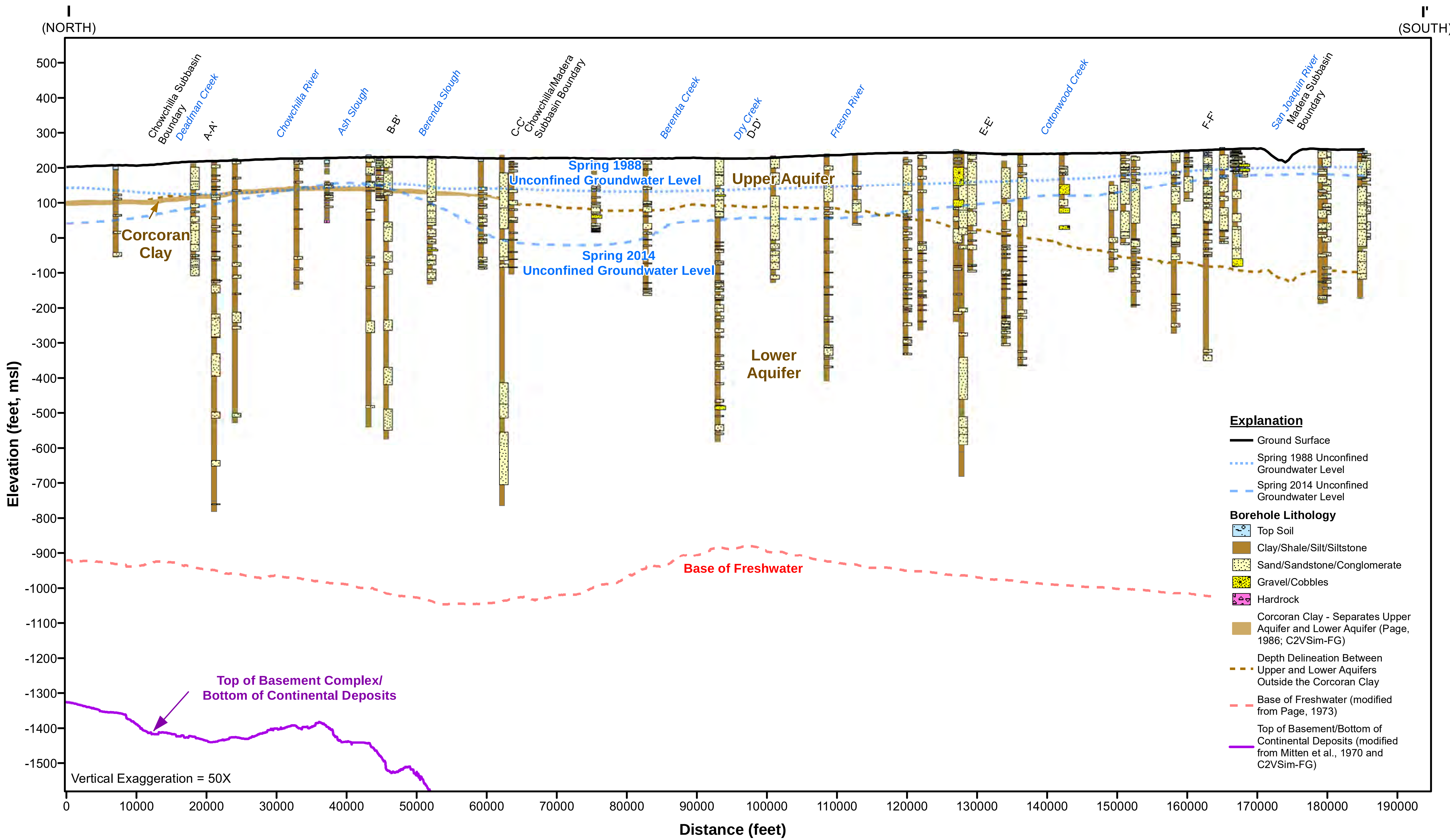
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-31

Madera County Geologic Cross-Section H

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-32 CrossSection_LSCE_I.mxd

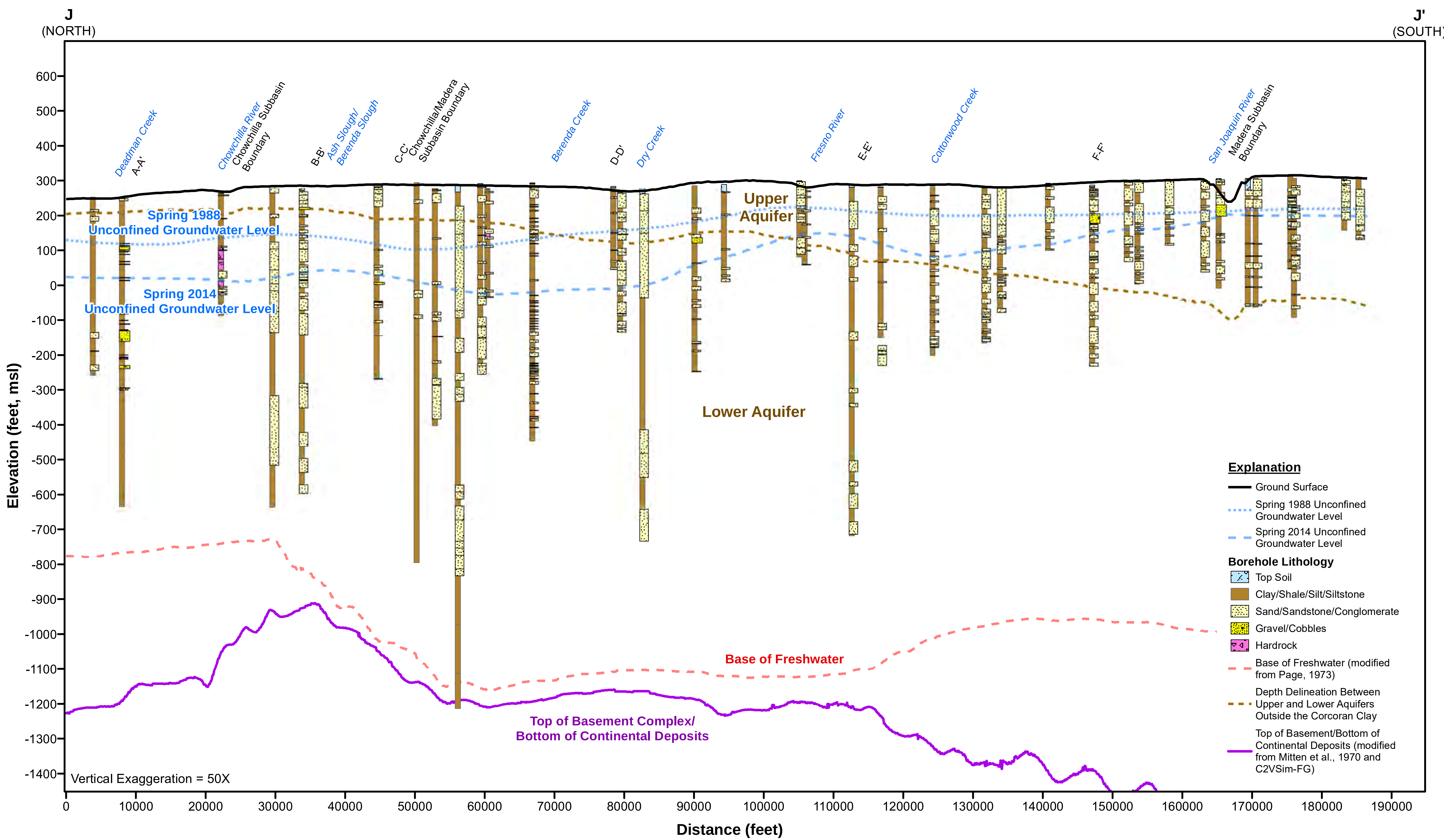
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-32

Madera County Geologic Cross-Section I

Madera Subbasin
Groundwater Sustainability Plan



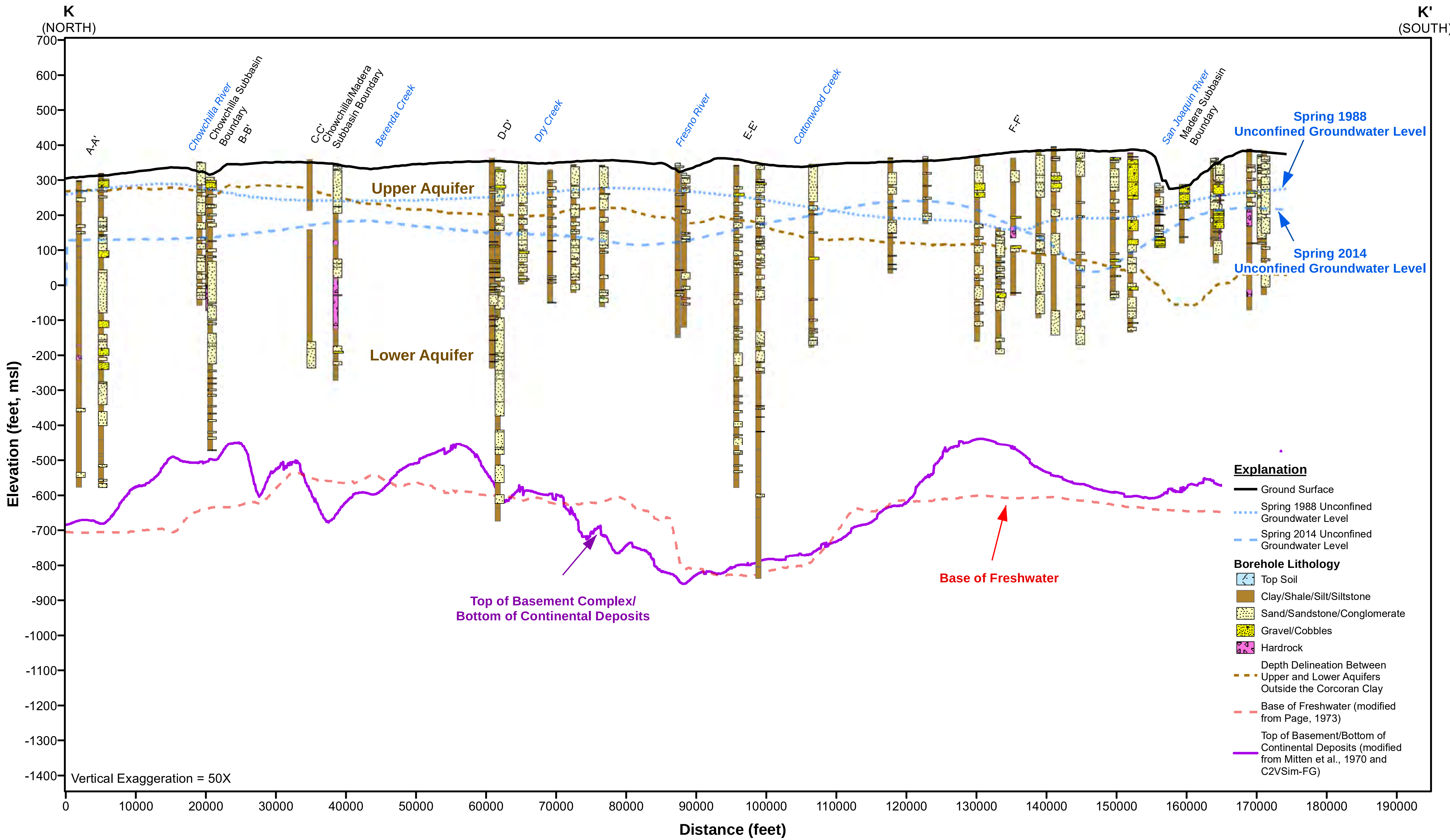
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-33 CrossSection_LSCE_J.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-33

Madera County Geologic Cross-Section J

Madera Subbasin
Groundwater Sustainability Plan



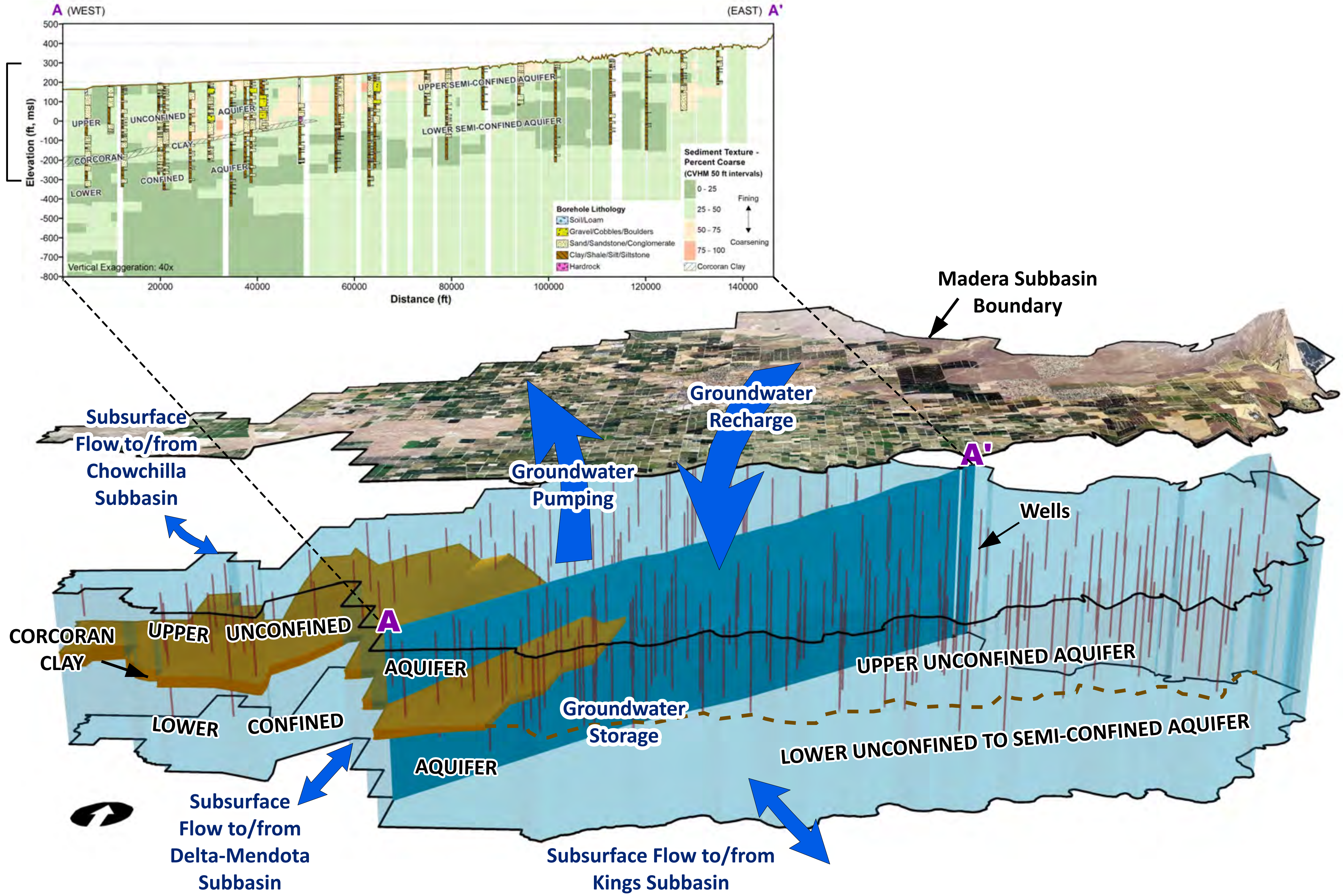
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-34 CrossSection_LSCE_K.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-34

Madera County Geologic Cross-Section K

Madera Subbasin Groundwater Sustainability Plan

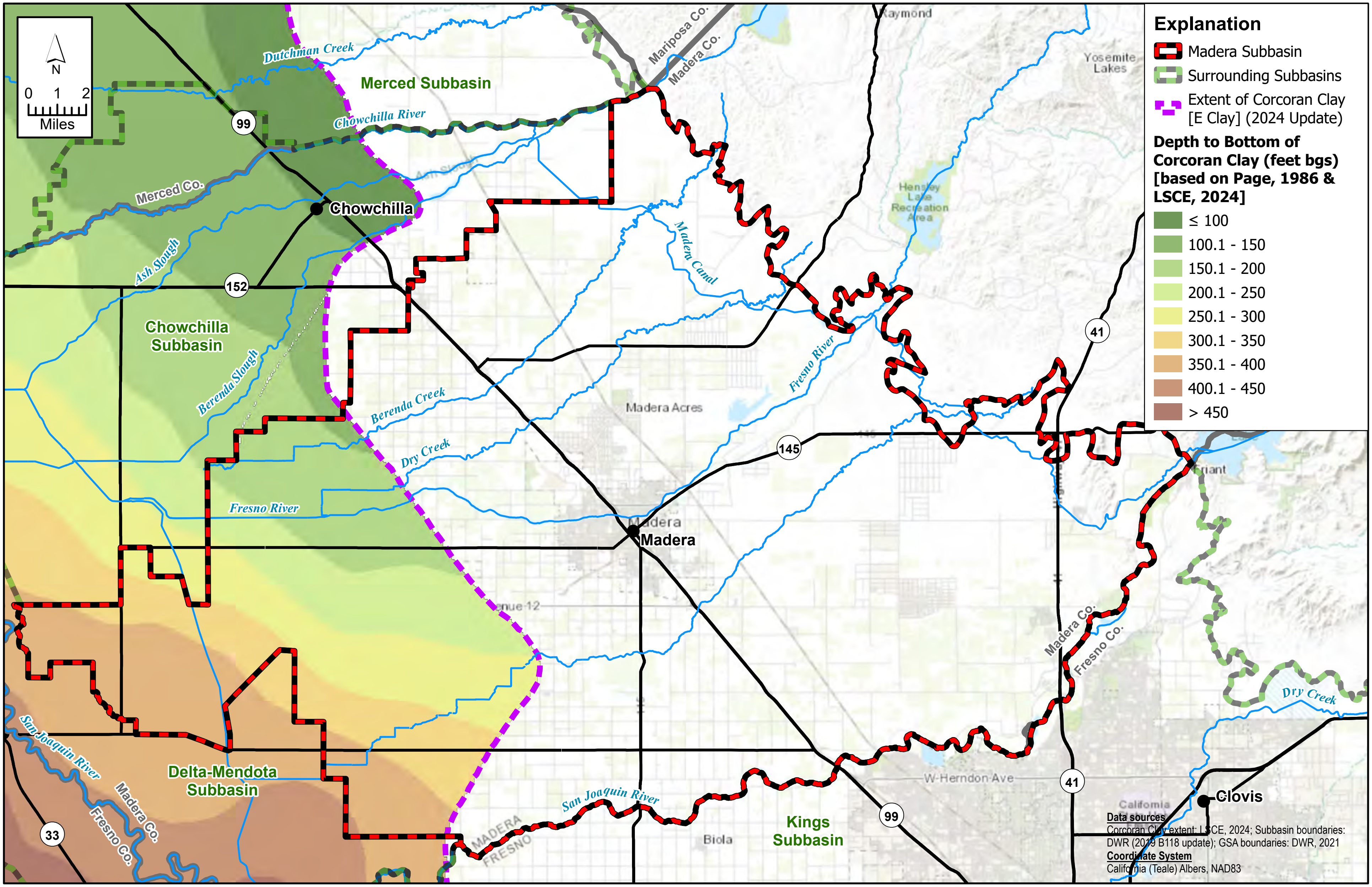


DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-35

Conceptual Hydrogeologic System



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Corcoran Clay_DepthBot

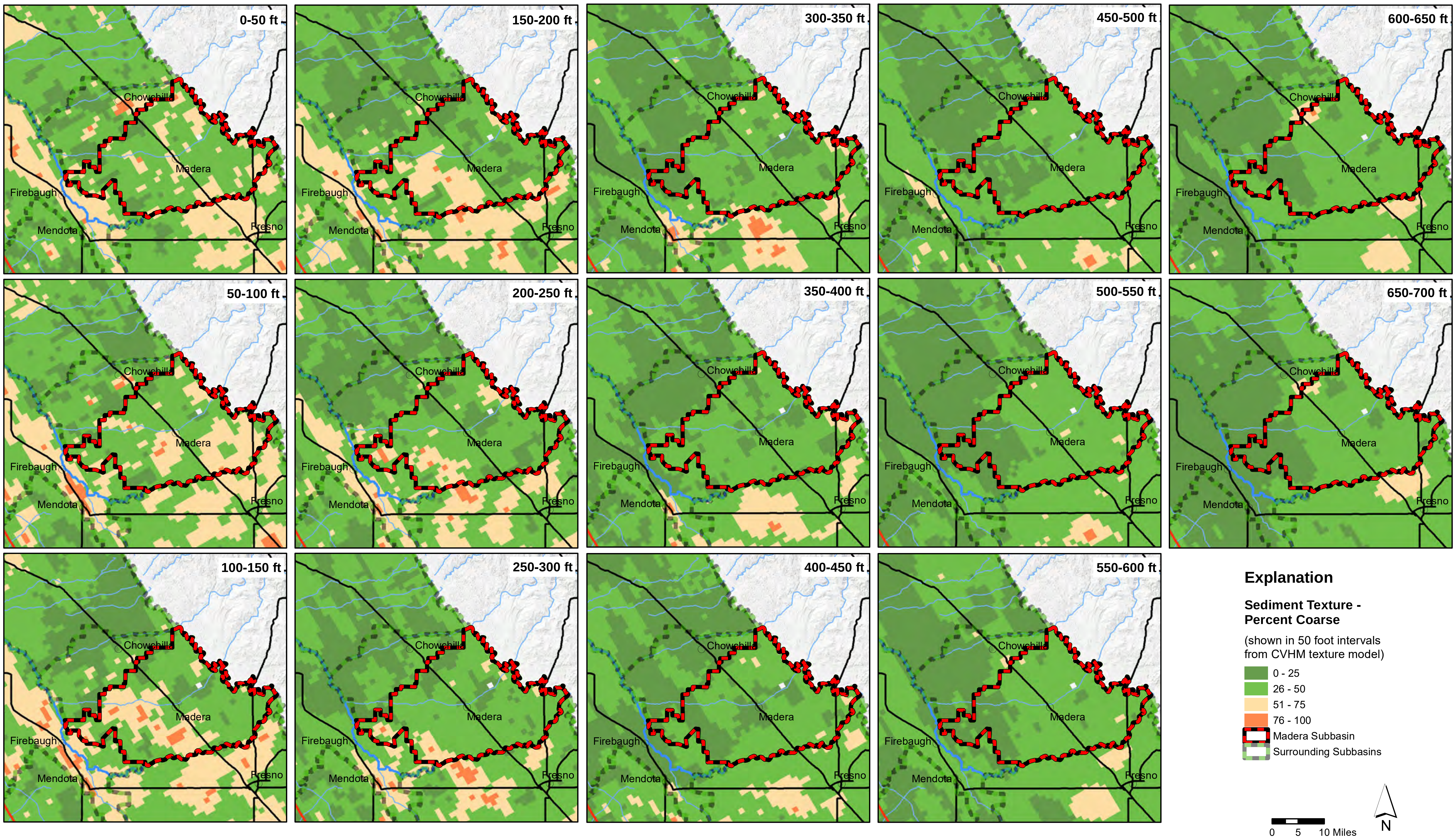
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-36

Extent of Confined Lower Aquifer

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-36 CVHM Sediment Texture Model 0 to 700.mxd

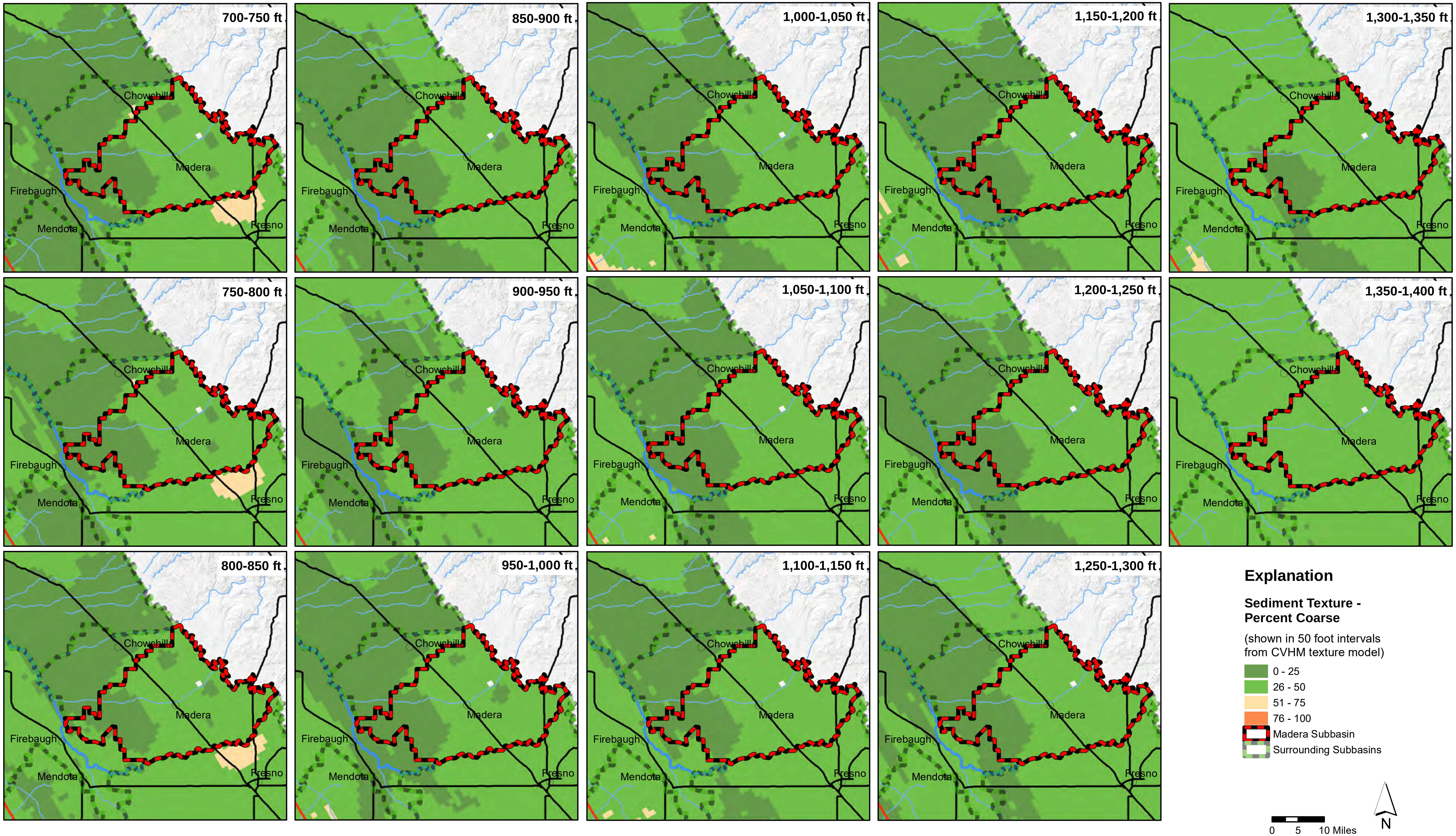
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-37

CVHM Sediment Texture Model: 0 to 700 feet

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-37 CVHM Sediment Texture Model 700 to 1400.mxd

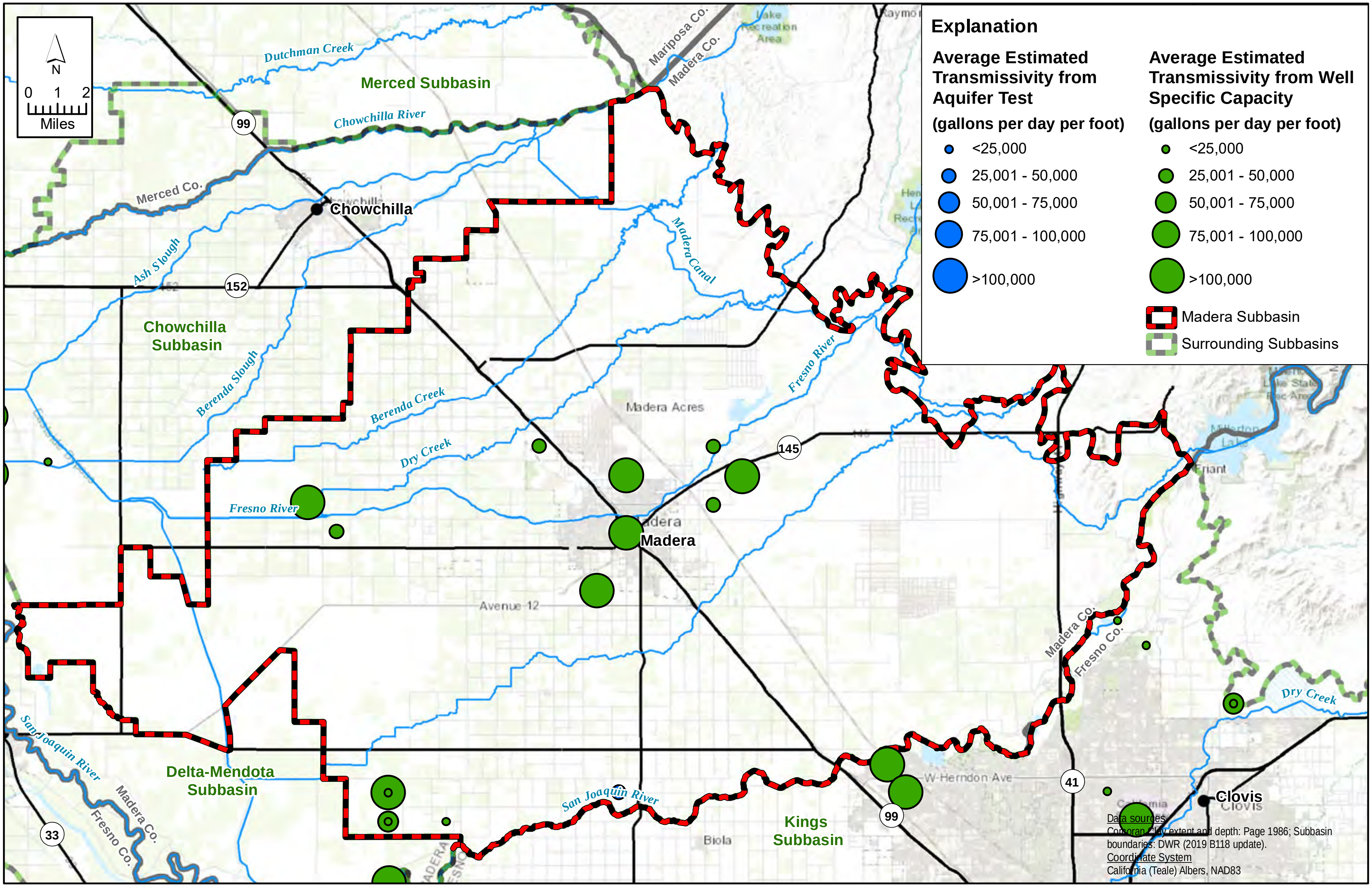
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-38

CVHM Sediment Texture Model: 700 to 1,400 feet

Madera Subbasin
Groundwater Sustainability Plan



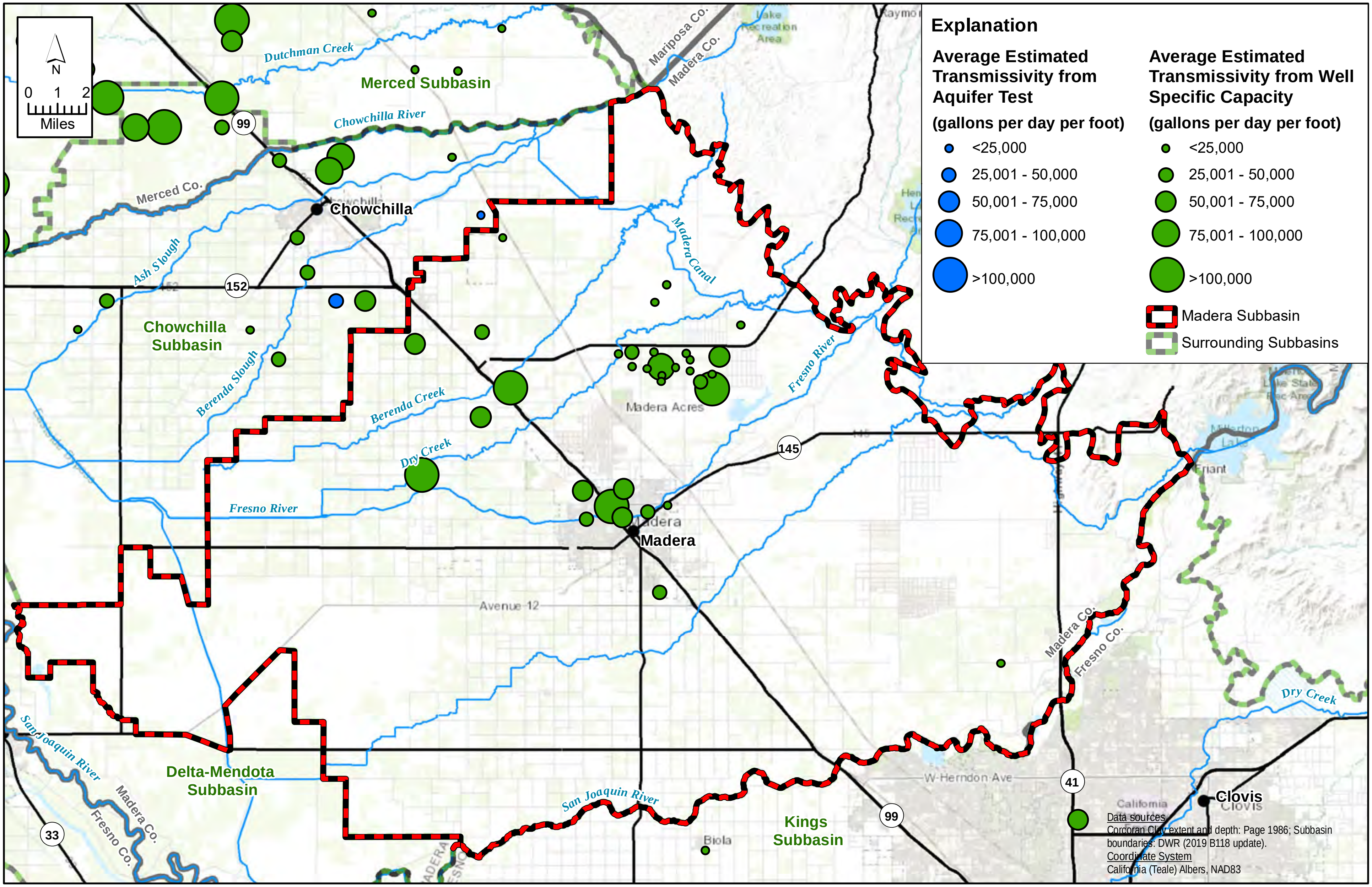
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-38 Madera Subbasin Aquifer Property Data_Upper.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-39
Map of Well Test Aquifer Property Data: Upper Aquifer

Madera Subbasin
Groundwater Sustainability Plan



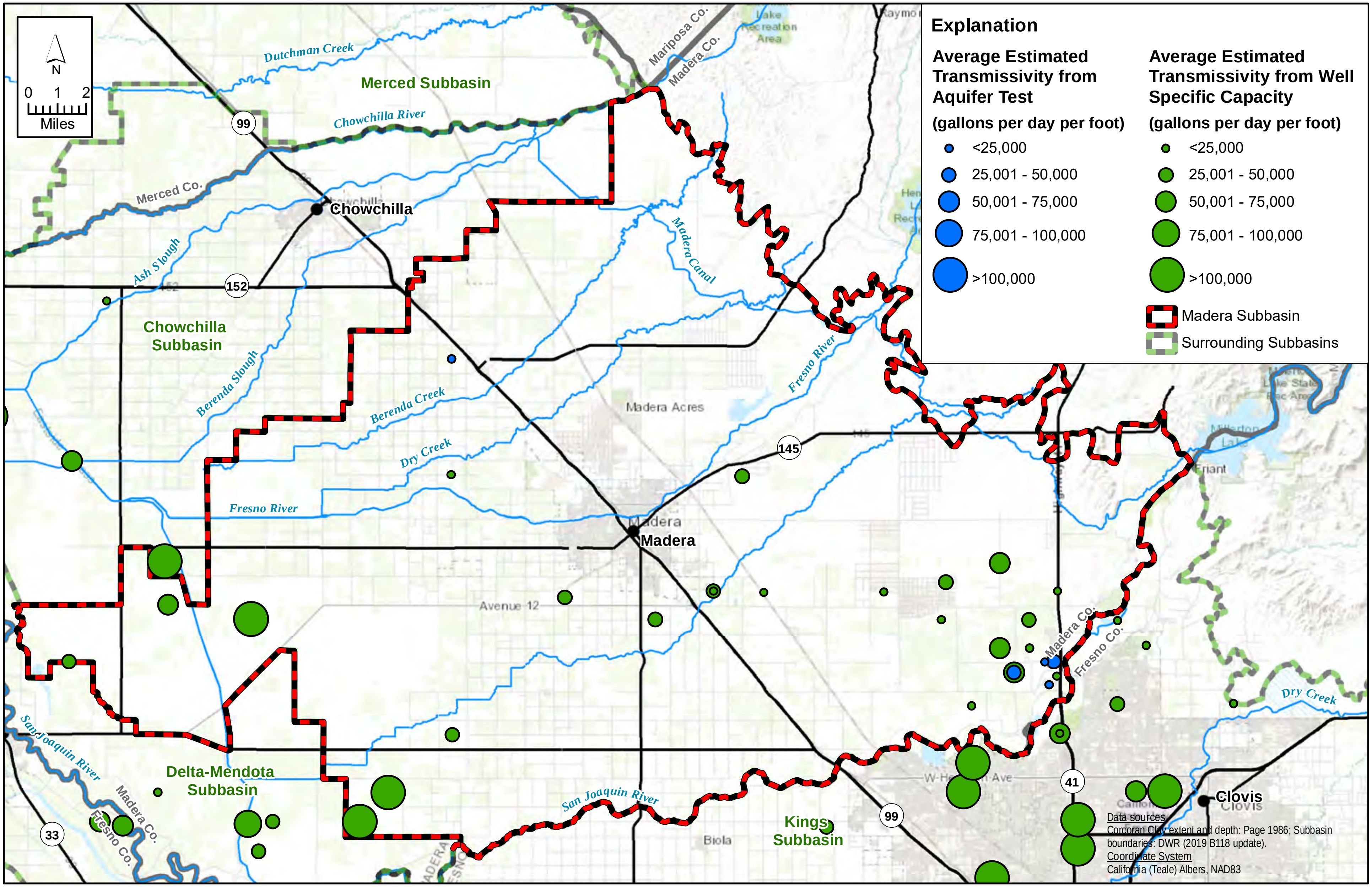
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-39 Madera Subbasin Aquifer Property Data_Lower.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-40
Map of Well Test Aquifer Property Data: Lower Aquifer

Madera Subbasin
Groundwater Sustainability Plan

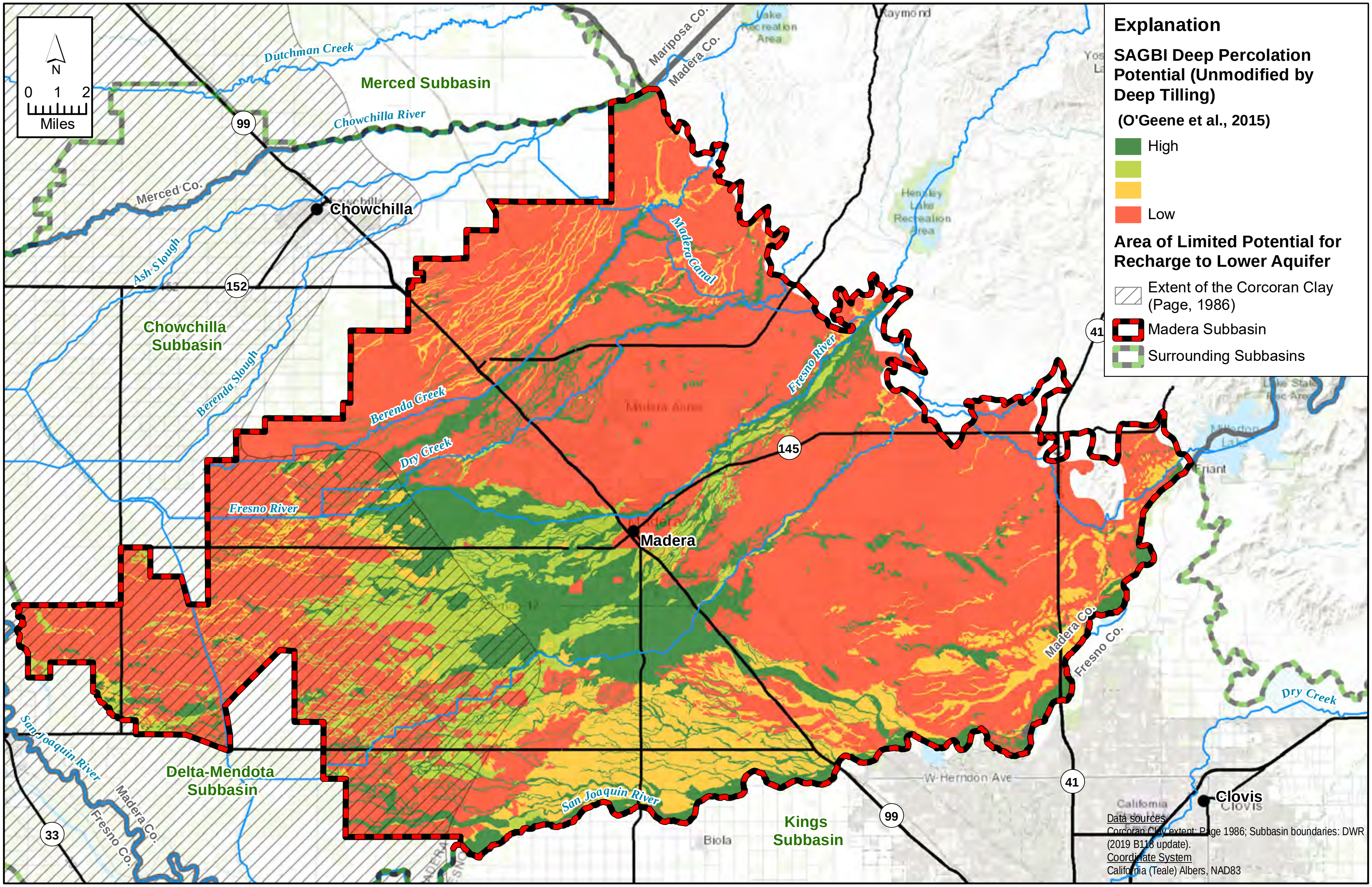


X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-40 Madera Subbasin Aquifer Property Data_CompositeUnknown.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-41
Map of Well Test Aquifer Property Data: Composite Wells or Unknown Depth

Madera Subbasin
Groundwater Sustainability Plan



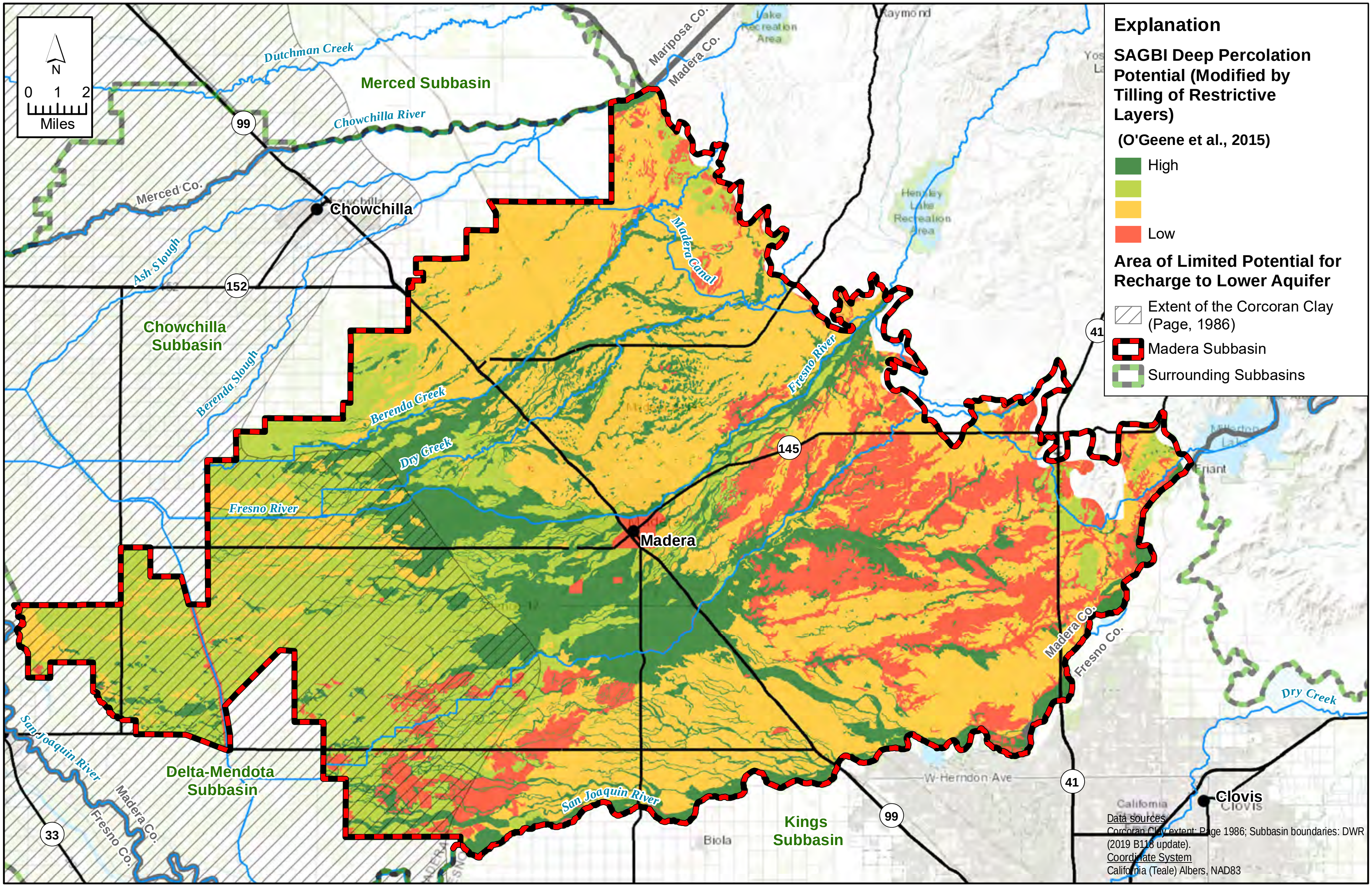
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-41 Madera Subbasin SAGBI Higher Recharge Potential Areas_unmodified.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-42
SAGBI Deep Percolation Potential: Unmodified by Tilling

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-42 Madera Subbasin SAGBI Higher Recharge Potential Areas_modified.mxd

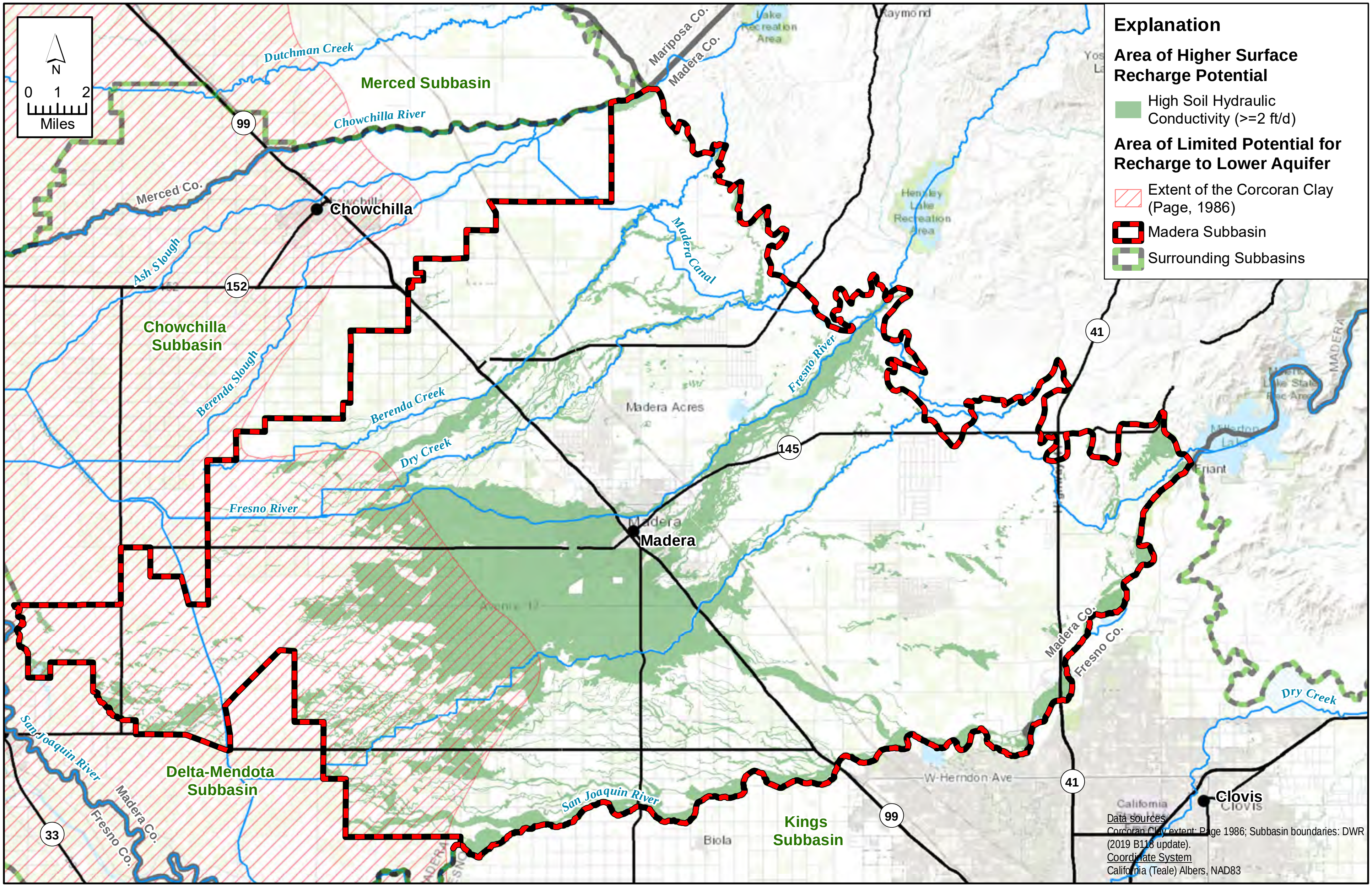
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-43

SAGBI Deep Percolation Potential: Modified by Tilling of All Restrictive Layers

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-43 Madera Subbasin Potential Recharge Areas.mxd

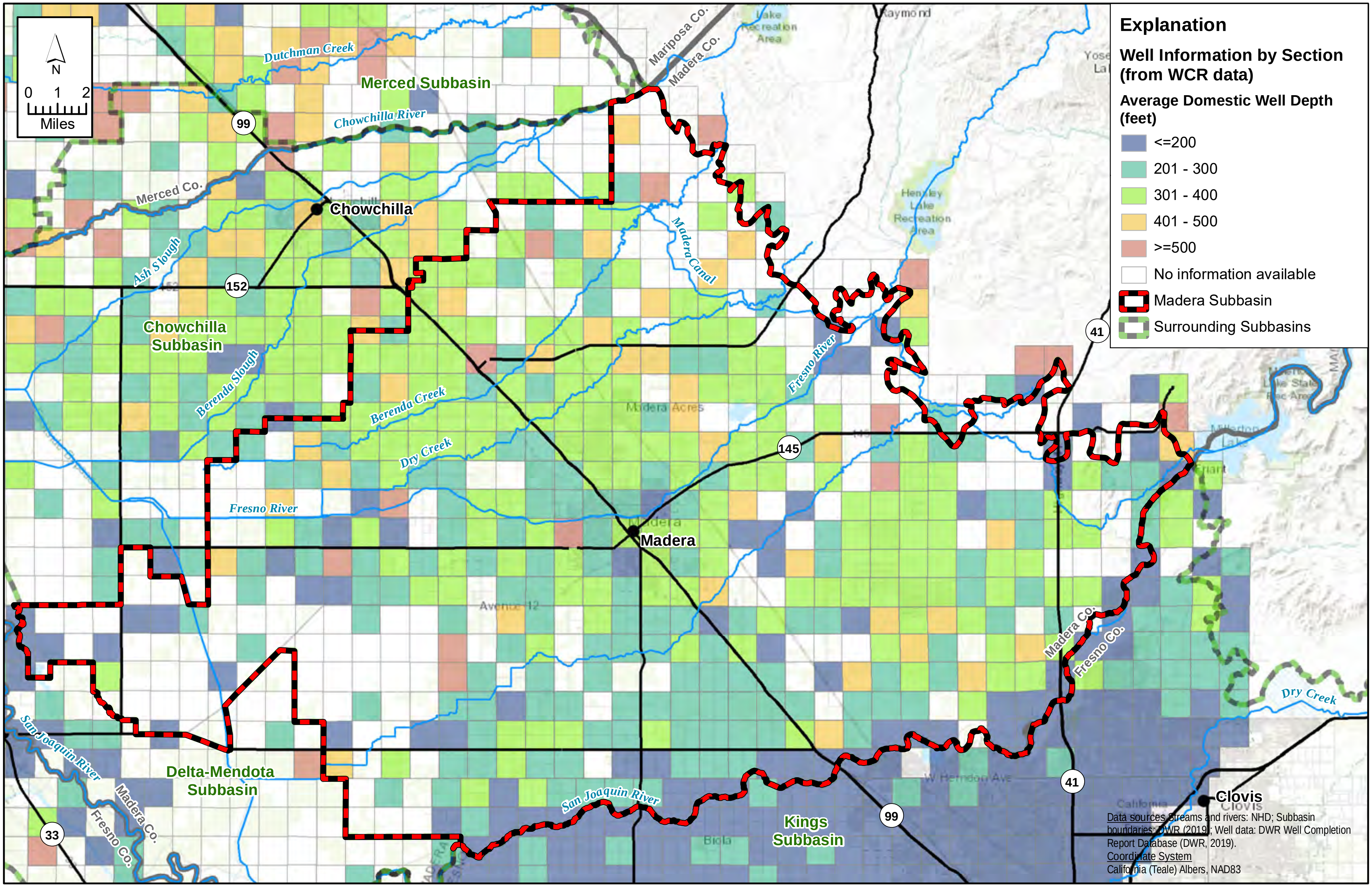
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-44

Areas of Higher Recharge Potential

Madera Subbasin
Groundwater Sustainability Plan



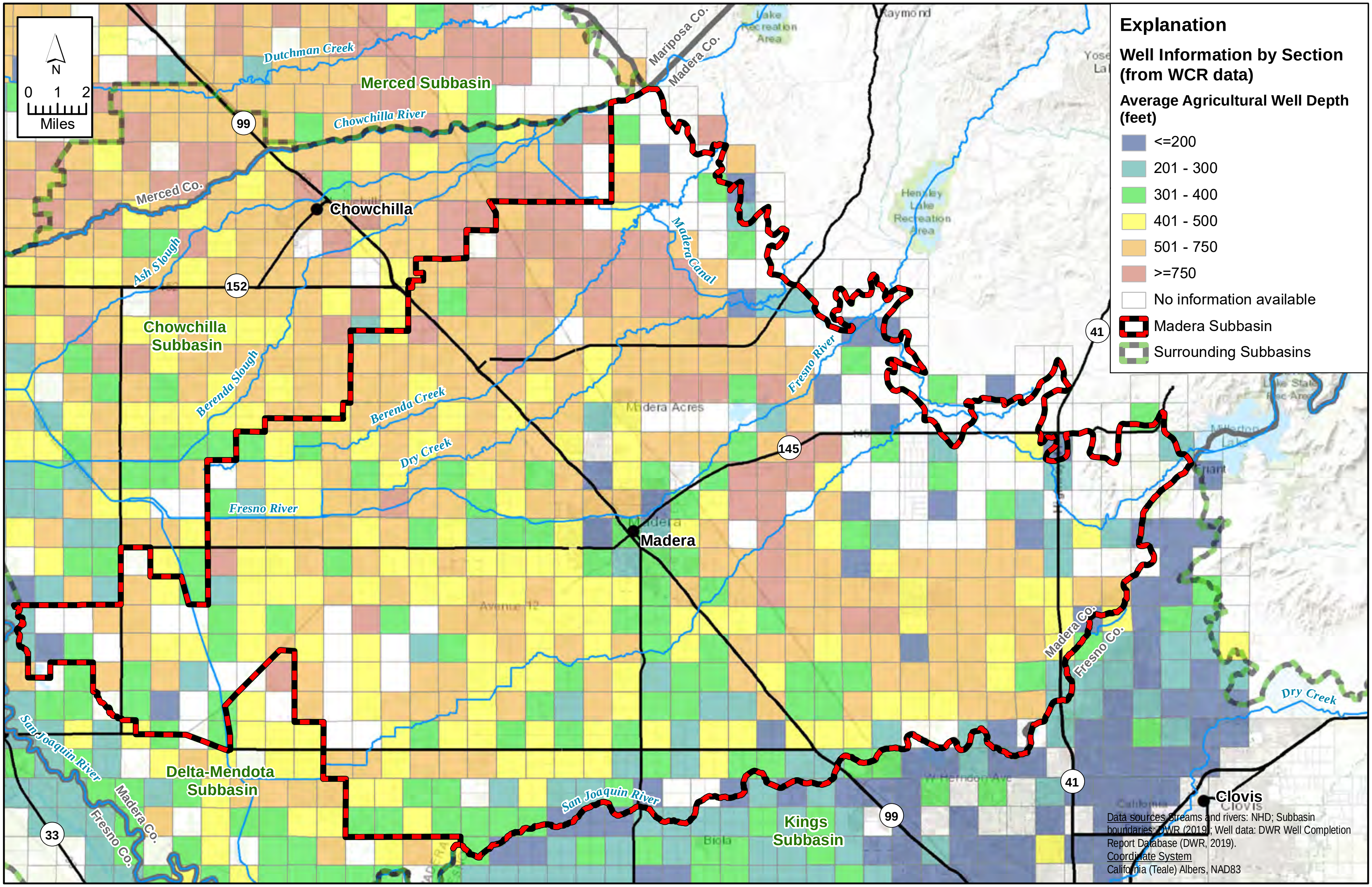
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-44 Madera Subbasin Wells By Section Dom Well Depth.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-45
Map of Well Information by Section: Average Domestic Well Depth (from WCR data)

Madera Subbasin
Groundwater Sustainability Plan



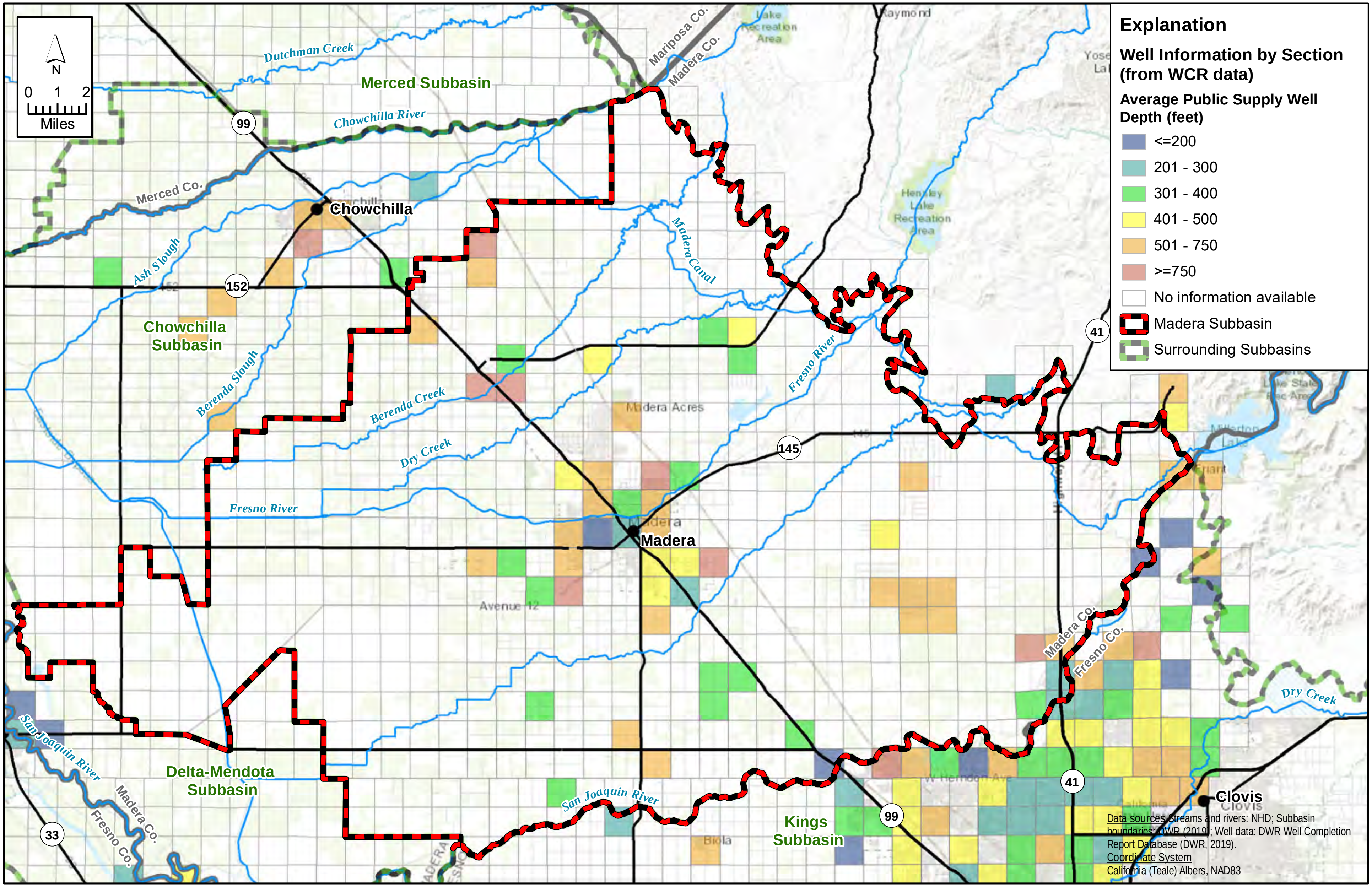
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-45 Madera Subbasin Wells By Section Ag Well Depth.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-46
Map of Well Information by Section: Average Agricultural Well Depth (from WCR data)

Madera Subbasin
Groundwater Sustainability Plan



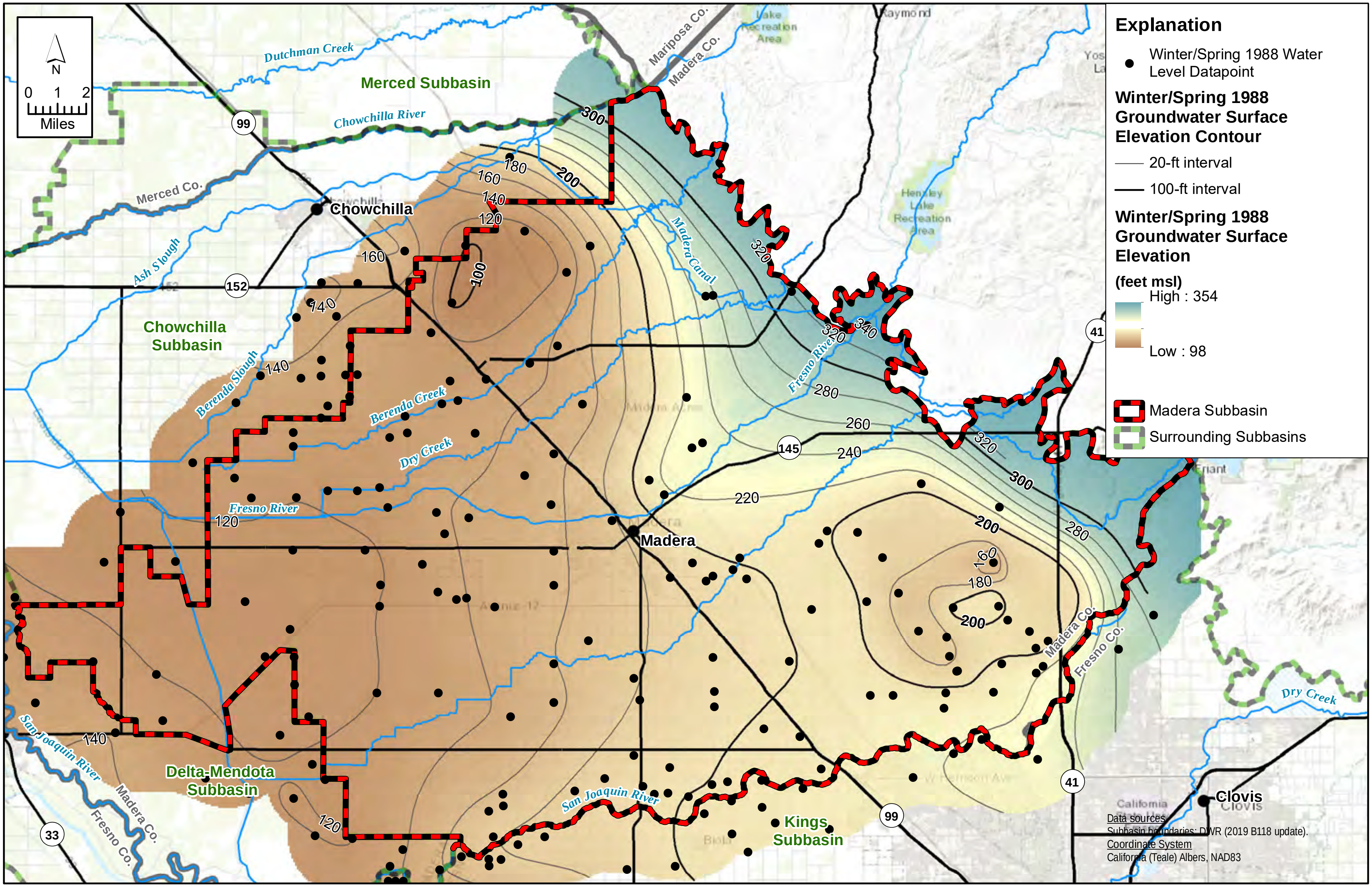
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-46 Madera Subbasin Wells By Section PWS Well Depth.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-47
Map of Well Information by Section: Average Public Supply Well Depth (from WCR data)

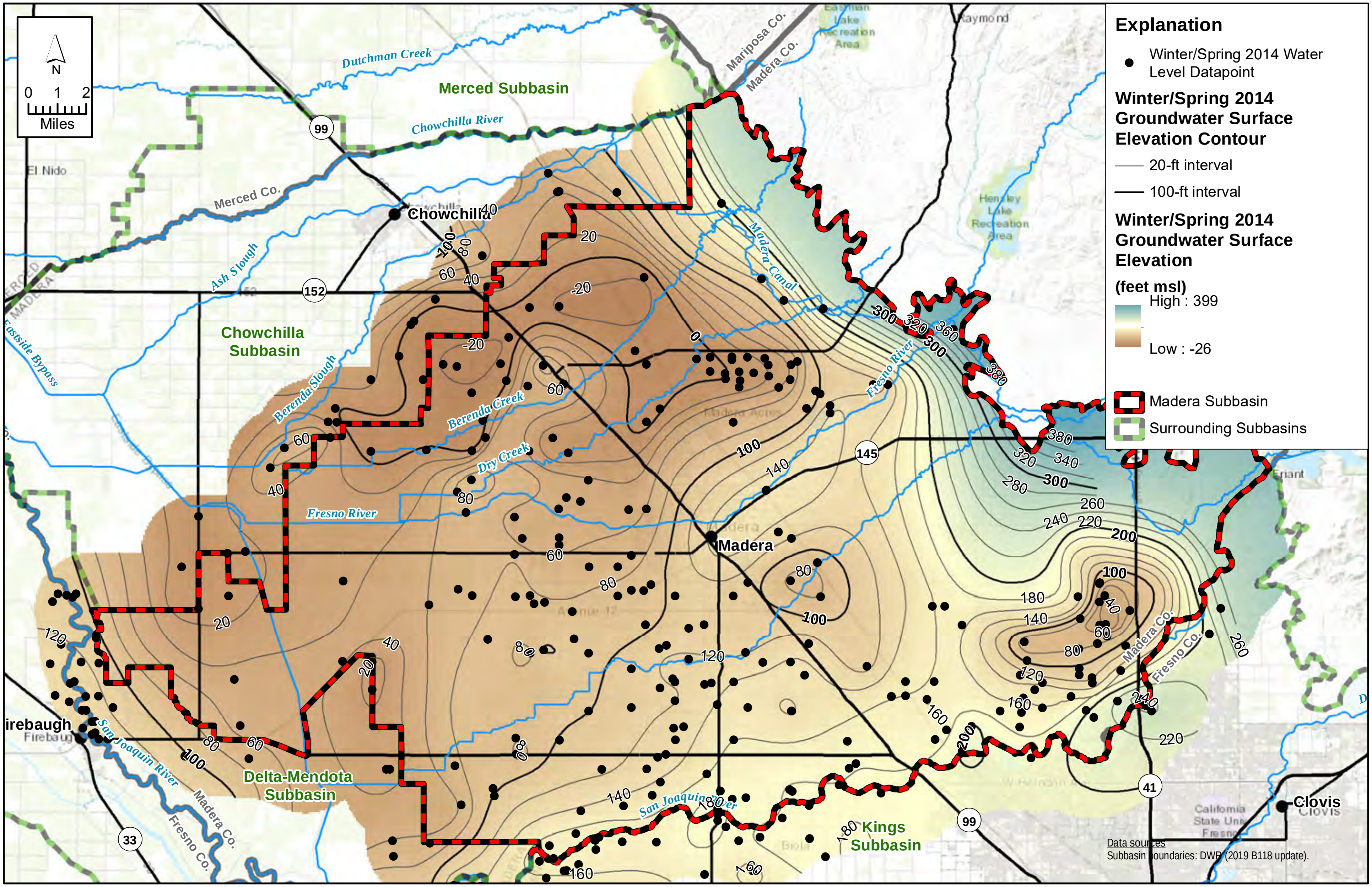
Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-47 Madera Subbasin SpW1988 GWEL Contours_Unconfined.mxd

FIGURE 2-48
Groundwater Surface Elevation Map: Winter/Spring 1988 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



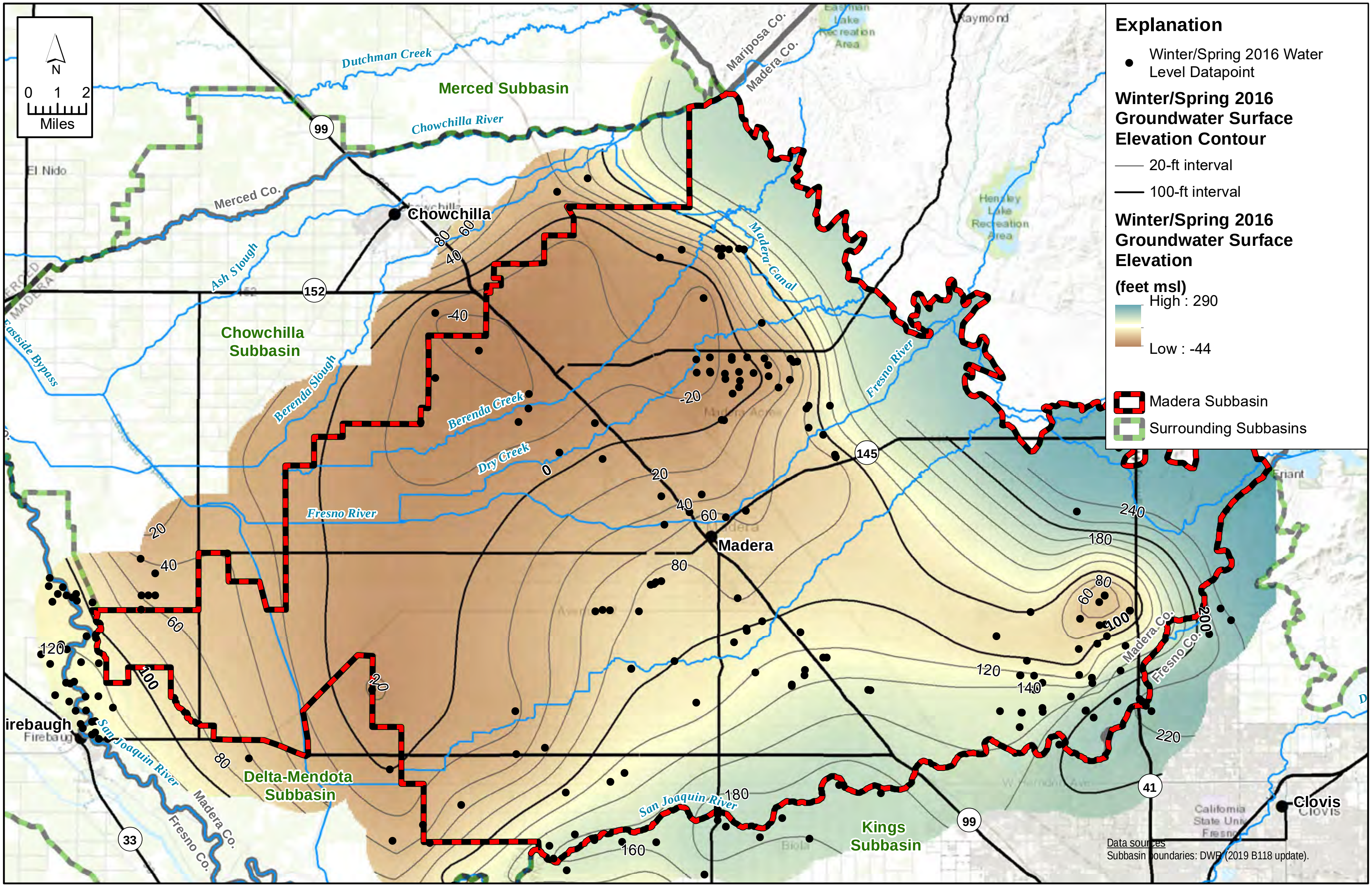
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-X Madera Subbasin SpW2014 GWEL Contours_Unconfined.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-49
Groundwater Surface Elevation Map: Winter/Spring 2014 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



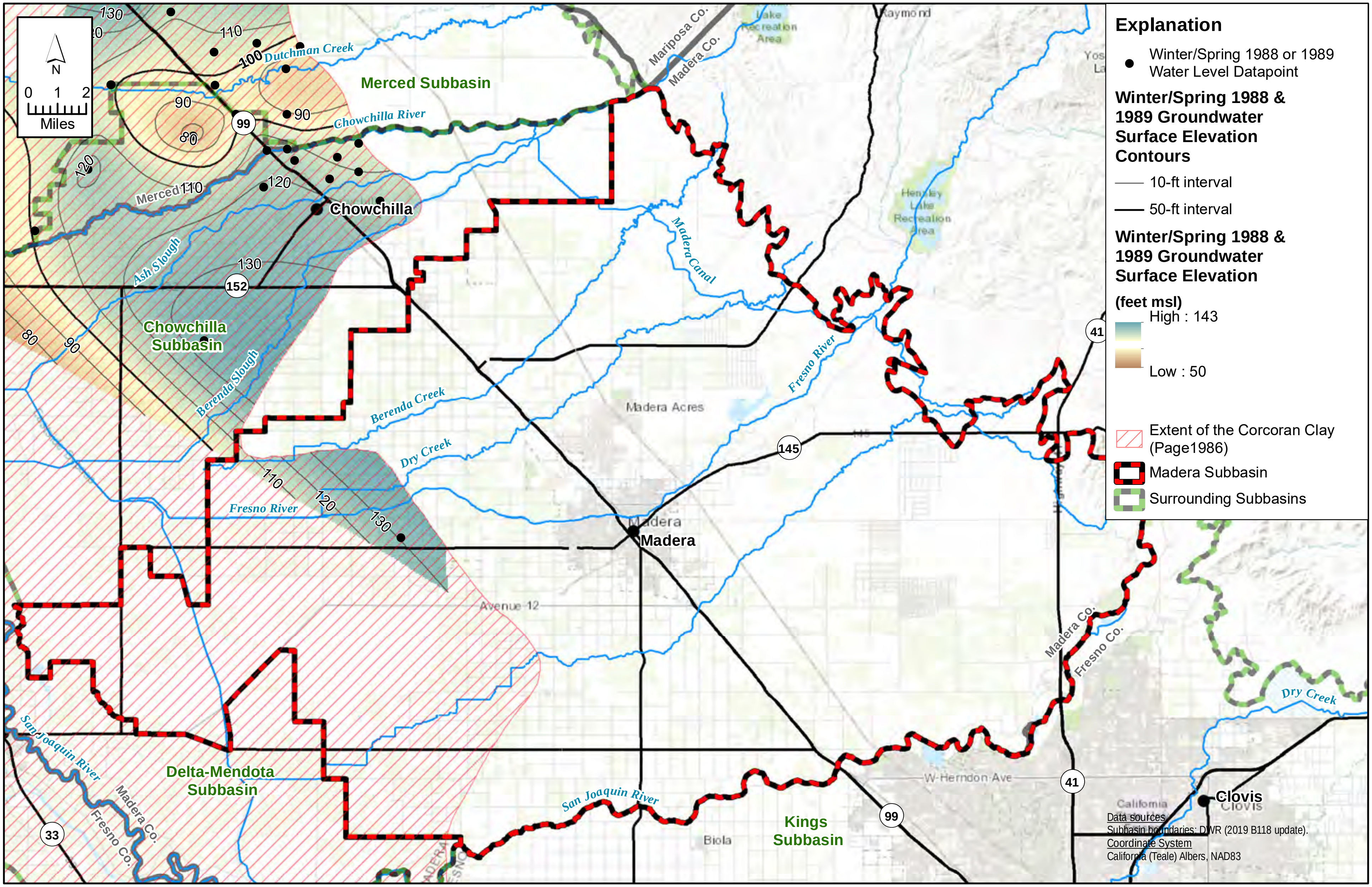
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-X Madera Subbasin SpW2016 GWEL Contours_Unconfined.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-50
Groundwater Surface Elevation Map: Winter/Spring 2016 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



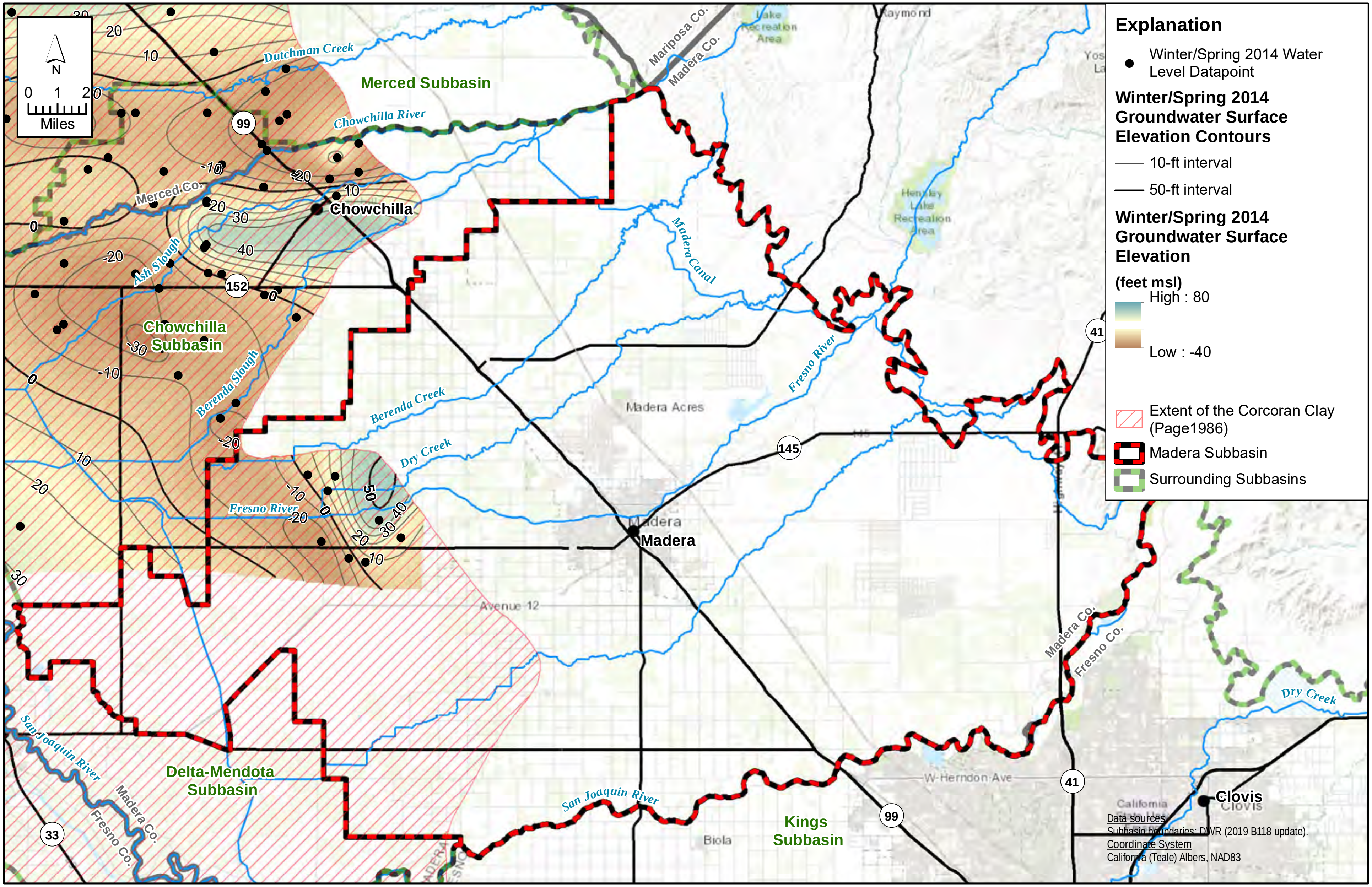
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-50 Madera Subbasin SpW1988 GWEL Contours_Lower.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-51
Groundwater Surface Elevation Map: Winter/Spring 1988 and 1989 - Lower Aquifer within Corcoran Clay

Madera Subbasin Groundwater Sustainability Plan



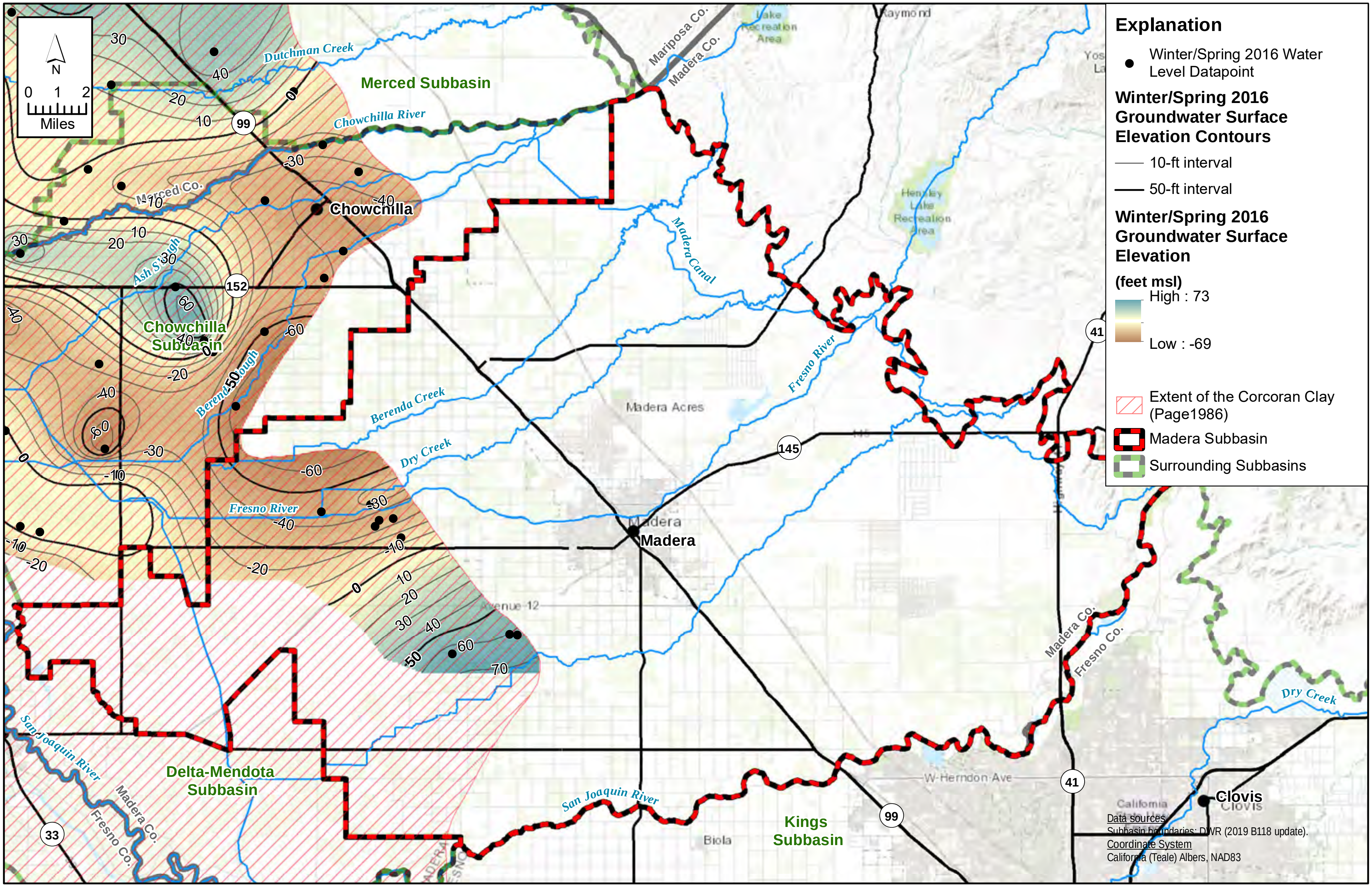
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-51 Madera Subbasin SpW2014 GWEL Contours_Lower.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-52
Groundwater Surface Elevation Map: Winter/Spring 2014 - Lower Aquifer within Corcoran Clay

Madera Subbasin
Groundwater Sustainability Plan



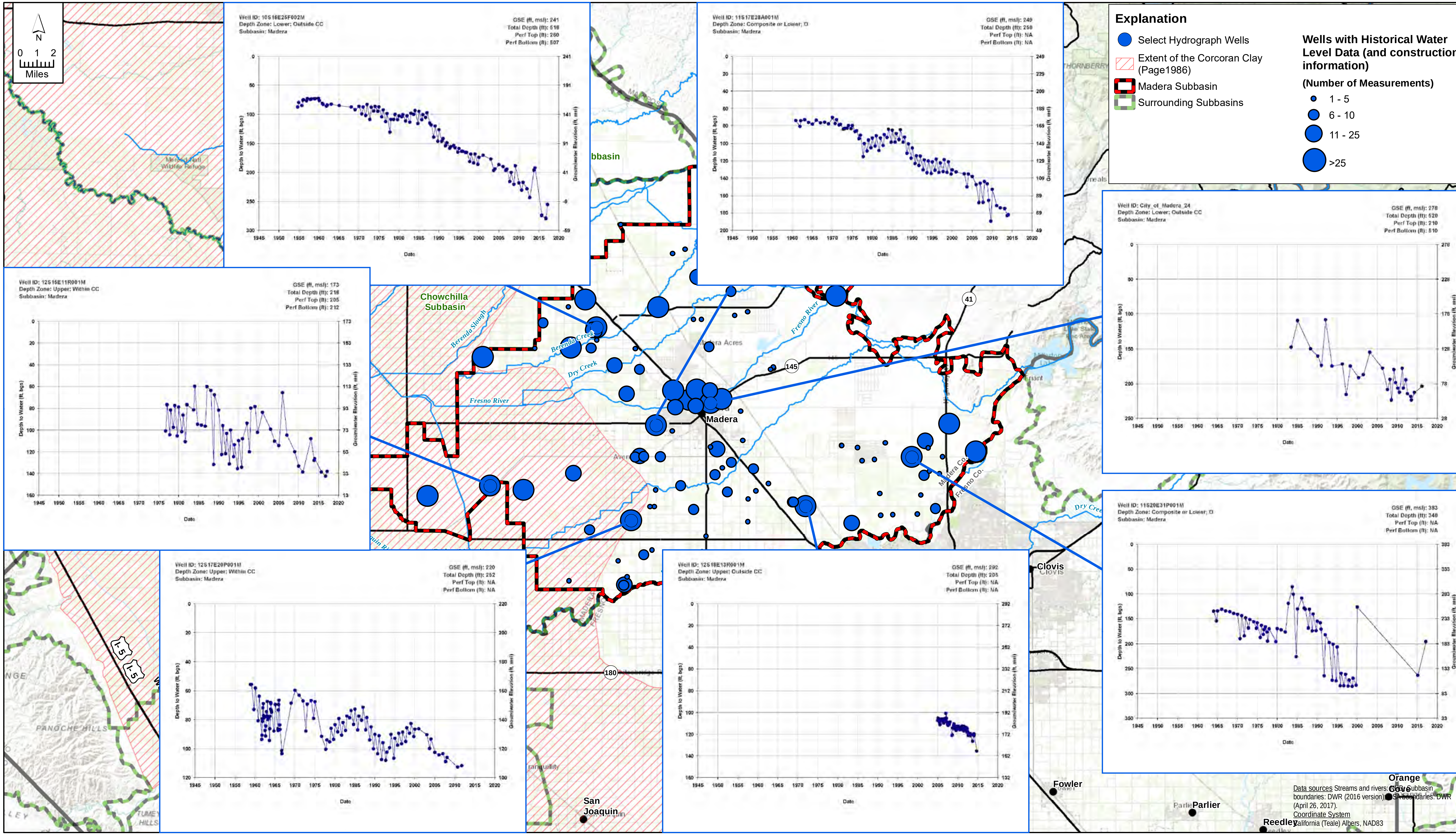
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-52 Madera Subbasin SpW2016 GWEL Contours_Lower.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-53
Groundwater Surface Elevation Map: Winter/Spring 2016 - Lower Aquifer within Corcoran Clay

Madera Subbasin
Groundwater Sustainability Plan

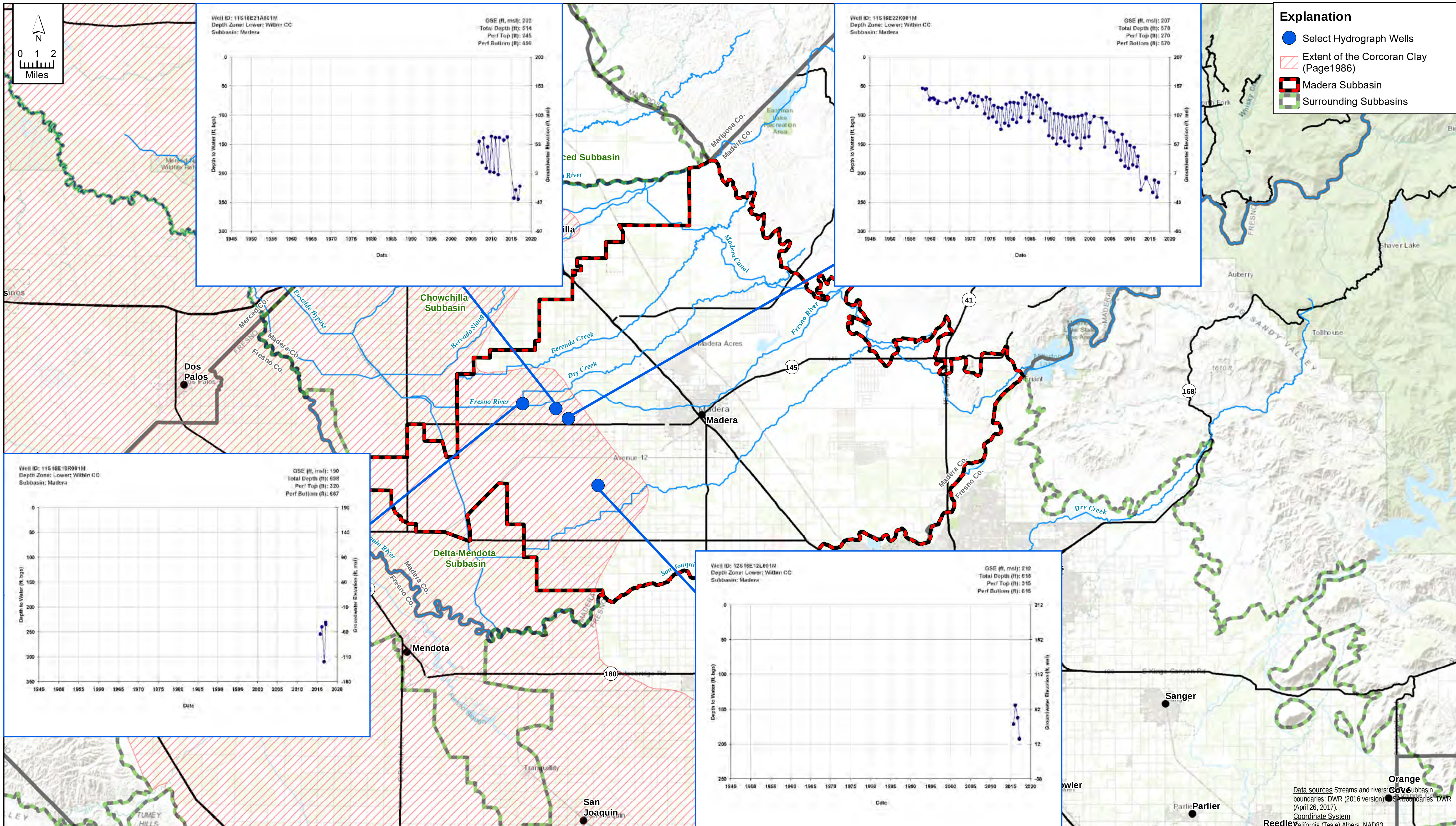


X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-53 Madera Subbasin GW Level Hydrographs_Upper.mxd

DAVIDS ENGINEERING, INC — Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-54
Select Groundwater Level Hydrographs: Outside the Corcoran Clay or Upper Aquifer within the Corcoran Clay

Madera Subbasin Groundwater Sustainability Plan



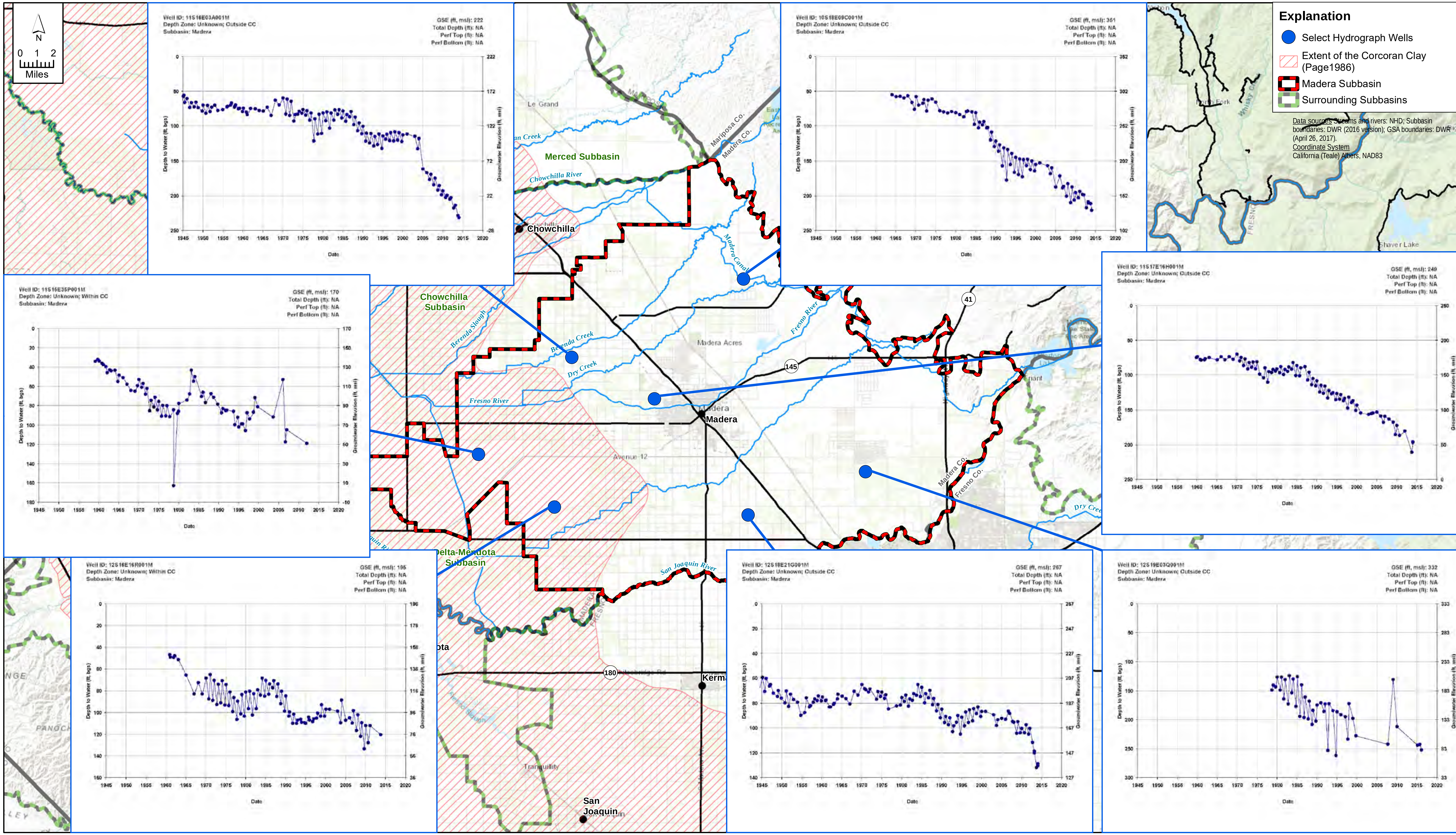
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-54 Madera Subbasin GW Level Hydrographs_Lower.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-55
Select Groundwater Level Hydrographs: Lower Aquifer within the Corcoran Clay

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-55 Madera Subbasin GW Level Hydrographs_Unknown.mxd

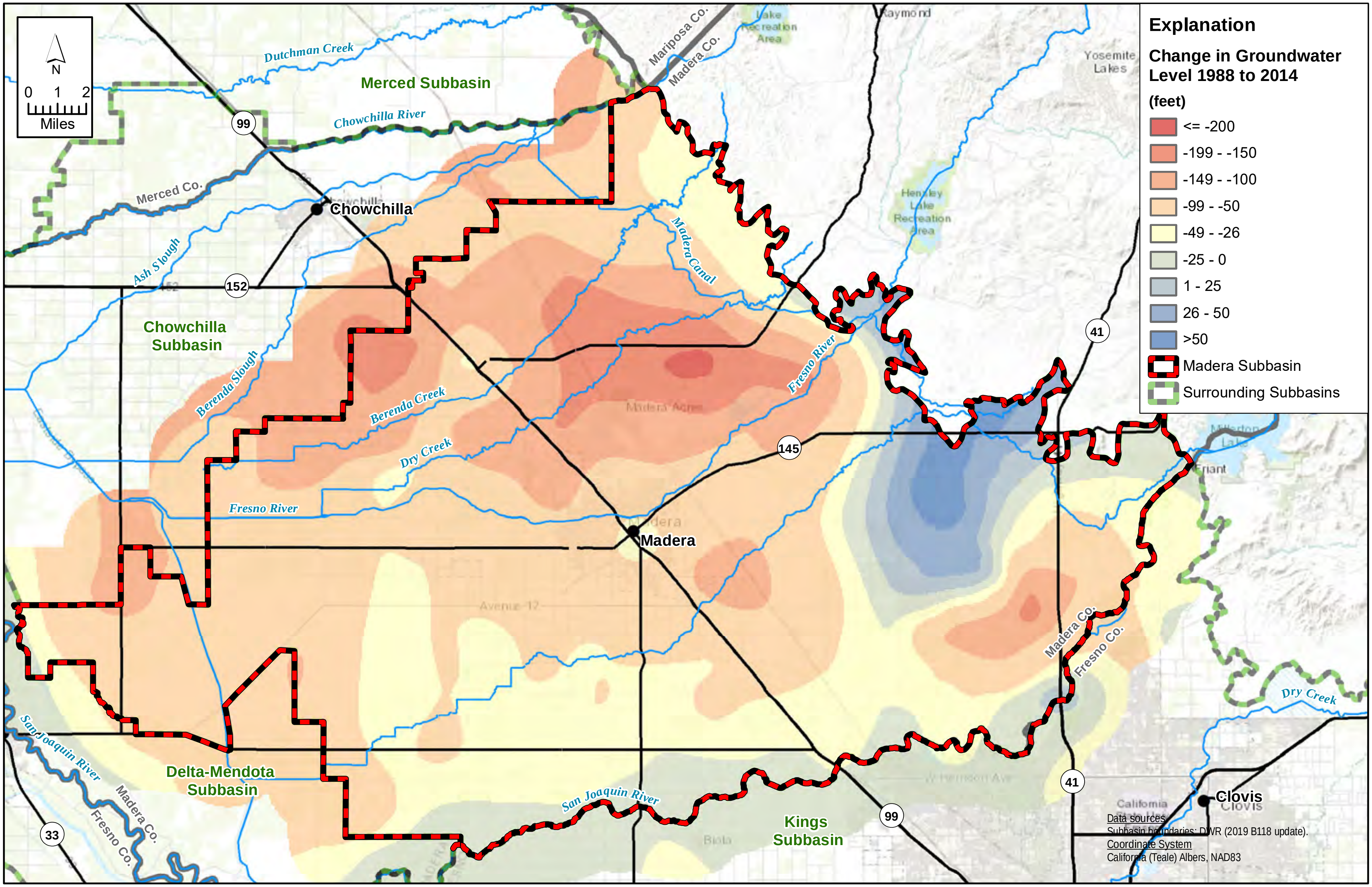
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-56

Select Groundwater Level Hydrographs: Wells of Unknown Construction

Madera Subbasin Groundwater Sustainability Plan



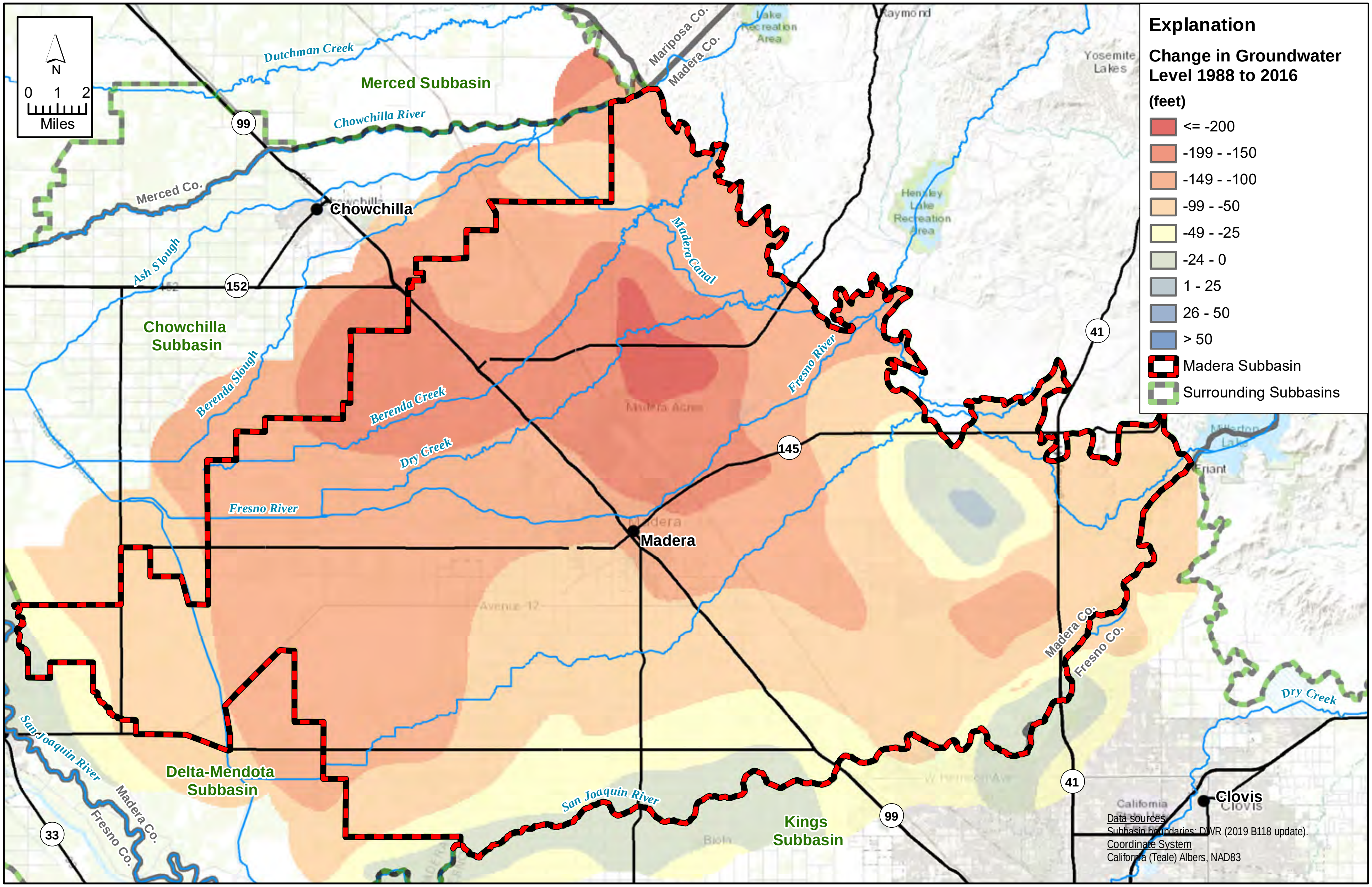
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-56 Madera Subbasin SpW1988 to 2014 GWEL Change_Unconfined.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-57
Groundwater Level Change Map: Winter/Spring 1988 to 2014 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



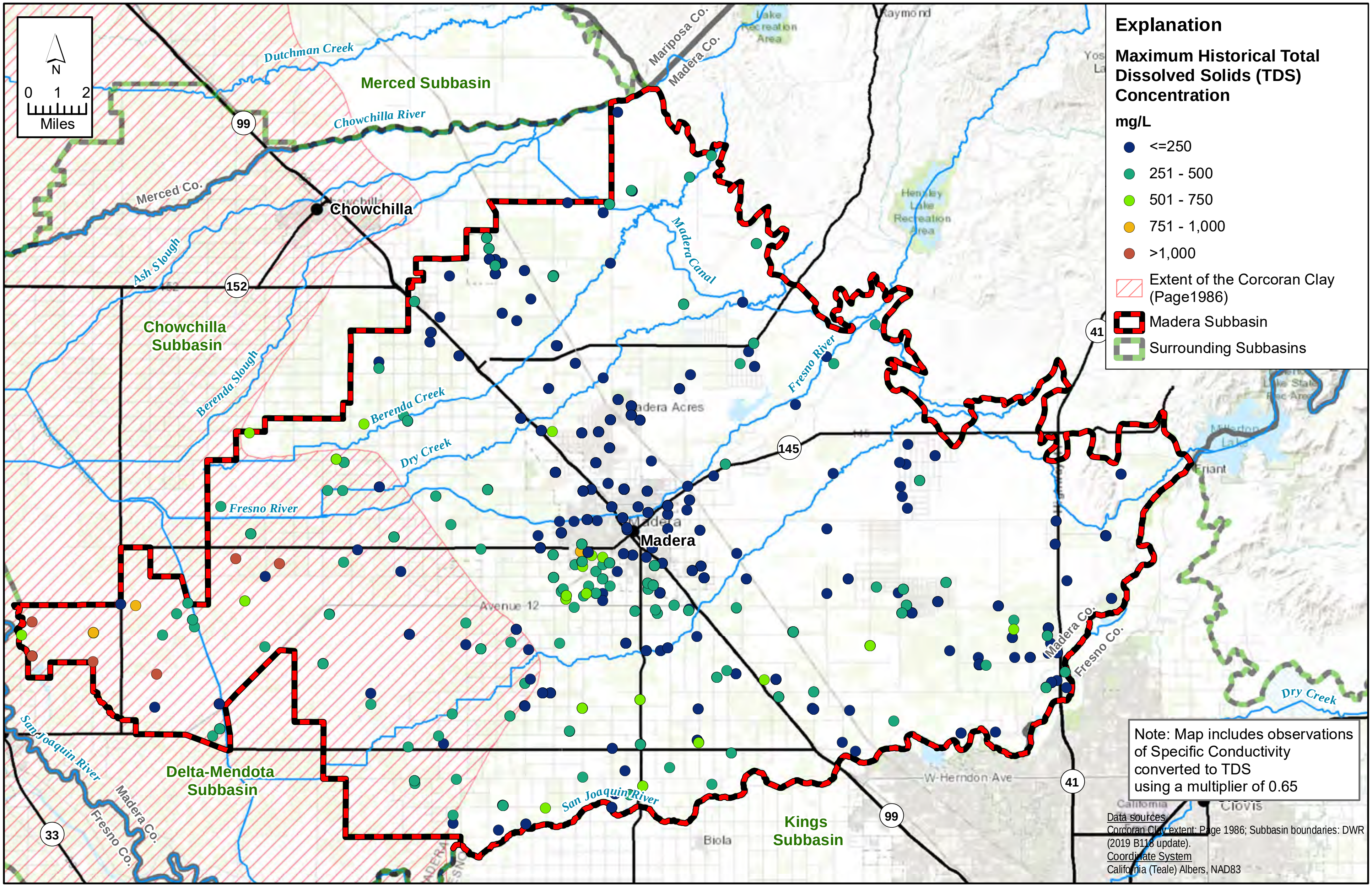
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-57 Madera Subbasin SpW1988 to 2016 GWEL Change_Unconfined.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-58
Groundwater Level Change Map:
Winter/Spring 1988 to 2016 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



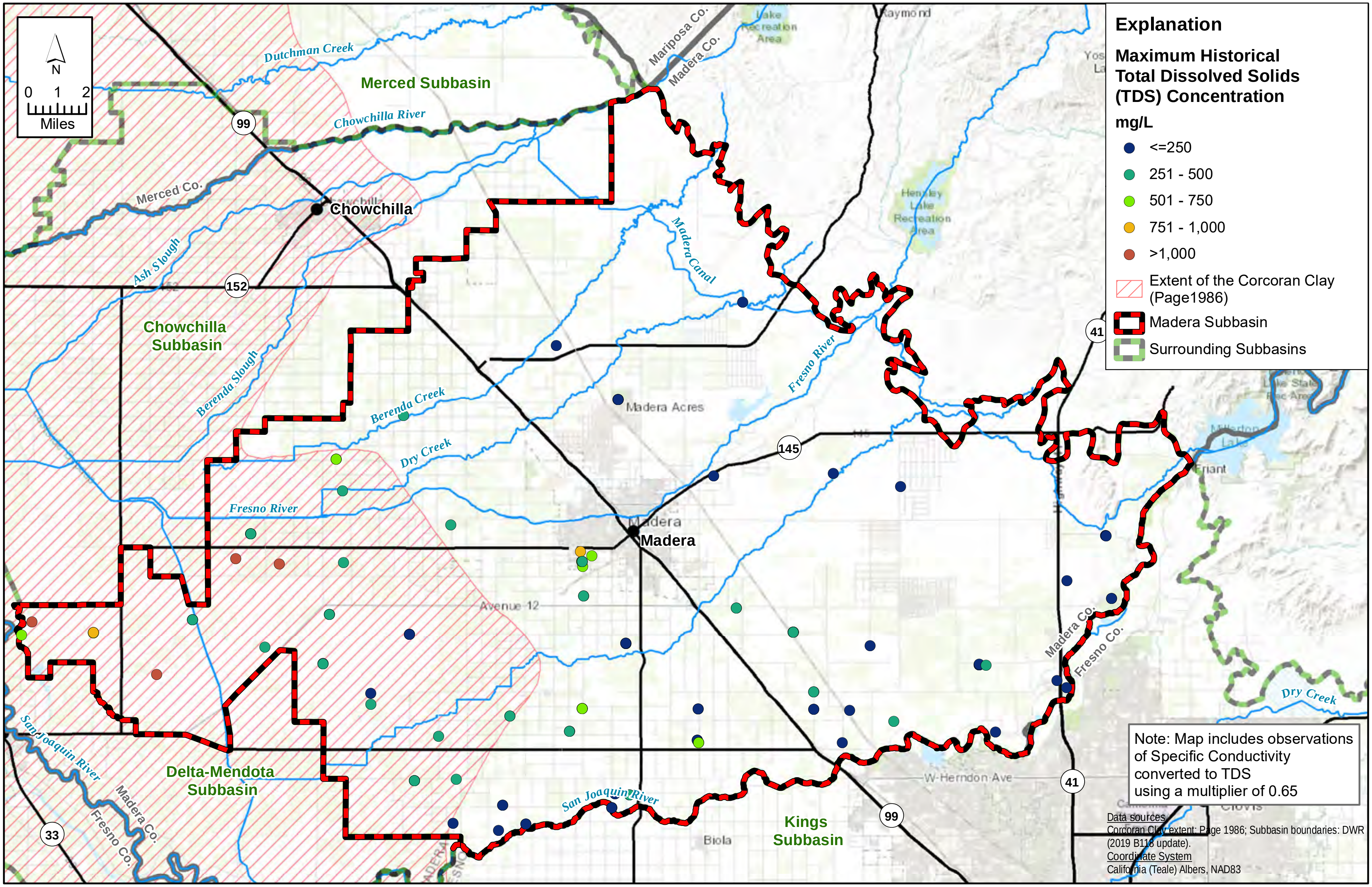
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-58 Madera Subbasin GW Quality Map TDS All Wells_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-59
Groundwater Quality Map: Total Dissolved Solids Concentrations in All Wells

Madera Subbasin
Groundwater Sustainability Plan



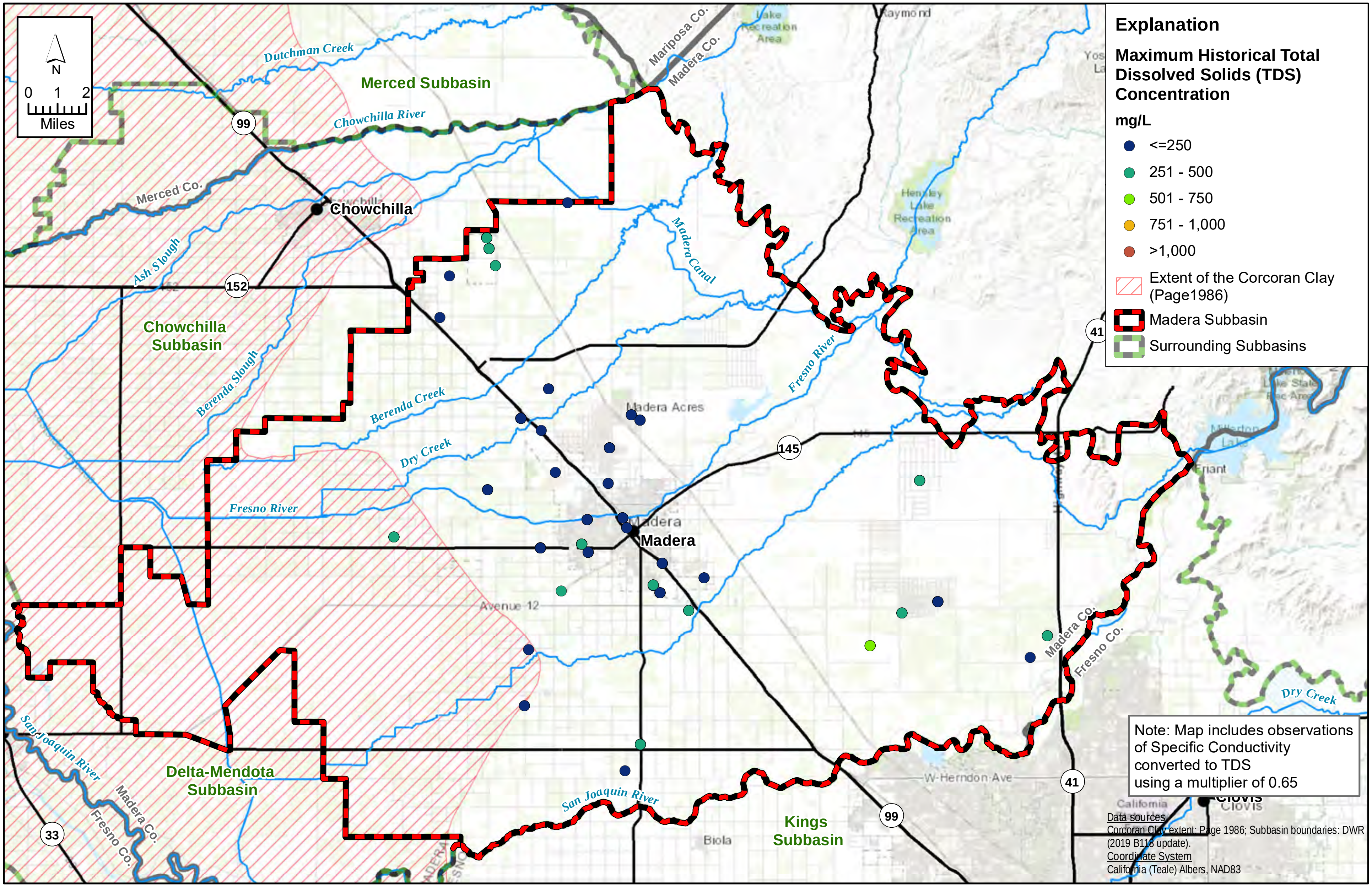
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-59 Madera Subbasin GW Quality Map TDS Upper_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-60
Groundwater Quality Map: Total Dissolved Solids Concentrations in Upper Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



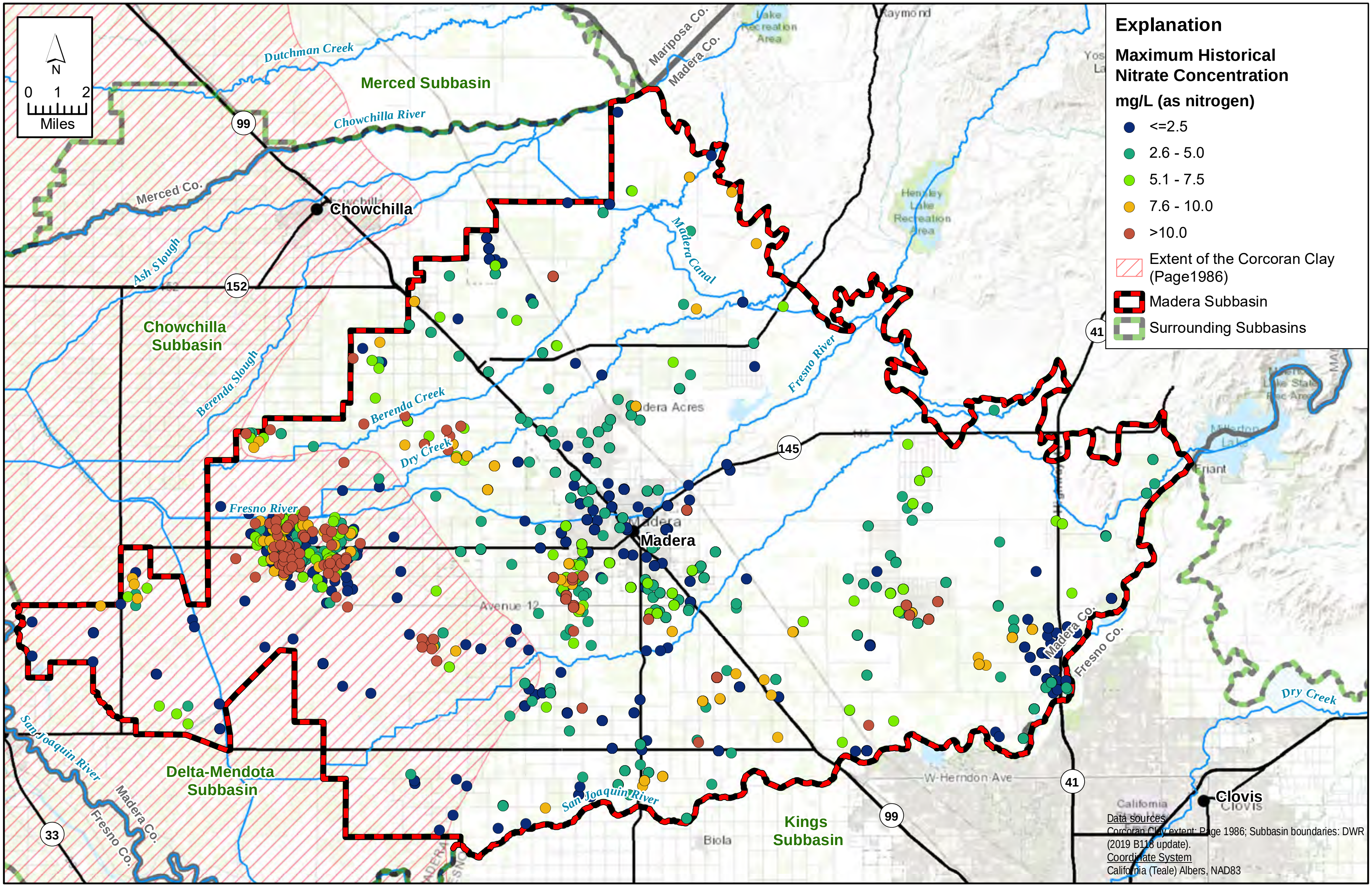
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-60 Madera Subbasin GW Quality Map TDS Lower_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-61
Groundwater Quality Map: Total Dissolved Solids Concentrations in Lower Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



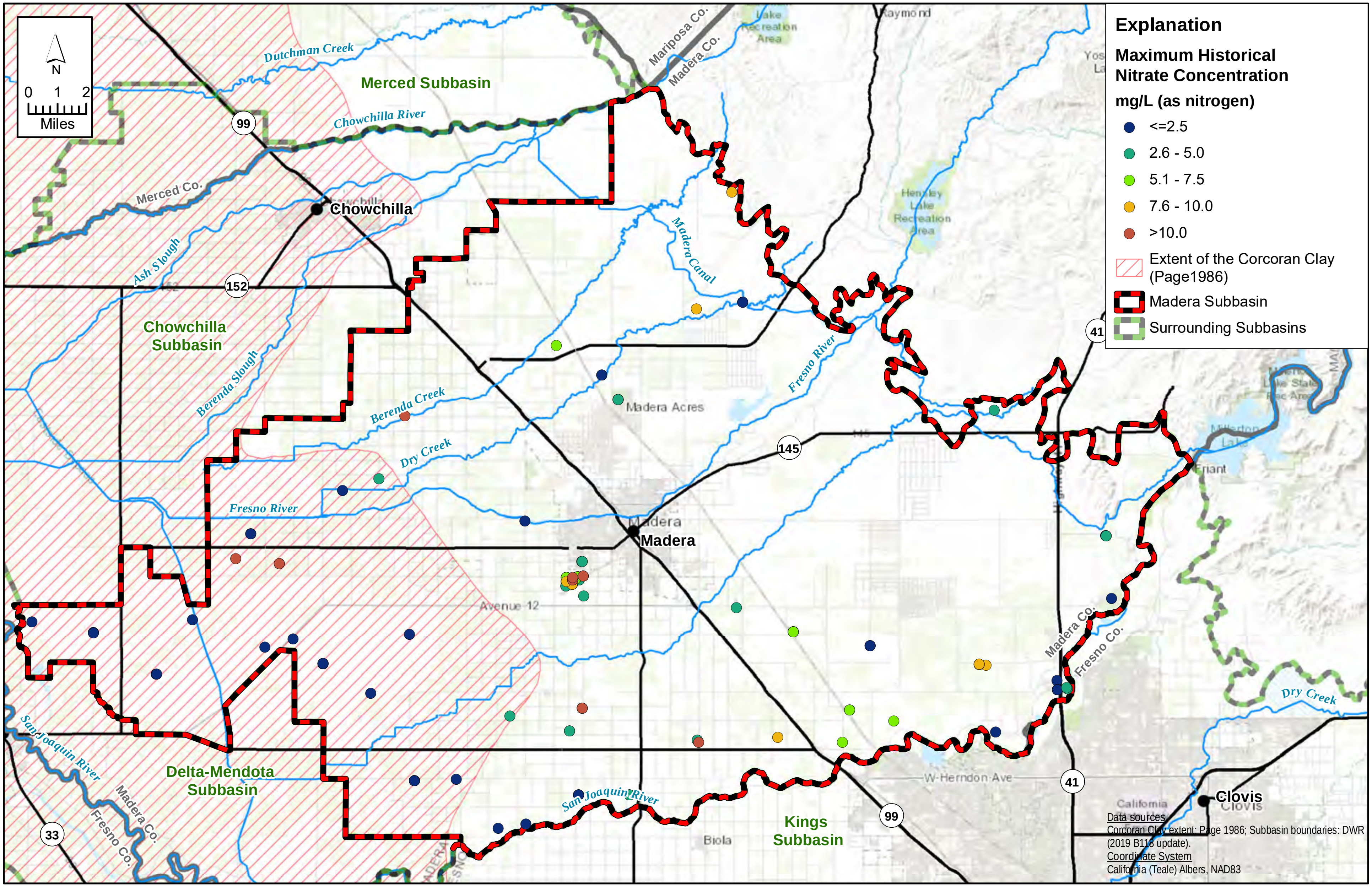
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-61 Madera Subbasin GW Quality Map Nitrate All Wells_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-62
Groundwater Quality Map: Nitrate Concentrations in All Wells

Madera Subbasin
Groundwater Sustainability Plan

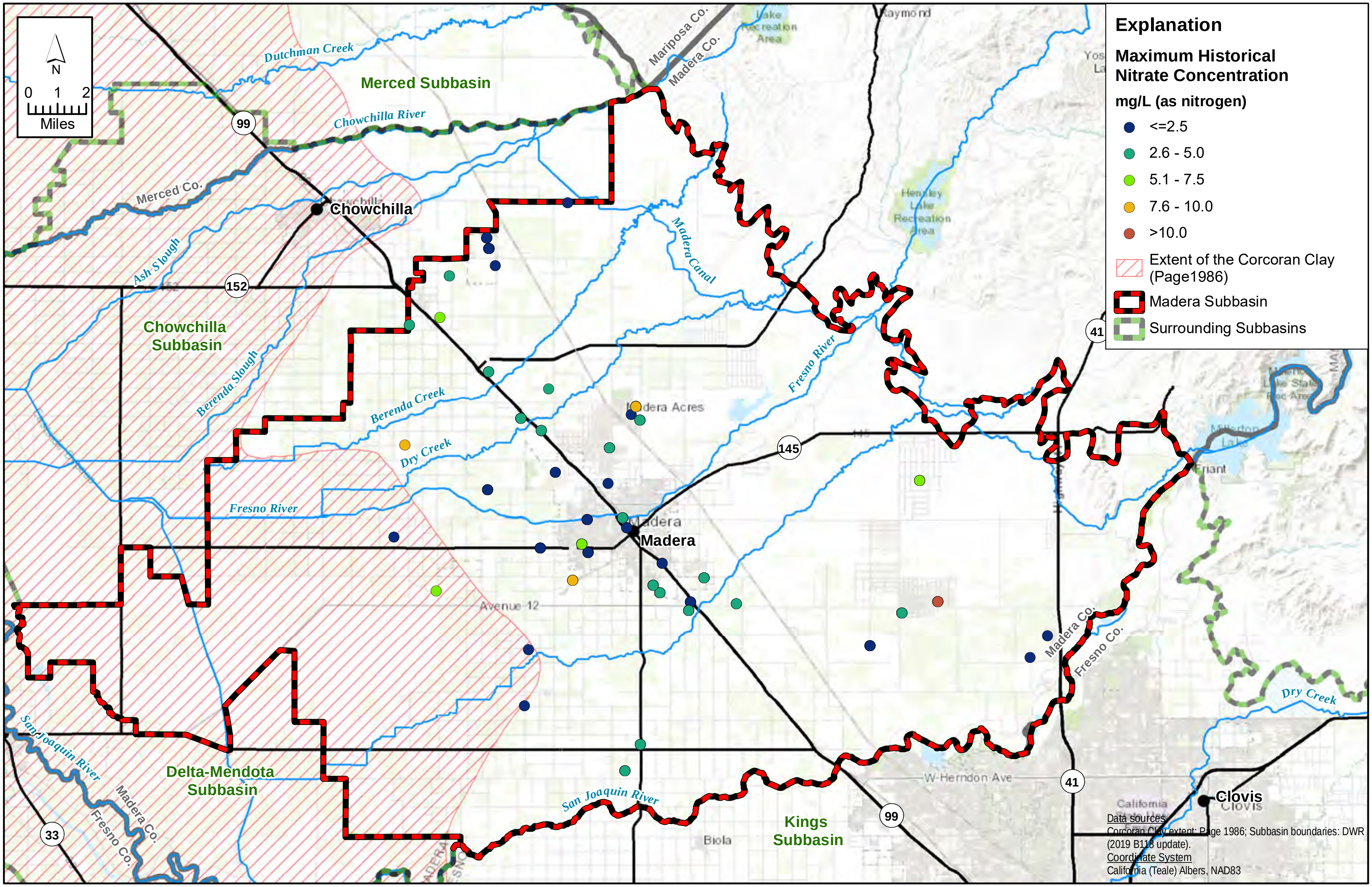


X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-62 Madera Subbasin GW Quality Map Nitrate Upper_20190708.mxd

FIGURE 2-63

Groundwater Quality Map: Nitrate Concentrations in Upper Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



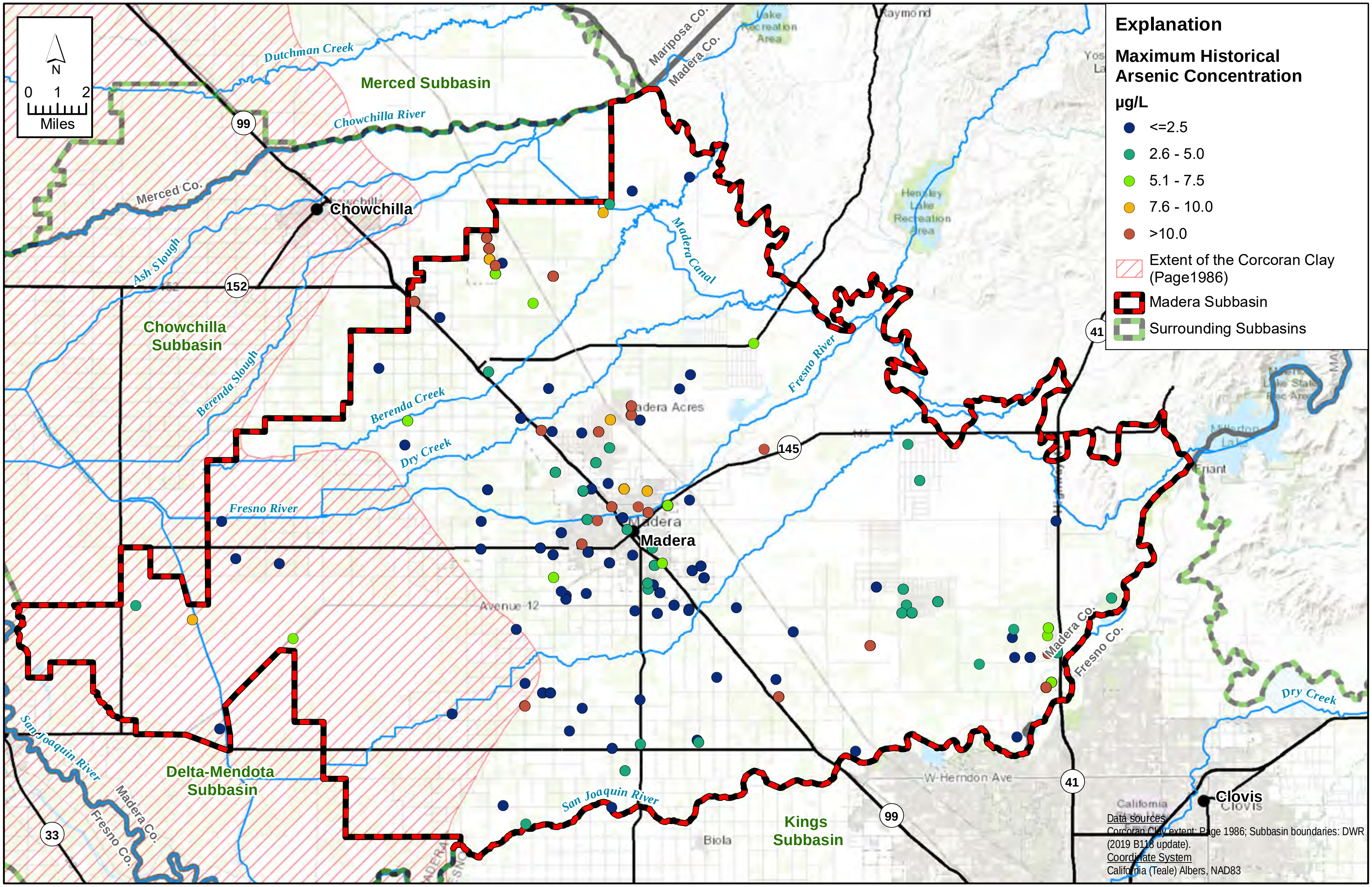
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-63 Madera Subbasin GW Quality Map Nitrate Lower_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-64
Groundwater Quality Map: Nitrate Concentrations in Lower Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



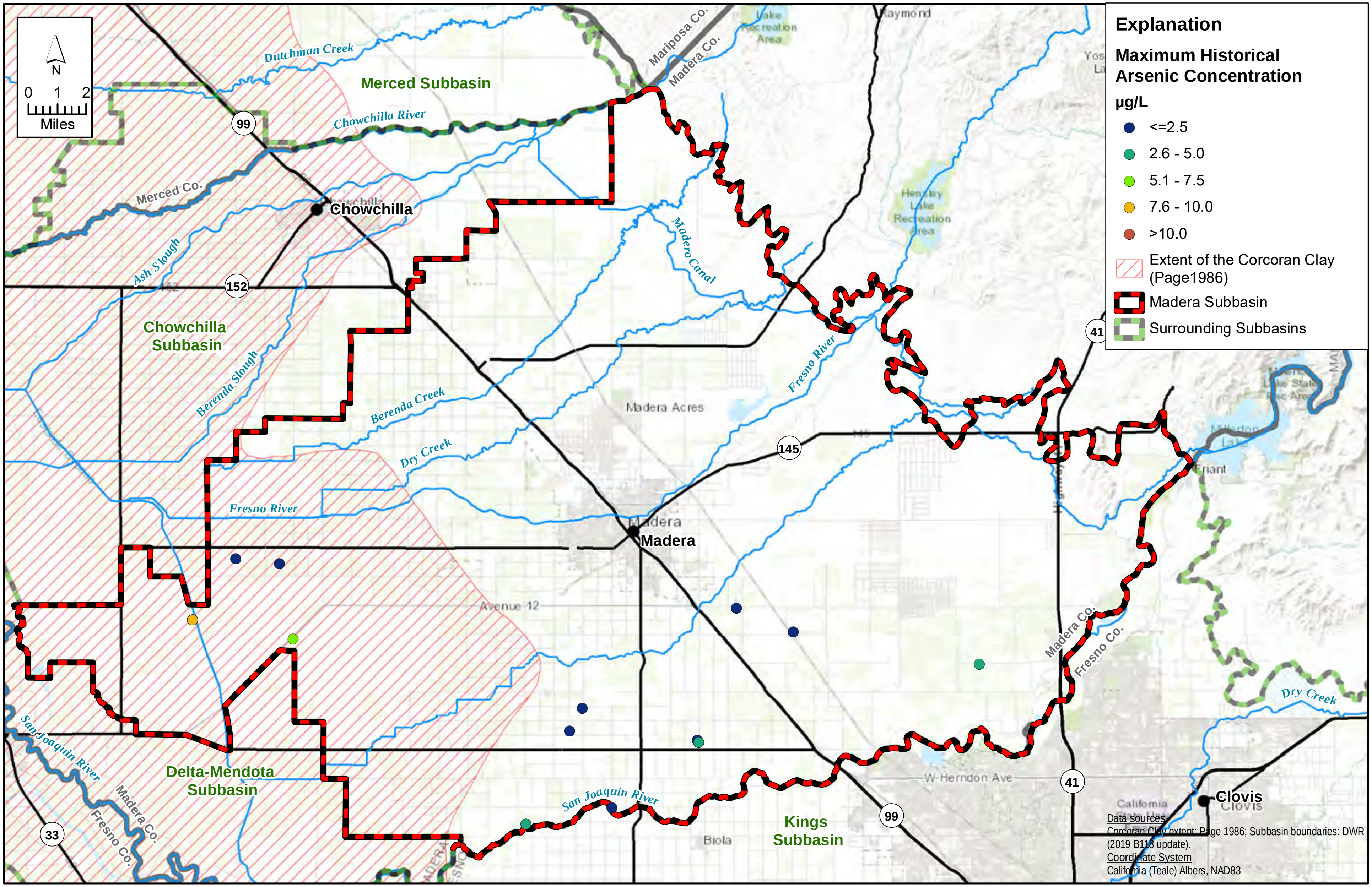
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-64 Madera Subbasin GW Quality Map Arsenic All Wells_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-65
Groundwater Quality Map: Arsenic Concentrations in All Wells

Madera Subbasin
Groundwater Sustainability Plan



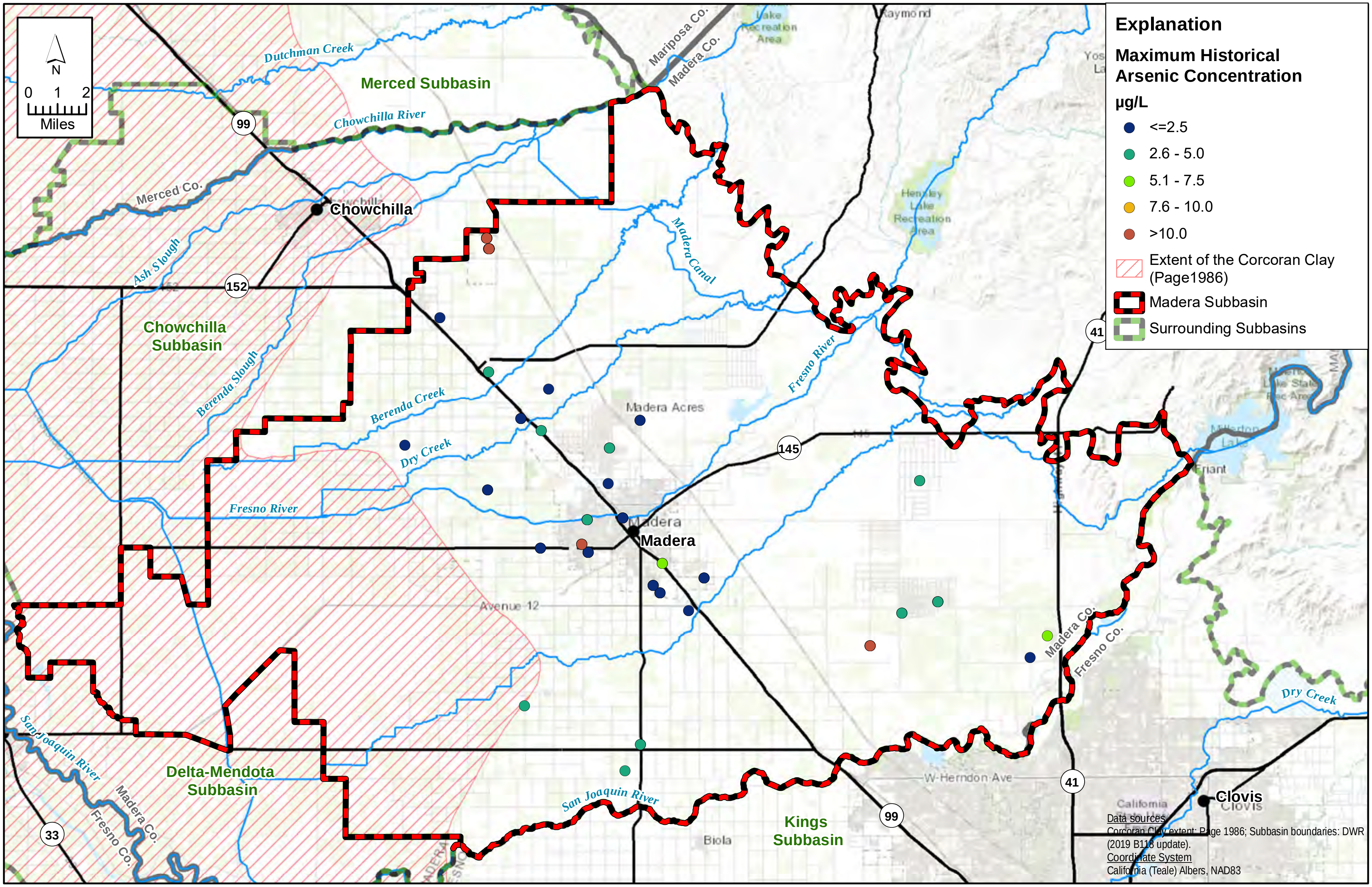
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-65 Madera Subbasin GW Quality Map Arsenic Upper_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-66
Groundwater Quality Map: Arsenic Concentrations in Upper Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



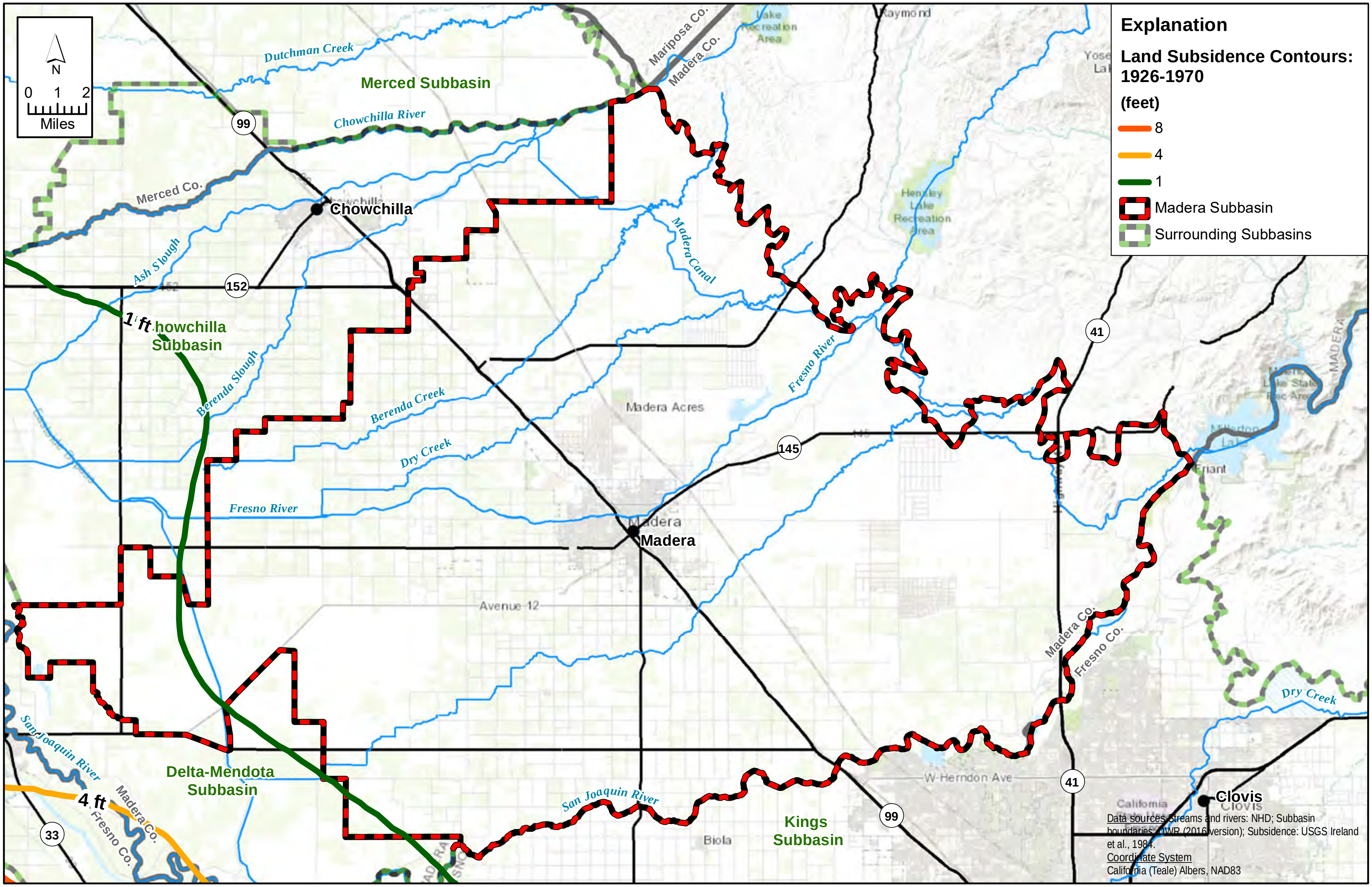
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-66 Madera Subbasin GW Quality Map Arsenic Lower_20190708.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-67
Groundwater Quality Map: Arsenic Concentrations in Lower Aquifer Wells

Madera Subbasin
Groundwater Sustainability Plan



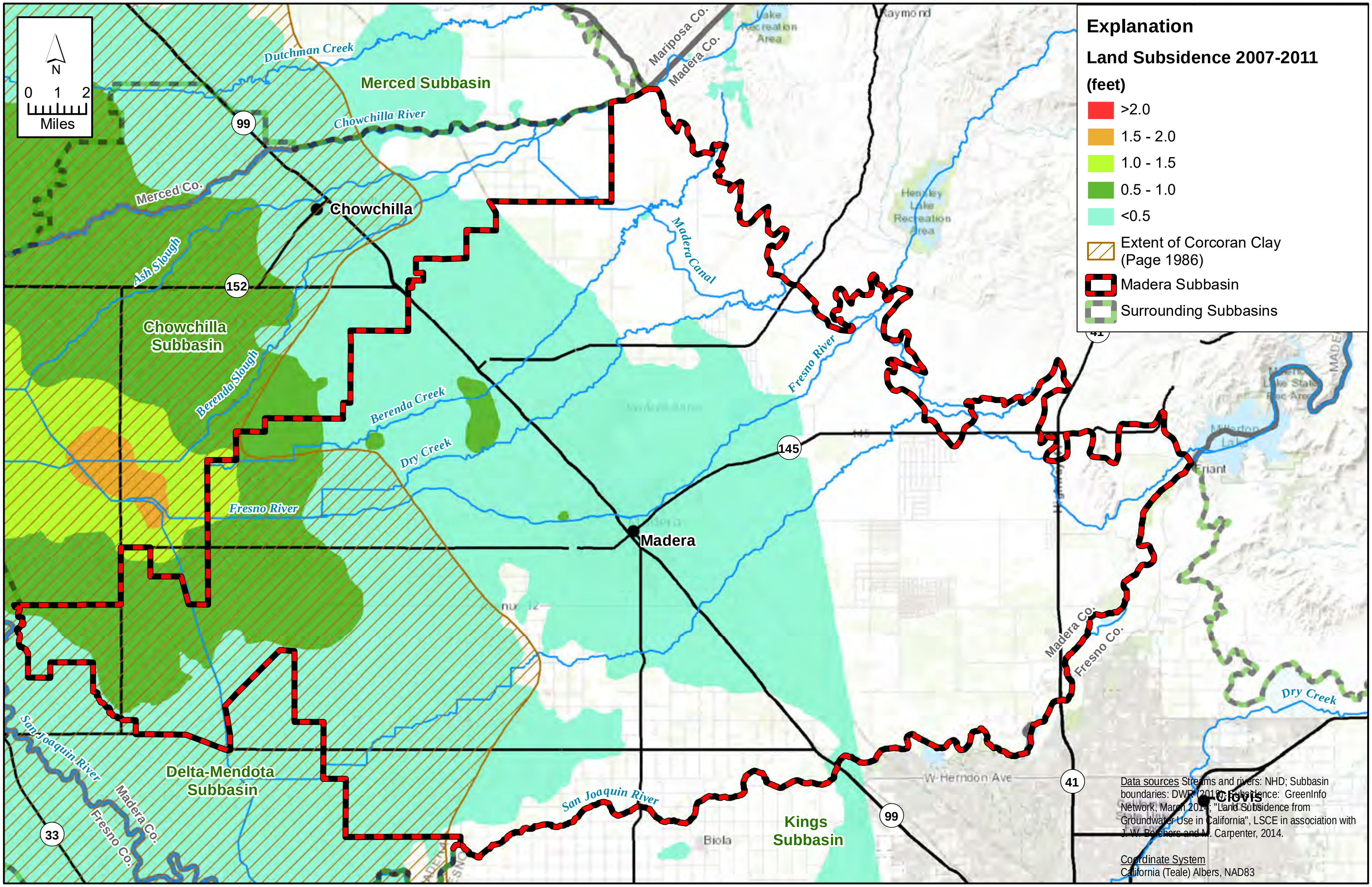
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-67 Madera Subbasin Land Subsidence 1926-1970.mxd

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-68

Map of Historical Land Subsidence Contours: 1926-1970

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-68 Madera Subbasin Land Subsidence 2007-2011.mxd

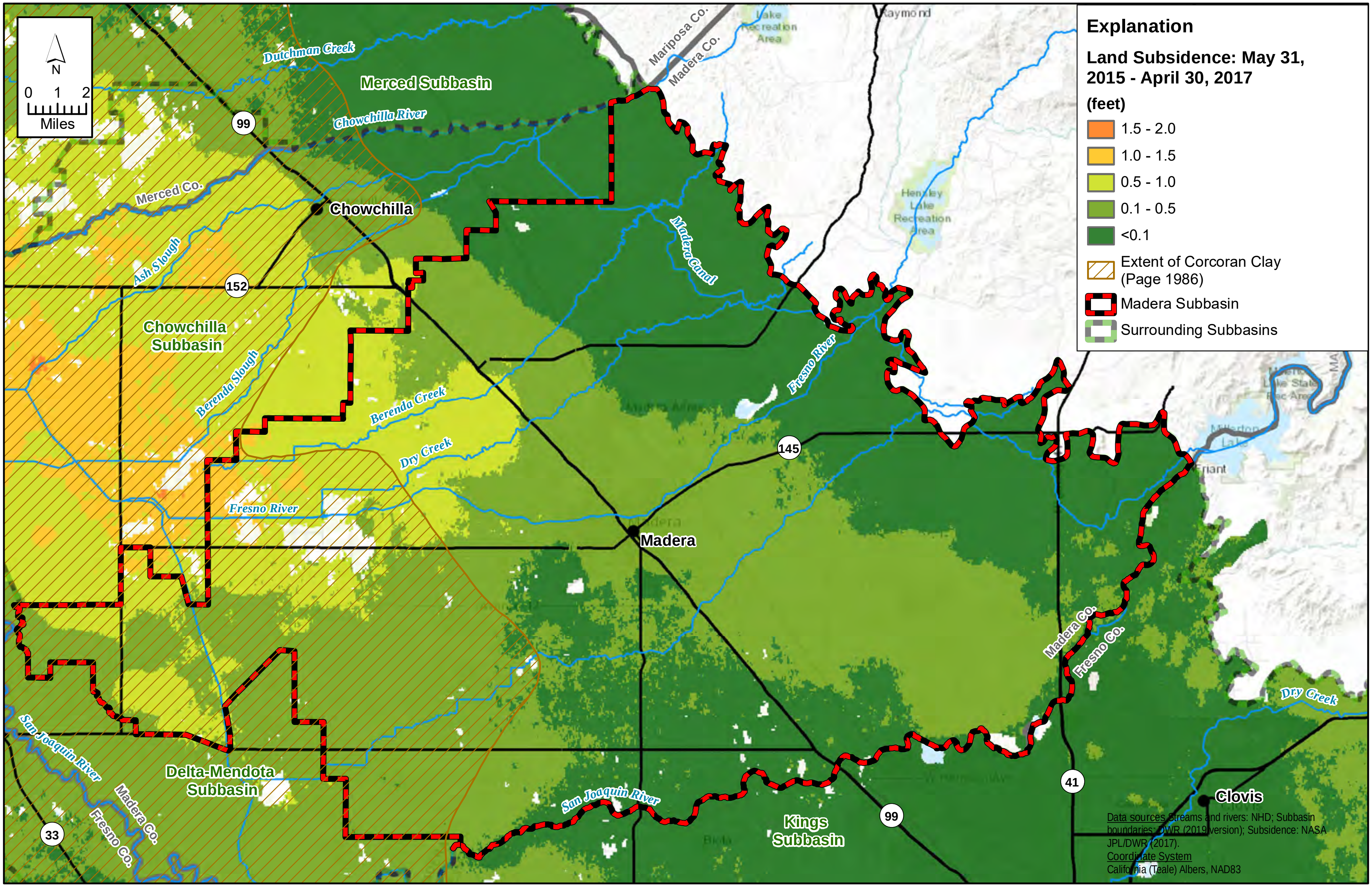
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-69

Map of Historical Land Subsidence: 2007-2011

Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-69 Madera Subbasin Land Subsidence 2015-2017.mxd

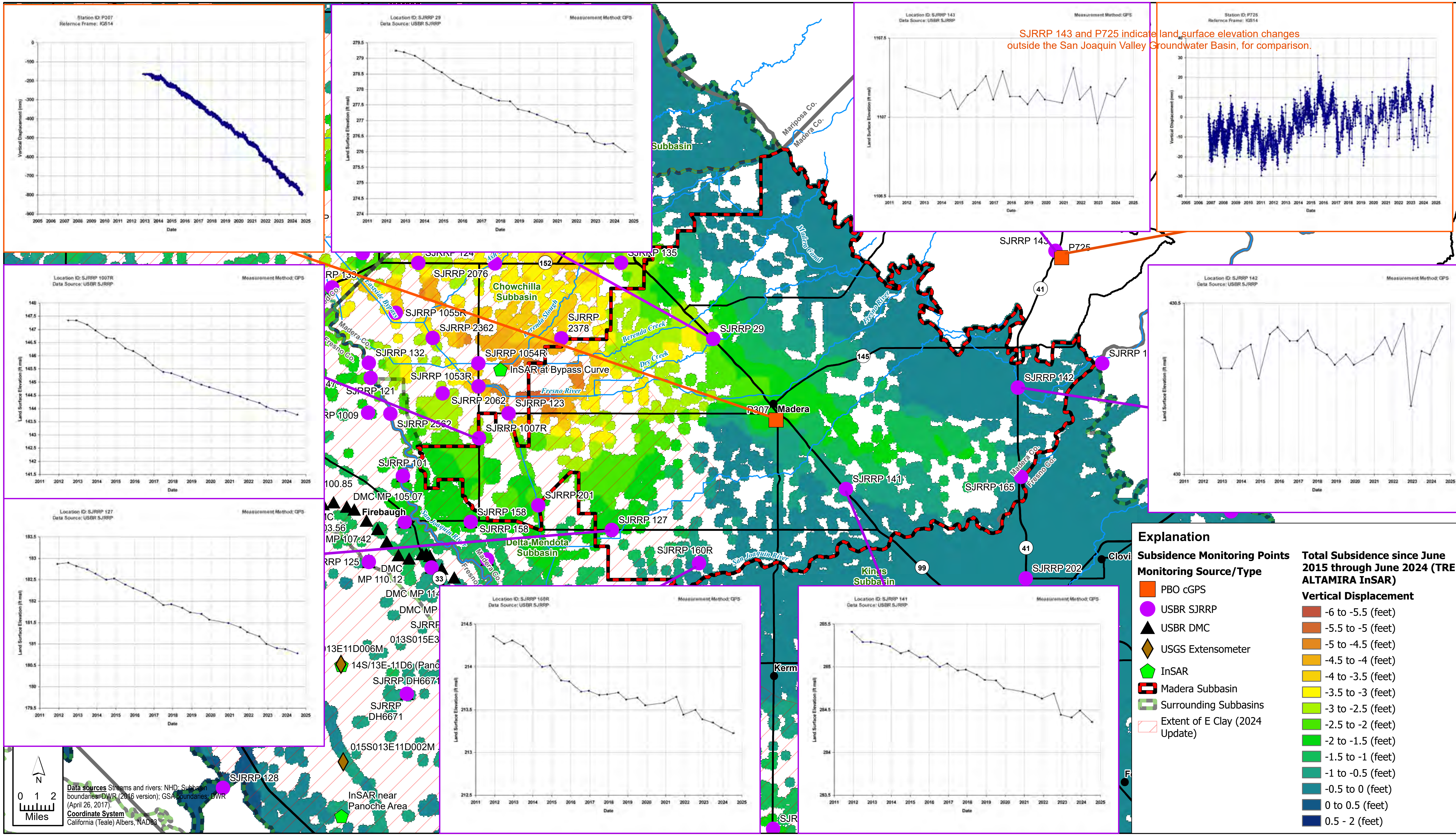
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-70

Map of Land Subsidence: 2015 to 2017

Madera Subbasin
Groundwater Sustainability Plan



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Subsidence Monitoring

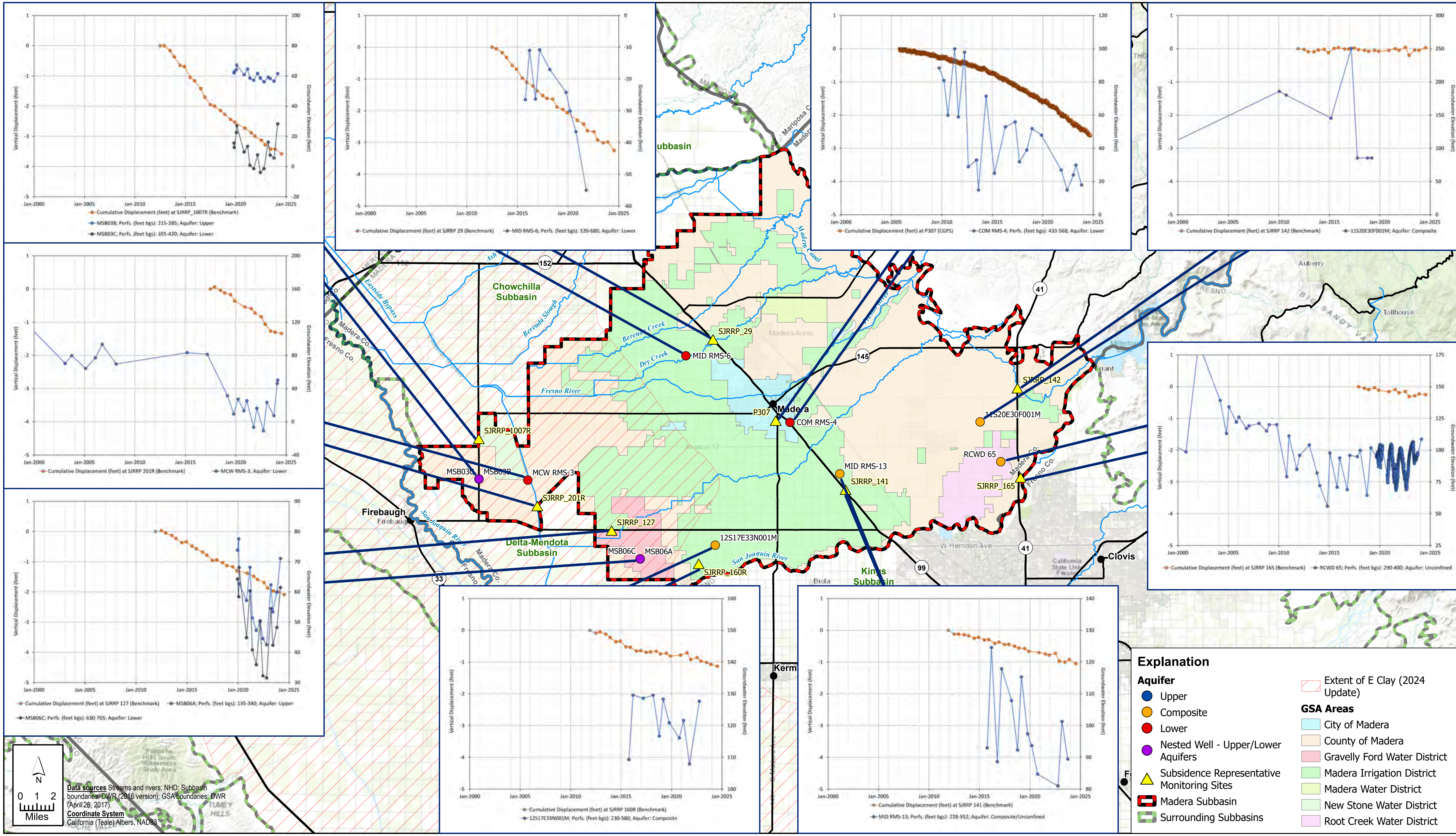
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-71

Map of Subsidence Monitoring Locations

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Subsidence Monitoring Point Trends with Water Levels

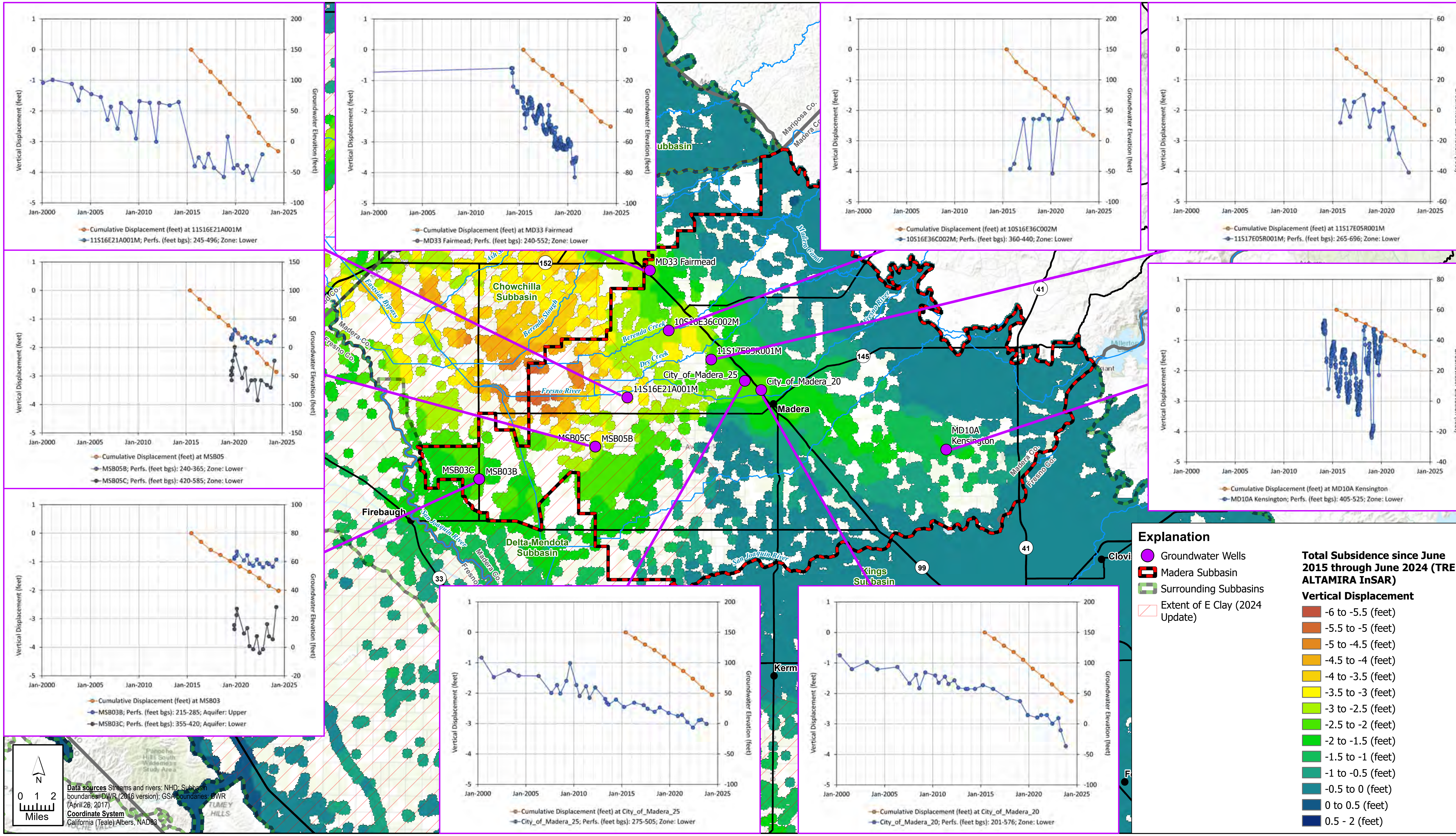
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-72A

Select Subsidence and Groundwater Level Hydrographs: SJRRP Benchmarks

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



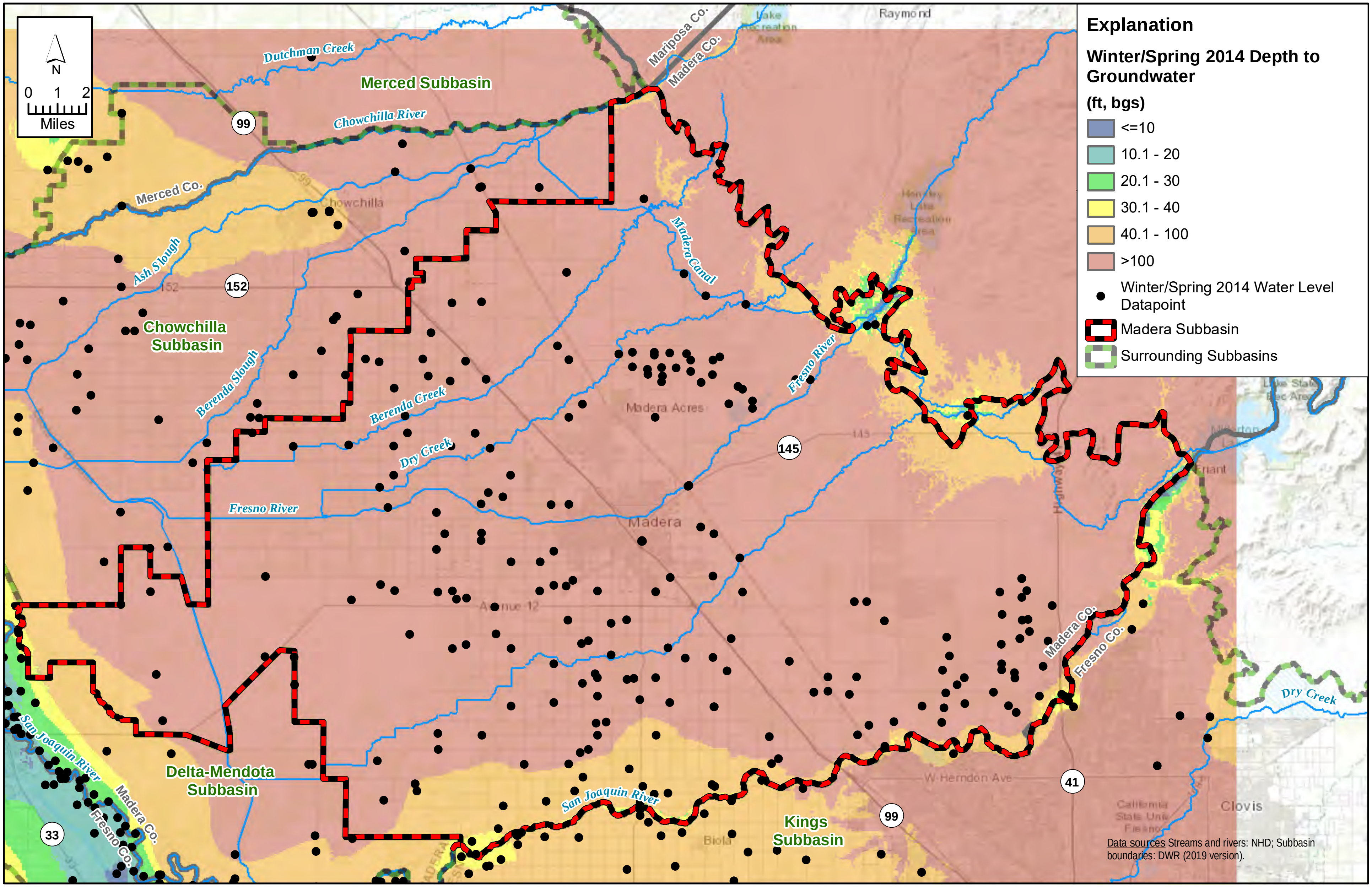
X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; Subsidence Monitoring INSAR Trends with Water Levels

DAVIDS ENGINEERING, INC — Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-72B

Select Subsidence and Groundwater Level Hydrographs: DWR Tre Altamira InSAR

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



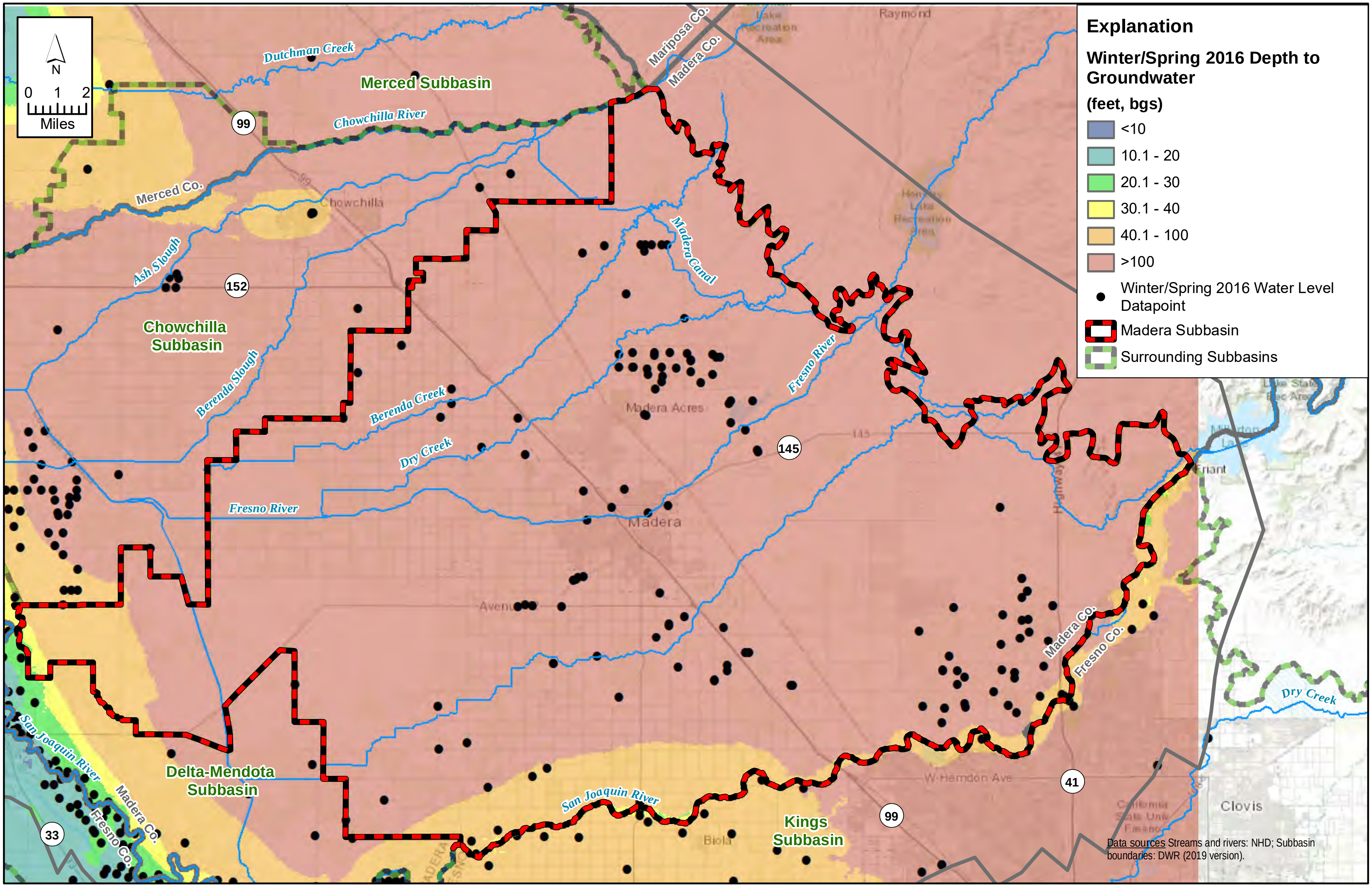
X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-71 Madera Subbasin Unconfined Depth to Water SpringWinter 2014.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-73
Map of Depth to Groundwater: Winter/Spring 2014 - Unconfined Groundwater

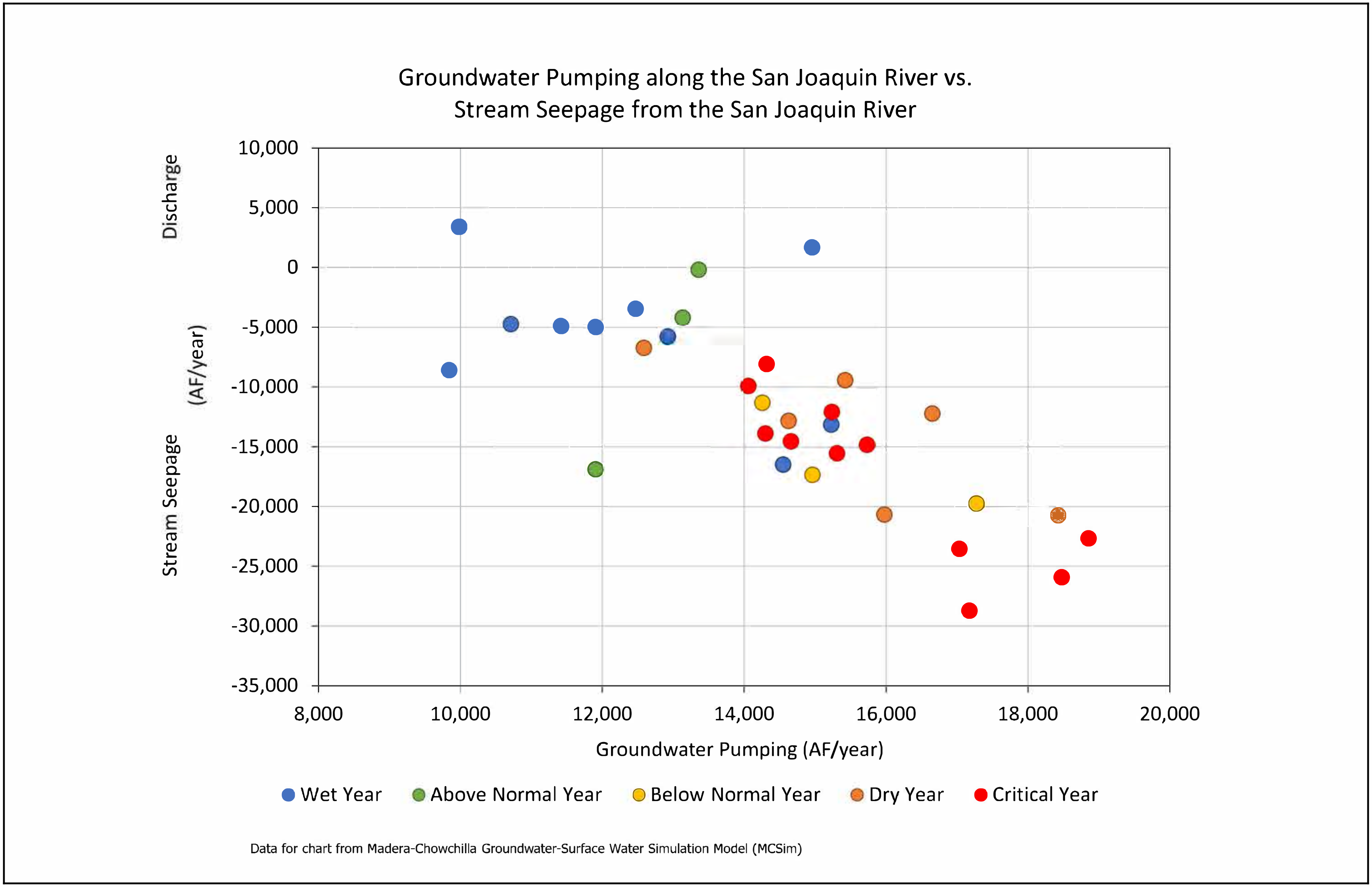
Madera Subbasin
Groundwater Sustainability Plan



X:\2017\17-113 Madera Subbasin GSP Development\GIS\Map Files\REPORT map files\Chapter 2\Figure 2-72 Madera Subbasin Unconfined Depth to Water SpringWinter 2016.mxd

FIGURE 2-74
Map of Depth to Groundwater:
Winter/Spring 2016 - Unconfined Groundwater

Madera Subbasin
Groundwater Sustainability Plan



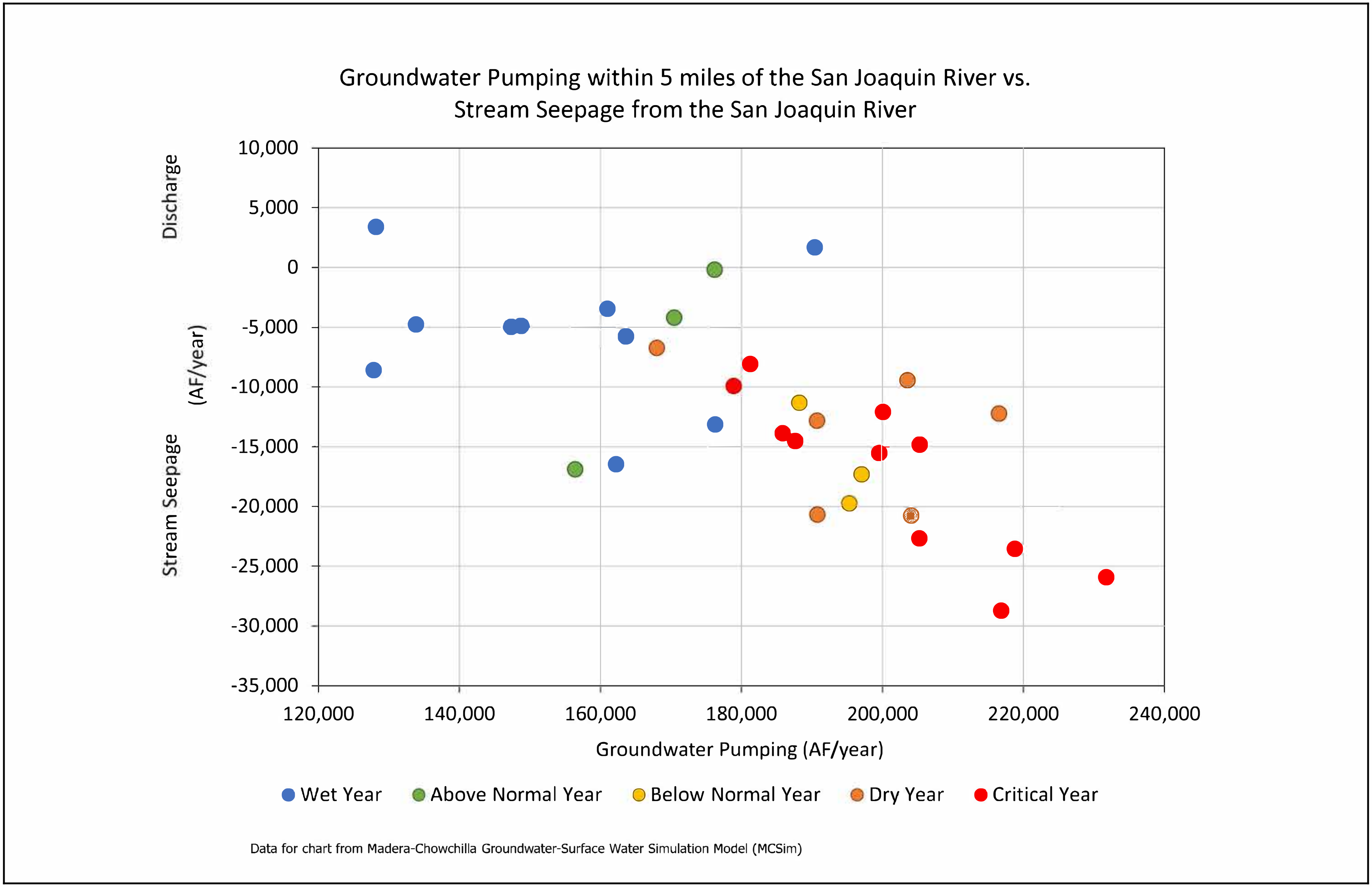
X:\2022\22-020 Davids Engineering (22-1-020) - Madera Subbasin GSP DWR Consultation Letter\GIS\MAD_GSP_UPDATE\MAD_GSP_UPDATE.aprx

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-75
Groundwater Pumping along the San Joaquin River vs. Stream Seepage from the San Joaquin River

Madera Subbasin
Groundwater Sustainability Plan



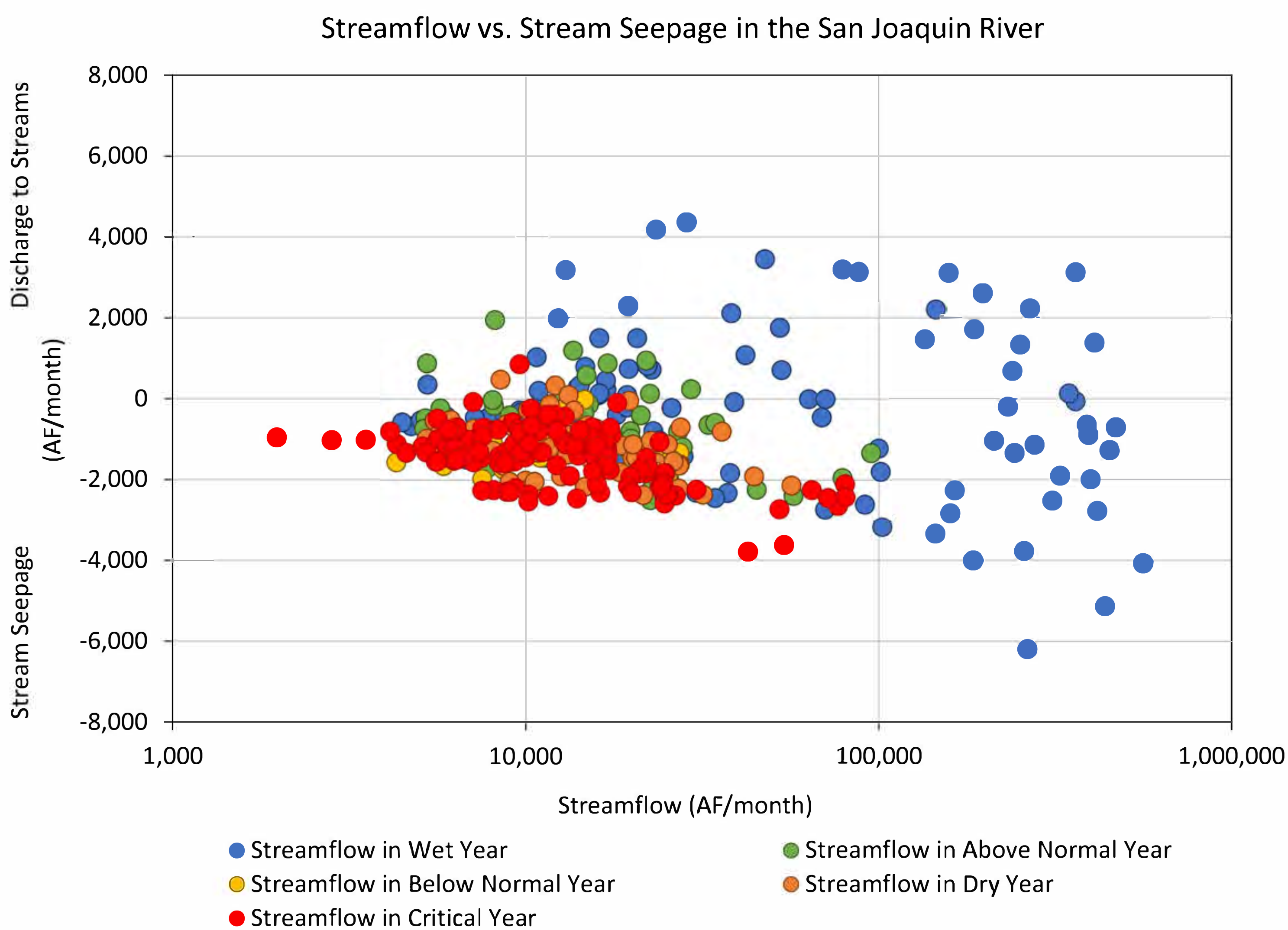
X:\2022\22-020 Davids Engineering (22-1-020) - Madera Subbasin GSP DWR Consultation Letter\GIS\MAD_GSP_UPDATE\MAD_GSP_UPDATE.aprx

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-76
Groundwater Pumping in the Western Management Area vs. Stream Seepage from the San Joaquin River

Madera Subbasin
Groundwater Sustainability Plan



Data for chart from Madera-Chowchilla Groundwater-Surface Water Simulation Model (MCSim)

X:\2022\22-020 Davids Engineering (22-1-020) - Madera Subbasin GSP DWR Consultation Letter\GIS\MAD_GSP_UPDATE\MAD_GSP_UPDATE.aprx

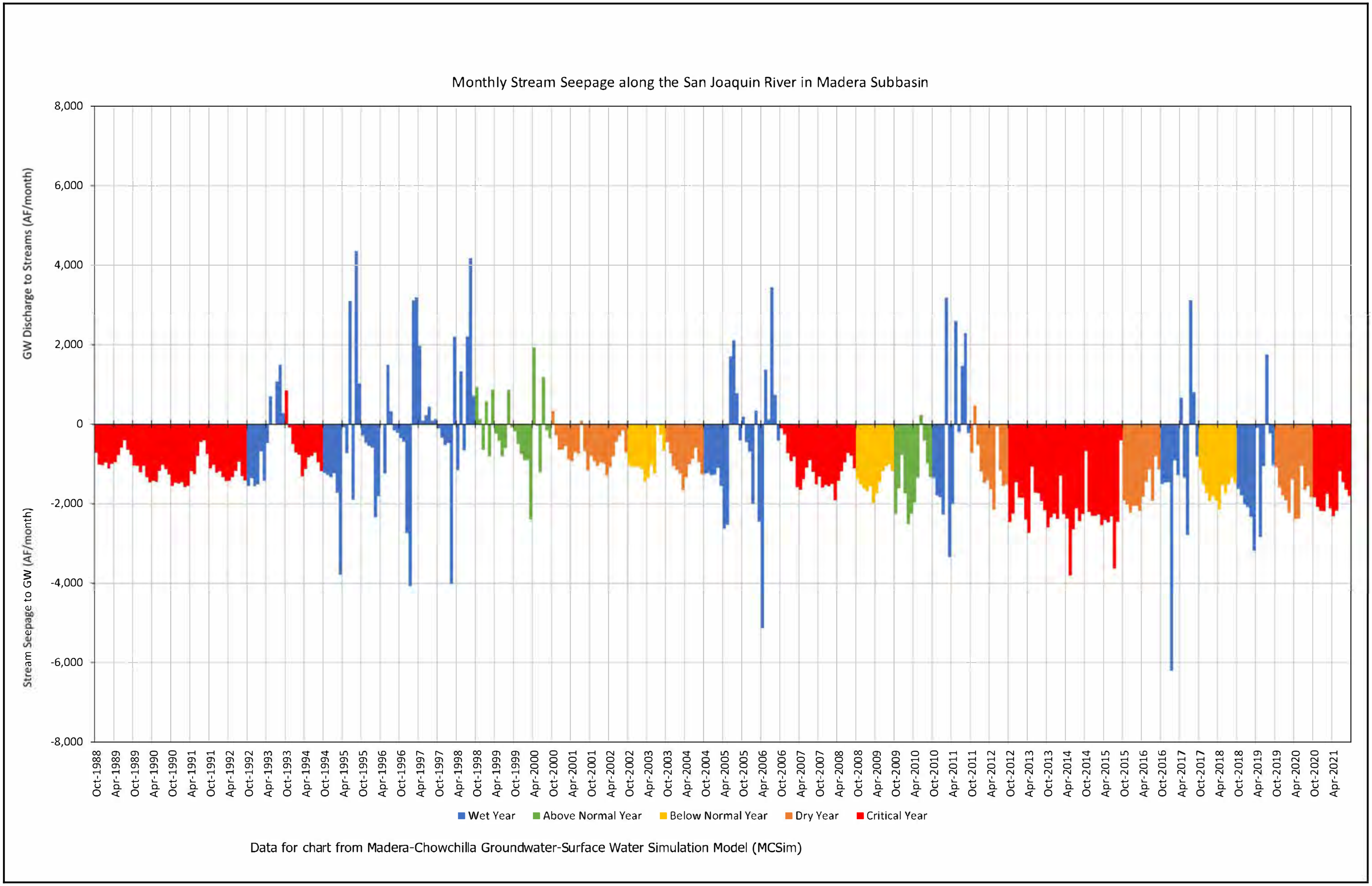
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-77

Streamflow vs. Stream Seepage in the San Joaquin River

Madera Subbasin
Groundwater Sustainability Plan



X:\2022\22-020 Davids Engineering (22-1-020) - Madera Subbasin GSP DWR Consultation Letter\GIS\MAD_GSP_UPDATE\MAD_GSP_UPDATE.aprx

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-78

Stream Seepage in the San Joaquin River in Madera Subbasin

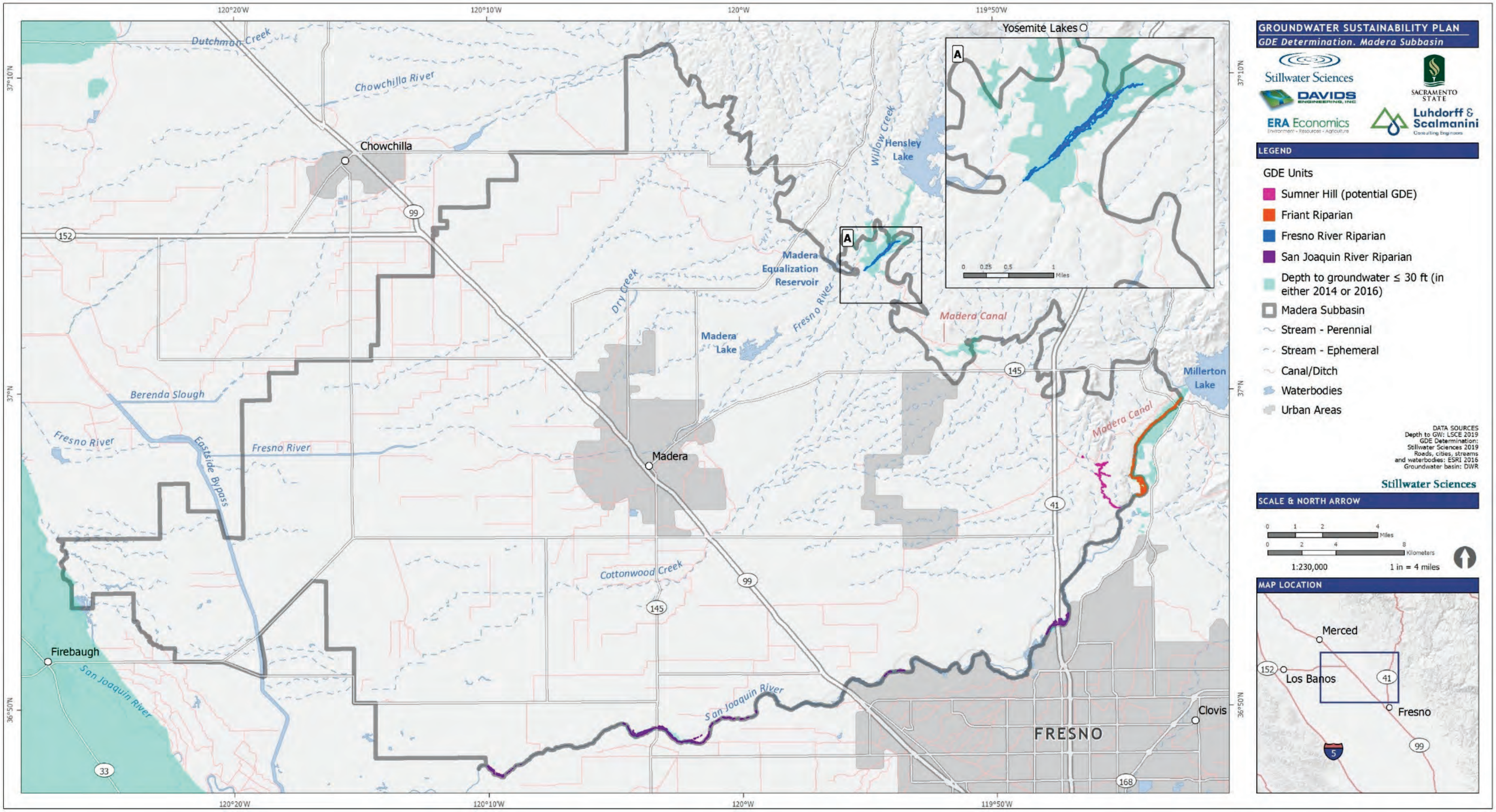


Figure 2-79**.** GDE units and depth to groundwater in the Madera Subbasin.

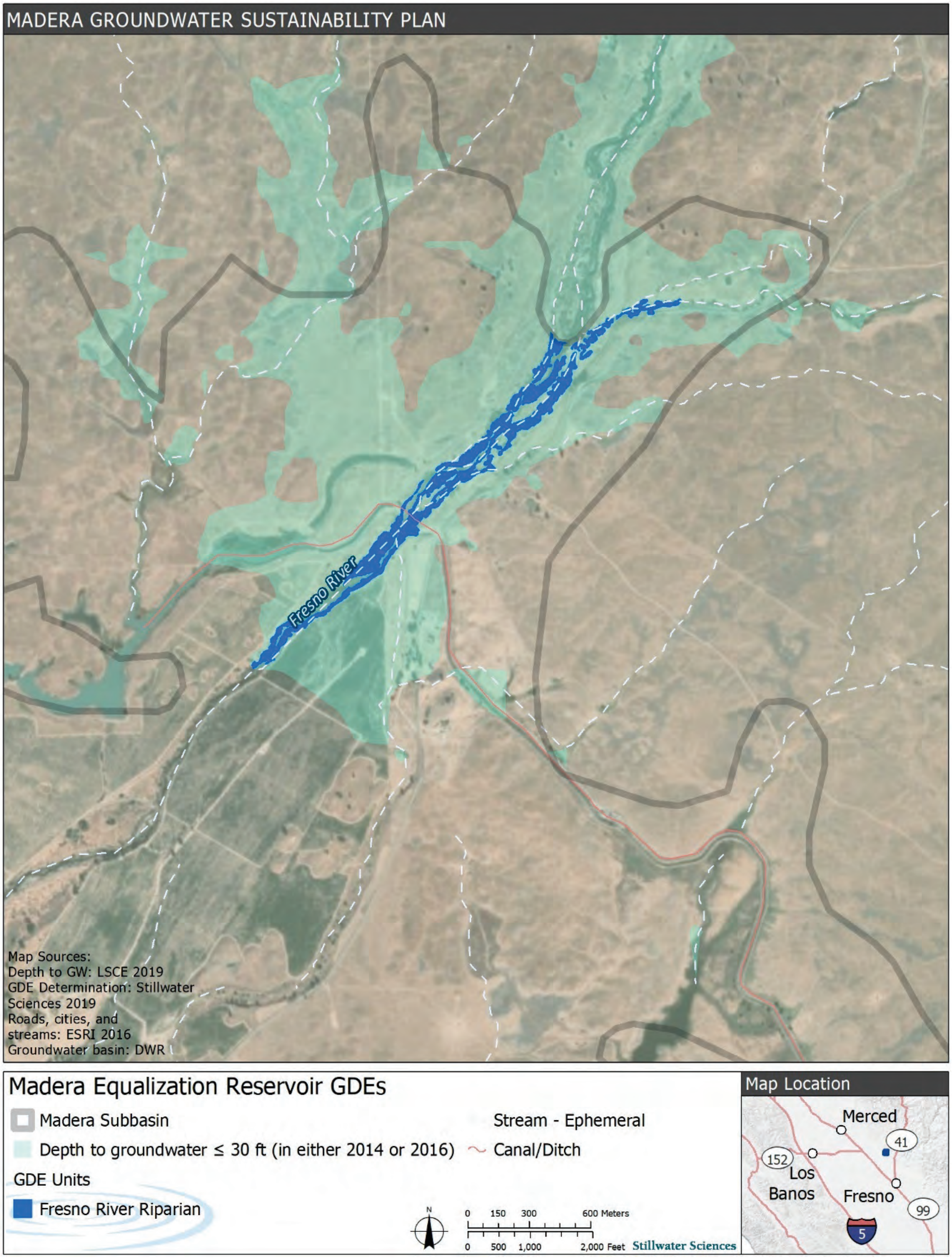


Figure 2-80**.** Fresno River Riparian GDE Unit.

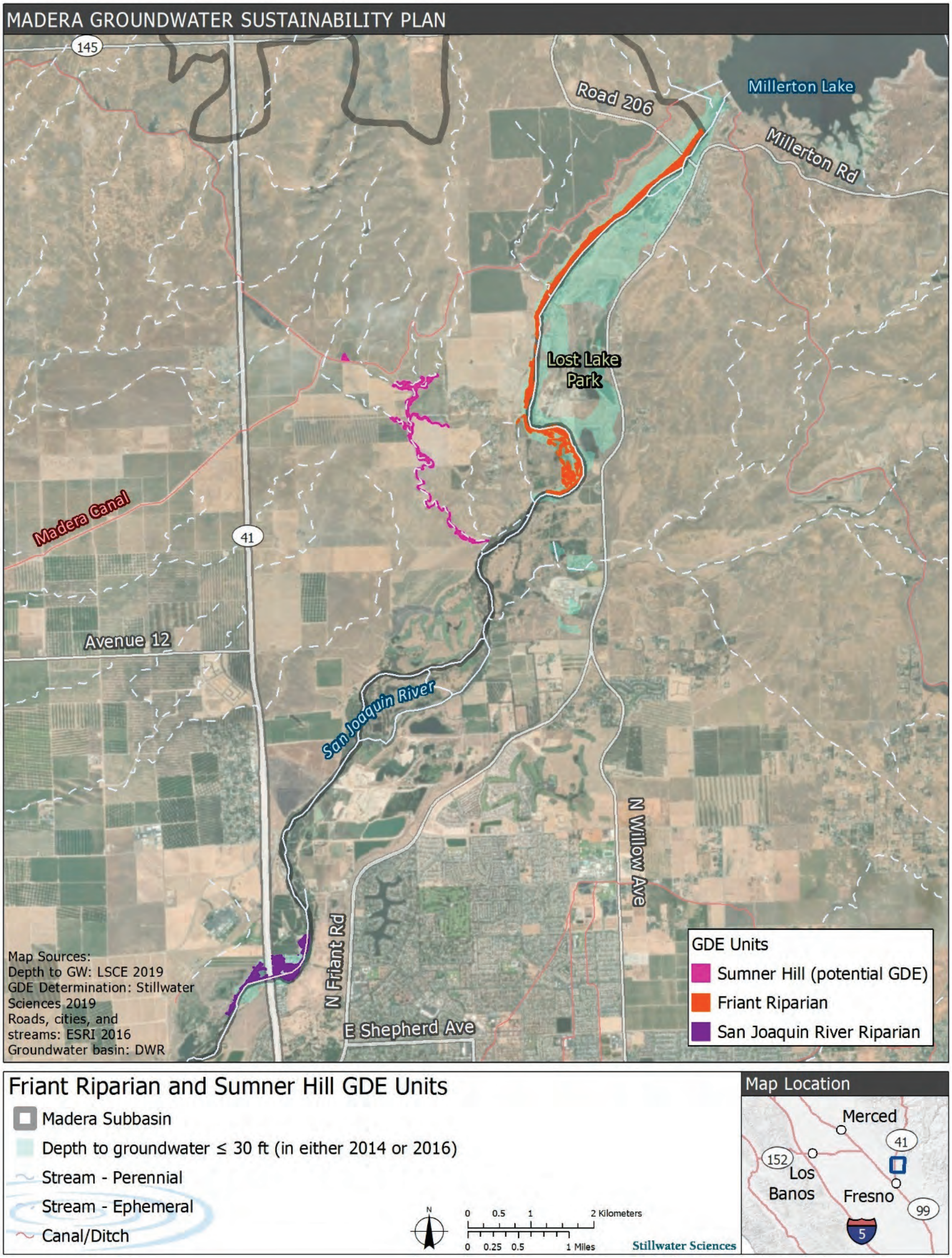


Figure 2-81**.** Sumner Hill potential GDE Unit, Friant Riparian GDE Unit, and upstream portion of San Joaquin River Riparian GDE Unit.

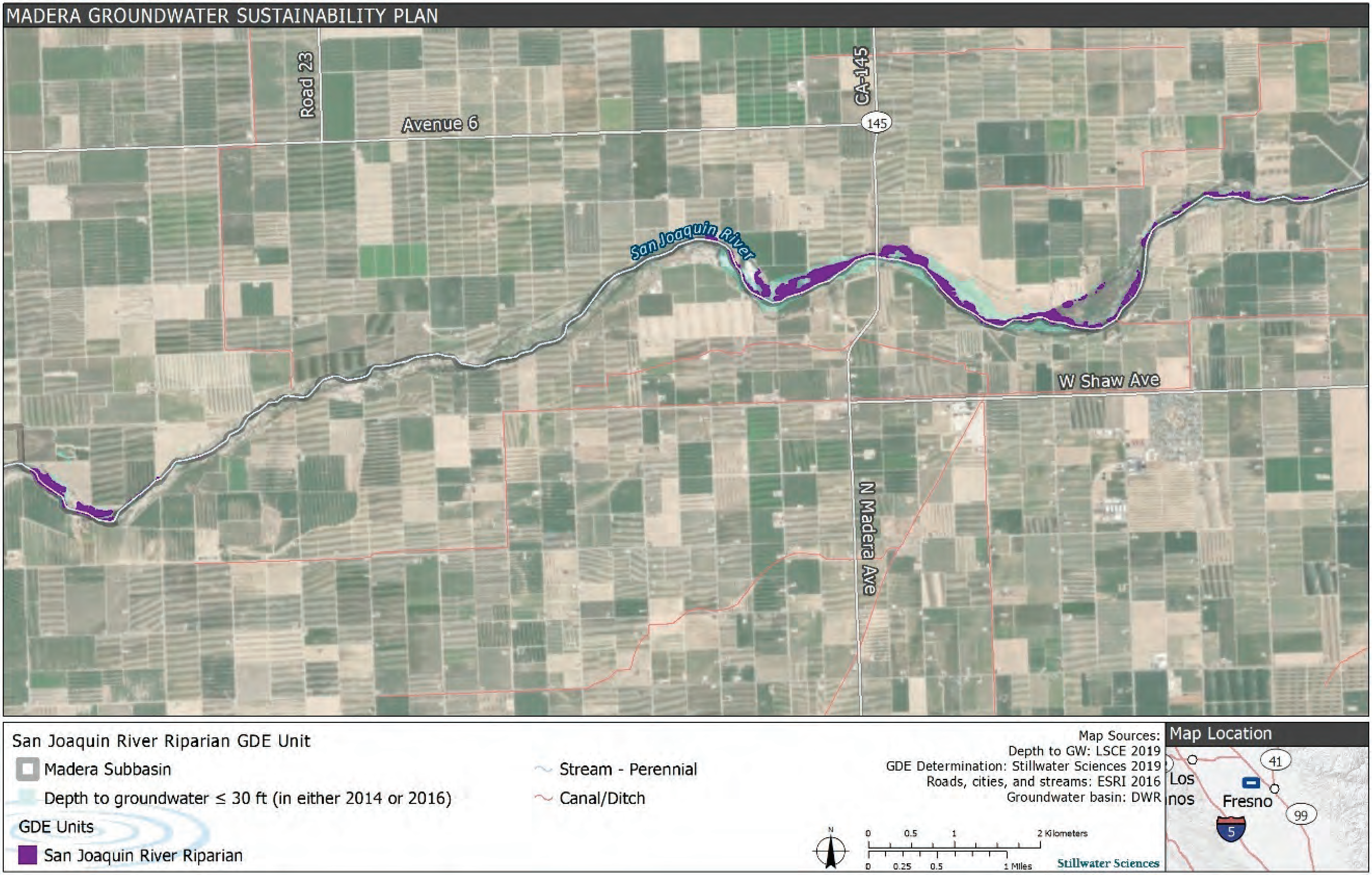


Figure 2-82. San Joaquin River Riparian GDE Unit, downstream portion.

3 SUSTAINABLE MANAGEMENT CRITERIA

This chapter of the Joint GSP provides a discussion of the sustainable management criteria (SMC), including the sustainability goals, measurable objectives (MOs), interim milestones, minimum thresholds (MTs), undesirable results, and the monitoring network for each sustainability indicator within the Joint GSP Plan Area. The SMC described in this chapter were developed and updated during the GSP Revisions process in 2022-2023 and again during the Plan Amendment and Periodic Evaluation processes ending in 2025 through an extensive and collaborative coordination process between the four Joint GSP GSAs (~~Madera County~~MC, ~~Madera Irrigation District~~MID, ~~Madera Water District~~MWD, and ~~the~~ CM~~City of Madera~~) and the three other GSAs in the Subbasin (~~Root Creek Water District~~RCWD, ~~Gravelly Ford Water District~~GFWD, and ~~New Stone Water District~~NSWD). Coordination efforts have resulted in SMC that are consistent across all four GSPs in the Subbasin.

This is the fundamental chapter that defines sustainability in the Subbasin;~~, and~~ it addresses significant regulatory requirements and includes updates since the initial Joint GSP that address DWR's identified deficiencies and corrective actions from their GSP review. ~~.~~ The MOs, MTs, and undesirable results presented in this chapter define the future sustainable conditions in the Subbasin, and commit the Joint GSP GSAs to actions that will achieve the Subbasin sustainability goal and avoid undesirable results.

The Sustainable Groundwater Management Act (SGMA) defines "sustainable groundwater management" as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" [CWC §10721(v)]. The "planning and implementation horizon" is defined 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" [CWC §10721(r)]. The 50-year planning and implementation horizon in the ~~Madera~~ Subbasin begins after the GSP implementation period ends in 2040. Prior to 2040, the GSAs are implementing PMAs, monitoring, and other efforts described in the GSP to achieve and maintain sustainable groundwater management. However, it is possible that groundwater conditions may temporarily exceed MTs during the GSP implementation period while these actions are occurring. By 2040, GSP implementation is expected to achieve the Subbasin sustainability goal through implementation of PMAs, demonstration that the SMC have been met, and demonstration that no undesirable results are occurring. The sustainability goal will be maintained through proactive monitoring and management by the GSAs.

Defining SMC requires considerable analysis and evaluation of many factors. This chapter presents the data and methods used to develop the SMC and demonstrates how they relate to beneficial uses and users within the Plan Area. The SMC presented in this chapter are based on the best ~~current~~ available data and applications of the best available science.

As noted in this Joint GSP, data gaps and ~~uncertainty~~ uncertainties exist in the characterization of the hydrogeologic conceptual model and groundwater conditions. These ~~uncertainty~~ uncertainties ~~was~~ were considered when developing the SMC and because of these uncertainties, the SMC presented herein are considered "working" ~~initial~~ criteria and subject to revision as part of adaptive management in the Subbasin. The GSAs will periodically evaluate this Joint GSP, assess changing conditions in the Plan Area that may warrant modifications of the GSP or management objectives, and may adjust components accordingly. An evaluation is anticipated to typically be completed as part of the Periodic Evaluation and/or Plan Amendment occurring every five years during GSP implementation, but the GSAs may initiate them at other times as well in response to hydrologic conditions or other factors. The GSAs will focus their evaluation on determining whether the actions under the GSP are meeting the GSP management objectives and whether those objectives are meeting the sustainability goal of the Subbasin.

This chapter is organized to address all the SGMA regulations regarding SMC and is organized in accordance with DWR's GSP annotated outline. This chapter includes a description of:

- How locally defined significant and unreasonable conditions were developed
- How MTs were developed, including:
    - The information and methodology used to develop MTs
    - The relationship between MTs and relationship of these MTs to other sustainability indicators
    - The effect of MTs on neighboring basins
    - The effect of MTs on beneficial uses and users
    - How MTs are related to relevant Federal, State or local standards
    - The method for quantifying measurable MTs
- How MOs were developed, including:
    - The methodology for setting MOs
    - Interim milestones
- How undesirable results were developed, including:
    - The criteria defining when and where the effect of the groundwater conditions cause undesirable results based on a quantitative description of the combination of MT exceedances
    - The potential causes of undesirable results
    - The effect of these undesirable results on the beneficial use and users.

The SMC presented in this chapter were developed using information from stakeholder and public input and correspondence with the GSAs, public meetings, hydrogeologic analysis, groundwater dependent ecosystem analysis, meetings with GSA technical representatives, meetings with the technical teams from other GSAs within the Subbasin, ~~and~~ meetings with DWR's technical experts during the coordination meetings held with DWR during the 180-day revision period, and the corrective actions outlined in DWR's Revised GSP approval letter. SMC may be revised in the future as more data are collected and more information is made available during GSP implementation and adaptive management.~~.~~ The general process for establishing revised SMC included:

- GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC.
- Conducting GSP public meetings to present proposed methodologies to establish MTs and MOs and receive additional public input. Two public meetings on SMC were held in the Plan Area.
- Reviewing public input on preliminary SMC methodologies with GSA staff/technical representatives.
- Providing a Draft GSP for public review and comment.

- Conducting technical coordination meetings between the Joint GSP technical team and the technical teams for the three other GSPs in the Subbasin.
- Establishing and modifying MTs, MOs, and definition of undesirable results based on feedback from public meetings, public/stakeholder review of the Draft GSP, and input from GSA staff/technical representatives.

To ensure the Plan Area meets its sustainabilityle goal by 2040, the GSAs have proposed the PMAs described in Section 4 to address undesirable results and to achieve and maintain sustainable groundwater conditions byat the end of the implementation period. The PMAs expected to be implemented will include projects (e.g., recharge basins, Flood MAR, in-lieu recharge) and management actions including demand reduction. The overarching sustainability goal and the absence of undesirable results are expected to be achieved by 2040 through implementation of the PMAs. The sustainability goal will be maintained through proactive monitoring and management by the GSAs as described in this and the following chapters. Table 3-1 summarizes whether each of the six undesirable results has occurred, is occurring, or is expected to occur in the future in the Plan Area without and with GSP implementation.

3.1 Sustainability Goal *(23 CCR § 354.24)*

3.1.1 Goal Description

The sustainability goal for the Subbasin is to implement a package of PMAs that will, by 2040, balance long-term groundwater system inflows with outflows based on a 50-year period representative of average historical hydrologic conditions. The six sustainability indicators, and established MOs, and MTs that for each, will ensure no undesirable results of significant and unreasonable economic, social, or environmental impacts occur as a result of GSP activities, as defined based on local values expressed in this Joint GSP.

Under SGMA, the six sustainability indicators are separate and independent metrics used to evaluate subbasin conditions relative to sustainability as defined by SMC. For sustainability indicators that are interdependent and influence one another (e.g., declining groundwater levels resulting in land subsidence), the most restrictive SMC will govern for determining if undesirable results have occurred (e.g., either groundwater level decline exceeding MTs, or subsidence exceeding MTs; each evaluated independently).

Table 3-1. Summary of Undesirable Results Applicable to the Plan Area.

Sustainable Indicator	Historical Period (Prior to 2015)	Existing Conditions	Future Conditions without GSP Implementation	Future Conditions with GSP Implementation (after 2040)
Chronic Lowering of Groundwater Levels	Yes	Yes	Yes	No
Reduction of Groundwater Storage	Yes	Yes	Yes	No
Land Subsidence	YesNo	YesNo	PossiblyYes	No
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Yes	Yes	Yes	No[1]
Depletion of Interconnected Surface Water	Yes	Possibly[2]	Possibly	No

[1] There may be future continued degradation of groundwater quality that is not related to GSP Projects and Management Actions.
[2] Based on review of available data, characterization of hydrogeologic conditions related to the potential for ISW is currently based on very limited data. A data gaps workplan for ISW (Appendix 3.I) will provide additional data to evaluate this sustainable indicator.

3.1.2 Description of Measures

Recharge projects, which include projects that replace groundwater use with surface water use (in-lieu recharge), and management actions that reduce total demand, are planned to be implemented over the GSP implementation period (2020 to 2040). Together the recharge projects and the management actions will increase groundwater inflows and decrease groundwater outflows to bring the groundwater system into balance by 2040 and will allow its operation to remain sustainable over a 50-year period representing average hydrologic conditions. If actual hydrologic conditions differ from the 50-year average (e.g., due to climate change), then additional measures may need to be taken.

3.1.3 Explanation of How the Goal Will Be Achieved in 20 Years

Implementation of recharge projects will increase inflow to the groundwater system, thus increasing groundwater levels in wet years when water is available for recharge. Implementation of projects that replace groundwater use with surface water use will reduce groundwater pumping to maximize the use of surface water, also contributing to increases or stabilization in groundwater levels and decreasing ongoing or future new subsidence. Demand reduction will decrease the consumptive use of groundwater, also contributing to increases or stabilization of groundwater levels and decreasing ongoing or future active subsidence. The combination of the increased inflows through recharge, decreased outflows through the projects that replace groundwater use with surface water use, and through the reduced demand resulting from the management actions, results in groundwater inflows equaling outflows over the sustainability period (2040 to 2090), as detailed in Chapter Section 2 (Plan Area and Basin Setting) of this Joint GSP.

3.2 Measurable Objectives *(23 CCR § 354.30)*

As detailed below, the MOs represent the expected operating conditions for the Subbasin. If the GSAs successfully operate to the MOs described, the Subbasin will be operating sustainably. MOs and interim milestones are detailed below. A description of the MOs and how they were established are provided, along with recognition of the anticipated fluctuations in Subbasin conditions around the established MOs. In addition, this section describes how the Joint GSP helps to meet each MO, how each MO is intended to achieve the sustainability goal for the Subbasin for the long-term beneficial uses, and how the interim milestones are intended to reflect the anticipated progress toward the MOs during the 2020 to 2040 implementation period.

The GSP regulations define MOs as specific, quantifiable goals for the maintenance or improvement of specific groundwater conditions that have been included in an adopted GSP to achieve the sustainability goal for the Subbasin.

Per the GSP regulations (23 CCR § 354.30):

1. MOs shall be established, "…including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of [GSP] implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon." (§ 354.30.a)
2. "[MOs] shall be established for each sustainability indicator, based on quantitative values using the same metric and monitoring sites as are used to define the [MTs]." (§ 354.30.b)
3. "[MOs] shall provide a reasonable margin of operational flexibility under adverse conditions, which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty." (§ 354.30.c)
4. "…a representative [MO] for groundwater elevation to serve as the value for multiple sustainability indicators…" may be established where "…the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual [MOs] as supported by adequate evidence." (§ 354.30.d)
5. "Each [GSP] shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of [GSP] implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the [MO], in increments of five years." (§ 354.30.e)

The MOs developed for each applicable sustainability indicator in this Joint GSP are based on the current understanding of the Plan Area and Basin Setting as discussed in detail in Chapter 2. Representative Monitoring Sites (RMS) are identified for monitoring of interim milestones, MOs, and MTs for each sustainability indicator, and are also known as sustainability indicator wells.

3.2.1 Chronic Lowering of Groundwater Levels

MOs and interim milestones for chronic lowering of groundwater levels are described below.

3.2.1.1 Measurable Objectives

MOs for groundwater levels were established in accordance with the sustainability goal through review and evaluation of measured groundwater level data, to the extent available, and simulated historical groundwater levels derived from the MCSim (**Appendix 6.D**). MOs for groundwater levels were set at Fall

2010 groundwater elevations, which represent Subbasin conditions prior to the drought period from 2012 to 2015, and are a target average condition for long-term sustainable groundwater management in the Subbasin. The MOs define an average sustainable groundwater level condition with the understanding that groundwater levels will fluctuate somewhat around the MO during the Sustainability Period (starting in 2040). The MO values at all groundwater level representative monitoring site (RMS) wells were set based on observed Fall 2010 groundwater elevation data, when available. In cases where observed Fall 2010 groundwater elevation data were not available, simulated Fall 2010 groundwater elevation values were used to determine the MO, with consideration for offsets between historically observed and simulated groundwater elevations at each RMS. and fluctuations in groundwater levels utilizing the numerical groundwater flow model (**Appendix 6.D.**). This analysis provides estimates of the expected groundwater level variability due to climatic and operational variability. Both annual (year to year) and seasonal (winter/spring to summer/fall) variability were considered. MOs for groundwater levels were set at Fall 2010 groundwater levels based on observed data when available. If observed data were not available, the Fall 2010 groundwater level was based on modeled results, modified if necessary, to account for offset between historically observed and modeled groundwater levels. Fall 2010 groundwater levels represent subbasin conditions prior to the pre-2012 to 2015 drought period, which are considered a reasonable expectation for the level at which Fall groundwater levels will fluctuate around under sustainable conditions after 2040.

MOs for groundwater levels for each sustainability indicator well or representative monitoring site (RMS) are summarized in Table 3-2, and locations of groundwater level sustainability indicator wells are shown in **Figure 3-1**[72]. These MOs are set specific to aquifer zones designated as Upper Aquifer (above the Corcoran Clay where present, and equivalent depth to the east where Corcoran Clay is not present) and Lower Aquifer (below the Corcoran Clay where present). Groundwater level hydrographs showing MOs for each groundwater level sustainable indicator well are provided in **Appendix 3.A.**

3.2.1.2 Interim Milestones

Interim milestones (IMs) for chronic lowering of groundwater levels were established at five-year intervals over the GSP implementation period from 2020 to 2035, at years 2025, 2030, and 2035. Interim milestones IMs for groundwater levels were established through review and evaluation of measured groundwater level data and future projected fluctuations in groundwater levels during the GSP implementation period utilizing the numerical groundwater flow model, which simulated implementation of projects and management actions. The lowest interim milestone was set for 2030 based on the lowest model groundwater elevations expected to occur during the GSP implementation period, while accounting for a small amount of hydrologic variability and operational flexibility with a 10-foot buffer. IMs were set at the Fall 2024, 2029, and 2034 simulated water levels for 2025, 2030, and 2035, respectively. Offsets between historically observed and modeled data were accounted for, as needed, based on Fall Spring observed and modeled groundwater levels., and Spring to Fall groundwater level fluctuations were accounted for to develop the Fall interim milestone for each year. Interim milestones IMs for groundwater levels for each RMS sustainable indicator well are summarized in Table 3-3, and locations of groundwater level RMS are shown in **Figure 3-1**.

3.2.1.3 Achieving and Maintaining Sustainability

The combination of IMs and MOs reflect how the Subbasin anticipates achieving and maintaining sustainability. It should be noted that future projections require assumptions about future hydrologic conditions, including the sequence of wet, average, and dry climatic years. The future climatic

[72] Figure titles that are bolded can be found at the end of each chapter.

assumptions for the GSP implementation period used in the Joint GSP incorporate sequences of wet, average, and dry years that represent overall long-term average historical climatic conditions over the GSP implementation period, without any prolonged periods of extremely dry or extremely wet years. Under these climatic assumptions, the GSP implementation period would involve some gradual and continued decline in groundwater levels after 2020 while PMAs are being implemented. Based on the hydrologic assumptions made, the modeled groundwater levels at most well locations are anticipated to reach future lows ~~between~~ around 2030 ~~and 2035~~, before stabilizing and then rebounding to higher levels after 2040 (when all PMAs are implemented). This overall pattern of anticipated fluctuations in groundwater levels reflects the time to design, permit, and construct projects and implement demand reduction (described in **Appendix 3.C**) that is planned to incrementally increase linearly between 2020 and 2040.

It is also important to note that review of RMS groundwater level hydrographs in **Appendix 3.A** demonstrate that average domestic well depths are generally below the lowest predicted groundwater levels during the GSP implementation period. Review of RMS groundwater hydrographs indicates that impacts to domestic wells during the GSP implementation period will be limited to a relatively small percentage of existing domestic wells. It should further be recognized that review of data for existing wells and ongoing installation of new nested monitoring wells generally indicate that water levels in deeper wells (i.e., depths typical for agricultural and municipal wells) are generally lower than groundwater levels in shallower domestic wells. This means that comparison of observed and modeled groundwater levels for RMS wells screened in deeper zones to average domestic well depths likely shows a worst-case scenario (i.e., groundwater levels for most nearby domestic wells will be higher than indicated on the hydrograph for a deep zone RMS well).

Nevertheless, the GSAs within the Subbasin have proceeded with coordination and focused planning efforts to develop a Domestic Well Mitigation Program, including the development of a memorandum of understanding (MOU). Once up and running, t~~T~~he Domestic Well Mitigation Program ~~could~~ will provide assistance to domestic and municipal wells adversely impacted by declining groundwater levels that interfere with groundwater production or quality and will be coordinated with the Madera County SB 552 Drought Plan that is also under development. It is expected that the Domestic Well Mitigation Program would be implemented during the GSP implementation period, as needed, and continue until groundwater sustainability is achieved. After 2040, groundwater levels will stabilize at historical levels, avoiding undesirable results for groundwater users. As of ~~March 2023~~December 2024, the GSAs are developing the Program eligibility criteria, terms, and conditions and are preparing to move forward with Program implementation, as needed, no later than 2025. The Domestic Well Mitigation Program and the MOU are discussed in Section 3.3.1.1.

3.2.1.3.1 *Impact of Groundwater Level IM on Groundwater Quality*

Background and Previous Studies

The relationship between changes in groundwater levels and groundwater quality is difficult to quantify due to the many additional variables that may be involved and may affect historical trends between levels and quality (e.g., variability in recharge quantities, land surface management activities). However, some studies have been conducted that document investigations into how TDS, nitrate, and arsenic may be affected by fluctuations in groundwater levels, and are summarized in the following paragraphs.

TDS: A study of a project area in Poland (Blaszyk and Gorski, 1981) suggests that TDS increases can occur via introduction of oxygen to the hydrogeochemical environment during pumping, which oxidizes sulfur compounds to produce acid that increases solubility of various chemical compounds, thereby leading to potential for increases in TDS. A USGS study (Hansen et al., 2018) study concluded that TDS concentrations in the San Joaquin Valley have increased by an average of about 100 mg/L in the last 100 years. This increase in TDS was attributed primarily to irrigated agricultural activities at the land surface and associated recharge of irrigation water. While the primary cause of overall increases in TDS was attributed to –land surface activities (and not changes in groundwater levels), the study concluded that declining groundwater levels from municipal and agricultural pumping served to cause shallow groundwater with higher TDS to migrate vertically downward. The study further concluded that continued municipal and agricultural pumping will likely lead to higher TDS concentrations in deeper groundwater in the future.

Nitrate: A USGS study (Levy et al., 2021) indicated the detection frequency of high nitrate (defined as greater than 5 mg/L as N in the study) in the San Joaquin Valley that was episodically higher during droughts and superimposed on a long-term upwards trend. Wells with long-term nitrate records indicate a tendency for lower concentrations during wet periods such as 1993-1999, 2010-2011, and 2016-2017. The study goes on to suggest that drought/overdraft conditions with declining groundwater levels may cause higher concentrations of nitrate in the shallower zone to migrate vertically downward to enter well screens in deeper zones, thereby resulting in overall contribution of a higher proportion of modern high nitrate groundwater to deep screened wells as groundwater levels decline.

Arsenic: A Stanford study (Smith et al., 2018) suggests higher arsenic concentrations residing in clay layers within aquifers (interbeds) may be released in association with groundwater pumping that causes compaction of clay layers. Another USGS study (Haugen et al., 2021) found both increasing and decreasing trends in arsenic: decreasing arsenic trends associated with groundwater pumping contributing younger more oxic groundwater, and increasing arsenic trends associated with higher pH and more reduced groundwater. More reduced groundwater tended to be associated with deeper wells along the San Joaquin Valley trough where aquifer materials are more fine-grained (favoring reducing conditions). A study by USGS and CDC (Lombard et al., 2021) for domestic wells across the U.S. found an inverse relationship between precipitation and arsenic concentrations (decreasing precipitation tends to correlate with increasing arsenic concentrations) but a positive relationship between groundwater recharge and arsenic concentrations (i.e., increasing recharge correlates to increasing arsenic concentrations). The inverse relationship between precipitation and arsenic concentrations was interpreted to be related to climate regimes and pattern of higher arsenic concentrations in arid regions. They suggested the positive relationship of recharge and arsenic concentrations may be a function of reductive desorption and/or dissolution of arsenic from iron oxides, and/or a flushing of arsenic into groundwater with increased recharge. Regardless of the physical mechanism, the association of increased rainfall with increased recharge would tend to mean these two variables act in opposition to each other.

GSP Actions Related to GWL Decline and Potential GW Quality Impacts

Project and management activities being conducted by the GSAs, -as described in Sections 4 and 5 of this GSP, are expected to help slow and potentially reverse groundwater level declines and minimize potential impacts of groundwater level IMs on groundwater quality as summarized below:

1) The GSAs are working diligently to implement PMAs to minimize future groundwater level declines and active subsidence, which should serve to reduce the possibility for impacts to groundwater quality.
2) More specifically, minimizing future water levels declines is expected to:
    a) Minimize the potential for increasing TDS concentrations that some studies suggest may occur with declining groundwater levels; ~~and~~
    b) Minimize the opportunity for greater contribution of water to deep screened wells from deeper reduced sediments that may have higher arsenic concentrations. Reduced sediments (typically blue to gray in color) tend to be more prevalent at deeper depths compared to

shallower depths where more oxidized sediments (typically brown, yellow, tan, red colors) tend to be present. In general, maintaining a greater proportion of water flowing into a well from shallower sediments would tend to result in lower arsenic concentrations;

c) Minimize the opportunity for a greater contribution of shallow groundwater with higher nitrate concentrations to deeper screened production wells due to vertical downward migration of this water;

d) Minimize the potential for increasing TDS concentrations that some studies suggest may occur with declining groundwater levels; and

e) Reduce the possibility for impacts to groundwater quality from general groundwater level declines while also reducing the amount of water with potentially higher arsenic concentrations that is being derived from compaction of interbed clay layers.; and.

b) Minimize the opportunity for greater contribution of water to deep screened wells from deeper reduced sediments that may have higher arsenic concentrations. Reduced sediments (typically blue to gray in color) tend to be more prevalent at deeper depths compared to shallower depths where more oxidized sediments (typically brown, yellow, tan, red colors) tend to be present. In general, maintaining a greater proportion of water flowing into a well from shallower sediments would tend to result in lower arsenic concentrations.;

f)

3) Available data indicate groundwater quality is generally relatively good with respect to TDS concentrations, provided wells are not screened below the base of fresh water previously defined by USGS (Page, 1973; **Figure 2-18**). There are no studies indicating significant changes in TDS concentrations with modest groundwater level fluctuations. However, to the extent that some wells in the subbasin may tap into areas or vertical depth zones with somewhat elevated existing TDS concentrations, the SMC used in the GSP for groundwater quality will serve to minimize future increases in concentrations.

3.2.1.3.2 *Impact of Groundwater Level IM on Subsidence*

Background

The total subsidence that may occur in the future is a combination of active subsidence caused by groundwater level declines to new lows and residual subsidence that may occur due to previous groundwater level declines from undeveloped (no pumping) conditions. The portion of total subsidence that occurs with any further groundwater level declines during the GSP implementation period prior to groundwater level stabilization and potential recovery with attainment of sustainable conditions would generally be associated with the active subsidence component.

GSP Actions Related to GWL Decline and Potential Subsidence Impacts

Project and management activities being conducted by the GSAs, as described in Sections 4 and 5 of this GSP, are expected to help slow and potentially reverse groundwater level declines and minimize potential impacts of groundwater level IMs on subsidence. The potential impact of establishment of the groundwater level IMs for this GSP that result in new lows can be estimated from use of the IWFM subsidence package that was recently incorporated into the MCSim Model update (**Appendix 6.D**). The relatively good calibration of the updated MCSim Model to recent active subsidence since 2012 allows for model estimation of the active subsidence component that may occur at the established groundwater level IMs. These estimates of future active subsidence, which generally occur around 2030 based on assumed hydrology and PMA implementation, are estimated to range up to about one foot as shown in **Figure 3-2**. Additional subsidence at the groundwater level IMs ranges from negligible along the San

Joaquin River along the southern subbasin boundary, to about 0.5 feet over the middle portion of the Ssubbasin, to a maximum of about one foot in the northwest portion of the Ssubbasin. The amount of subsidence described above is within the estimated tolerance of approximately two feet discussed in Section 3.4.3.

While the above description provides our best estimate of -groundwater level IM impact on subsidence, it should be noted that residual subsidence (which is more difficult to predict) may be a significant component of total subsidence that would occur without any further groundwater level decline. Thus, even if the groundwater level IM were not set any lower than lows that have already occurred (generally 2022), residual subsidence would still be expected to occur during the GSP implementation period. More discussion of residual subsidence is provided in Chapter 2 and **Appendix 6.E**.

3.2.1.4 Impact of Selected Measurable ObjectiveMOs on Adjacent Basins

The MOs established for Plan Area provide a good basis for evaluation of anticipated impacts on adjacent subbasins from implementation of the GSP. This is because MOs are set to reflect the expected average groundwater levels to be maintained during the sustainability period. Ultimately, the potential for impacts on adjacent subbasins will be primarily a function of average water levels in Plan Area during the sustainability period, average water levels in adjacent subbasins during the sustainability period, and natural groundwater flow conditions that would be expected to occur at Plan Area boundaries (e.g., pre-development groundwater flow conditions). The average groundwater levels expected for the Plan Area are reflected in the MOs. As indicated in the individual RMS hydrographs in **Appendix 3.A**, the MOs are higher than the MTs. MOs set for the Subbasin are based on Fall 2010 groundwater elevations, which is consistent with proposed Chowchilla Subbasin MOs and generally higher than MOs proposed in Delta Mendota Subbasin and higher than DWR--approved MOs in Kings Subbasin. In addition, gGroundwater model results indicate that the anticipated groundwater levels after 2040 will result in greatly reduced net subsurface inflow to the Plan Area from surrounding subbasins compared to historical net subsurface inflow. Therefore, the projects and management actions implemented for this GSP are expected to benefit adjacent subbasins (compared to historical conditions) and not hinder the ability of adjacent subbasins to be sustainable.

Table 3-2. Summary of Groundwater Level Measurable Objectives for Representative Monitoring Sites.

Well I.D.	Estimated Surface Elevation (msl, feet)	Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation	MO Depth[2] (feet)	MO Elev (msl, feet)	GSA[3]	CASGEM Well?
COM-RMS-1	278	520	210 - 510	4	Lower	210	68	City of Madera	No
COM RMS-2	262	590	370 - 590	5	Lower	212	50	City of Madera	No
COM RMS-4	268	588	433 - 568	4	Lower	221	47	City of Madera	No
MCE RMS-2	378	Unknown	Unknown	3	Upper	261	117	Madera County East	Voluntary
MCE RMS-3	325	Unknown	Unknown	6	Lower	258	67	Madera County East	Voluntary
MCE RMS-5	340	Unknown	Unknown	4	Lower	259	81	Madera County East	Voluntary
MCE RMS-6	328	550	450 - 550	5	Lower	288	40	Madera County East	CASGEM
MCE RMS-9	271	37	17 - 37	1	Upper	12	259	Madera County East	No
MCW RMS-3	162	Unknown	Unknown	6	Lower	88	74	Madera County West	Voluntary
MCW RMS-5	202	30	Unknown	1	Upper	18	184	Madera County West	No
MID RMS-2	218	563	298 - 509	5	Lower	232	-14	Madera Irrigation District	CASGEM
MID RMS-3	241	516	260 - 507	4	Lower	226	15	Madera Irrigation District	CASGEM
MID RMS-4	190	698	320 - 667	5	Lower	224	-34	Madera Irrigation District	CASGEM
MID RMS-5	204	570	270 - 570	5	Lower	185	19	Madera Irrigation District	CASGEM
MID RMS-6	237	680	320 - 680	5	Lower	218	19	Madera Irrigation District	CASGEM
MID RMS-7	237	656	290 - 635	5	Lower	157	80	Madera Irrigation District	CASGEM
MID RMS-10	213	615	315 - 615	5	Lower	149	64	Madera Irrigation District	CASGEM
MID RMS-11	232	315	Unknown	3	Upper	120	112	Madera Irrigation District	CASGEM
MID RMS-12	262	176	Unknown	3	Upper	134	128	Madera Irrigation District	CASGEM
MID RMS-13	271	600	228 - 552	3	Composite	159	112	Madera Irrigation District	CASGEM
MID RMS-15	247	502	160 - 200	2	Upper	96	151	Madera Irrigation District	CASGEM
MID RMS-16	308	452	348 - 388	4	Lower	280	28	Madera Irrigation District	CASGEM
MID RMS-17	224	47	26 - 46	1	Upper	24	200	Madera Irrigation District	No
MSB03B	148	295	215 - 285	3	Upper	79	69	Madera County	No
MSB03C	148	430	355 - 420	4	Lower	132	16	Madera County	No
MSB04B	271	695	530 - 685	4	Lower	213	58	Madera County	No
MSB05A	177	210	140 - 200	3	Upper	100	77	Madera County	No

Well I.D.	Estimated Surface Elevation (msl, feet)	Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation	MO Depth[2] (feet)	MO Elev (msl, feet)	GSA[3]	CASGEM Well?
MSB05B	177	375	240 - 365	4	Lower	134	43	Madera County	No
MSB06A	192	350	135 - 340	3	Upper	124	68	Madera County	No
MSB06C	192	715	630 - 705	5	Lower	129	63	Madera County	No
MSB09C	233	955	880 - 945	5	Lower	130	103	Madera County	No
MSB10C	251	880	790 - 870	5	Lower	255	-4	Madera County	No
MSB11C	306	880	775 - 870	5	Lower	336	-30	Madera County	No
MSB12	350	465	355 - 465	4	Lower	286	64	Madera County	No
MWD RMS-1	330	504	200 - 500	4	Lower	306	24	Madera Water District	CASGEM
MWD RMS-2	310	537	200 - 537	4	Lower	303	7	Madera Water District	CASGEM
MWD RMS-3	295	800	380 - 800	5	Lower	301	-6	Madera Water District	CASGEM

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

The actual MO is based on the groundwater elevation, but the depth to water corresponding to the surface elevation in the project database is also provided.

[2] The actual MO is based on the groundwater elevation, but the depth to water corresponding to the surface elevation in the project database is also provided.

Each GSA is responsible for collecting groundwater levels for the sustainability indicator wells within their GSA area.

[3] Each GSA is responsible for collecting groundwater levels for the sustainability indicator wells within their GSA area.

Ground surface elevation is based on DEM data.

Table 3-3. Summary of Groundwater Level Interim Milestones for Representative Monitoring Sites.

Well I.D.	Aquifer Designation	2025 Depth (feet)	2030 Depth (feet)	2035 Depth (feet)	2025 Elev (msl, feet)	2030 Elev (msl, feet)	2035 Elev (msl, feet)	CASGEM Well?
COM RMS-1	Lower	266	274	274	12	4	4	No
COM RMS-2	Lower	261	264	264	1	-2	-2	No
COM RMS-4	Lower	257	264	265	11	4	3	No
MCE RMS-2	Upper	298	298	294	80	80	84	Voluntary
MCE RMS-3	Lower	323	325	315	2	0	10	Voluntary
MCE RMS-5	Lower	305	307	296	35	33	44	Voluntary
MCE RMS-6	Lower	339	340	329	-11	-12	-1	CASGEM
MCE RMS-9	Upper	12	13	13	259	258	258	No
MCW RMS-3	Lower	158	162	159	4	0	3	Voluntary
MCW RMS-5	Upper	17	18	19	185	184	183	No
MID RMS-2	Lower	310	327	334	-92	-109	-116	CASGEM
MID RMS-3	Lower	308	316	316	-67	-75	-75	CASGEM
MID RMS-4	Lower	273	285	280	-83	-95	-90	CASGEM
MID RMS-5	Lower	260	272	274	-56	-68	-70	CASGEM
MID RMS-6	Lower	296	306	310	-59	-69	-73	CASGEM
MID RMS-7	Lower	208	214	218	29	23	19	CASGEM
MID RMS-10	Lower	185	190	192	28	23	21	CASGEM
MID RMS-11	Upper	164	167	167	68	65	65	CASGEM
MID RMS-12	Upper	194	198	199	68	64	63	CASGEM
MID RMS-13	Composite	194	195	194	77	76	77	CASGEM
MID RMS-15	Upper	124	126	127	123	121	120	CASGEM
MID RMS-16	Lower	361	374	372	-53	-66	-64	CASGEM
MID RMS-17	Upper	23	24	25	201	200	199	No
MSB03B	Upper	94	103	97	54	45	51	No
MSB03C	Lower	149	154	151	-1	-6	-3	No
MSB04B	Lower	301	305	303	-30	-34	-32	No
MSB05A	Upper	134	138	133	43	39	44	No

Well I.D.	Aquifer Designation	2025 Depth (feet)	2030 Depth (feet)	2035 Depth (feet)	2025 Elev (msl, feet)	2030 Elev (msl, feet)	2035 Elev (msl, feet)	CASGEM Well?
MSB05B	Lower	171	175	169	6	2	8	No
MSB06A	Upper	146	154	154	46	38	38	No
MSB06C	Lower	156	161	162	36	31	30	No
MSB09C	Lower	174	178	180	59	55	53	No
MSB10C	Lower	363	374	371	-112	-123	-120	No
MSB11C	Lower	441	458	453	-135	-152	-147	No
MSB12	Lower	332	326	314	18	24	36	No
MWD RMS-1	Lower	356	388	391	-26	-58	-61	CASGEM
MWD RMS-2	Lower	367	393	393	-57	-83	-83	CASGEM
MWD RMS-3	Lower	387	410	409	-92	-115	-114	CASGEM

3.2.2 Reduction in Groundwater Storage

MOs and interim milestones for reduction in groundwater storage are described below.

3.2.2.1 Measurable Objective

There is a direct relationship between groundwater levels and groundwater storage (see Section 3.3 for additional discussion); thus allowing groundwater levels to be used as a proxy for the groundwater storage sustainability indicator in this Joint GSP. Therefore, the MO for reduction in groundwater storage is based on the MOs for chronic lowering of groundwater levels. The MO for reduction in groundwater storage is no long-term reduction in groundwater storage within the Subbasin, during the sustainability period after 2040, which will be represented by the MOs for groundwater levels.

3.2.2.2 Interim Milestones

Groundwater levels are being used as a proxy for groundwater storage; therefore, the interim milestones for reduction in groundwater storage are based on the interim milestones for chronic lowering of groundwater levels.

3.2.2.3 Achieving and Maintaining Sustainability

The combination of interim milestones and MOs reflect how the Subbasin will achieve and maintain sustainability. Since groundwater levels serve as a practical proxy for evaluating reduction in groundwater storage, achieving and maintaining sustainability relative to this indicator is similar to that described above in ~~the groundwater level section~~ Section 3.2.1 on chronic lowering of groundwater levels.

3.2.2.4 Impact of Selected Measurable Objectives on Adjacent Basins

Groundwater model results indicate that the average groundwater levels reflected in the MOs will result in greatly reduced net subsurface inflow to the Plan Area from surrounding subbasins compared to historic net subsurface inflow. This will serve to allow more groundwater to remain in storage in adjacent subbasins. Therefore, the PMAs implemented for this Joint GSP will not hinder the ability of adjacent subbasins to be sustainable with regards to groundwater storage.

3.2.3 Land Subsidence

MOs and IMs for land subsidence are described below.

3.2.3.1 Measurable Objectives

An MO for subsidence of 0.00 feet/year was established with the goal of long-term avoidance of land subsidence. Achieving this MO will take into consideration the level of uncertainty associated with survey measurements. SJRRP has reported that survey measurements have a vertical accuracy of +/-2.5 centimeters (Reclamation, 2011). With two measurements necessary to calculate a rate (before and after), the total uncertainty in the subsidence rate value is 5 centimeters, or approximately -0.16 feet/year. Therefore, a rate of subsidence of less than -0.16 feet/year (values that are less negative) are considered to be within the uncertainty of the measurement and would be considered compliant with the MO of 0.00 feet/year. This is not meant to allow for a continued rate of 0.16 feet/year or less of subsidence in the Subbasin. Rather, this is an acknowledgement that there may be instances where measurement uncertainty will indicate a rate of subsidence greater than the MO. The definition of undesirable results (as described in Section 3.4.3) will govern and, should an IM be exceeded or an undesirable result occur, a subsidence working group committee consisting of technical representatives of each Subbasin GSA as appointed by the Coordination Committee will be formed to define areas of the basin subject to taking additional actions to eliminate subsidence.

Land subsidence has historically not resulted in significant and unreasonable impacts to infrastructure in the Plan Area. Information on historical subsidence in the Subbasin is presented in the hydrogeologic conceptual model (HCM) (Chapter 2). The MO for land subsidence is set recognizing that land subsidence within Subbasin is tied to actions in neighboring subbasins, and the ability to meet this MO is dependent on the successful implementation of PMAs in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are not specifically tied to subsidence thresholds, they are consistent with the objective to limit the potential for continued active future subsidence.

3.2.3.2 Interim Milestones

Interim milestones for land subsidence were established at five-year intervals over the GSP implementation period from 2020 to 2040, at years 2025, 2030, and 2035. Interim milestones were informed by a detailed infrastructure sensitivity assessment (**Appendix 3.G**) and recent interviews with critical infrastructure owners and operators (Section 3.4.3). set recognizing the The established IMs also have capacity to accommodate some residual subsidence that may continue to occur due to historical cycles of lower groundwater levels and subsidence, while and to providinge adequate time for GSAs to implement PMAs. A combination of eightsix survey benchmarks monitored by the US Bureau of Reclamation (USBR) on a semi-annual basis since 2011 as part of the San Joaquin River Restoration Program (SJRRP) and one continuous GPS station monitored daily since 2005 as part of the UNAVCO Plate Boundary Observatory (PBO) project have been selected as part of the land subsidence RMS network. Locations of subsidence RMS are shown in **Figure 3-32** and described in **Table 3-4**.. RMS stations have been separated into two groups for the purpose of establishing interim milestones for land subsidence: stations within the area of greater subsidence concern and stations within the general subsidence monitoring area (i.e., areas of lesser concern). The maximum rate of annual subsidence for each RMS station is presented in Table 3-4.

Table 3-4. Summary of Observed Maximum Rate of Land Subsidence for Representative Monitoring Sites.

RMS ID	Data Source	Period of Record for Available Data
29	SJRRP	2013 to 2023
127	SJRRP	2012 to 2023
1007R	SJRRP	2013 to 2023
141	SJRRP	2012 to 2023
142	SJRRP	2012 to 2023
160R	SJRRP	2012 to 2023
165	SJRRP	2018 to 2023
201R	SJRRP	2018 to 2023
P307	PBO	2005 to 2023

Station ID	Dataset	Time Period	Maximum Annual Rate of Subsidence (feet)	Group
1007R	SJRRP	Dec. 2015 to Dec. 2016	-0.54	Area of Subsidence Concern
29	SJRRP	Dec. 2014 to Dec. 2015	-0.41	Area of Subsidence Concern

127	SJRRP	Dec. 2014 to Dec. 2015	-0.22	Area of Subsidence Concern
160R	SJRRP	Dec. 2014 to Dec. 2015	-0.19	Subsidence Monitoring
P307	PBO	Dec. 2014 to Dec. 2015	-0.19	Subsidence Monitoring
141	SJRRP	Dec. 2011 to Dec. 2012	-0.12	Subsidence Monitoring
142	SJRRP	Dec. 2011 to Dec. 2012	-0.09	Subsidence Monitoring

A detailed Infrastructure Assessment has been conducted and describes critical infrastructure in the Subbasin (e.g., highways, bridges, waterways, wells, etc.) and the historical and potential future impacts from subsidence (**Appendix 3.G**). The infrastructure assessment was based on a combination of review and assessment of discussions with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, input received by various GSA representatives from individual stakeholders, review of historical subsidence, and meetings with all technical representatives from all GSAs in the Subbasin regarding existing and potential impacts of subsidence across the Subbasin on critical infrastructure (e.g., waterways, wells). In addition, in 2024, GSP consultants conducted interviews with critical infrastructure owners and operators to better understand subsidence concerns and how the potential for future subsidence may be accounted for in agency maintenance and/or future design of critical infrastructure within the Subbasin. The results of this infrastructure assessment indicated a certain amount of tolerance for some impacts (e.g., growers willing to accept costs for some replacement wells to account for agricultural well collapse), a neutral to beneficial impact from subsidence on some impacts (e.g., southwest flowing waterways where channel gradients steepened, thereby increasing flow capacity), and/or a degree of planning/design to accommodate future subsidence (e.g., 2.5 to 5 feet of additional subsidence are planned for by SJRRP). While the GSAs recognize the importance of reducing the rates of active subsidence across the Subbasin immediately, it should be recognized that residual subsidence will occur regardless of future actions due to the lag time associated with historical low groundwater elevations (see Section 2.2.2.4.3 for more detailed discussion of residual subsidence).

Based on the updated Infrastructure Assessment, it has been determined that the maximum allowable additional cumulative subsidence within the Subbasin should be set at two feet between now (December 2023) and January 2040 in order to be further protective of critical infrastructure. This amount of tolerable cumulative subsidence is less than the 2.5 to 5 feet of additional subsidence in the planning criteria for the SJRRP and two feet is consistent with the tolerable additional subsidence proposed in the recent Public Draft GSP for adjacent Delta Mendota Subbasin. IMs were established for additional cumulative subsidence between now (December 2023) and January 2025, and at five-year intervals for 2025 to 2030, 2030 to 2035, and 2035 to 2040 to ensure a ramp down to the zero subsidence MO by 2040 (**Table 3-5**). An IM for average annual rate of subsidence has also been set for each five-year interval in order to evaluate annual progress toward meeting the cumulative subsidence IMs.

Review of critical infrastructure and historical subsidence impacts indicates there is likely greater tolerance for additional subsidence in the southern portion of the Subbasin compared to the central/northern portions of the Subbasin based on the generally lower amounts of historical subsidence along the San Joaquin River. However, it has been determined that the maximum allowable additional cumulative subsidence in all areas of the subbasin should be set at two feet between now (December 2023) and January 2040. As described above, IMs were also established for five-year intervals through 2040 to ensure a ramp down , along with an average annual rate of subsidence for each five-year interval in order to evaluate annual progress toward meeting the cumulative subsidence IMs. As described in Section 4.9.5, if rates of subsidence exceed the IMs, this will trigger additional management actions by the GSAs to achieve sustainability.

Table 3-5. Summary of Land Subsidence Interim Milestones.

5-Year Interval Ending at Year	Maximum Average Annual Rate of Subsidence (feet)	Maximum 5-Year Cumulative Subsidence (feet)
2025		1.5[73]
2030	0.2	1.0
2035	0.1	0.5
2040	0.05	0.25

The nine RMS stations identified in **Table 3-4** will be reviewed on an annual basis to track progress towards IMs. Achievement of these IMs will take into consideration the level of uncertainty associated with survey measurements (+/- 0.16 feet/year as described in Section 3.2.3.1, assuming two measurements per year). However, this uncertainty is not intended to allow for up to 0.16 feet of subsidence per year on an ongoing basis, but rather that an amount of subsidence within this range for a given year should be considered as potentially within the uncertainty of that year's measurements.

The IMs for land subsidence are set recognizing that land subsidence within the Subbasin is influenced by actions in neighboring subbasins; thus, ability to meet these IMs is also influenced by the successful implementation of PMAs in neighboring subbasins.

The GSAs will continue to prioritize implementation of PMAs, to the extent feasible, in those areas of the Subbasin where subsidence rates have historically been greatest to ensure that sustainable groundwater conditions are reached by 2040. Ultimately, progress toward achieving IMs for the most constraining sustainability indicator will govern the determination of whether the Subbasin is on track toward achieving sustainability. Progress toward implementation of projects and management actions will be reported in Annual Reports.

~~Within each group, the initial land subsidence interim milestone for 2025 was set at a rate slightly higher than what has been observed between 2011 and 2016. The subsequent interim milestones have reduced subsidence rates as PMAs are implemented to address groundwater levels and subsidence.~~

~~The area of greater subsidence concern includes SJRRP Benchmark Survey points within the area of the Subbasin where higher rates of subsidence have been recently observed, identified in **Section 2.2.2.4**. The interim milestones for the area of subsidence concern are defined as:~~

~~2025: -0.60 feet/year~~

~~2030: -0.40 feet/year~~

~~2035: -0.20 feet/year~~

~~2040: 0.00 feet/year~~

[73] A cumulative total of up to 1.0 feet of subsidence has already occurred in some portions of the subbasin between December 2019 and December 2023 (see **Appendix 3.H**). Therefore, the maximum allowable cumulative subsidence of 1.5 feet as of December 2024 requires annual subsidence in 2024 to be less than 0.5 feet. Subsequent years after 2024 have significantly lower allowable annual rates of subsidence.

~~The area of subsidence monitoring includes SJRRP Benchmark Survey points and a UNAVCO PBO continuous GPS station within the area of the Subbasin where subsidence has not been historically observed (or at very low rates). The interim milestones for the area of subsidence are defined as:~~

~~2025: -0.20 feet/year~~

~~2030: -0.13 feet/year~~

~~2035: -0.07 feet/year~~

~~2040: 0.00 feet/year~~

~~The interim milestones for land subsidence are set recognizing that land subsidence within Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is dependent on the successful implementation of PMAs in neighboring subbasins.~~

3.2.3.3. Achieving and Maintaining Sustainability

The combination of IMs and the MO reflect how the Subbasin will achieve and maintain sustainability. The land subsidence IMs and MO are set at values reflecting gradual reductions in the rate of subsidence over the Implementation Period with the intent of limiting future active subsidence and achieving a long-term rate of zero subsidence by 2040.~~anticipates achieving and maintaining sustainability.~~ The ~~interim milestones~~IMs and MO for land subsidence are set recognizing that land subsidence within the Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is dependent on the successful implementation of PMAs in neighboring subbasins.

3.2.4 Degraded Water Quality

Varied levels of particular constituents within the groundwater exist and affect water quality considerations throughout the Plan Area. In some cases, the levels of certain constituents have raised water quality concerns for the use of groundwater for drinking or for irrigated agriculture (Chapter 2 and **Appendix 3.B**). Effects on groundwater dependent ecosystems (GDEs) due to degraded water quality can result in visually detectable declines in the health of terrestrial vegetation. However, available data do not provide evidence of any such effects in the Plan Area (**Appendix 2.B**). Elevated concentrations of naturally occurring and existing constituent concentrations resulting from historical land use practices are present in certain areas of the Plan Area. As noted in Chapter~~Section~~ 2 ~~(HCM)~~, elevated concentrations of nitrate are present in some wells in the Plan Area, and trends in these wells may be increasing with time. Continued increases in these concentrations may occur due to historic nitrogen loading in the unsaturated zone independent of any GSP activities. The planned PMAs are not intended to remediate or halt these trends of increasing concentrations; however, they also are not anticipated to exacerbate these trends and conditions. Rather, over the long term, the GSP anticipates that achieving sustainability will actually help the Plan Area's interested parties meet water quality objectives. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Plan Area; therefore, groundwater quality degradation is considered significant and unreasonable based on adverse impacts to this beneficial use. The GSAs intend to implement planned PMAs in manners that do not further exacerbate groundwater quality impacts to beneficial uses.

3.2.4.1 Measurable Objectives

MOs for groundwater quality are established to not exacerbate adverse impacts on all beneficial uses of groundwater resulting from implementation of GSP PMAs. MOs for the groundwater quality sustainability indicator are intended to assure that GSP PMAs do not cause groundwater quality conditions to become unsuitable for any beneficial use, especially municipal and domestic supply uses since these are the most restrictive from a water quality standpoint. The groundwater quality MOs are defined for individual representative groundwater quality indicator wells (RMS) for the key water quality constituents arsenic, nitrate, and TDS based on consideration of existing or historical groundwater quality conditions and the drinking water MCLs for each of the key constituents. These key constituents were selected for assigning of MOs for groundwater quality because they currently exist at elevated concentrations in the Subbasin or reflect a range of potential groundwater quality impacts related to implementation of GSP PMAs and overall groundwater extraction. As discussed in ~~Section~~ Chapter 2 of this Joint GSP, nitrate is the most widespread water quality constituent of concern in the area, occurring at elevated concentrations in groundwater in some areas, mainly as a result of historical and agricultural practices and associated legacy groundwater quality impacts. Because of the widespread association of elevated nitrate concentrations with agricultural fertilization application, MOs for nitrate are also likely to address other groundwater quality impacts associated with agricultural activities, including for much less common groundwater contaminants such as pesticides. The MOs for arsenic and TDS are intended to address additional potential groundwater quality impacts associated with GSP PMAs that may result from lowered groundwater levels in some areas or altered groundwater flow dynamics.

The RMS consist of wells to be monitored by the GSAs along with wells being monitored by the other entities through existing groundwater quality monitoring programs for the Division of Drinking Water (DDW) or Irrigated Lands Regulatory Program (ILRP) and were selected to represent groundwater quality conditions across the Plan Area including in areas of greater domestic and public water supply well density (see **Section 2**). For all groundwater quality RMS, the MO concentrations for arsenic, nitrate, and TDS are set at levels representative of ~~recent~~ baseline concentrations observed in the well with the intent to ensure that activities related to GSP PMAs, and overall groundwater extraction do not significantly adversely impact groundwater quality conditions. C~~Recent c~~oncentrations observed from 2015 to ~~early~~ 2019 (where possible), ~~as well as anticipated continued trends that this period may reflect~~and/or from 2020 to 2023 (where the well was installed since 2019 or sufficient samples were not collected prior to 2020), were used as the basis for setting the MO concentrations. The MO concentrations ~~for wells with existing or historical water quality results~~ are based on the average of ~~the recent concentrations~~at least three baseline sampling events for each of the key constituents rounded up to the nearest full integer of concentration for arsenic (in units of µg/L) and nitrate (in units of mg/L as nitrogen) and rounded up to the nearest interval of 50 mg/L for TDS. MO concentrations for groundwater quality for each sustainability indicator well are summarized in Table 3-6~~5~~, and locations of groundwater quality sustainability indicator wells are shown in **Figure 3-4~~3~~**. Tables and graphs of historical results for key water quality constituents in the representative groundwater quality indicator wells are presented in **Appendix 3.B**.

3.2.4.2 Interim Milestones

The interim milestones for the groundwater quality sustainability indicator are the same as the MOs and include ensuring that during the implementation period, GSP PMAs and overall groundwater extraction do not lead to degradation of existing groundwater quality conditions that would make groundwater unsuitable for the most restrictive beneficial use of municipal and domestic supply. The groundwater quality interim milestones are maintaining existing groundwater quality concentrations for arsenic, nitrate, and TDS at each sustainability indicator well over the implementation period as summarized in Table 3-7~~6~~. Consistent with the MOs, groundwater quality interim milestones also include maintaining existing or historical groundwater quality conditions over the implementation period for wells in which the existing or historical conditions already exceed the MCL. The GSP does not include any plan or milestones specifically intended to improve groundwater quality conditions in wells with existing or historical MCL exceedances.

Table 3-6~~5~~. Summary of Groundwater Quality Measurable Objectives for Representative Monitoring Sites.

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MO Arsenic Concentration (µg/L)	MO Nitrate Concentration (mg/L)	MO TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
Wells Monitored by GSP Entities: Existing									
MCE RMS-3	Unknown	Unknown	Unknown	Composite	8†	8†	400†	GSP Entities	Annual
MID RMS-4	Irrigation	698	320-667	Lower	8†	8†	400†	GSP Entities	Annual
MID RMS-5B	Irrigation	514	245-496	Lower	8†	8†	400†	GSP Entities	Annual
MID RMS-6	Irrigation	680	320-680	Lower	8†	8†	400†	GSP Entities	Annual
MID RMS-7	Irrigation	656	290-635	Lower	8†	8†	400†	GSP Entities	Annual
MID RMS-13	Irrigation	600	228-552	Composite	8†	8†	400†	GSP Entities	Annual
MWD RMS-1	Irrigation	500	200-500	Lower	8†	8†	400†	GSP Entities	Annual
~~MCW RMS-1~~	~~Other~~	~~800~~	~~Unknown~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-4~~	~~Irrigation~~	~~698~~	~~320-667~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-5~~	~~Irrigation~~	~~570~~	~~270-570~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-6~~	~~Irrigation~~	~~680~~	~~320-680~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-7~~	~~Irrigation~~	~~656~~	~~290-635~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-1~~	~~Other~~	~~500~~	~~420-500~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-3~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Composite~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-2~~	~~Irrigation~~	~~216~~	~~205-212~~	~~Upper~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-9~~	~~Unknown~~	~~143~~	~~Unknown~~	~~Upper~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-4~~	~~Irrigation~~	~~580~~	~~220-580~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-13~~	~~Irrigation~~	~~600~~	~~228-552~~	~~Composite~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MWD RMS-1~~	~~Irrigation~~	~~500~~	~~200-500~~	~~Lower~~	~~8†~~	~~8†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
Wells Monitored by GSP Entities: Future Monitoring Wells									
MSB03A	Monitoring	139	74 - 134	Upper	8†	8†	400†	ILRP/GSP Entities	Annual
MSB03B	Monitoring	295	215 - 285	Lower	8†	8†	400†	GSP Entities	Annual
MSB03C	Monitoring	430	355 - 420	Lower	8†	8†	400†	GSP Entities	Annual
MSB04A	Monitoring	375	180 - 365	Upper	8†	8†	400†	ILRP/GSP Entities	Annual
MSB04B	Monitoring	695	530 - 685	Lower	8†	8†	400†	GSP Entities	Annual
MSB04C	Monitoring	905	750 - 895	Lower	8†	8†	400†	GSP Entities	Annual
MSB05A	Monitoring	210	140 - 200	Upper	8†	8†	400†	ILRP/GSP Entities	Annual
MSB05B	Monitoring	375	240 - 365	Lower	8†	8†	400†	GSP Entities	Annual
MSB05C	Monitoring	585	420 - 585	Lower	8†	8†	400†	GSP Entities	Annual
MSB06A	Monitoring	350	135 - 340	Upper	8†	8†	400†	ILRP/GSP Entities	Annual
MSB06B	Monitoring	520	425 - 510	Lower	8†	8†	400†	GSP Entities	Annual
MSB06C	Monitoring	715	630 - 705	Lower	8†	8†	400†	GSP Entities	Annual

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MO Arsenic Concentration (µg/L)	MO Nitrate Concentration (mg/L)	MO TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
MSB09A	Monitoring	320	200 - 310	Upper	8†	8†	400†	ILRP/GSP Entities	Annual
MSB09B	Monitoring	725	520 - 715	Lower	8†	8†	400†	GSP Entities	Annual
MSB09C	Monitoring	955	880 - 945	Lower	8†	8†	400†	GSP Entities	Annual
MSB10B	Monitoring	510	400 - 500	Lower	8†	8†	400†	GSP Entities	Annual
MSB10C	Monitoring	880	790 - 870	Lower	8†	8†	400†	GSP Entities	Annual
MSB11C	Monitoring	880	775 - 870	Lower	8†	8†	400†	GSP Entities	Annual
MSB13A	Monitoring	290	200 - 280	Upper	8†	8†	400†	GSP Entities	Annual
MSB13B	Monitoring	446	396 - 436	Lower	8†	8†	400†	GSP Entities	Annual
MSB13C	Monitoring	532	522 - 532	Lower	8†	8†	400†	GSP Entities	Annual
~~Lavina MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Lavina MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Lavina MW – Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 3 MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 3 MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 3 MW – Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 4 MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 4 MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 4 MW – Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 5 MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 5 MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 5 MW – Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 6 MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 6 MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 6 MW – Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 10 MW – Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 10 MW – Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 10 MW - Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 11 MW - Shallow~~	~~Monitoring~~	~~300*~~	~~100-300*~~	~~Upper~~	~~8‡~~	~~8‡~~	~~400‡~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 11 MW - Middle~~	~~Monitoring~~	~~500*~~	~~300-500*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
~~Site 11 MW - Deep~~	~~Monitoring~~	~~700*~~	~~500-700*~~	~~Lower~~	~~8‡~~	~~8‡~~	~~400‡~~	~~GSP Entities~~	~~Annual~~
Wells Monitored for Other Programs									
2000507-001	Public Supply	Unknown	372-Unknown	Lower	5	3	400	DDW	Variable, according to DDW reqs.
2000553-001	Public Supply	Unknown	450-500	Lower	3	4	250	DDW	
2000682-002	Public Supply	Unknown	295-420	Lower	3	3	400	DDW	

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MO Arsenic Concentration (µg/L)	MO Nitrate Concentration (mg/L)	MO TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
2000727-001	Public Supply	Unknown	280-360	Lower	2	2	250	DDW	
2000938-001	Public Supply	Unknown	420-560	Lower	1	2	150	DDW	
2010002-014	Public Supply	Unknown	280-610	Lower	1	2	200	DDW	
2010002-032	Public Supply	Unknown	310-600	Lower	1	3	250	DDW	
2010008-005	Public Supply	Unknown	250-465	Composite	4	5	300	DDW	
2010009-002	Public Supply	Unknown	324-369	Composite	5	2	150	DDW	
2010010-007	Public Supply	Unknown	242-374	Lower	2	2	400	DDW	
2010801-001	Public Supply	Unknown	375-760	Lower	15	1	400	DDW	
2801077-001	Public Supply	Unknown	60-500	Composite	8†	1	400	DDW	
ESJ12	Domestic	276	160-172	Upper	N/A‡	5	450	ILRP	Annual‡
ESJ17	Domestic	Unknown	Unknown	Unknown	N/A‡	8†‡	400†‡	ILRP	Annual‡

* Construction details and locations for future monitoring wells are estimated; information will be updated upon completion of final site selection and well construction.

1 * Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

† Values will be confirmed and/or adjusted as needed based on results from initial sampling for constituents.

‡ Monitoring for the Irrigated Lands Regulatory Program does not include testing for arsenic; annual monitoring includes nitrate and specific conductance (SC), TDS is tested every five years; SC will be used as proxy for TDS in years in which TDS is not tested.

Table 3-76. Summary of Groundwater Quality Interim Milestones for Representative Monitoring Sites.

Well ID	Aquifer Designation[1]	2025 Arsenic Concentration (µg/L)	2030 Arsenic Concentration (µg/L)	2035 Arsenic Concentration (µg/L)	2040 Arsenic Concentration (µg/L)	2025 Nitrate Concentration (mg/L)	2030 Nitrate Concentration (mg/L)	2035 Nitrate Concentration (mg/L)	2040 Nitrate Concentration (mg/L)	2025 TDS Concentration (mg/L)	2030 TDS Concentration (mg/L)	2035 TDS Concentration (mg/L)	2040 TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
Wells Monitored by GSP Entities: Existing															
MCE RMS-3	Composite	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MID RMS-4	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MID RMS-5B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MID RMS-6	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MID RMS-7	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MID RMS-13	Composite	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MWD RMS-1	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
~~MCW RMS-1~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-4~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-5~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-6~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-7~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-1~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-3~~	~~Composite~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-2~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-9~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-4~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-13~~	~~Composite~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~MWD RMS-1~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
Wells Monitored by GSAs: Future Monitoring Wells															
MSB03A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	ILRP/GSP Entities	Annual
MSB03B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB03C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB04A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	ILRP/GSP Entities	Annual
MSB04B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB04C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB05A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	ILRP/GSP Entities	Annual
MSB05B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB05C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB06A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	ILRP/GSP Entities	Annual

Well ID	Aquifer Designation[1]	2025 Arsenic Concentration (µg/L)	2030 Arsenic Concentration (µg/L)	2035 Arsenic Concentration (µg/L)	2040 Arsenic Concentration (µg/L)	2025 Nitrate Concentration (mg/L)	2030 Nitrate Concentration (mg/L)	2035 Nitrate Concentration (mg/L)	2040 Nitrate Concentration (mg/L)	2025 TDS Concentration (mg/L)	2030 TDS Concentration (mg/L)	2035 TDS Concentration (mg/L)	2040 TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
MSB06B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB06C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB09A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	ILRP/GSP Entities	Annual
MSB09B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB09C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB10B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB10C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB11C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB13A	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB13B	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
MSB13C	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	GSP Entities	Annual
~~Lavina MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Lavina MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Lavina MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 3 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 3 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 3 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 4 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 4 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 4 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 5 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 5 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 5 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 6 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 6 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 6 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 10 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 10 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 10 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
~~Site 11 MW - Shallow~~	~~Upper~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~ILRP/GSP Entities~~	~~Annual~~
~~Site 11 MW - Middle~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~

Well ID	Aquifer Designation[1]	2025 Arsenic Concentration (µg/L)	2030 Arsenic Concentration (µg/L)	2035 Arsenic Concentration (µg/L)	2040 Arsenic Concentration (µg/L)	2025 Nitrate Concentration (mg/L)	2030 Nitrate Concentration (mg/L)	2035 Nitrate Concentration (mg/L)	2040 Nitrate Concentration (mg/L)	2025 TDS Concentration (mg/L)	2030 TDS Concentration (mg/L)	2035 TDS Concentration (mg/L)	2040 TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
~~Site 11 MW - Deep~~	~~Lower~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~8†~~	~~400†~~	~~400†~~	~~400†~~	~~400†~~	~~GSP Entities~~	~~Annual~~
Wells Monitored for Other Programs															
2000507-001	Lower	5	5	5	5	3	3	3	3	400†	400†	400†	400†	DDW	Variable, according to DDW reqs.
2000553-001	Lower	3	3	3	3	4	4	4	4	250	250	250	250	DDW	
2000682-002	Lower	3	3	3	3	3	3	3	3	200	200	200	200	DDW	
2000727-001	Lower	2	2	2	2	2	2	2	2	250	250	250	250	DDW	
2000938-001	Lower	1	1	1	1	2	2	2	2	150	150	150	150	DDW	
2010002-014	Lower	1	1	1	1	2	2	2	2	200	200	200	200	DDW	
2010002-032	Lower	1	1	1	1	3	3	3	3	250	250	250	250	DDW	
2010008-005	Composite	4	4	4	4	5	5	5	5	300	300	300	300	DDW	
2010009-002	Composite	5	5	5	5	2	2	2	2	150	150	150	150	DDW	
2010010-007	Lower	2	2	2	2	2	2	2	2	150	150	150	150	DDW	
2010801-001	Lower	15	15	15	15	1	1	1	1	250	250	250	250	DDW	
2801077-001	Composite	8†	8†	8†	8†	1	1	1	1	400†	400†	400†	400†	DDW	
ESJ12	Upper	N/A‡	N/A‡	N/A‡	N/A‡	5	5	5	5	450	450	450	450	ILRP	Annual‡
ESJ17	Unknown	N/A‡	N/A‡	N/A‡	N/A‡	8†	8†	8†	8†	400†‡	400†‡	400†‡	400†‡	ILRP	Annual‡

~~* Construction details and locations for future monitoring wells are estimated; information will be updated upon completion of final site selection and well construction.~~

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

† Values will be confirmed and/or adjusted as needed based on results from initial sampling for constituents.

‡ Monitoring for the Irrigated Lands Regulatory Program does not include testing for arsenic; annual monitoring includes nitrate and specific conductance (SC), TDS is tested every five years; SC will be used as proxy for TDS in years in which TDS is not tested.

3.2.4.3 Achieving and Maintaining Sustainability

The combination of interim milestones and MOs reflect how the Subbasin will achieve and maintain sustainability by ensuring that GSP PMAs do not significantly and unreasonably degrade groundwater quality conditions or exacerbate already degraded conditions, impacting beneficial uses in the Plan Area. The network of groundwater quality sustainability indicator wells will enable tracking of groundwater quality conditions as they relate to GSP-related activities and activities unrelated to GSP actions. If evaluation of groundwater quality monitoring suggests that GSP PMAs are having adverse impacts on groundwater quality affecting beneficial uses, modifications to the GSP PMAs may be required. Evaluation of monitoring data to distinguish any groundwater quality impacts related to GSP actions or overall groundwater extraction from other impacts or trends that may occur unrelated to GSP implementation, will be conducted on a case-by-case basis considering information and context associated with the impact such as hydrogeologic setting, location relative to GSP projects or management actions and other land use activities, groundwater level fluctuations, historical conditions, and other considerations, to assess the likely source or cause of any exceedances. Such an evaluation would also include consideration of analysis and reporting from other WQ monitoring programs including for ILRP and regulated facilities.

3.2.4.4 Impact of Selected Measurable Objectives on Adjacent Basins

Groundwater quality MOs are set to protect and maintain groundwater quality conditions suitable for all beneficial uses in the Plan Area, including municipal and drinking water supply, and as a result are not anticipated to impact beneficial uses for groundwater in adjacent subbasins.

3.2.5 Depletion of Surface Water

As described in the HCM in Chapter 2 (Plan Area and Basin Setting), regional groundwater levels have generally been below the stream channel bottoms in Plan Area for at least the last several years, and for many decades in most of the Plan Area. Thus, the connection between regional groundwater and streams was broken prior to 2015 along most streams, and the surface water depletion sustainability criteria is not applicable for more of the Plan Area. However, at times when sufficient water is released from Millerton Lake into the San Joaquin River, shallow groundwater levels are observed along the portion of the San Joaquin River adjacent to the southern ~~Madera~~ Subbasin boundary. These shallow groundwater levels indicate the San Joaquin River may sometimes be connected to groundwater, even if the shallow groundwater zone in connection with the San Joaquin River is hydraulically separated from the regional groundwater system. The underlying stratigraphy and hydrogeologic relationships between groundwater in shallow zones along the San Joaquin River and deeper zones where regional pumping occurs are not well understood, and a workplan has been developed to refine and improve the hydrogeologic understanding related to ~~interconnected surface water (~~ISW~~)~~. The ISW workplan is included in **Appendix 3.I**. In the meantime, interim SMC have been developed for ISW along the San Joaquin River.

In addition to the GSAs' workplan described above, since late 2023 and as a result of individual comments received following submission of the 2020 and 2023 revised Joint GSP, representatives from the Madera and Kings Subbasins have been meeting monthly with representatives from the USBR and FWA to better understand their issues and concerns related to ISW along the SJR from Reach 1A to the Mendota Pool, as well as with representatives of the SJRRP. This work has resulted in development of an MOU between the Madera and Kings Subbasins and USBR and FWA. The GSAs also plan to review DWR's ISW guidance documents (released in 2024) and may consider revisions to the current ISW SMC as GSP implementation continues. These activities are described in more detail in Section 4.9.5.

Available data and analyses (see Section 2.2.2.5) indicate that while the San Joaquin River along the southern boundary of thee Madera Subbasin is primarily a losing reach that may be disconnected, it is also sometimes connected to groundwater under certain hydrologic conditions. It is assumed that these conditions constitute interconnected surface water as defined by the GSP regulations and therefore the GSP outlines interim SMC while efforts continue to more fully characterize shallow hydrogeologic conditions along the San Joaquin River prior to making a final determination regarding the presence/absence of interconnected surface water.

For the purposes of establishing interim SMC for ISW along the San Joaquin River, four RMS wells screened in the Upper Aquifer in close proximity to the San Joaquin River were evaluated by comparing modeled groundwater elevations to adjacent stream thalweg elevations (**Figure 3-54** and Table 3-87). It is assumed that when groundwater elevations are at or above the stream thalweg elevation interconnected surface water is present at this location, and when groundwater elevations are below the adjacent stream thalweg elevation that interconnected surface water is not present. The percent of time over a given time period when the groundwater elevations at an RMS well are at or above the stream thalweg elevation is defined as the percent of time ISW exists at that given location. As indicated in Table 3-87, the percent of time connected among the four RMS wells was 73% at MCE RMS-9, 30% at MCW RMS-5, 0% at MID RMS-14, and 100% at MID RMS-17 over the historical time period from 1989 to 2015. MID RMS-14 was eliminated form further consideration as an ISW RMS because it never shows a connection to surface water (i.e., groundwater level always remains below stream thalweg) and the percent connected time of 0% can never be violated (i.e., the MT would never be exceeded).

San Joaquin River Restoration Program began Interim Flow releases from Friant Dam into the San Joaquin River on October 1, 2009. Restoration Flows began on January 1, 2014, but were curtailed in 2014 and 2015 due to drought conditions. Restoration Flows were reinitiated in August 2016 and have continued to present. Table 3-98 presents the allocation of Program Restoration Flows.

While it remains uncertain how/if groundwater pumping from the regional aquifer affects surface water flows in the Plan area, there is at least some potential for the shallow groundwater system supporting GDEs to be affected by regional pumping. If regional pumping depletes shallow groundwater, beneficial uses and users of shallow groundwater could be negatively affected. These include riparian vegetation along the San Joaquin River and the wildlife habitat and ecosystem functions it provides. Special-status species and their habitats are included in the analyses of potential effects on GDE Units presented in **Appendix 2.B**. However, it should be noted relative to historical conditions prior to October 2009 that the additional flows required to remain in the San Joaquin River (and not be diverted for irrigation purposes) for the San Joaquin River Restoration Program (SJRRP) will also serve to provide support for the shallow groundwater system and GDEs associated with the San Joaquin River.

There are three primary options for the metric that can be used as the basis for SMC for interconnected surface water: 1) an amount of surface water depletion; 2) shallow groundwater levels as a proxy; and 3) percent of time that a surface water – groundwater connection exists over a given time period. The metric used needs to be capable of distinguishing that an impact has occurred related to groundwater pumping in the Subbasin. Analyses described in **Section 2.2.2.5** indicate that the amount of surface water seepage is most closely related to hydrologic conditions (i.e., water year type: wet, above normal, below normal, dry, critical) in the Subbasin. Therefore, recognizing the altered flow regime in the San Joaquin River since the SJRRP, using the amount of surface water depletion as the metric for ISW SMC would not be appropriate. Similarly, review of available data indicates that shallow groundwater elevations are also closely tied to hydrologic conditions, including the SJRRP regime of flow releases; therefore, using groundwater levels as a proxy for ISW SMC would also not be appropriate. Accordingly, the most appropriate metric for ISW SMC is percent of time connected as discussed further in **Section 3.2.5.1**.

Table 3-~~8~~7. Comparison of Interconnected Surface Water Representative Monitoring Sites Groundwater Elevations to Stream Thalweg Elevations – Percent of Time Connected.

RMS / Period	Count of Groundwater Elevation Measurements	Count of Groundwater Elevation Measurements that are greater than the Stream Thalweg Elevation	Percent of Time that Groundwater and Surface Water are Connected
MCE RMS-9 (distance to San Joaquin River = 0.13 mi; streambed elevation = 256.22 feet; Model Layer 1)			
1989-2015	324	236	73%
2016-2019	48	48	100%
2020-2039	240	163	68%
2040-2090	612	425	69%
MCW RMS-5 (distance to San Joaquin River = 0.14 mi; streambed elevation = 184.63 feet; Model Layer 1)			
1989-2015	324	98	30%
2016-2019	48	33	69%
2020-2039	240	53	22%
2040-2090	612	217	35%
MID RMS-14 (distance to San Joaquin River = 1.06 mi; streambed elevation = 186.58 feet; Model Layer 2)			
1989-2015	324	0	0%
2016-2019	48	0	0%
2020-2039	240	0	0%
2040-2090	612	0	0%
MID RMS-17 (distance to San Joaquin River = 0.09 mi; streambed elevation = 197.21 feet; Model Layer 1)			
1989-2015	324	324	100%
2016-2019	48	48	100%
2020-2039	240	240	100%
2040-2090	612	612	100%

Table 3-9~~8~~. History of San Joaquin River Restoration Program Restoration Allocations.

Water Year (Type)	Flow Type	Restoration Allocation (TAF)
2009 (AN)	Interim Flows	261.5
2010 (AN)	Interim Flows	98.2
2011 (W)	Interim Flows	152.4
2012 (D)	Interim Flows	183.0
2013 (D)	Interim Flows	65.5
2014 (C)	Restoration Flows	0-1
2015 (C)	Restoration Flows	0
2016 (BN)	Restoration Flows	263.3
2017 (W)	Restoration Flows	556.5
2018 (BN)	Restoration Flows	280.3
2019 (W)	Restoration Flows	556.5
2020 (D)	Restoration Flows	202.2
2021 (C)	Restoration Flows	70.9
2022 (BN)	Restoration Flows	232.5

Source: SJRRP, 2022

3.2.5.1 Measurable Objective

The MO for ISW along the San Joaquin River is to maintain the percent of time the San Joaquin River is connected to shallow groundwater levels equal to or greater than existing and historical conditions at RMS wells screened in the Upper Aquifer in close proximity to the San Joaquin River. The interim MOs are established as the percent of time connected over the historical base period (1989 to 2015), as indicated in Table 3-10~~9~~ for the four RMS wells screened in the Upper Aquifer near the San Joaquin River (**Figure 3-5~~4~~**). However, in terms of the percent of time connected percentages that serve as a baseline for annual comparisons in the future, these MOs may need to be adjusted to reflect an equivalent hydrologic period from the baseline to make a proper comparison to the future five-year rolling average as described below.

In order to create SMC that can be evaluated using this metric on an annual basis, a rolling average for the past five years will be used as the current conditions for percent of time connected. The five-year current rolling average will be compared to the historical base period percent of time connected (i.e., the MOs listed **in Table 3-10~~9~~**) to determine if MOs are being achieved. It should be noted that while the 1989-2015 period is considered to represent long-term average climatic/hydrologic conditions, a given five-year rolling average may or may not represent a period with average climatic/hydrologic conditions. Therefore, an adjustment of the baseline period used for comparison to the current five-year rolling average may be needed. For example, if the last five years included in the rolling average represent drought years, the percent of time connected during the most similar period in the historical base period will be used for comparison.

3.2.5.2 Interim Milestones

Interim Milestones for ISW along the San Joaquin River are the same as the MOs described in Section 3.2.5.1.

Table 3-109. Summary of Interconnected Surface Water Measurable Objectives for Representative Monitoring Sites.

Well I.D.	Surface Elevation	Well Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation	MO[1]	GSA
MCE RMS-9	265.4	38	17-37	1	Upper	73%	Madera County East
MCW RMS-5	197.8	30	Unknown	1	Upper	30%	Madera County West
MID RMS-17	224.9	47	26-46	1	Upper	100%	Madera Irrigation District

[1] The MOs are established as the percent of time connected over the historical base period (1989 to 2015). For comparison to future five-year rolling average, baseline MOs may need to be updated to reflect climatic/hydrologic conditions represented in five-year rolling average.

3.2.5.3 Achieving and Maintaining Sustainability

Sustainability will be achieved and maintained through implementation of projects (e.g., dedicated recharge basins, Flood-MAR) and management actions (e.g., pumping reductions). In addition, implementation of the SJRRP since 2009 has been, and is expected to continue, changing the hydrology along the San Joaquin River. If the SJRRP is implemented as planned, it is expected that more streamflow (than would have been present without the SJRRP) will be present in the San Joaquin River along the southern boundary of- the Madera Subbasin under certain climatic/hydrologic conditions. To the extent that the SJRRP adds more streamflow to the system, it is expected there will be more stream seepage, higher groundwater levels in the shallow zone beneath/adjacent to the San Joaquin River, and an equal or greater percentage of time during which shallow groundwater levels and the San Joaquin River are connected. Thus, the combination of the Madera Subbasin PMAs and the SJRRP are expected to achieve and maintain sustainability relative to ISW during the sustainability period.

3.2.5.4 Impact of Selected Measurable Objectives on Adjacent Basins

Maintaining a similar percent of time connected under sustainable groundwater conditions for the Madera Subbasin is not expected to have any significant impacts on adjacent subbasins. However, if the percent of time connected increases significantly, whether it be through PMAs conducted by the Madera Subbasins GSAs and/or due to other factors such as the SJRRP, it is possible that the downstream Delta-Mendota Subbasin may be affected by higher groundwater levels in the shallow zone.

3.2.6 Seawater Intrusion

The seawater intrusion sustainability criteria are not applicable to Plan Area, because it is located more than 70 miles inland and hydraulically disconnected from the ocean.

3.3 Minimum Thresholds *(23 CCR § 354.28)*

The GSP regulations define undesirable results as occurring when significant and unreasonable effects are caused by groundwater conditions occurring throughout the Plan Area for a given sustainability indicator. Significant and unreasonable effects occur when minimum thresholds (MTs) are exceeded for one or more sustainability indicators. This section describes the following for each sustainability indicator relevant to Plan Area: the methodology used to set the MT and how selected MTs avoid causing undesirable results, relationships to other sustainability indicators, impact on adjacent subbasins, impacts on beneficial use/users, comparison to relevant federal, state, local standards, and the measurement method.

3.3.1 Chronic Lowering of Groundwater Levels

The GSP regulations provide that the "[MTs] for chronic lowering of groundwater levels shall be the groundwater level indicating a depletion of supply at a given location that may lead to undesirable results." (23 CCR § 354.28.c.1) Chronic lowering of groundwater levels in the Subbasin cause significant and unreasonable declines if they are sufficient in magnitude to lower the rate of production of pre-existing groundwater wells below that necessary to meet the minimum required to support overlying beneficial uses and users where alternative means of obtaining sufficient groundwater resources are not technically or financially feasible.

MTs for chronic lowering of groundwater levels were updated in 2022-2023 through an extensive and collaborative coordination process between all seven GSAs in the Subbasin. Coordination efforts have resulted in MTs that are consistent across all four GSPs in the Subbasin. As described below, the MT for groundwater levels is defined as the Fall 2015 groundwater level at each RMS well.[74] This MT maintains groundwater levels generally at or 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.

Groundwater levels in the Subbasin will be managed with consideration of the MTs to ensure the major aquifers in the Subbasin are not depleted in a manner to cause significant and unreasonable impacts to other sustainability indicators. At the same time, the GSAs recognize that while groundwater levels are anticipated to fall below 2015 levels during the GSP implementation period, the implementation of projects and management actions is expected to cause groundwaters to return to historical levels by 2040.

The SMC for chronic lowering of groundwater levels have been designated with these considerations in mind, and with the GSAs' ongoing development of a Domestic Well Mitigation Program, to be implemented as needed during the GSP implementation period, but no later than 2025. Considerations for setting the MTs for chronic lowering of groundwater levels are described further in the sections below.

3.3.1.1 Domestic Well Mitigation Program

The ~~Madera~~ Subbasin GSAs are committed to upholding the Human Right to Water (CWC § 106.3), and are serious in their commitment to sustainably managing groundwater in the Subbasin for all beneficial uses and users, including domestic and municipal well owners.

In their ongoing efforts to uphold these commitments, the GSAs within the Subbasin have proceeded with coordination and focused planning efforts to develop a Domestic Well Mitigation Program (Program), including the development of an MOU (see ~~**Appendices 3.D and**~~**Appendix 3.E**). Analyses developed as part of the initial GSP in January 2020 served as an initial basis for the GSAs' recognition that the Program is needed in the Subbasin to mitigate potential impacts to beneficial uses and users of groundwater during the GSP implementation period (see **Appendix 3.D**). ~~During~~ Since 2022~~-2023~~, the GSAs have met on numerous occasions to discuss, among other aspects, the principles, objectives, roles, responsibilities, and requirements that will guide administration of the Program. ~~All seven GSAs are cooperating in these discussions and development efforts.~~

Once up and running, t~~T~~he Program ~~could~~ will provide assistance to domestic and/or municipal wells adversely impacted by declining groundwater levels since 2015 that interfere with groundwater production or quality, and ~~will~~ is being coordinated with the Madera County SB 552 Drought Plan that is also under development. It is noted that the Program is not intended to mitigate well issues not caused by regional groundwater conditions nor is it intended to resolve issues related to normal wear and tear. Assistance efforts would benefit domestic and municipal well users, including ~~disadvantaged communities~~DACs and underrepresented communities, experiencing adverse impacts as a result of overdraft conditions.

The MC GSA has been awarded $125,000 grant from DWR to assist with Senate Bill 552 (SB 552) compliance. The grant has two main components:~~;~~ (1) installation of a new monitoring well in the Ranchos and (2) facilitation and related services, in connection with the Domestic Well Mitigation Program (Program). This grant is supporting implementation of the Subbasin Program (**Appendix 4.B**). Related to component 2, the MC GSA has contracted with David M. Ceppos to provide neutral, stakeholder

[74] MT is set equal to the Fall 2015 measurement, if this observed data point is available at the RMS. Otherwise, the MT is set equal to the expected Fall 2015 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.

engagement and consultation support to the MC GSA regarding implementation of a Program in the Subbasin with a specific focus on developing rules of said Program. Specific tasks include the following:.

1. Conduct Background Review
2. Conduct Engagement Strategy Discussions
3. Conduct Stakeholder Interviews
4. Design and Conduct Program Public Meetings
5. Project Management

Following development of the MOU Establishing a Domestic Well Mitigation Program for the Subbasin of the San Joaquin Valley Groundwater Basin and execution by 5 of the 7 GSAs within the Subbasin in 2023, this is a critical and necessary step in advancing a well-functioning and Subbasin-wide Program. For purposes of the 2025 Plan Amendment, it is assumed that the facilitation and related services associated with the Program as set-forth above will result in complete development of the Program such that implementation can begin in 2025 as set-forth and agreed upon in the MOU.

As currently envisioned, well owners seeking mitigation would be required to sign up for the Program and a board, committee, or agency staff would review and approve eligible well mitigation claims. It is expected that the Program would will be implemented during the GSP implementation period, as needed, and as described above, no later than in 2025. Program implementation would continue until groundwater sustainability is achieved. After 2040, groundwater levels will stabilize at Fall 2015 historical levels, avoiding undesirable results for groundwater uses and users.

Economic analyses conducted to compare costs of implementing a Domestic Well Mitigation Program versus immediately requiring full implementation of demand reduction in 2020 are provided in **Appendix 3.D**. These analyses found that immediate and substantial cutbacks in groundwater pumping would result in major impacts to the local economy and all Subbasin stakeholders, including domestic well owners, that would be more significant than the costs of implementing a Domestic Well Mitigation Program (**Appendix 3.D**).

As of March 2023, the GSAs are continuing to develop the Program eligibility criteria, terms, and conditions and are preparing to move forward with Program implementation, as needed. The GSAs will continue to coordinate on the basic roles and responsibilities of a Program within the first 5 years of GSP implementation (by 2025), although initiation of the Program will occur pending further analysis and identification of specific needs for Program implementation, but no later than 2025. Additional details about Program development and implementation will be reported in future- Periodic Evaluations and Annual ReportsAnnual Reports and GSP updates.

3.3.1.2 Other Considerations for Setting Minimum Thresholds

The MTs for groundwater levels and overall SMC program for this Joint GSP are also intended to protect against significant and unreasonable impacts to groundwater storage volumes, land subsidence, and some groundwater quality concerns. GDEs were also considered in setting of MTs. The four potential GDE units identified in the Plan Area are dominated by terrestrial vegetation and some wetland vegetation, which is susceptible to adverse impacts (i.e., undesirable results) if underlying groundwater levels experience chronic lowering exceeding historical lows (see **Appendix 2.B**). The development of MTs for chronic lowering of groundwater levels included review of the hydrogeologic conceptual model, climate, current and historical groundwater conditions including groundwater level trends and groundwater quality, land subsidence, and the water budget discussed in previous sections of this Joint GSP.

The MTs for chronic lowering of groundwater levels are based on selection of RMS from among existing production and monitoring wells located throughout the Plan Area and screened in both in the Upper and Lower Aquifers. The selected sustainability indicator wells are listed in Table 3-1110 and shown on **Figure 3-1**. Groundwater level hydrographs showing MTs for each groundwater level RMS are provided in **Appendix 3.A.**

The RMS described in Table 3-10 11 and **Figure 3-1** are in locations that reflect a wide cross section of Plan Area groundwater conditions. These locations are representative of the overall Plan Area conditions because they are spatially distributed throughout the Plan Area both vertically (within the Upper and Lower Aquifers in the Corcoran Clay area) and laterally throughout the Plan Area. The distribution of designated Upper Aquifer wells is limited because the definition of Upper Aquifer used in this study (above the Corcoran Clay where present, and equivalent depth to the east where Corcoran Clay is not present), results in relatively large areas of unsaturated conditions in the Upper Aquifer in the central to eastern portions of the Plan Area. The GSAs have determined that setting the MTs at historical levels will avoid the undesirable results of chronic lowering of groundwater levels by reducing the likelihood that access to adequate water resources for beneficial users within the Plan Area will be compromised.

Table 3-11. Summary of Groundwater Level Minimum Thresholds for Representative Monitoring Sites.

Well ID	Estimated Surface Elevation[3] (msl, feet)	Depth	Screen Top-Bottom (ft)	Model Layer(s)	Aquifer Designation[1]	Reduced Deposits Depth (ft)	MT Depth[2][1] (feet)	MT Elev (msl, feet)	GSA[3][2]	CASGEM Well?	MT Rationale
COM RMS-1	278	520	210 - 510	4	Lower	490	228	50	City of Madera	No	MT based on Model Layer 4 Fall 2015 water level.
COM RMS-2	262	590	370 - 590	5	Lower	600	219	43	City of Madera	No	MT based on Model Layer 5 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
COM RMS-4	268	588	433 - 568	4	Lower	571	244	24	City of Madera	No	MT based on Model Layer 4 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MCE RMS-2	378	Unknown	Unknown	3	Upper	420	263	115	Madera County East	Voluntary	MT based on Model Layer 3 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MCE RMS-3	325	Unknown	Unknown	6	Lower	650	287	38	Madera County East	Voluntary	MT based on Model Layer 6 Fall 2015 water level.
MCE RMS-5	340	Unknown	Unknown	4	Lower	600	271	69	Madera County East	Voluntary	MT based on Model Layer 4 Fall 2015 water level.
MCE RMS-6	328	550	450 - 550	5	Lower	600	309	19	Madera County East	CASGEM	MT based on observed Fall 2015 drought water level.
MCE RMS-9	265	37	17 - 37	1	Upper	NA	13	258	Madera County East	No	MT based on observed Fall 2015 drought water level.
MCW RMS-3	162	Unknown	Unknown	6	Lower	NA	97	65	Madera County West	Voluntary	MT based on Model Layer 6 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MCW RMS-5	197	30	Unknown	1	Upper	NA	20	182	Madera County West	No	MT based on observed Fall 2015 drought water level.
MID RMS-2	218	563	298 - 509	5	Lower	600	283	-65	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-3	241	516	260 - 507	4	Lower	420	273	-32	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-4	190	698	320 - 667	5	Lower	NA	254	-64	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-5	204	570	270 - 570	5	Lower	NA	230	-26	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-6	237	680	320 - 680	5	Lower	600	264	-27	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-7	237	656	290 - 635	5	Lower	NA	188	49	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-10	213	615	315 - 615	5	Lower	NA	171	42	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-11	232	315	Unknown	3	Upper	NA	143	89	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-12	262	176	Unknown	3	Upper	550	164	98	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-13	271	600	228 - 552	3	Composite	525	178	93	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-15	247	502	160 - 200	2	Upper	NA	117	130	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-16	308	452	348 - 388	4	Lower	600	316	-8	Madera Irrigation District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-17	224	47	26 - 46	1	Upper	NA	26	198	Madera Irrigation District	No	MT based on observed Fall 2015 drought water level.
MSB03B	148	295	215 - 285	3	Upper	NA	96	52	Madera County	No	MT based on Model Layer 3 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB03C	148	430	355 - 420	4	Lower	NA	143	5	Madera County	No	MT based on Model Layer 4 Fall 2015 water level with offset to account for difference between simulated and observed water levels.

Well ID	Estimated Surface Elevation[3] (msl, feet)	Depth	Screen Top-Bottom (ft)	Model Layer(s)	Aquifer Designation[1]	Reduced Deposits Depth (ft)	MT Depth[2] (feet)	MT Elev (msl, feet)	GSA[3]	CASGEM Well?	MT Rationale
MSB04B	271	695	530 - 685	4	Lower	NA	242	29	Madera County	No	MT based on Model Layer 4 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB05A	177	210	140 - 200	3	Upper	NA	114	63	Madera County	No	MT based on Model Layer 3 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB05B	177	375	240 - 365	4	Lower	NA	151	26	Madera County	No	MT based on Model Layer 4 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB06A	192	350	135 - 340	3	Upper	NA	141	51	Madera County	No	MT based on Model Layer 3 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB06C	192	715	630 - 705	5	Lower	NA	144	48	Madera County	No	MT based on Model Layer 5 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB09C	233	955	880 - 945	5	Lower	680	154	79	Madera County	No	MT based on Model Layer 5 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MSB10C	251	880	790 - 870	5	Lower	760	313	-62	Madera County	No	MT based on Model Layer 5 Fall 2015 water level.
MSB11C	306	880	775 - 870	5	Lower	320	385	-79	Madera County	No	MT based on Model Layer 5 Fall 2015 water level.
MSB12	350	465	355 - 465	4	Lower	400	313	37	Madera County	No	MT based on Model Layer 4 Fall 2015 water level with offset to account for difference between simulated and observed water levels.
MWD RMS-1	330	504	200 - 500	4	Lower	450	344	-14	Madera Water District	CASGEM	MT based on observed Fall 2015 drought water level.
MWD RMS-2	310	537	200 - 537	4	Lower	450	347	-37	Madera Water District	CASGEM	MT based on Model Layer 4 Fall 2015 water level.
MWD RMS-3	295	800	380 - 800	5	Lower	450	351	-56	Madera Water District	CASGEM	MT based on observed Fall 2015 drought water level.
MID RMS-1	308	950	320-942	4	Lower	475	331	-23	MID	CASGEM	Observed WL data limited but tracks Model Layer 4 ranging from about 15-20 above/below modeled WLs. MT accounts for offset below modeled WLs; MO based on Model Layer 4 average.
MID RMS-2	218	563	298-509	4	Lower	600	283	-65	MID	CASGEM	Observed WL data limited but tracks Model Layer 4. MO based on Model Layer 4 average.
MID RMS-3	241	516	260-507	4	Lower	420	273	-32	MID	CASGEM	Observed WL data generally track modeled WL, ranging up to about 30 feet above/ below modeled WLs. MT accounts for 30 feet of offset. MO based on Model Layer 4 average.
MCW RMS-1	169	800	Unknown	4	Lower	NA	139	30	Madera County West	CASGEM	Observed WL data limited but tracks Model Layer 4. MO based on Model Layer 4 average.
MID RMS-4	190	698	320-667	5	Lower	NA	254	-64	MID	CASGEM	Observed WL data limited but tracks Model Layer 5 (review possible anomalous data point). MT assumes possible anomalous data point is valid measurement (if not, MT is at Elev. -110 instead of -150). MO based on Mode Layer 5 average.
MID RMS-5	204	570	270-570	5	Lower	NA	231	-27	MID	CASGEM	Observed WL data tracks well with Model Layer 5 WL. MO based on Model Layer 5 average.
MID RMS-6	237	680	320-680	4,5	Lower	600	264	-27	MID	CASGEM	Observed WL tracks in between Model Layers 4 and 5. MO based on Model Layer 4 and 5 average.
MID RMS-7	237	656	290-635	4	Lower	NA	187	50	MID	CASGEM	Observed WL data tracks Model Layer 4. MO based on Model Layer 4 average.
MCE RMS-1	332	500	420-500	4	Lower	600	306	26	Madera County East	Voluntary	Observed WL limited but track Model Layer 4. Low observed level is about 10 feet below Model Layer 4. MT accounts for observed offset; MO based on Model Layer 4 average.
MID RMS-8	287	Unknown	Unknown	2,3,4	Composite	500	257	30	MID	CASGEM	Observed WL spans Model Layers 2, 3, 4. MT/MO based on Model Layer 4.
MCE RMS-2	378	Unknown	Unknown	3,4,5	Composite	420	273	105	Madera County East	Voluntary	Observed WL data span Model Layers 3, 4, 5. MO based on Model Layer 4 average.
MCE RMS-3	325	Unknown	Unknown	2,3,4	Composite	650	318	7	Madera County East	Voluntary	Observed WL spans Model Layers 2, 3, 4. MT/MO based on Model Layer 4.
MCE RMS-4	404	Unknown	Unknown	4	Lower	450	260	144	Madera County East	Voluntary	Observed WL data tracks Model Layer 4. MO based on Model Layer 4 average.

Well ID	Estimated Surface Elevation[3] (msl, feet)	Depth	Screen Top-Bottom (ft)	Model Layer(s)	Aquifer Designation[1]	Reduced Deposits Depth (ft)	MT Depth[21] (feet)	MT Elev (msl, feet)	GSA[32]	CASGEM Well?	MT Rationale
MCW RMS-2	173	216	205-212	3	Upper	NA	139	34	Madera County West	CASGEM	Observed WL data tracks about 20-50 feet below Model Layer 3. MT accounts for maximum offset. MO set 35 feet below Model Layer 3 average.
MCW RMS-3	162	Unknown	Unknown	2,3	Upper	NA	107	55	Madera County West	Voluntary	Observed WL data limited but tracks between Model Layers 2 and 3. MO based on average of Model Layers 2 and 3.
MID RMS-9	202	144	Unknown	3	Upper	NA	144	58	MID	Voluntary	Observed WL data track about 20 feet below Model Layer 3 WLs. MT/MO account for offset.
MID RMS-10	213	615	315-615	4,5	Lower	NA	171	42	MID	CASGEM	Observed WL data limited but tracks Model Layers 4 and 5. MO based on average of Model Layers 4 and 5.
MCW RMS-4	208	580	220-580	3,4	Lower	NA	141	67	Madera County East	CASGEM	Observed WL data limited but tracks Model Layers 3 and 4 (with exception of one data point about 20 feet below modeled WLs). MO based on Model Layer 3 and 4 average.
MID RMS-11	232	Unknown	Unknown	3	Upper	NA	143	89	MID	CASGEM	Observed WL data track Model Layer 3 WLs well. MO based on Model Layer 3 average.
MID RMS-12	262	176	Unknown	3	Upper	550	164	98	MID	CASGEM	Observed WL data track Model Layer 3 WLs well. MO based on Model Layer 3 average.
MID RMS-13	271	600	228-552	3,4	Composite	525	178	93	MID	CASGEM	Observed WL data limited but tracks Model Layer 3 and 4 WLs. MO based on Model Layer 3 average.
MCE RMS-5	340	Unknown	Unknown	4	Lower	600	302	38	Madera County East	Voluntary	Observed WL data track Model Layer 4 WLs. MO based on Model Layer 4 average.
MID RMS-14	214	Unknown	Unknown	2	Upper	NA	99	115	MID	CASGEM	Observed WL data track Model Layer 2 WLs. MO based on Model Layer 2 average.
COM RMS-1	278	520	210-510	4	Lower	490	241	37	City of Madera	No	Observed WL data track Model Layer 4 WLs, with up to 20 feet of offset. MT accounts for offset and additional buffer (20 feet) needed to cover IP anticipated low WL. MO based on Model Layer 4 average.
COM RMS-2	262	590	370-590	4,5	Lower	600	226	36	City of Madera	No	Observed WL data tracks Model Layers 4 and 5. MO based on average of Model Layers 4 and 5.
COM RMS-3	264	620	310-600	4,5	Lower	700	254	10	City of Madera	No	Observed WL data tracks Model Layers 4 and 5. MO based on average of Model Layers 4 and 5.
MWD RMS-1	330	500	200-500	4	Lower	450	360	-30	Madera WD	CASGEM	Observed water levels range up to 20 feet below modeled water levels for Model Layer 4. MT accounts for offset plus additional buffer (35 feet) needed to account for anticipated IP low WL. MO is set at 20 feet below Model Layer 4 average.
MWD RMS-2	310	537	200-537	4	Lower	450	347	-37	Madera WD	CASGEM	Observed water levels range up to 40 feet below modeled water levels for Model Layer 4. MT accounts for offset plus additional buffer (20 feet) needed to account for anticipated IP low WL. MO is set at 20 feet below Model Layer 4 average (offset ranges from 0 to 40 feet).
MWD RMS-3	295	800	380-800	4,5	Lower	450	355	-60	Madera WD	CASGEM	Observed WLs limited but track between Model Layers 4 and 5. MT includes additional buffer (50 feet) to account for anticipated IP low. MO is based on Model Layers 4 and 5 average.
MID RMS-15	247	502	160-200	2,3	Upper	NA	117	130	MID	CASGEM	Observed WL data limited, but tracks Model Layer 2. MO based on Model Layer 2 average.
MCE RMS-6	328	550	450-550	5	Lower	600	308	20	Madera County East	CASGEM	Observed WL data limited, but tracks Model Layer 5. MO based on Model Layer 5 average.
MID RMS-16	308	452	348-388	4	Lower	600	318	-10	MID	CASGEM	Observed WLs range up to 25 feet below Model Layer 4 WLs. MT accounts for offset plus additional buffer (40 feet) to account for anticipated IP low WL. MO is set 15 feet below Model Layer 4 average (offset ranges from 0 to 25 feet).
MCE RMS-7	388	840	370-820	4,5,6	Lower	600	302	86	Madera County East	CASGEM	Observed WLs range across Model Layers 4, 5, and 6 (and up to 10 feet below Layer 6 WLs), over which the well is screened. MT accounts for 10 feet offset from Layer 6. MO based on average of Model Layers 4, 5, and 6.
MCE RMS-8	367	92	32-92	1,2	Upper	NA	33	334	Madera County East	CASGEM	Observed WLs are consistently below Model Layer 1 and fluctuate above and below Model Layer 2 WLs. MT is based on Model Layer 2 and offsets from observed data.
MCE RMS-9	265	37	17-37	1	Upper	NA	13	252	Madera County East	No	Observed WLs are about 5 feet below Model Layer 1 water levels. MT is based on 2012 to 2015 drought and observed water level trends, and accounts for offset of observed from modeled water levels.
MID RMS-17	224	47	27-47	1	Upper	NA	26	198	MID	No	Observed WLs are about 7-8 feet above Model Layer 1 water levels. MT is based on 2012 to 2015 drought and observed water level trends, and accounts for offset of observed from modeled water levels.

Well ID	Estimated Surface Elevation[3] (msl, feet)	Depth	Screen Top-Bottom (ft)	Model Layer(s)	Aquifer Designation[1]	Reduced Deposits Depth (ft)	MT Depth[21] (feet)	MT Elev (msl, feet)	GSA[32]	CASGEM Well?	MT Rationale
MCW RMS-5	197	30	Unknown	1	Upper	NA	21	178	Madera County West	No	Observed WLs are about 5 feet below Model Layer 1 water levels. MT is based on 2012 to 2015 drought and observed water level trends, and accounts for offset of observed from modeled water levels.

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.
[2] The actual proposed MT is based on the groundwater elevation, but the depth to water corresponding to the surface elevation in the project database is also provided.
[3] Each GSA is responsible for collecting groundwater levels for representative monitoring sites within their GSA area.
1 The actual proposed MT is based on the groundwater elevation, but the depth to water corresponding to the surface elevation in the project database is also provided.
2 Each GSA is responsible for collecting groundwater levels for representative monitoring sites within their GSA area.
3 Ground surface elevation is based on DEM data.

3.3.1.3 Methodology

The methodology to develop MTs for groundwater levels was based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, individual public/stakeholder input to various GSA representatives, meetings with GSA technical experts for other Subbasin GSPs, and meetings with DWR.[75] The methodology also considers the approach taken to establish MTs in the Merced Subbasin revised GSP, which was approved by DWR. Stakeholder input has included substantial verbal and written comments from representatives of ~~disadvantaged communities~~DACs, which has been meaningfully considered in development of this GSP.[76] There were several steps involved with determination of groundwater level MTs as follows:

- Review available wells with regard to several variables/criteria (e.g., is well in CASGEM program, known well construction details, preference for wells with relatively long history of observed water levels, availability of recent water level data, good spatial distribution) and select appropriate representative monitoring sites;
- For each selected representative monitoring site, review/evaluate the fluctuation of observed vs. modeled historical groundwater levels;
- Set the groundwater level MT equal to the Fall 2015 measurement, if this observed data point is available at a given RMS;
- If no Fall 2015 groundwater level measurement is available, utilize groundwater model results to determine the expected Fall 2015 groundwater level, with adjustments up or down to account for offset between historical observed and modeled data, if necessary.

Groundwater level MTs set by this methodology were reviewed relative to other sustainability indicator MTs, and it was determined that no further groundwater level MT adjustments were needed.

Example hydrographs showing the steps in determining MTs based on available Fall 2015 groundwater level measurements are provided in **Figures 3-6~~5~~ and 3-7~~6~~**. The hydrographs for Representative Monitoring Sites MCE RMS-6 (**Figure 3-6a**) and MID RMS-12 (**Figure 3-6b**) ~~MCE RMS-6 (**Figure 3-5a**) and MCW~~ MID ~~RMS-1~~24 ~~(**Figure 3-5b**)~~ demonstrate the MT determination based on observed Fall 2015 data. In these cases, groundwater model results are not needed and MTs are set based on observed data. Example hydrographs illustrating additional MT determination steps related to use of groundwater model results are provided in **Figure 3-7~~6~~**.~~-~~ The hydrographs for Representative Monitoring Sites MSB-03B and MSB-09C ~~MCE~~~~MSB-03B RMS-5 and MID RMS-14~~~~MSB-09C~~ demonstrate application of the groundwater model to help determine MTs when Fall 2015 observed data are not available (**Figure 3-7~~6~~**). The consideration of offset of observed vs. modeled data (also demonstrated in **Figure 3-7~~6~~a** for ~~MCE RMS-5~~RMS MSB-03B) is intended to reflect cases where observed data are either consistently above or below modeled water levels, or situations where observed water levels occasionally spike below seasonal low modeled water levels. An example of using model results with no offset necessary to set the MT is provided for RMS MSB-09C in **Figure 3-7b**. Overall, the purpose of adjusting for differences between

---

[75] During initial GSP development, a meeting was held on May 1, 2019 in DWR offices in Fresno between GSA representatives and DWR staff, including Amanda Peisch-Derby, Chris Olvera, Chris Montoya, and Dane Mathis. During the GSP revisions process, GSA representatives met with DWR staff two (2) times: on November 10, 2022 (to discuss coordination among GSAs and across GSPs) and on December 8, 2022 (to discuss deficiencies related to groundwater levels, subsidence, and interconnected surface water).

[76] Communications received from representatives of ~~disadvantaged communities~~DACs included a letter dated June 27, 2019 from the Leadership Council.

observed and modeled data is to obtain the most representative value for the expected Fall 2015 measurement had it been collected. (**Figure 3-6b**).

The GSAs are developing a Domestic Well Mitigation Program to address potential declines in groundwater levels during the implementation period, as needed, while PMAs are being implemented to achieve sustainability by 2040. The Domestic Well Mitigation Program and the MOU are discussed in Section 3.3.1.1.

It should be noted that groundwater level MTs (and MOs) were set based on Fall groundwater levels, which are more protective of domestic wells than using Spring groundwater levels.

3.3.1.4 Relationship to Other Sustainability Indicators

Groundwater elevation MTs can influence other sustainability indicators. The groundwater elevation MTs were set to avoid undesirable results for other sustainability indicators as evaluated and described below.

1. Reduction in groundwater storage. A significant and unreasonable condition for change in groundwater storage is pumping groundwater in excess of the sustainable yield for an extended period of years during the Ssustainability Pperiod. Pumping at or less than the sustainable yield will maintain or raise average groundwater elevations in the Plan area. The groundwater elevation MTs are set at Fall 2015 groundwater elevations, consistent with avoiding long-term declines in groundwater storage. Therefore, management of the Subbasin according to the groundwater elevation MTs established for this GSP will not result in significant or unreasonable long-term change in groundwater storage.the groundwater elevation MTs established for this GSP will not result in long term significant or unreasonable change in groundwater storage.

2. Subsidence. A significant and unreasonable condition for land subsidence is measurable permanent (inelastic) subsidence that significantly damages existing infrastructure. Inelastic subsidence is caused by reduction in pore pressure and compaction of clay-rich sediments in response to declining groundwater levels. There have been small amounts of land surface elevation fluctuation/subsidence that have been recorded across the Plan area; however, these levels of recent historical fluctuation/subsidence have not yet resulted in any known significant impacts to infrastructure. Nonetheless, a A rate of 0.00 feet/year zero MT for subsidence has been set for the Subbasin to avoid potential future active subsidence impacts as well. The groundwater level MT set equal to Fall 2015 groundwater levels is consistent with the subsidence MT established for the Subbasin. Additional information on potential impacts related to subsidence and their evaluation is described below:

    a. A detailed infrastructure assessment was completed in coordination with owners and operators of infrastructure that describes critical infrastructure in the Subbasin (e.g., highways, bridges, waterways, wells, etc.) and the historical and potential future impacts from subsidence. This is described in greater detail in Section 3.2.3.2 and **Appendix 3.G**.

    b. The potential impact of establishment of the groundwater level SMC on subsidence can be estimated from use of the IWFM subsidence package that was recently incorporated into the MCSim Model update (**Appendix 6.D**). The relatively good calibration of the updated MCSim Model to recent active subsidence since 2012 allows for model estimation of the active subsidence component that may occur at the established groundwater level IMs, which is estimated to be within the tolerance specified to avoid undesirable results. This is described in greater detail in Section 3.2.1.3.2.

2.3. Degraded water quality. Protecting groundwater quality is critically important to all who depend upon the groundwater resource, particularly drinking water and agricultural uses. A significant and unreasonable condition of degraded water quality is exceeding regulatory limits for constituents of concern in wells due to actions proposed in the GSP. Water quality could be affected through three processes:

a. Low groundwater elevations in an area could cause deeper, poor-quality groundwater to flow upward (e.g., arsenic) or downward (e.g., nitrate) into existing wells. Groundwater elevation MTs are based on historical Fall 2015 levels and generally set well above depths to reduced sediments that may provide poorer quality water with respect to naturally occurring constituents (e.g., arsenic), thereby minimizing opportunities for poor quality groundwater flowing into wells. To the extent that temporary declines during the GSP implementation period may exceed MT and increase risk of poor quality groundwater flowing into wells, additional discussion is provided in Section 3.2.1.3.1~~result in domestic wells previously below the arsenic MCL to be above the MCL as a direct result of declining groundwater levels after 2020, a proposed Domestic Well Mitigation Program would help to address this issue (**Appendices 3.D and 3.E**). Therefore, the combination of the groundwater elevation MTs and Domestic Well Mitigation Program will avoid poor-quality water (resulting directly from GSP actions) from impacting existing wells.~~

b. Changes in groundwater elevation as a result of PMAs or overall groundwater extraction implemented to achieve sustainability could change groundwater gradients, which could cause poor quality groundwater (i.e., contaminant plumes) from documented contaminant sites to flow towards wells that would not have otherwise been impacted. These groundwater gradients, however, are dependent on differences between groundwater elevations, not in the groundwater elevations themselves. Therefore, the MT for groundwater elevations do not directly lead to significant and unreasonable degradation of groundwater quality in wells. Although distributed areas of degraded groundwater quality from non-point source contamination exist in the Plan area (most notably elevated nitrate concentrations), there are no current documented large-scale contaminant plumes of concern in the regional groundwater aquifers. Smaller localized and shallow contaminant site plumes have been documented in parts of the Plan area, although these contaminants are generally restricted to very shallow depths above the regional aquifer system. RWQCB files for existing and potential new documented contaminant site plumes will be reviewed every five years for potential changes in contaminant movement that may be related to GSP PMAs, and adaptive management implemented as necessary.

c. GSP PMAs include a number of recharge basins and Flood MAR programs that will recharge surface water available in wet years through the vadose zone (unsaturated zone about the regional water table) to the water table. Such PMAs have the potential to flush existing constituents of concern (i.e., TDS, nitrates) from the vadose zone to the water table. While such flushing has been occurring and will continue to occur naturally (e.g., via rainfall recharge, excess irrigation recharge) without such GSP PMAs, it may be the case that GSP PMAs temporarily increase the rate of vadose zone flushing and result in temporarily higher constituent concentrations in groundwater prior to eventual dilution (due to recharge of higher quality water) and a reduction in these constituent concentrations. Overall, it is anticipated that there will likely be an overall net benefit to groundwater quality from GSP PMAs; however, the overall groundwater monitoring program developed for this GSP plus additional site-specific monitoring if determined to be needed (e.g., additional groundwater or potentially soil sampling), will be utilized to evaluate need for adaptive management related to GSP recharge projects.

4. Depletion of interconnected surface waters. The assessment of surface water flows and groundwater levels indicate that there are likely time periods with interconnected surface waters in the Plan area. Interim sustainable management criteria for ISW have been established for the San Joaquin River based on the percent of time historical groundwater elevations at key Upper Aquifer RMS wells near the San Joaquin River reflect direct connection between groundwater and the San Joaquin River. The interim MT for interconnected surface water require that the future percent of time with connected between surface water and shallow groundwater be maintained. Therefore, the MT for interconnected surface water is consistent with the groundwater elevation MTs being equal to historical Fall 2015 groundwater elevations.

It is worth noting that, under SGMA, the six sustainability indicators are separate and independent metrics used to evaluate subbasin conditions relative to sustainability as defined by SMC. For sustainability indicators that are interdependent and influence one another (such as those described above), the most restrictive SMC will govern for determining if undesirable results have occurred.

3.3.1.5 Impact of Selected Minimum Thresholds to Adjacent Basins

The potential for impacts on adjacent subbasins will primarily be a function of average water levels in the Plan area during the sustainability period, average water level in adjacent subbasins during the sustainability period, and natural groundwater flow conditions that would be expected to occur along subbasin boundaries (e.g., pre-development groundwater flow conditions). The average groundwater levels expected for the Plan Area are reflected in the MOs. Therefore, the impact to adjacent subbasins is primarily described ~~in more detail~~ under the section on MOs. With regard to MTs, the Subbasin set MTs at Fall 2015 groundwater levels, which is consistent with proposed groundwater level MTs in Chowchilla and Delta Mendota Subbasins. The Kings Subbasin was approved by DWR with groundwater level MTs lower than Fall 2015 groundwater levels. Thus, the- Subbasin MTs are consistent with or beneficial to adjacent subbasins and will not hinder their ability to achieve their own MTs.

3.3.1.6 Minimum Thresholds Impact on Beneficial Uses and Users

Groundwater level MTs are likely to have several effects on beneficial uses, users, land use, and property owners. Those expected to be impacted include agricultural land use and users, urban land use and users, domestic land use and users, and ecological land use and users. Overall agricultural land use and users will be significantly impacted in terms of increased costs to design and construct recharge projects and in terms of reduced crop yields from required reductions in consumptive use for irrigation. While conversion of current agricultural lands to urban areas that may occur in the future will tend to reduce per acre water demands, it is likely that urban water users will need to continue water conservation efforts due to limited water supplies. Domestic well owners may experience declining groundwater levels during the initial 10 to 15 years of the GSP implementation period, followed by stabilization of water levels during the latter portion of the GSP implementation period and recovery to historical Fall 2015 groundwater levels after 2040. However, potential adverse impacts to domestic and municipal wells from declining groundwater levels are expected to be addressed through a Domestic Well Mitigation Program that will be implemented during the GSP implementation period, ~~as needed~~as described in **Section 3.3.1.1** (see **Appendi**x~~**ces**~~ ~~**3.D and**~~ **3.E**), ~~but~~ beginning no later than 2025. ~~The economic analyses conducted to~~

~~compare costs of implementing a Domestic Well Mitigation Program versus immediately requiring full implementation of demand reduction in 2020 are provided in **Appendix 3.D**.~~

Potential ecological impacts are limited to small areas along the eastern and southern margins of the Plan Area, related to groundwater levels in the shallowest aquifer within the upper 50 feet of sediments. The Fresno River Riparian, Friant Riparian, and San Joaquin River Riparian potential GDE units are composed of vegetation which may access shallow groundwater within approximately 30 feet of the surface. The Sumner Hill potential GDE Unit includes open water wetland as well as emergent wetland vegetation and riparian vegetation which also depend in part on shallow groundwater within approximately 30 feet of the surface. The potential for impacts in each GDE unit is summarized as follows:

- Fresno River Riparian potential GDE Unit – There are no shallow groundwater wells in the vicinity of this GDE unit and thus measured no data representing baseline or projected future shallow groundwater levels. Review of the model data indicates that estimated future groundwater levels are within a similar range as historical groundwater levels. ~~Shallow groundwater levels in this GDE unit are represented by well MCE RMS-8 (see Figure 6 in **Appendix 2.B**).~~ Its susceptibility to impacts related to groundwater management is considered low because current and future groundwater conditions are projected to be within the baseline range (i.e., not exceeding historical lows from 1989-2015) and because pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying this GDE unit.

- Friant Riparian potential GDE Unit – There are no shallow groundwater wells in the vicinity of this GDE unit and thus measured no data representing baseline or projected future shallow groundwater levels. Review of the model data indicates that estimated future groundwater levels are within a similar range as historical groundwater levels. The susceptibility of this GDE unit to impacts related to groundwater management is considered low because pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying the GDE unit and because shallow groundwater levels in this unit are largely dependent on and expected to be maintained by releases from Friant Dam and restoration flows in the San Joaquin River under the SJRRP.

- San Joaquin River Riparian potential GDE Unit – Shallow groundwater levels in this GDE unit are represented by wells MCE RMS-9 (Figure 9 in **Appendix 2.B**), MID RMS-17 (Figure 10 in **Appendix 2.B**), and MCW RMS-5 (Figure 11 in **Appendix 2.B**). Although the perched/mounded shallow groundwater associated with this unit has a potential connection with the regional aquifer and could be affected by groundwater pumping, current and projected future trends in depth to water indicate stable groundwater conditions in the unit within the historical baseline range (i.e., not exceeding historical lows from 1989-2015). These stable trends persist for current and projected conditions with deeper pumping occurring within the regional aquifer. This suggests that this GDE unit's susceptibility to impacts related to groundwater management is low.

- Sumner Hill potential GDE Unit – There are no shallow groundwater wells in the vicinity of this GDE unit (likely because geologic maps suggest minimal unconsolidated alluvium beneath this GDE) and thus no data representing baseline or projected future shallow groundwater levels. The susceptibility of this GDE unit to impacts related to groundwater management is considered low because this GDE unit appears to essentially lie directly on top of bedrock and pumping in the main groundwater basin aquifers is unlikely to impact water levels underlying the GDE unit.

Overall, sustainable groundwater management in the Subbasin is expected to maintain the health and resiliency of the vegetation communities composing the potential GDE units and adverse impacts are not expected.

3.3.1.7 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

There are no Federal, State (except SGMA), or local standards that exist for chronic lowering of groundwater levels.

3.3.1.8 Minimum Thresholds Measurement Method

Groundwater level MTs will be directly measured for existing and new monitoring wells. The groundwater level monitoring will be conducted in accordance with the monitoring plan and protocols outlined in Section 3.5. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the SGMA regulations. As noted in Section 3.5, the current groundwater monitoring network includes 11 wells in the Upper Aquifer and 22 wells in the Lower Aquifer (plus four additional composite wells). Since initial GSP development, the GSAs in the Madera Subbasin applied for and were awarded a Proposition 1 grant from DWR to install 21 new monitoring wells at seven sites and a Proposition 68 grant from DWR to install six four new monitoring wells at two sites in the Subbasin, among other efforts. The new nested monitoring wells were successfully installed in 2019-2020 (for Prop 1) and in 2022 (for Prop 68) and are expected to behave been incorporated into the monitoring network once sufficient data is collected.

3.3.2 Reduction in Groundwater Storage

The cause of Subbasin groundwater conditions that would result in significant and unreasonable reduction in groundwater storage is excessive overall annual average groundwater pumping and other outflows from the Subbasin that exceed average annual inflows. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable reduction in groundwater storage occurs when there is: 1) Long term reduction in groundwater storage during the sustainability period (i.e., after 2040), or 2) Interference with other sustainability indicators.

3.3.2.1 Methodology

The methodology to develop MTs for reduction in groundwater storage was based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives, and a meeting with DWR.

The selected methodology of using groundwater levels as a proxy involves field measurement of groundwater levels in the RMS monitoring well network and comparison to established groundwater level MTs. To the extent that groundwater levels are collectively (on average) maintained above MTs, groundwater storage would be considered not to exceed its MT. A key benefit of this approach is that it is the simplest and most direct approach to ensuring that groundwater storage MTs align with groundwater level MTs. In addition, groundwater levels are the fundamental underlying field data required to implement any method of quantifying groundwater storage.

Given that the MT is no long-term reduction in groundwater storage during the sustainability period, Pperiodic Eevaluations of changes in groundwater storage will be conducted after 2040. Annual reporting will involve evaluation and comparison of groundwater levels over a period of average climatic conditions that occurs within the sustainability period after 2040. Groundwater level contour maps will be developed for the beginning and ending year of the analysis period (of average climatic conditions) and the beginning year contour map is then "subtracted" from the ending year contour map. If the net result of this process is essentially no change in levels/storage or a net positive gain in levels/storage, then there is no long-term reduction in groundwater storage. If there is a significant net negative change in groundwater levels/storage, then there may be a reduction in groundwater storage. This method evaluates changes in groundwater storage and most specifically addresses the concept of a reduction in groundwater storage. It should be noted that this calculation relies on contouring groundwater levels using RMS that will not provide coverage of the entire Subbasin such as would be important for a total Subbasin-wide groundwater storage calculation. However, this calculation is not as reliant upon accurate assumptions for key variables (e.g., specific yield, depth of fresh water, area of calculation) as a total Subbasin groundwater storage calculation. Rather, the main purpose is to determine the representative relative change in storage for the Subbasin and the spatial distribution of RMS should be adequate for that purpose.

The groundwater storage reduction metric will be evaluated using groundwater levels as a proxy in conjunction with annual evaluations of long-term groundwater level changes over average climatic periods during the sustainability period. Based on considerations applied in developing the groundwater level MTs, reduction in groundwater storage MTs do not exceed any identified significant and unreasonable level of depleted groundwater storage volume.

3.3.2.2 Relationship to Other Sustainability Indicators

The representative monitoring sites described in Table 3-110 and **Figure 3-1** are in locations that reflect a wide cross section of Plan Area groundwater conditions. These locations are representative of the overall Plan Area conditions because they are spatially distributed throughout the Plan Area both vertically (across the Upper and Lower Aquifer) and spatially. The distribution of Upper Aquifer wells is limited because the definition of Upper Aquifer used in this study (above the Corcoran Clay where present, and equivalent depth to the east of where Corcoran Clay is present), results in relatively large areas of unsaturated Upper Aquifer in the central to eastern portions of the Plan Area. The GSAs have determined that use of the groundwater level MTs at each of the listed wells will help avoid the undesirable result of reduction in groundwater storage because it will minimize the chance that access to adequate water resources for beneficial users within the Plan Area will be compromised.

The reduction in groundwater storage MT can influence other sustainability indicators.

- Chronic Lowering of Groundwater Levels. Because groundwater elevation will essentially be used as a proxy for estimating changes in groundwater storage, the reduction in groundwater storage would not cause undesirable results for this sustainability indicator.
- Subsidence. Because future average groundwater levels will be stable under the reduction in groundwater storage MT, they will not induce subsidence.
- Degraded water quality. The MT proxy of stable groundwater levels for reduction in groundwater storage will not directly lead to a degradation of groundwater quality.
- Depletion of interconnected surface waters. The assessment of surface water flows and groundwater levels indicate that there are not interconnected surface water bodies in most of the Plan Area. ~~Therefore, there are no current MTs or undesirable results that could be affected by the reduction in groundwater storage MT.~~ The potential for reduction in groundwater storage to impact to potentially interconnected surface water along the San Joaquin River and GDE areas is covered under chronic lowering of groundwater levels.

3.3.2.3 Impact of Selected Minimum Thresholds to Adjacent Basins

A MT that does not allow for reduction in groundwater storage during the sustainability period will not have negative impacts on adjacent subbasins. A MT for reduction in groundwater storage tied to evaluation of changes in groundwater storage over a long-term period with average climatic conditions during the sustainability period will be protective of adjacent subbasins.

3.3.2.4 Minimum Thresholds Impact on Beneficial Uses and Users

The reduction in groundwater storage MT is maintaining stable average groundwater elevations during the sustainability period and will require some amount of reduction in groundwater pumping in the Plan Area. Reduced pumping may impact beneficial uses and users of groundwater in the Plan Area. Those expected to be most impacted by pumping reductions are agricultural land use and users. In general, agricultural land use/users will be negatively impacted by pumping reductions since it is their pumping that will be reduced, while other users may benefit from agricultural pumping reductions. Most domestic well pumping is considered de minimis and will not be subject to pumping reductions. These impacts will be similar to those described above for chronic lowering of groundwater levels. Beneficial uses and users will also be impacted during the implementation period by gradual increases in required groundwater pumping reductions over the time period from 2020 to 2040.

3.3.2.5 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

There are no Federal, State, or local standards that exist for reduction in groundwater storage.

3.3.2.6 Minimum Thresholds Measurement Method

The MTs for groundwater storage reduction are based on groundwater levels being measured for the groundwater level MT methodology. The representative wells use the groundwater level MTs for avoidance of reduction in groundwater storage.

3.3.3 Land Subsidence

The cause of Subbasin groundwater conditions that would result in significant and unreasonable land subsidence is excessive overall average annual groundwater pumping and other outflows from the Subbasin that exceed average annual inflows. Locally defined significant and unreasonable conditions were determined based on discussions with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable land subsidence would result in significant impacts to infrastructure.

The MT for land subsidence was updated in 2022-2023 through an extensive and collaborative coordination process between all seven GSAs in the Subbasin. Coordination efforts have resulted in MTs that are consistent across all four GSPs in the Subbasin. As described below, the MT for land subsidence is 0 feet/year (subject to uncertainty of +/-0.16 feet/year). With no subsidence after 2040, there are no anticipated undesirable results of land subsidence during the sustainability period after 2040.

3.3.3.1 Methodology

The MT for land subsidence was selected to prevent undesirable results. ~~Within the Subbasin, W~~While an increased rate of subsidence has been observed in recent years in some areas of the Subbasin, no significant impacts to infrastructure have been noted to date in the Plan Area. As discussed in Section 2.2.2.4.3 of this GSP, some amount of subsidence is assumed to be occurring and will likely occur for some time into the future. Given the lack of historical undesirable results experienced in the Subbasin and the results of the Infrastructure Assessment (which included coordination with owners and operators of critical infrastructure that may be impacted by subsidence, see Section 3.2.3.2) combined with the expectation of some future subsidence that is already occurring due to past cycles of lower groundwater levels and land subsidence, interim milestones were set to manage cumulative subsidence during GSP implementation. Interim milestones for subsidence are described in Section 3.2.3.2 of this GSP.

The land subsidence MT is set at a rate of 0.00 feet/year. However, compliance with this threshold will take into consideration the level of uncertainty associated with survey measurements. SJRRP has reported that survey measurements have a vertical accuracy of +/-2.5 centimeters (Reclamation, 2011). With two measurements necessary to calculate a rate (before and after), the total uncertainty in the subsidence rate value is 5 centimeters, or approximately -0.16 feet/year. Therefore, a rate of subsidence of less than -0.16 feet/year (values that are less negative) are considered to be within the uncertainty of the measurement and would be considered compliant with the MT of 0.00 feet/year. This is not meant to allow for a continued rate of 0.16 feet/year or less of subsidence in the Subbasin. Rather, this is an acknowledgement that there may be instances where measurement uncertainty will indicate a rate of subsidence greater than the MT. The definition of undesirable results (as described in Section 3.4.3) will govern and exceedances of the undesirable result will trigger further management actions within the Subbasin.

The MT for land subsidence is set recognizing that land subsidence within the Subbasin is tied to actions in neighboring subbasins, and the ability to meet these interim milestones is influenced by ~~dependent on~~ the successful implementation of ~~project and management actions~~PMAs in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are a separate sustainability indicator and are not specifically tied to subsidence thresholds, they are consistent with the objective to limit the potential for continued active ~~future~~ subsidence.

The ~~This~~ MT may require modification in the future if subsidence continues to be seen approaching the end of the 20-year GSP implementation period.

3.3.3.2 Relationship to Other Sustainability Indicators

Although there are potential relationships between land subsidence and other sustainability indicators, setting of a MT of 0.00 feet/year for land subsidence does not conflict with other sustainability indicators and associated MTs. It should also be noted that while land subsidence MTs and MOs are not specifically tied to groundwater levels, PMAs to halt declines, stabilize, and possibly raise groundwater levels will limit the potential for continued active ~~future~~ subsidence along with serving to prevent chronic lowering of groundwater levels.

3.3.3.3 Impact of Selected Minimum Thresholds to Adjacent Basins

The MT for land subsidence is set to prevent significant and unreasonable impacts to infrastructure, and are therefore not likely to impact adjacent subbasins or their ability to achieve sustainability.

3.3.3.4 Minimum Thresholds Impact on Beneficial Uses and Users

Given that no significant impacts to infrastructure have been noted to date in the Plan Area, MTs set to prevent any future impacts will not have any impacts on beneficial uses or users.

3.3.3.5 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

There are no Federal, State, or local standards that exist for land subsidence.

3.3.3.6 Minimum Thresholds Measurement Method

Subsidence will continue to be monitored twice a year at SJRRP survey benchmarks by the UBSR and daily at the continuous GPS station by UNAVCO. Subsidence MTs will be evaluated on an annual (December to December) basis.

3.3.3.7 Other Considerations for Setting Minimum Thresholds

Infrastructure Sensitivity Assessment

As part of the initial Joint GSP development, t~~T~~he GSAs completed an infrastructure assessment to evaluate the characteristics of critical infrastructure in the Subbasin, including its proximity, orientation, and relative vulnerability to adverse effects of land subsidence and areas where it has occurred or is occurring. The assessment is documented in **Appendix 3.G.** and the results of this assessment were considered during development of SMC in the Subbasin with the goal of protecting this critical infrastructure from experiencing significant adverse impacts.~~has been used to inform development of SMC in the Subbasin with the goal of protecting this critical infrastructure from undesirable results of groundwater conditions during GSP implementation. Given the subsidence MT of 0 feet/year, there are no anticipated undesirable results to critical infrastructure during the planning and implementation horizon.~~

In 2024, critical infrastructure, the potential impacts of land subsidence, and the extent to which they are considered significant and unreasonable were re-evaluated by the GSAs with input from interested stakeholders and members of the public. Owners and operators with critical infrastructure in the Subbasin were interviewed in Summer 2024 to confirm identification of their critical infrastructure, further document observed and possible impacts attributable to land subsidence, and assess the potential future impacts of land subsidence. See Section 3.4.3 for more information.

Proposed Subsidence Control Measures

The GSAs in the Subbasin are analyzing the potential to couple their GSP PMAs and implementation efforts with provisions that complement and are consistent with the Subsidence Control Measures Agreement (Agreement) that is currently in effect in parts of the Chowchilla Subbasin near the Subbasin boundary. The reduction in subsidence rates seen in the western portion of the Chowchilla Subbasin since 2017 is attributed, in part, to successful implementation of the Agreement (see Chowchilla Subbasin revised GSP, Section 3.3.3).

The Agreement was initially executed in 2017 between certain landowners in the Western Management Area of the Chowchilla Subbasin, the Central California Irrigation District, ~~and~~ San Luis Canal Company, and Henry Miller Reclamation District. Among other goals, the Agreement is intended to reduce groundwater pumping from the Lower Aquifer. Loss of groundwater storage and associated reduction in pore pressures in clay layers in the Lower Aquifer (indicated by lowering groundwater levels) is understood by all parties to lead to conditions that cause and/or exacerbate land subsidence. The relationship between loss of groundwater storage and associated reduction in pore pressures in clay layers, lowering groundwater levels, and land subsidence is a central and common point of understanding between all parties who signed the Agreement, including the Expert Panel established under the Agreement. Under the Agreement, parties in the Chowchilla Subbasin are required, among other provisions, to restrict the amount of groundwater they pump from the Lower Aquifer and to report, under penalty of perjury, the amounts of groundwater pumped, the source of that groundwater (Upper Aquifer or Lower Aquifer), the amounts recharged, the amounts of surface water used for irrigation, and other information about their irrigated acreage and crops. Parties in the Chowchilla Subbasin are also required to implement projects that increase use of surface water for irrigation (providing in-lieu recharge benefits to the Lower Aquifer) and increase use of surface water for direct recharge (increasing storage in the Upper Aquifer to support sustainable use of groundwater from the Upper Aquifer instead of the Lower Aquifer). The initial Agreement was in effect from 2017-2021, and the parties ~~are currently~~have ~~working~~ worked under ~~a one-year~~ short-term extensions in the time since the original Agreement.~~through 2022 with the goal of signing a new five-year extension in 2023.~~

In the ~~Madera~~ Subbasin, GSAs are considering PMAs and policies that similarly:

- Increase the use of surface water for irrigation (providing in-lieu recharge benefits to the Lower Aquifer),
- Increase the use of surface water for direct recharge (increasing storage in the Upper Aquifer to support sustainable use of groundwater from the Upper Aquifer instead of the Lower Aquifer),
- Potentially restrict the amount of groundwater they pump from the Lower Aquifer, encouraging conjunctive use of groundwater recharge from the Upper Aquifer.

For example, the GSAs are developing groundwater recharge projects that will enhance groundwater storage in the Upper Aquifer. For projects that will require agreements with participating landowners, the GSAs are considering provisions that only permit the recovery of project groundwater recharge benefits from wells in the Upper Aquifer, where the recharge from the projects will be occurring. These provisions will effectively reduce groundwater extraction from the Lower Aquifer and shift extraction to the Upper Aquifer, similar to the Agreement, and are anticipated to reduce subsidence rates in areas where the projects occur. While development of these groundwater recharge projects is ongoing, the GSAs will continue to coordinate and review the progress and subsidence mitigation benefits of the Agreement in areas along the northwestern boundary of the Subbasin. These findings will be used to inform development of Lower Aquifer groundwater pumping restrictions or other efforts to mitigate subsidence in the Subbasin.

As an example of the recharge projects described above and recent progress, as of early 2024, the Madera County GSA has developed recharge credit policies (Madera County GSA Resolution No. 2024-030[77]) that credit recharge benefits to the allocation of areas where recharge occurred. Madera County GSA Resolution No. 2024-030 includes two policies: one related to recharge with surface water that is purchased, and one related to recharge with water derived from an approved diversion during a flood event. Both policies have a “floor” of a 75% recharge credit and a "ceiling" of 90% recharge credit depending on data specific to the land on which the recharge occurred.

Of specific importance in both policies is term 5. Term 5 was intentionally included such that extraction of the recharge credit shall be limited to the aquifer in which recharge water was percolated. Recognizing the presence of the Corcoran Clay in the Subbasin and subsidence resulting from the extraction of groundwater from below the Corcoran Clay, this is a critically important provision to avoid the proliferation of subsidence in areas where recharge takes place. If recharge took place in the upper aquifer where the Corcoran Clay is present, extraction too must occur in the upper aquifer. Additionally, both policies state that as of January 1, 2025, any well that has been screened both above and below the defined Corcoran Clad layer shall be considered to be extracting from below the Corcoran Clay.

Limitations on groundwater pumping from the Lower Aquifer may also be achieved through well permitting provisions in response to Executive Order N-7-22 or by other means determined by the GSAs.

[77] For more details the full Madera County GSA Resolution No. 2024-030 can be found online at: https://www.maderacountywater.com/wp-content/uploads/2024/03/RES-NO.-2024-030.pdf

~~Based on the results of the "Projected, With Projects" water budget scenario modeled in MCSim~~[78]~~, it is expected that shifts in pumping practices, paired with implementation of the planned PMAs, will help to achieve sustainable groundwater conditions in the Subbasin.~~ Updates and outcomes of other subsidence mitigation measures will be reported in future Periodic Evaluations and Annual Reports~~GSP updates and Annual Reports~~. Together, landowners and GSAs are making consistent efforts to achieve and maintain groundwater sustainability in the Subbasin.

3.3.4 Degraded Water Quality

The cause of subbasin groundwater conditions that would result in significant and unreasonable degraded water quality is implementation of a GSP project or management action that causes concentrations of key groundwater quality constituents to increase to concentrations exceeding the MTs, which are set at the MCLs for drinking water for identified key constituents (10 mg/L for nitrate as nitrogen; 500 mg/L for TDS; 10 µg/L for arsenic) or when existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent. Although distributed areas of degraded groundwater quality from non-point source contamination exist in the Plan Area (most notably elevated nitrate concentrations), there are no current documented large-scale contaminant plumes in the regional groundwater aquifers. Smaller more localized and shallow contaminant site plumes have been documented in parts of the Plan Area, most notably in the vicinity of the City of Madera, although these contaminants are generally restricted to depths above the regional aquifer system. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Plan Area; therefore, groundwater quality degradation resulting from a GSP project or management action or overall groundwater extraction is considered significant and unreasonable based on adverse impacts to this beneficial use. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, and input received from interested stakeholders and the public through public meetings and through individual stakeholder input to various GSA representatives. Significant and unreasonable degradation of water quality occurs when beneficial uses for groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs for one of the key constituents (nitrate, arsenic, TDS) previously identified in Chapter 2 (Plan Area and Basin Setting) of the GSP at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action or overall groundwater extraction. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent.

Adverse impacts related to groundwater quality could include additional costs being imposed on municipal or domestic well owners for water treatment, a decrease in water available for certain beneficial uses (e.g., irrigation water supply), or need for remediation -systems for control of contaminant plumes. A potential scenario of adverse groundwater quality impacts related to municipal and domestic wells could include increases in nitrate concentrations from ongoing agricultural and wastewater treatment and disposal activities in the subbasin from below to above the MCL, thereby requiring treatment, blending, and/or deeper well drilling to provide for drinking water supply. In addition, ongoing land surface activities combined with additional long-term -groundwater level declines may result in TDS increases that create aesthetic (e.g., taste) concerns for -drinking water supplies that require municipal

~~[78] See **Appendix 6.D**, Section 3.3.5.2. In the MCSim projected model, pumping specifications in certain areas were shifted such that approximately 90 percent of groundwater pumping was simulated from the Upper Aquifer and approximately 10 was simulated from the Lower Aquifer. These shifts were made to mitigate for potential subsidence impacts.~~

and/or domestic well owners to purchase bottled water. Excessive increases in TDS may also impact the suitability of irrigation water supplies for certain crops. Similarly, unmitigated and ongoing groundwater level declines could lead to increasing arsenic concentrations that require use of bottled -water. Another adverse scenario could involve excessive groundwater pumping in an area near a contaminant plume that requires major modifications to a remediation system to maintain control of the plume. The development of groundwater quality SMC in this GSP are intended to avoid or minimize the types of scenarios described above.

The MTs for degraded water quality apply to RMS selected from among existing and ~~proposed future wells~~production and monitoring located throughout the Plan Area and screened in ~~both in~~ the Upper Aquifer, and Lower Aquifer~~s~~, and Undifferentiated Aquifer. The RMS for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Plan Area GSAs together with wells that are sampled by others as part of other groundwater quality monitoring programs. The selected RMS for groundwater quality are listed in Table 3-12~~1~~ and shown on **Figure 3-4~~3~~**.

Table 3-12~~1~~. Summary of Groundwater Quality Minimum Thresholds for Representative Monitoring Sites.

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MT Arsenic Concentration (µg/L)	MT Nitrate Concentration (mg/L)	MT TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
Wells Monitored by GSP Entities: Existing									
MCE RMS-3	Unknown	Unknown	Unknown	Composite	10†	10†	500†	GSP Entities	Annual
MID RMS-4	Irrigation	698	320-667	Lower	10†	10†	500†	GSP Entities	Annual
MID RMS-5B	Irrigation	514	245-496	Lower	10†	10†	500†	GSP Entities	Annual
MID RMS-6	Irrigation	680	320-680	Lower	10†	10†	500†	GSP Entities	Annual
MID RMS-7	Irrigation	656	290-635	Lower	10†	10†	500†	GSP Entities	Annual
MID RMS-13	Irrigation	600	228-552	Composite	10†	10†	500†	GSP Entities	Annual
MWD RMS-1	Irrigation	500	200-500	Lower	10†	10†	500†	GSP Entities	Annual
~~MCW RMS-1~~	~~Other~~	~~800~~	~~Unknown~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-4~~	~~Irrigation~~	~~698~~	~~320-667~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-5~~	~~Irrigation~~	~~570~~	~~270-570~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-6~~	~~Irrigation~~	~~680~~	~~320-680~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-7~~	~~Irrigation~~	~~656~~	~~290-635~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-1~~	~~Other~~	~~500~~	~~420-500~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MCE RMS-3~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Composite~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-2~~	~~Irrigation~~	~~216~~	~~205-212~~	~~Upper~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-9~~	~~Unknown~~	~~143~~	~~Unknown~~	~~Upper~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MCW RMS-4~~	~~Irrigation~~	~~580~~	~~220-580~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MID RMS-13~~	~~Irrigation~~	~~600~~	~~228-552~~	~~Composite~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
~~MWD RMS-1~~	~~Irrigation~~	~~500~~	~~200-500~~	~~Lower~~	~~10†~~	~~10†~~	~~500†~~	~~GSP Entities~~	~~Annual~~
Wells Monitored by GSP Entities: Future Monitoring Wells									
MSB03A	Monitoring	139	74 - 134	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
MSB03B	Monitoring	295	215 - 285	Lower	10†	10†	500†	GSP Entities	Annual
MSB03C	Monitoring	430	355 - 420	Lower	10†	10†	500†	GSP Entities	Annual
MSB04A	Monitoring	375	180 - 365	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
MSB04B	Monitoring	695	530 - 685	Lower	10†	10†	500†	GSP Entities	Annual
MSB04C	Monitoring	905	750 - 895	Lower	10†	10†	500†	GSP Entities	Annual
MSB05A	Monitoring	210	140 - 200	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
MSB05B	Monitoring	375	240 - 365	Lower	10†	10†	500†	GSP Entities	Annual
MSB05C	Monitoring	585	420 - 585	Lower	10†	10†	500†	GSP Entities	Annual
MSB06A	Monitoring	350	135 - 340	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
MSB06B	Monitoring	520	425 - 510	Lower	10†	10†	500†	GSP Entities	Annual
MSB06C	Monitoring	715	630 - 705	Lower	10†	10†	500†	GSP Entities	Annual
MSB09A	Monitoring	320	200 - 310	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
MSB09B	Monitoring	725	520 - 715	Lower	10†	10†	500†	GSP Entities	Annual
MSB09C	Monitoring	955	880 - 945	Lower	10†	10†	500†	GSP Entities	Annual

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MT Arsenic Concentration (µg/L)	MT Nitrate Concentration (mg/L)	MT TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
MSB10B	Monitoring	510	400 - 500	Lower	10†	10†	500†	GSP Entities	Annual
MSB10C	Monitoring	880	790 - 870	Lower	10†	10†	500†	GSP Entities	Annual
MSB11C	Monitoring	880	775 - 870	Lower	10†	10†	500†	GSP Entities	Annual
MSB13A	Monitoring	290	200 - 280	Upper	10†	10†	500†	GSP Entities	Annual
MSB13B	Monitoring	446	396 - 436	Lower	10†	10†	500†	GSP Entities	Annual
MSB13C	Monitoring	532	522 - 532	Lower	10†	10†	500†	GSP Entities	Annual
Lavina MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Lavina MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Lavina MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 3 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Site 3 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 3 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 4 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities*	Annual
Site 4 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 4 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 5 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Site 5 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 5 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 6 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Site 6 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 6 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 10 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Site 10 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 10 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Site 11 MW - Shallow	Monitoring	300*	100-300*	Upper	10†	10†	500†	ILRP/GSP Entities	Annual
Site 11 MW - Middle	Monitoring	500*	300-500*	Lower	10†	10†	500†	GSP Entities	Annual
Site 11 MW - Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	GSP Entities	Annual
Wells Monitored for Other Programs									
2000507-001	Public Supply	Unknown	372-Unknown	Lower	10	10	500	DDW	Variable, according to DDW reqs.
2000553-001	Public Supply	Unknown	450-500	Lower	10	10	500	DDW	
2000682-002	Public Supply	Unknown	295-420	Lower	10	10	500	DDW	
2000727-001	Public Supply	Unknown	280-360	Lower	10	10	500	DDW	
2000938-001	Public Supply	Unknown	420-560	Lower	10	10	500	DDW	
2010002-014	Public Supply	Unknown	280-610	Lower	10	10	500	DDW	
2010002-032	Public Supply	Unknown	310-600	Lower	10	10	500	DDW	
2010008-005	Public Supply	Unknown	250-465	Composite	10	10	500	DDW	

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation[1]	MT Arsenic Concentration (µg/L)	MT Nitrate Concentration (mg/L)	MT TDS Concentration (mg/L)	Responsible Monitoring Entity	Measurement Frequency
2010009-002	Public Supply	Unknown	324-369	Composite	10	10	500	DDW	
2010010-007	Public Supply	Unknown	242-374	Lower	10	10	500	DDW	
2010801-001	Public Supply	Unknown	375-760	Lower	18	10	500	DDW	
2801077-001	Public Supply	Unknown	60-500	Composite	10†	10	500†	DDW	
ESJ12	Domestic	276	160-172	Upper	N/A‡	10	500	ILRP	Annual‡
ESJ17	Domestic	Unknown	Unknown	Unknown	N/A‡	10†‡	500†‡	ILRP	Annual‡

* Construction details and locations for future monitoring wells are estimated; information will be updated upon completion of final site selection and well construction.
[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

† Values will be confirmed and/or adjusted as needed based on results from initial sampling for constituents. If existing levels exceed the MCL, then the MT is set at the existing concentration plus 20 percent.
‡ Monitoring for the Irrigated Lands Regulatory Program does not include testing for arsenic; annual monitoring includes nitrate and specific conductance (SC), TDS is tested every five years; SC will be used as proxy for TDS in years in which TDS is not tested.

3.3.4.1 Methodology

The methodology to develop MTs for groundwater quality is based on the objective of protecting all designated beneficial uses from significant and unreasonable adverse impacts from implementation of GSP PMAs or overall groundwater extraction. In accordance with the Water Quality Control Plan (Basin Plan) for the Sacramento and San Joaquin River Basins (RWQCB, 2018), groundwater in the Plan Area is considered suitable or potentially suitable for municipal and domestic water supply (MUN), agricultural supply (AGR), industrial service supply (IND), and industrial process supply (PRO) beneficial uses. From a groundwater quality standpoint, the municipal and domestic supply beneficial use is the most restrictive with Basin Plan water quality objectives linked to drinking water MCLs. As a result, the MTs for groundwater quality set for each of the three identified key water quality constituents (nitrate, arsenic, TDS) are the respective MCL values, except for cases where existing or historical concentrations for these constituents already exceed the MCL. When existing or historical concentrations for the key constituents already exceed the MCL, the MT is set at the recent concentration plus 20 percent. The summary of currently available groundwater quality data for RMS wells provided in **Appendix 3.L** provides an indication of the baseline for each key constituent for the RMS wells relative to MCLs. The vast majority of RMS wells have baseline concentrations below MCLs and are expected to have MTs set at MCLs. When current or historical water quality for the key constituents has not been measured, the MT will be set as the MCL and will be adjusted if needed after the ~~GSP~~ baseline groundwater quality ~~monitoring program commences~~data have been collected (see Section 3.5.1.4). The applicable MTs for groundwater quality in the GSP apply to degraded groundwater quality as a direct result of impacts from projects/MAs or overall groundwater extraction under the GSP that cause an exceedance to occur. Future exceedances of the MT may occur due to activities or conditions unrelated to the GSP, in which case they would not constitute an MT exceedance that contributes to an undesirable result.

A review of literature reveals several studies related to the uncertainty in hydrologic measurements, including water quality. Montgomery and Sanders (1986) noted that data acquisition involves three main activities: network design, sample collection, and lab analysis. Focusing on the latter two activities, sample collection comprises sampling technique, field measurements, sample preservation, and sample transport; and lab analysis involves analysis techniques, operational procedures, quality control, and data recording. Each component listed above has the potential to slightly alter the final results reported for a given constituent, thereby creating a degree of uncertainty. One study (McMillan et al., 2018) suggested that hydrologic data uncertainties, including for water quality, are typically in the range of 10 to 40%. Another study (Harmel et al., 2006) found uncertainties in the range of 4 to 48% for sample collection, 2 to 16% for sample preservation and storage, and 5 to 21% for laboratory analysis.

The East Bay Plain Subbasin GSP (LSCE et al., 2022) noted the following:

The technical justification for using a 20% increase from baseline concentrations to set the interim MT for RMS wells that already exceed the MCL for a key constituent is based on evaluation of three potential sources of fluctuations in key constituent concentrations from a series of sampling events at a given well:

1) *Variability/uncertainty related to analytical lab methods/analysis;*
2) *Variability/uncertainty caused by slight differences in sampling methods or purge rates (this will be addressed to some extent with GSP sampling protocols, but some variability can still occur between different sampling personnel or from one sampling event to another plus existing data that may have been collected using slightly different protocols), and*

3) Fluctuations/variability in constituent concentrations in the groundwater system due to the rise/fall of groundwater levels, changes in local groundwater flow directions, fluctuations in recharge rates, water year type, and other natural conditions affecting the groundwater system.

Consultation with the EBMUD analytical laboratory indicated that the margin of error associated with analytical lab measurements within a method may be set as:

a. The method reference used in the analysis.

b. Statistically calculated based on historical data of laboratory fortified blank samples or fortified matrix spikes.

c. Estimating the uncertainty of measurement by taking into consideration all sources contributing to the uncertainty, including, but not limited to standard references, reference materials, equipment used, environmental conditions, properties and conditions of the samples being tested or calibrated, and the operator.

d. Based on The National Environmental Laboratory Accreditation Program Institute (TNI) acceptable criteria of performance testing (PT) study; these may be set by EPA or statistically calculated for the study.

Table 3-13. Analytical Laboratory Error of Measurement for Key Constituents

Analyte	Method Reference	Method Reference or Laboratory Statistically Calculated Precision (% RPD[1])	Method Acceptance Criteria for Accuracy (% Recovery)	TNI Acceptance Criteria of Performance Testing Study (% Recovery)
TDS	SM2540C	10%	±15%	±20%
Nitrate	EPA 300.1	At ≥ 10xMRL[2]xMRL[2]: ±10% RPD At < 10xMRL: ±20% RPD	±15%	±10%
Chloride	EPA 300.1	At ≥ 10xMRL: ±10% RPD At < 10xMRL: ±20% RPD	±15%	±15%
Arsenic	EPA 200.8	20%	±15%	±30%

[1] Relative percent difference (RPD).

[2] Minimum reporting limit (MRL) typically set by a lab as 3 x Method Detection Limit ≈ 3 x Standard Deviation.

Based on the laboratory input summarized above, the error based on the "Method Acceptance Criteria for Accuracy" may be the best reference to use since it is 15% for all the constituents and takes into consideration sources that contribute to the uncertainty.

Work being conducted for other programs, such as the Central Valley Irrigated Lands Regulatory Program (ILRP), requires extensive review of QA/QC procedures for field sampling and analytical lab analyses for various constituents of concern (including nitrate and TDS), along with quantification of the expected Relative Percent Difference (RPD) that may occur with key constituent concentrations from groundwater quality sampling events. An RPD of up to 25% constitutes the acceptance criteria for field duplicate samples, which accounts for analytical laboratory plus field sampling methods/procedures but not natural factors influencing the groundwater system. The groundwater system fluctuations/variability factor would add greater uncertainty beyond the 25% from laboratory and field sampling methods/procedures factors.

Based on prior experience, the potential constituent fluctuations from various natural factors influencing the groundwater system likely exceed 5% and result in a total expected range of fluctuations from all three factors of greater than 30%. Therefore, use of a 20% increase over baseline conditions is likely a conservative (i.e., low) value relative to the reasonably expected range of fluctuations in constituent concentrations that could be expected to occur during a series of sampling events.

Based on the review of the studies and reports described above, it is reasonable and justified to set MTs by adding 20% to groundwater quality RMS with existing concentrations near or above the MCL. This methodology provides a relatively conservative and narrow range to account for the uncertainties in several variables that may affect lab reported concentrations for a key constituent. Using this methodology will help avoid the occurrence of false positives in which expected variability in sample collection and/or lab analyses results in developing a conclusion that undesirable results have occurred when there is actually no (or a very minimal) increase in concentrations. In addition, a 20% increase when baseline concentrations exceed the MCL (e.g., baseline of 15 mg/L increases to between 15 and 18 mg/L for nitrate) represents a relatively small net increase that would not be expected to have significant and unreasonable effects. Finally, the selection of the greater of the MCL or 20% increase is intended to avoid more false positives that could easily result when a baseline concentration is very close to but less than the MCL (e.g., a baseline arsenic concentration at 9.8 ug/L only needs to have sample results that increase by 3% to exceed the MCL).

3.3.4.2 Relationship to Other Sustainability Indicators

Although there are potential relationships between groundwater quality and other sustainability indicators, setting of MTs for groundwater quality does not conflict with other sustainability indicators and associated MTs. Management of groundwater for other sustainability indicators and associated MTs may not ensure that impacts on groundwater quality are avoided

3.3.4.3 Impact of Selected Minimum Thresholds to Adjacent Basins

The MTs for groundwater quality established for the Plan Area are intended to protect all beneficial uses within the Plan Area, including municipal and domestic water supply uses, from groundwater quality degradation caused by projects or management actions included in the GSP and overall groundwater extraction, and are therefore not likely to impact adjacent subbasins or their ability to achieve sustainability.

3.3.4.4 Minimum Thresholds Impact on Beneficial Uses and Users

Municipal and domestic supply is the most restrictive beneficial use standard for groundwater quality with water quality objectives equal to drinking water MCLs. Setting the groundwater quality MTs for key constituent concentrations at respective drinking water MCLs, or within a tolerance for no more than a 20 percent increase above historical concentrations when existing or historical concentrations already exceed the MCL, is intended to limit degradation of groundwater quality caused by GSP PMAs in order to protect municipal and domestic supply beneficial uses. Protection of municipal and domestic beneficial uses is also protective of all other groundwater beneficial uses.

3.3.4.5 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

The Federal and State drinking water quality standards are represented through MCLs that are applicable to public drinking water supplies and provide reasonable guidance on water quality for safe drinking water in non-public supplies. As described above, the State of California drinking water MCLs for arsenic, nitrate, and TDS are being used to define MTs for groundwater quality degradation caused by GSP PMAs, except in cases where existing or historical groundwater quality conditions already exceed these levels.

3.3.4.6 Minimum Thresholds Measurement Method

Groundwater quality will be monitored on an annual basis at identified representative groundwater quality monitoring indicator wells presented in Table 3-121 and **Figure 3-43**. Monitoring will be conducted through sampling of groundwater quality conducted for the GSP monitoring along with evaluation of groundwater quality data reported for other monitoring programs. All groundwater quality sampling and analysis will be conducted in accordance with the monitoring protocols and procedures described in the GSP. The monitoring network and monitoring protocols for groundwater quality are described in Section 3.5 (Monitoring Network and Monitoring Protocols for Data Collection).

3.3.5 Depletion of Surface Water

As described in the HCM in Chapter 2, regional groundwater levels have been below the stream channel bottoms in the Plan Area for at least the last several years, and for many decades in most of the Plan Area. It has been determined that a direct hydraulic connection between regional groundwater and streams does not exist for streams in most of the Subbasin; therefore, the surface water depletion sustainability criteria are not applicable over most of the Subbasin. However, water levels in the shallowest groundwater zone below and along parts of the San Joaquin River at the southern boundary of the Subbasin periodically rise to elevations equal to or above the stream thalweg. Although it appears this shallow groundwater is associated with infiltration of streamflow from the nearby river resulting from upstream reservoir releases, interim SMC are being established for ISW along the San Joaquin River until additional field investigations, studies, evaluations, and monitoring can be completed to update and refine the hydrogeologic understanding of subsurface conditions and interactions between groundwater and surface water in this area.

The interim MTs for ISW were updated in 2022-2023 through an extensive and collaborative coordination process between all seven GSAs in the Subbasin. Coordination efforts have resulted in MTs that are consistent across the four GSPs in the Subbasin. The interim MTs are the same as the interim MOs: to maintain the percent of time of surface water – groundwater connectivity consistent with conditions during the baseline historical time period, as measured over a rolling five-year period.

In addition to the GSAs' workplan described above, since late 2023 and as a result of individual comments received following submission of the 2020 Joint GSP, representatives from the Subbasin and Kings Subbasin have been meeting monthly with representatives from the USBR and FWA to better understand their issues and concerns related to ISW along the San Joaquin River (SJR) from Reach 1A to the Mendota Pool, as well as with representatives of the SJRRP. This work has resulted in development of an MOU between the Madera and Kings Subbasins and USBR and FWA. The GSAs also plan to review DWR's ISW guidance documents (released in 2024) and may consider revisions to the current ISW SMC as GSP implementation continues. These activities are described in more detail in Section 4.9.5.

3.3.5.1 Methodology

As described in the HCM in Section 2 and in the discussion the MOs in Section 3.2.5, interim SMC are being established for interconnected surface water along the San Joaquin River. It is intended to put the interim SMC in place with submittal of this GSP, with final SMC pending further data collection and analysis to make a more informed assessment of whether or not interconnected surface water is present at this location and, if so, to refine SMC if necessary based on the improved understanding of hydrogeologic conditions. The interim MTs are the same as the interim MOs: to maintain the percent of time with surface water – groundwater connection over a given time period as equal to or greater than the percent of time connected over the baseline time period. Therefore, the MTs for each RMS well shown in Table 3-14~~2~~ are the same as the MOs shown in Table 3-10~~9~~.

3.3.5.2 Relationship to Other Sustainability Indicators

The interim MTs established for ISW along the San Joaquin River will be evaluated independent of other sustainability indicators. The other sustainability indicator most closely related to ISW is chronic decline of groundwater levels as described in Section 3.3.1. However, the MTs for chronic groundwater level decline are based on potential impacts relative to wells going dry, whereas MTs for interconnected surface water are established in relation to maintaining a certain percentage of time with connection to the San Joaquin River. While it may be the case that the four RMS wells being assigned MTs for both chronic decline in groundwater levels and ISW may produce different conclusions regarding undesirable results when groundwater levels in these wells are at a certain elevation (e.g., UR for ISW but no UR for chronic groundwater level decline), the assignment of independent MTs for two different sustainability indicators at the same well will inform basin stakeholders if a conclusion that an undesirable result has occurred is related to chronic groundwater level declines (and therefore caused too many wells to go dry and impacting well users) vs. being related to interconnected surface water (and having potential impacts on surface water flows or GDEs).

3.3.5.3 Impact of Selected Minimum Thresholds to Adjacent Basins

Maintaining a similar percent of time connected for interconnected surface water along the San Joaquin River under sustainable groundwater conditions for Subbasin is not expected to have any significant impacts on adjacent subbasins. However, if the percent of time connected increases significantly, whether it be through PMAs conducted by the Subbasin GSAs and/or due to other factors such as the SJRRP, it is possible that the downstream Delta-Mendota Subbasin may be affected by higher groundwater levels in the shallow zone.

3.3.5.4 Minimum Thresholds Impact on Beneficial Uses and Users

Interconnected surface water MTs may have effects on certain beneficial uses, users, land use, and property owners. Those with potential to be impacted include agricultural land use and users, ecological land use and users, and downstream surface water rights holders. Overall, agricultural land use and users will be impacted in terms of increased costs to design and construct recharge projects and in terms of reduced crop yields from required reductions in consumptive use for irrigation. Ecological beneficial users and downstream surface water rights holders are expected to benefit from implementation of MTs for interconnected surface water.

3.3.5.5 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

There are no relevant state, federal, or local standards for comparison related to this sustainability criterion.

3.3.5.6 Minimum Thresholds Measurement Method

Interconnected surface water will be monitored on an annual basis by measuring groundwater levels at identified representative ISW RMS wells presented in Table 3-14~~2~~ and **Figure 3-5~~4~~**. The groundwater level monitoring will be conducted in accordance with the monitoring plan and protocols outlined in Section 3.5. Furthermore, the groundwater level monitoring will meet the requirements of the technical and reporting standards included in the SGMA regulations.

Table 3-14~~32~~. Summary of Interconnected Surface Water Minimum Thresholds for Representative Monitoring Sites.

Well I.D.	Surface Elevation	Well Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation	MT[1]	GSA
MCE RMS-9	265.4	38	17-37	1	Upper	73%	Madera County East
MCW RMS-5	197.8	30	Unknown	1	Upper	30%	Madera County West
MID RMS-17	224.9	47	26-46	1	Upper	100%	Madera Irrigation District

[1] The MTs are established as the percent of time connected over the historical base period (1989 to 2015). For comparison to future five-year rolling average, baseline MTs may need to be updated to reflect climatic/hydrologic conditions represented in five-year rolling average.

3.3.6 Seawater Intrusion

The seawater intrusion sustainability criterion is not applicable to the ~~Madera~~ Subbasin.

3.4 Undesirable Results *(23 CCR § 354.26)*

As described previously, the GSP regulations define undesirable results as occurring when significant and unreasonable effects are caused by groundwater conditions occurring throughout the Subbasin for a given sustainability indicator during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), not the GSP implementation period.

This section provides a description of undesirable results for the relevant sustainability indicators, including:

- Cause of groundwater conditions that would lead to undesirable results
- Criteria used to define undesirable results based on MTs
- Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results

A summary of criteria used to define undesirable results is provided below in Table 3-15~~43~~ and detailed discussion of each sustainability indicator is provided in subsequent sections of this Chapter.

Under SGMA, the six sustainability indicators are separate and independent metrics used to evaluate subbasin conditions relative to sustainability as defined by SMC. For sustainability indicators that are interdependent and influence one another (e.g., declining groundwater levels resulting in land subsidence), the most restrictive SMC will govern for determining if undesirable results have occurred (e.g., either groundwater level decline exceeding MTs, or subsidence exceeding MTs; each evaluated independently).

Table 3-1~~5~~3. Summary of Minimum Thresholds, Measurable Objectives, and Undesirable Results.

Sustainability Indicator	Minimum Threshold	Measurable Objective	Undesirable Result (after 2040)[1]
Chronic Lowering of Groundwater Levels	Set equal to the Fall 2015 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2015 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Set equal to the Fall 2010 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2010 groundwater level determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and modeled data.	Same 30 percent of RMS wells within the Subbasin below minimum threshold for two consecutive fall measurements.
Reduction of Groundwater Storage	Same as MTs for chronic lowering of groundwater levels. (Groundwater levels used as a proxy.)	Same as MOs for chronic lowering of groundwater levels. (Groundwater levels used as a proxy.)	Same 30 percent of RMS wells within the Subbasin below minimum threshold for two consecutive fall measurements. (Groundwater levels used as a proxy.)
Land Subsidence	0 feet/year, subject to uncertainty of +/-0.16 feet/year	0 feet/year, subject to uncertainty of +/-0.16 feet/year	Average subsidence across greater than ~~75~~ 25 percent of ~~or more~~ RMS exceeding minimum threshold for two consecutive years.
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Nitrate = 10 mg/L or existing level plus 20% (whichever is greater) Arsenic = 10 µg/L or existing level plus 20% (whichever is greater) TDS = 500 mg/L or existing level plus 20% (whichever is greater)	Current constituent concentrations	10 percent of wells above the minimum threshold for the same constituent due to projects and/or management actions~~,~~ or overall groundwater extraction, based on average of most recent three year period.
Depletion of Interconnected Surface Water	A percent of time surface water is connected to shallow groundwater that is equal to historical conditions for a similar climatic/hydrologic period.	A percent of time surface water is connected to shallow groundwater that is equal to historical conditions for a similar climatic/hydrologic period.	Greater than 30 percent of RMS wells below minimum threshold for two consecutive annual five-year rolling average annual evaluations.

[1] 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)]. The "planning and implementation horizon" is defined 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" [CWC §10721(r)]. The 50-year time period in the ~~Madera~~ Subbasin begins after the GSP implementation period.

3.4.1 Chronic Lowering of Groundwater Levels

The cause of Subbasin groundwater conditions that would result in significant and unreasonable lowering of groundwater levels is excessive overall average annual groundwater pumping and other outflows from the Plan Area that continue to exceed average annual inflows. Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable lowering of groundwater levels are those conditions that: 1) Cause significant financial burden to local agricultural interests or other beneficial uses and users who rely on the Subbasin's groundwater resources, 2) Cause groundwater level conditions at private domestic wells that cannot be mitigated, and 3) Interfere with other sustainability indicators.

As described in Section 3.3.1.1, the Madera Subbasin GSAs have proceeded with coordination and development of a Domestic Well Mitigation Program, including the development of an MOU. As of March 2023the writing of the January 2025 Plan Amendment, the GSAs are developing the Program eligibility criteria, terms, and conditions and are preparing to move forward with Program implementation, as needed, but no later than 2025.

The chronic lowering of groundwater levels undesirable result is a quantitative combination of groundwater elevation MT exceedances. A MT exceedance for a given RMS is two consecutive Fall measurements (assumed to be collected in October) that are both below the MT level. For the Joint GSP GSAs, a groundwater elevation undesirable result is defined to occur when greater than 30% of the representative monitoring sites each exceed the groundwater level MTs for the same two consecutive Fall readings.

The definition of undesirable results under SGMA provides flexibility in defining sustainability. Increasing the percentage of allowed MT exceedances provides more flexibility but may lead to significant and unreasonable conditions for a number of beneficial users. Reducing the percentage of allowed MTs exceedances ensures strict adherence to MTs but reduces flexibility due to due to uncertainty in characterizing hydrogeologic conditions and the uncertainty inherent in any analytical or numerical tool used for future predictions of water levels. The undesirable result for groundwater levels is defined as more than 30 percent of RMS in the Subbasin (the same 30 percent, including RMS in all four GSP plan areas) exceeding their MTs for the same two consecutive Fall readings. The 30 percent criterion was selected to balance the interest of beneficial use with the practical aspect of groundwater management uncertainty. As the number of RMS evolves over time (e.g., adding nested monitoring well sites), the total number of RMS that have to exceed their MTs to yield an undesirable result will change accordingly.

Conditions other than excessive Subbasin-wide pumping (plus other outflows) greater than average annual inflows that may lead to an undesirable result include extensive and unanticipated drought, and may also include overdraft in neighboring subbasins. MTs were established based on historical groundwater levels and reasonable estimates of future groundwater levels (including a future drought longer than historic droughts). Extensive, unanticipated droughts (beyond that accounted for already in historical conditions, or earlier in the implementation period or sustainability period than assumed herein) may lead to excessively low groundwater levels and undesirable results.

3.4.2 Reduction in Groundwater Storage

The cause of Subbasin groundwater conditions that would result in significant and unreasonable reduction in groundwater storage is excessive overall groundwater pumping and other outflows from the Plan Area that exceed average annual inflows. Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable reduction in groundwater storage occurs when there is: 1) Long term reduction in groundwater storage during the sustainability period (i.e., after 2040), or 2) Interference with other sustainability indicators.

Reduction of groundwater storage in the Plan Area has the potential to impact the beneficial uses and users of groundwater by limiting the volume of groundwater available for agriculture, municipal, industrial and domestic use. The undesirable results of reduction in groundwater storage are the same as those previously described for chronic lowering of groundwater levels. Continuing the current rate of loss of groundwater in storage could also impact other sustainability indicators such as groundwater quality. Reduction in groundwater storage is significant and unreasonable if its sufficient in magnitude to lower the rate of production in pre-existing groundwater wells below that needed to meet the minimum required to support overlying beneficial users and where means of obtaining sufficient groundwater or imported resources are not technically or financially feasible for the well owner to absorb, either independently or with assistance from the GSA or other available assistance (grants). As described in Section 3.3.1.1, the ~~Madera~~ Subbasin GSAs have proceeded with coordination and development of a Domestic Well Mitigation Program, including the development of an MOU. As of December 2024~~March 2023~~, the GSAs are developing the Program eligibility criteria, terms, and conditions and are preparing to move forward with Program implementation, as needed.

Conditions that may lead to an undesirable result for the reduction in groundwater storage sustainability indicator include extensive, unanticipated drought. Similar to groundwater levels, which act as a proxy for the groundwater storage sustainability indicator, MTs were established based on historical groundwater levels.~~and reasonable estimates of future groundwater elevations that would occur with the GSP PMAs, and accounting for a future drought longer than historic droughts.~~ Extensive, unanticipated droughts (beyond that accounted for already in historical conditions, or earlier in the implementation period or sustainability period than assumed herein) may lead to excessively low groundwater elevations and undesirable results.

The practical effect of the reduction in groundwater storage undesirable result is that it encourages no net change in average groundwater elevations and storage during average hydrologic conditions and over the long-term during the sustainability period. Therefore, during average hydrologic conditions and over the long-term, beneficial uses and users will have access to the same amount of groundwater in storage that exists in a subbasin with average inflows equal to average outflows, and the undesirable result will not have a negative effect on the beneficial users and uses of groundwater. Pumping at the long-term sustainable yield during dry years will temporarily lower groundwater elevations and reduce the amount of groundwater in storage. Groundwater storage would then be replenished during wet years. Therefore, Subbasin groundwater users can expect significant fluctuations in groundwater levels, but such fluctuations are expected to remain above the established MTs.

3.4.3 Land Subsidence

The cause of Subbasin groundwater conditions that would result in significant and unreasonable land subsidence is excessive overall average annual groundwater pumping and other outflows from the Plan Area that exceed average annual inflows and results in groundwater levels that decline to a level that, combined with clay layers having certain properties conducive to compaction, result in significant land subsidence. Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040.

Prior to the First Plan Amendment, lLocally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, through individual stakeholder input to various GSA representatives, review of historical land subsidence, and in meetings with technical representatives from all GSAs in Subbasin. Through these discussions, it was determined that sSignificant and unreasonable land subsidence may result in significant impacts to critical infrastructure. A survey of critical infrastructure in Subbasin was conducted and is provided in **Appendix 3.G**. The information presented below uses the initial assessment as a foundation upon which subsequent detailed analysis was completed.

In 2024, critical infrastructure, the potential impacts of land subsidence, and the extent to which they are considered significant and unreasonable were re-evaluated by the GSAs with input from critical infrastructure owners and operators and members of the public. Owners and operators with critical infrastructure in the Subbasin were interviewed in Summer 2024 to confirm identification of their critical infrastructure, further document observed and possible impacts attributable to land subsidence, and assess the potential future impacts of land subsidence. Table 3-165 lists the agencies contacted, the identified critical infrastructure, and references to GSP figures showing the locations of critical infrastructure.

Table 3-165. Agencies, Critical Infrastructure, Reported and Possible Subsidence Impacts, GSP Figure Reference, and Interview Date.

Agency	Identified Critical Infrastructure in Madera Subbasin	Reported Impacts in the Madera Subbasin	Possible Impacts	GSP Figure Reference	Interview Date
Madera Irrigation District	Supply canals, pipelines, diversion infrastructure.	None noted.None.	None noted.	Figure 1-8	6/19/2024
Madera Water District	Pipelines, diversion infrastructure.	None None noted.	None notedNone.	Figure 1-10	6/19/2024
City of Madera (Public Works)	Potable water system, groundwater wells, wastewater system, roads, stormwater/floodwater control infrastructure, Madera Municipal Airport.	None None noted.	None notedNone.	Figure 1-2	6/25/2024
County of Madera (Public Works)	Roads, bridges, stormwater/floodwater control infrastructure, potable water system, sewer water system, wells.	Protrusion of urban wells out of the ground.	Collapsed urban well casings.	Figure 1-6	7/8/2024
Central Valley Flood Protection Board	Control structures, Drop structures, and Levees within the Chowchilla Bypass, San Joaquin River, Fresno River, Ash Slough, and Berenda Slough.	Washouts and scouring, loss of freeboard, impacts to control structures and drop structures.	Loss of freeboard, loss of capacity to move flood flows.	Figure 2-1	6/26/2024
San Joaquin River Restoration Program	Wells, fish bypasses/ladders.	None notedNone.	Change in water stage and velocities.	Figure 2-1	7/2/2024
Lower San Joaquin Levee District	Control structures, Drop structures, and Levees within the San Joaquin River, and Chowchilla Bypass..	Impacts to drop structures, washouts and scouring.	Impacts to drop structures on Fresno River and Ash Slough, worsening scouring on the Chowchilla Bypass.	Figure 2-1	6/24/2024
New Stone Water District	Chowchilla Bypass, Eastside Bypass, distribution systems, wells, pumps.	None notedNone.	Damage to wells and pipelines, loss of conveyance in Chowchilla Bypass and Eastside Bypass.	Figure 1-12	8/20/2024
Root Creek Water District	San Joaquin River.	None None noted.	None notedNone.	Figure 1-14	6/10/2024

Agency	Identified Critical Infrastructure in Madera Subbasin	Reported Impacts in the Madera Subbasin	Possible Impacts	GSP Figure Reference	Interview Date
Gravelly Ford Water District	Agricultural wells, San Joaquin River lift pump station, Gravelly Ford Canal, road crossings, San Joaquin River.	None notedNone.	Damage to wells, damage to pump stations, reduction in canal capacity, pipeline failure.	Figure 1-4	7/24/2024

Key findings from these interviews are summarized in the table above and list below:

- The County of Madera noted that some urban wells were reported to be protruding out of the ground a distance of up to approximately 18 inches.
- The San Joaquin River Restoration Program expressed concern for changing water level and velocities falling outside the design criteria for fish passage. This would make them noncompliant with biological opinions and require them to re-open consultation with fishery agencies to continue operations.
- San Joaquin River Restoration Program noted two planned future projects in which future subsidence was being incorporated into the design. Mendota Dam is being designed to withstand up to 2.5 feet of subsidence and Sack Dam is being designed to withstand up to 5 feet of subsidence.
- The Central Valley Flood Protection Board noted that the Fresno River has lost roughly 3 to 4 feet of freeboard since 2015.
- Both the Central Valley Flood Protection Board and the Lower San Joaquin Levee District noted impacts to drop structures on the Fresno River and Ash Slough as well as scouring on Berenda Slough and the Chowchilla Bypass.

To continue coordination and stay informed on impacts to critical infrastructure within the Subbasin, the GSAs, with support from the agencies interviewed, are proposing to establish a Subbasin Critical Infrastructure Operator Group. Although discussions are ongoing, the Critical Infrastructure Operator Group is planning to meet annually to provide updates on any potential critical infrastructure impacts related to subsidence, coordinate ongoing PMA implementation, and to discuss any potential critical infrastructure mitigation concerns.

All agencies interviewed expressed a strong interest in participating in the Subbasin Critical Infrastructure Operator Group.

An undesirable result is defined as occurring when the average subsidence across greater than 25 75 percent of or more RMS in the Subbasin (including RMS in or adjacent to all four GSP plan areas) exceeds the minimum threshold for two consecutive years. Conditions that may lead to an undesirable result for of a significant and unreasonable amount for land subsidence have historically occurred during periods with groundwater pumping in excess of sustainable yield in areas where critical infrastructure exists, because of the confined nature of the groundwater conditions in these areas coupled with the presence of sediments that are more susceptible to compaction when the piezometric head in the aquifer is reduced. . This is of particular concern in the Lower Aquifer where the Corcoran Clay exists and in similar deep zones elsewhere in the Subbasin. Conditions that may lead to an undesirable result include the following:

- Localized pumping. Even if regional pumping is maintained within the sustainable yield, clusters (or pumping centers) of high-capacity wells pumping below the Corcoran Clay and from other deeper zones may cause excessive localized drawdowns that lead to undesirable results in specific areas. These effects could also be caused exacerbated by pumping in neighboring subbasins.
- Extensive, unanticipated drought. Extensive, unanticipated droughts may lead to excessively low groundwater elevations and subsidence.

As described in Chapter 4, the GSAs have developed and are implementing both a subsidence workplan and PMAs that are designed to minimize or eliminate subsidence.

3.4.4 Degraded Water Quality

The cause of Subbasin groundwater conditions that would result in significant and unreasonable degraded water quality is implementation of a GSP project or management action or overall groundwater extraction that causes levels of key groundwater quality constituents to increase to concentrations exceeding the MCLs for drinking water. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Plan Area; therefore, groundwater quality degradation is considered significant and unreasonable based on adverse impacts to this beneficial use. Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040. Locally defined significant and unreasonable conditions were determined based on discussion with GSA staff and technical representatives, input received from interested stakeholders and the public through public meetings, and through individual stakeholder input to various GSA representatives. Significant and unreasonable degradation of water quality occurs when beneficial uses for groundwater are adversely impacted by constituent concentrations increasing to levels above the drinking water MCLs (or more than 20% above baseline concentrations that already exceed MCL) for one of the key constituents of interest previously identified in **Section 2** of the GSP (nitrate, arsenic, TDS) at indicator wells in the representative groundwater quality monitoring network due to implementation of a GSP project or management action or overall groundwater extraction. One of the most notable groundwater quality constituents of concern in the Plan Area is nitrate and distributed areas of elevated nitrate concentrations in groundwater occur within the Plan Area as a result of historical activities. Exacerbating existing nitrate concentrations in groundwater quality and ongoing (current and future) increasing trends in nitrate concentrations related to continued impacts from these historic land use activities is an important consideration in the implementation of GSP PMAs. There are no known significant and large-scale groundwater quality contamination plumes (i.e., point-source contaminant site plumes) in the regional aquifers within the Plan Area; therefore, exacerbating plume migration or impacting the ability to contain localized contamination plumes is not a significant concern for GSP PMAs, but will also be considered in GSP implementation.

Degraded water quality is significant and unreasonable if the magnitude of degradation precludes the use of groundwater for existing beneficial use(s). Therefore, an undesirable result for degraded groundwater quality occurs when groundwater quality exceeds an established MCL and MT for arsenic, nitrate, or TDS for a significant duration of time and at a significant number of representative monitoring sites and is the direct result of projects or management actions undertaken as part of the GSP implementation or overall groundwater extraction. An exceedance of a MT at a given representative monitoring site is defined based on the average concentration for a given key constituent over a three-year monitoring period. An undesirable result for degraded groundwater quality is greater than 10 percent of representative groundwater quality monitoring wells exceeding a MT for a given constituent related to GSP actions or overall groundwater extraction.

Notable conditions that may lead to an undesirable result for degraded groundwater quality sustainability indicator include the following:

- Localized Pumping - Even if regional pumping is maintained within the sustainable yield, clustered areas (or pumping centers) of high capacity wells may cause excessive localized drawdowns that lead to undesirable results related to groundwater quality in specific areas, especially areas prone to elevated arsenic concentrations occurring at greater pumping water level depths. While an undesirable result for groundwater quality degradation would require 10 percent of RMS to have exceedances, the Domestic Well Mitigation Program would likely address eligible wells that go from arsenic below the MCL to arsenic exceeding the MCL due to groundwater level declines during GSP implementation.

- Enhanced Groundwater Recharge - Active recharging of groundwater through use of recharge basins or Flood-MAR activities could cause localized mounding of groundwater near recharge sites resulting in altered flow directions and potentially movement of chemical constituents towards wells in concentrations that exceed relevant water quality standards. Enhanced groundwater recharge activities may also impact groundwater quality by leaching of constituents from the unsaturated zone and into groundwater. This mechanism may be of particular importance when considering enhanced groundwater recharge on actively or formerly cultivated lands where high residual concentrations of nutrients, especially nitrogen, may exist in the unsaturated zone and may be susceptible to leaching into the groundwater resulting in degraded groundwater quality conditions. Water of poor quality characteristics should not be used for enhanced recharge activities. -Altered chemical conditions from enhanced recharge projects could also lead to changes in groundwater chemistry.

3.4.5 Depletion of Surface Water

The occurrence of shallow groundwater levels during certain time periods along the San Joaquin River at the southern boundary of the Subbasin, combined with extensive data gaps related to hydrogeologic conditions affecting characterization of interconnected surface water in this area, require that interim SMC be established pending further data collection and studies. The SMC for interconnected surface water along the San Joaquin River are based on a metric for the percent of time shallow groundwater levels are connected to the San Joaquin River (i.e., groundwater elevations at RMS wells are at/above stream thalweg elevations). An undesirable result is defined as greater than 30 percent of RMS wells (the same 30 percent) exceeding their MTs for two consecutive five-year rolling averages (e.g., two of the current 4 RMS wells). Consistent with SGMA, implementation of the GSP is designed to avoid undesirable results during the sustainability period (i.e., the "planning and implementation horizon," per CWC §10721(v)), after 2040.

Current evidence is unclear regarding the effect of groundwater pumping from the regional aquifer on San Joaquin River flows in the Subbasin. However, the shallow groundwater system underlying the portion of the San Joaquin River that supports the San Joaquin River Riparian potential GDE Unit does have at least the potential to be affected by regional groundwater pumping (because some roots may extend below the thalweg of the San Joaquin River). Therefore, hydrologic and biological GDE monitoring are incorporated as discussed elsewhere in this chapter. Characteristics of the hydrogeology in the Friant Riparian potential GDE unit suggests a low likelihood that groundwater pumping in the regional aquifer would affect river surface flows or the shallow groundwater associated with this GDE unit. Likewise, the hydrogeology in the area of the Sumner Hill potential GDE Unit suggests that pumping in the regional aquifer is unlikely to affect surface water or shallow groundwater in the unit. Accordingly, monitoring of these two potential GDE units will be focused on biological GDE monitoring.

Additionally, since late 2023 representatives from the Subbasin and Kings Subbasin have been meeting monthly with representatives from USBR and FWA to coordinate on ISW along the SJR from Reach 1A to the Mendota Pool, as well as with representatives of the SJRRP. This work has resulted in development of an MOU between the Madera and Kings Subbasins and USBR and FWA. The GSAs also plan to review DWR's ISW guidance documents (released in 2024) and may consider revisions to the current ISW SMC as GSP implementation continues. These activities are described in more detail in Section- 4.9.5.

3.4.6 Seawater Intrusion

The seawater intrusion sustainability criterion is not applicable to this Subbasin.

3.5 Monitoring Network

This section describes the monitoring network and includes the following subsections:

- Description of Monitoring Network
- Monitoring Protocols for Data Collection and Monitoring
- Representative Monitoring
- Assessment and Improvement of Monitoring Network

3.5.1 Description of Monitoring Network *(23 CCR § 354.34)*

This subsection on the monitoring network is intended to:

- Describe how the monitoring network is capable of collecting sufficient data about groundwater conditions to evaluate GSP implementation
- Describe monitoring network objectives
- Describe how monitoring network demonstrates progress towards achieving MOs, monitors impacts to beneficial uses/users, monitors changes in groundwater conditions, and quantifies annual changes in water budget components
- Describe how monitoring network allows documentation of groundwater occurrence, flow, and hydraulic gradients, calculation of annual groundwater storage change, rate and extent of subsidence, and groundwater quality trends
- Describe how monitoring network provides adequate coverage of sustainability indicators
- Describe monitoring network density and measurement frequency
- Describe monitoring network site selection rationale
- Describe data and reporting standards
- Provide map(s) with location and types of monitoring sites

The GSP groundwater level monitoring network was initially developed using existing wells in the Plan Area, ~~and will be supplemented (and/or some initial wells replaced) by new nested monitoring wells installed by 2020.~~ The database for existing wells was reviewed with the following criteria in mind:

- CASGEM wells preferred;
- Known construction (screen intervals, depth) preferred;
- Long histories of water level data (including recent data) preferred;
- Relatively good match between observed and modeled water levels preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Plan Area) and Lower Aquifers preferred.

As part of the January 2025 Plan Amendment, a comprehensive review of the RMS network was conducted, and the network was updated as necessary. Notable in this update of the monitoring network is the inclusion of dedicated monitoring wells that have been drilled to date as part of the Joint GSP implementation. A detailed discussion of wells removed and added to the network as part of this evaluation is presented in **Appendix 3.K**.

To the extent possible, the network was composed of wells known to represent either the Upper or Lower Aquifer, but not screened in both. However, this was not always possible due to need to consider all the criteria above. Matching of modeled to observed data was used to some extent to initially assign wells with unknown construction details to a given aquifer. The network will enable the collection of data to assess sustainability indicators, the effectiveness of management actions and projects to achieve sustainability, and evaluate the MOs and MTs of each applicable sustainability indicator (i.e., chronic lowering of groundwater levels, reduction in groundwater storage, ~~and~~ degraded water quality, and depletion of interconnected surface waters). The Subbasin is isolated from the Pacific Ocean and is not threatened by seawater intrusion; therefore, this Joint GSP does not provide monitoring for the seawater intrusion sustainability indicator. ~~For depletion of interconnected surface waters, available data indicate that streams in the Plan Area do not have direct connections to the regional groundwater system; therefore, this Joint GSP does not provide monitoring for the surface water depletion sustainability indicator.~~

As described above, for the purposes of the GSP monitoring program, a subset ~~of existing wells~~of wells was identified that best meet certain criteria. Not all the criteria were satisfied for each well, but this effort resulted in 37 wells to represent the Plan Area, with 10~~1~~ wells in the Upper Aquifer and 26~~2~~ wells in the Lower Aquifer, and 1~~4~~ composite well~~s~~. These wells are~~ –~~ referred to as the representative monitoring sites. Due to incomplete well construction information for ~~some~~ four of these wells, the portion of the aquifer being monitored could not be determined with certainty for ~~all~~these wells, but was initially classified based on match to model results where construction data is unknown. The subsidence monitoring network utilizes 8 benchmark locations that are survey twice per year and one continuous monitoring station.

These wells are distributed throughout the Plan Area to provide coverage of the entire area to the extent possible. This ~~initial~~ coverage generally allows for the collection of data to evaluate groundwater gradients and flow directions over time and the annual change in storage over most of the Plan Area for the Lower Aquifer. The spatial coverage for the Upper Aquifer is currently limited to the southwestern portion of the Plan Area due to availability of existing wells and the general lack of Upper Aquifer saturation in the eastern portion of the Plan Area (although the installation of nested monitoring wells ~~by 2020 is expected~~since 2019 ~~to~~has helped to expand the area of coverage for the Upper Aquifer). Furthermore, the monitoring frequency of the representative monitoring sites will allow for the monitoring of seasonal highs and lows. For wells that have relatively long historical data records, future groundwater data will be able to be compared to historical data. The monitoring network is expected to evolve over time as new wells are drilled and water level data histories are developed; a recent example of this at the time of January 2025 Plan Amendment is the ~~(included DWR grant funded~~ nested monitoring wells ~~to be~~ installed ~~by 2020)~~using DWR grant funds. The monitoring network will be periodically reviewed and improvements made where possible, with improvements reported in future Periodic Evaluations and Annual Reports.

3.5.1.1 Groundwater Level Monitoring Program

The MTs and MOs for the chronic lowering of groundwater levels sustainability indicator are evaluated by monitoring groundwater levels. The SGMA regulations require a network of monitoring wells sufficient to demonstrate groundwater occurrence, flow direction and hydraulic gradients between principal aquifers and surface water features. The overall proposed monitoring network for groundwater levels, comprised of wells monitored for CASGEM, by GSAs, and by USBR is provided in **Appendices 3.A and 3.J**.

The objectives of the groundwater level monitoring program include the following:

- Improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, especially in areas where short- and long-term development of groundwater resources are planned;
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation), irrigation, and surface water seepage to groundwater or recharge PMAs (recharge basins, Flood MAR) that affect groundwater levels and trends;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater Subbasin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

The overall groundwater level monitoring network is summarized in **Appendix 3.J**. **Figures 3-87** and **3-98** illustrate the locations of the wells selected as representative monitoring sites for monitoring of groundwater levels in the Upper and Lower Aquifers, respectively (composite wells are included in **Figure 3-109**). Tables 3-1714 and 3-1815 list the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the Upper and Lower Aquifer, respectively. Similar information for composite wells is provided in Table 3-1619.

In order to assist GSAs with the preparation of their GSP's, DWR released a series of best management practices. The best management practices document for monitoring networks provides guidance on determining an appropriate number of monitoring wells for a given area. The method developed by Hopkins (1984) was applied to the Plan Area. This methodology states that for districts pumping more than 10,000 acre-feet/year per 100 square miles, they should have four monitoring wells for every 100 square miles. The Madera Subbasin area occupies an area of approximately 543 square miles, yielding 22 monitoring wells. Subtracting the areas of the three GSAs not included in this Joint GSP yields an area of approximately 509 square miles and minimum of 20 monitoring wells. This number was taken to be the minimum number of monitoring wells for the Plan Area and additional wells were added based on informational needs resulting from management actions and historical trends in groundwater levels. This Joint GSP includes a total of 37 existing RMS with a potential for future addition of up to 21 monitoring wells from the 2019 nested well installation program. The selection rationale for all water level monitoring wells is summarized in Tables 3-1417 through 3-16.19.

3.5.1.2 Reduction in Groundwater Storage Monitoring Program

The objectives of the monitoring program to calculate changes in groundwater storage include the following:

- Improve the understanding of the occurrence of groundwater; monitor Upper and Lower Aquifer groundwater levels including seasonal and long-term trends in the aquifer system to calculate changes in groundwater storage on an annual basis and in areas where management actions and projects are planned;

Because changes in groundwater storage are directly dependent on changes in groundwater levels, this Joint GSP adopts groundwater levels as a proxy for assessing change in storage, as described previously in this section. The wells selected for monitoring changes in groundwater storage will be the same wells used for groundwater level monitoring. **Figures 3-8** and **3-9** illustrate the locations of the wells selected for monitoring of groundwater levels for the Upper and Lower Aquifers, respectively. Tables 3-1417 and 3-1518 list the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the Upper and Lower Aquifer wells, respectively.

Because the same wells for water level monitoring are being used for groundwater storage monitoring, the selection process and rationale for selection is also the same (Tables 3-1314 and 3-1416).

Table 3-~~14~~17. Summary of Upper Aquifer Groundwater Level Monitoring Network Wells.

Well I.D.	Well Depth	Screen Interval	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number of Measurements	Selection Rationale
MCE RMS-2	NA[1]	NA[1]	36.9852	-119.8799	Spring/Fall	1979	2024	45	43	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCE RMS-9	37	17-37	36.8780	-119.7900	Spring/Fall	2009	~~2019[1]~~2019[2]	10	348	SJRRP well; known well construction; spatial/vertical distribution; GDE monitoring
MCW RMS-5	30	NA[1]	36.7991	-120.1592	Spring/Fall	2012	~~2018[1]~~2018[2]	6	288	SJRRP well; known well depth; spatial/vertical distribution; GDE monitoring
MSB03B	295	215-285	36.8951	-120.3818	Spring/Fall	2019	2024	5	15	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB05A	210	140-200	36.9238	-120.2552	Spring/Fall	2019	2024	5	18	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB06A	350	135-340	36.8257	-120.2057	Spring/Fall	2019	2024	5	14	Dedicated monitoring well; known well construction; spatial/vertical distribution
MID RMS-11	315	NA[1]	36.8946	-120.1108	Spring/Fall	1962	~~2023[2]~~2023[3]	61	106	CASGEM well; long history of WL data; spatial/vertical distribution
MID RMS-12	176	NA[1]	36.9138	-120.0383	Spring/Fall	2008	~~2023[2]~~2023[3]	15	24	CASGEM well; known well depth; spatial/vertical distribution
MID RMS-15	502	160-200	36.8541	-120.0561	Spring/Fall	2015	~~2023[2]~~2023[3]	8	16	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-17	47	26-46	36.8235	-120.0565	Weekly	2009	~~2023[2]~~2023[3]	14	324	SJRRP well; known well construction; spatial/vertical distribution; GDE monitoring

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.
[2] Have communicated with well owner. Plan is for Madera County to take over monitoring.
[3] Well is currently monitored, but 2024 data has not yet been reported.

~~[1] Have communicated with well owner. Plan is for Madera County to take over monitoring.~~

[2] Well is currently monitored, but 2024 data has not yet been reported.

*Fall measurements are sporadic in recent years

Table 3-~~15~~18. Summary of Lower Aquifer Groundwater Level Monitoring Network Wells.

Well I.D.	Well Depth	Screen Interval	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number of Measurements	Selection Rationale
COM RMS-1	520	210-510	36.9708	-120.0513	Spring/Fall	1983	2023[2]	40	48	Known well construction; long history of water level data; spatial/vertical distribution
COM RMS-2	590	370-590	36.9670	-120.0898	Spring/Fall	1996	2023[2]	27	36	Known well construction; long history of water level data; spatial/vertical distribution
COM RMS-4	588	433-568	36.9452	-120.0423	Spring/Fall	2009	2023[2]	14	23	Known well construction; long history of water level data; spatial/vertical distribution
MCE RMS-3	NA[1]	NA[1]	36.9552	-119.9441	Spring/Fall	1964	2024	60	74	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCE RMS-5	NA[1]	NA[1]	36.9082	-119.8641	Spring/Fall	1978	2024	46	55	CASGEM Voluntary well; long history of water level data; spatial/vertical distribution
MCE RMS-6	550	450-550	36.9337	-119.9080	Spring/Fall	2014	2023[2]	9	301	CASGEM well; known well construction; spatial/vertical distribution
MCW RMS-3	NA[1]	NA[1]	36.8943	-120.3285	Spring/Fall	1950	2024	74	78	CASGEM voluntary well; spatial/vertical distribution
MSB03C	430	355-420	36.8951	-120.3818	Spring/Fall	2019	2024	5	15	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB04B	695	530-685	36.9922	-120.0825	Spring/Fall	2019	2024	5	19	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB05B	375	240-365	36.9238	-120.2552	Spring/Fall	2019	2024	5	18	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB06C	715	630-705	36.8257	-120.2057	Spring/Fall	2019	2024	5	14	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB09C	955	880-945	36.8814	-120.1105	Spring/Fall	2019	2024	5	14	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB10C	880	790-870	37.0750	-120.1948	Spring/Fall	2019	2024	5	21	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB11C	880	775-870	37.0692	-120.0745	Spring/Fall	2019	2024	5	10	Dedicated monitoring well; known well construction; spatial/vertical distribution
MSB12	465	355-465	37.0516	-119.9820	Spring/Fall	2022	2024	2	5	Dedicated monitoring well; known well construction; spatial/vertical distribution
MID RMS-2	563	298-509	37.0407	-120.2342	Spring/Fall	2015	2023[2]	8	13	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-3	516	260-507	37.0366	-120.1760	Spring/Fall	1954	2023[2]	69	114	CASGEM well; known well construction; long history of WL data; spatial/vertical distribution

Well I.D.	Well Depth	Screen Interval	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number of Measurements	Selection Rationale
MID RMS-4	698	320-667	36.9709	-120.2568	Spring/Fall	2015	2023[2]	8	16	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-5	570	270-570	36.9581	-120.2067	Spring/Fall	1958	2023[2]	65	120	CASGEM well; known well construction; long history of WL data; spatial/vertical distribution
MID RMS-6	680	320-680	37.0033	-120.1561	Spring/Fall	2015	2023[2]	8	22	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-7	656	290-635	36.9243	-120.1288	Spring/Fall	1936	2023[2]	87	142	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-10	615	315-615	36.8996	-120.1742	Spring/Fall	2015	2023[2]	8	18	CASGEM well; known well construction; spatial/vertical distribution
MID RMS-16	452	348-388	37.0196	-120.0526	Spring/Fall	2011	2023[2]	12	15	CASGEM well; known well construction; spatial/vertical distribution
MWD RMS-1	504	200-500	37.0472	-120.0248	Spring/Fall	1994	2024	30	31	CASGEM well; known well construction; spatial/vertical distribution
MWD RMS-2	537	200-537	37.0436	-120.0610	Spring/Fall	2003	2024	21	29	CASGEM well; known well construction; spatial/vertical distribution
MWD RMS-3	800	380-800	37.0436	-120.0697	Spring/Fall	2011	2024	13	29	CASGEM well; known well construction; spatial/vertical distribution

[1] Aquifer designations for wells with no construction information were derived through comparison of water levels to other nearby, known-construction wells, as well as comparisons with simulated water levels at these wells derived from the calibrated groundwater model.

[2] Well is currently monitored, but 2024 data has not yet been reported.

~~[1] Well is currently monitored, but 2024 data has not yet been reported.~~

~~*Fall measurements are sporadic in recent years~~

Table 3-1619. Summary of Composite Groundwater Level Monitoring Network Wells.

Well I.D.	Well Depth	Screen Interval	- Latitude	- Longitude	- Frequency	First Year Data	Last Year Data	Years Measured	Number of Measurements	Selection Rationale
MID RMS-13	600	228-552	36.9003	-119.9879	Spring/Fall	2015	2023[1]	8	14	CASGEM well; known well construction; spatial/vertical distribution

[1] Well is currently monitored, but 2024 data has not yet been reported.

[1] Well is currently monitored, but 2024 data has not yet been reported.

3.5.1.3 Land Subsidence Monitoring Program

The sustainability management criteria for the land subsidence sustainability indicator will be evaluated by monitoring land subsidence.

The objectives of the monitoring program to calculate changes in land subsidence include the following:

- Monitor vertical displacement of the land surface to improve the understanding of the potential occurrence of land subsidence.

The proposed monitoring network, shown in **Figure 3-310**, is comprised of all eight benchmark survey points monitored by the United States Bureau of Reclamation (USBR) as part of the SJRRP and one local continuous GPS stations monitored by UNAVCO as part of the Plate Boundary Observatory (PBO) Project. Locations of subsidence RMS are shown in **Figure 3-2**. Additional monitoring stations located outside of the Subbasin are included in the network to provide regional context (**Figure 3-11**). In addition to the point locations included in the monitoring network, InSAR data provided by DWR will be evaluated on an annual basis as part of the Annual Report to monitor subsidence within the Subbasin. The control points selected for inclusion in the monitoring network are currently monitored for other purposes. As a result, control points may be added or removed from the monitoring network as they are added or removed from the various programs currently maintaining these networks. An expansion of the subsidence monitoring network is planned in the Subbasin and described in more detail in the subsidence workplan provided in **Appendix 3.H**.

3.5.1.4 Groundwater Quality Monitoring Program

The sustainability indicator for degraded water quality is evaluated by monitoring groundwater quality at a network of wells.

The objectives of the groundwater quality monitoring program for the Plan Area include the following

The objectives of the groundwater quality monitoring program for the Plan Area include the following as they relate to the implementation of GSP PMAs:

- Evaluate groundwater quality conditions in the various areas of the Subbasin, and identify differences in water quality spatially between areas and vertically in the aquifer system;
- Detect the occurrence of and factors attributable to key constituents of interest as represented by nitrate, arsenic, and TDS;
- Assess the changes and trends in groundwater quality; and
- Identify the natural and human factors that affect changes in water quality.

For the purpose of monitoring groundwater quality conditions and potential impacts from GSP PMAs and overall groundwater extraction, a network of representative monitoring sites selected from among existing and proposed future wells located throughout the Joint GSP GSAs and screened in both in the Upper and Lower Aquifers. The representative monitoring sites for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Joint GSP GSAs together with wells that are sampled by others as part of other groundwater quality monitoring programs. The selected RMS for groundwater quality are listed in **Table 3-121** and shown on **Figure 3-43**. Information on well construction and historical groundwater quality monitoring for each of the indicator wells is included in **Appendix 3.B**.

As part of the January 2025 Plan Amendment, a comprehensive review of the RMS network was conducted, and the network was updated as necessary. A detailed discussion of wells removed and added to the network as part of this evaluation is presented in **Appendix 3.L.** The network of groundwater quality representative monitoring sites includes 7~~12~~ existing wells that are also part of the water level monitoring indicator well network and will also be sampled for groundwater quality by the Joint GSP GSAs. Additionally, 23~~seven future~~ dedicated monitoring wells at nine nested monitoring well sites that were ~~are in the process of being~~ constructed in the Joint GSP GSAs as part of GSP implementation, and each~~ach of the three individual monitoring wells at each site~~ will be sampled for groundwater quality by the Joint GSP GSAs. Ongoing groundwater quality monitoring being conducted by other entities for the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) program of 12~~3~~ selected public supply wells will also be incorporated into the representative groundwater quality monitoring in the Plan Area. Available results from groundwater quality sampling conducted by the monitoring entities for these public supply wells will be acquired and incorporated into the ongoing evaluation of groundwater quality monitoring as part of implementing the GSP. Monitoring and assessment of groundwater quality is also being conducted for the Irrigated Lands Regulatory Program (ILRP), currently including sampling of two domestic wells and future incorporation of the new monitoring wells described above as part of the Groundwater Quality Trend Monitoring program for the East San Joaquin Water Quality Coalition. The two current domestic wells will also be included in the representative groundwater quality monitoring network. As details of GSP PMAs are refined, the groundwater quality monitoring network will be reviewed and modified if needed to ensure that the network is sufficient to achieve the objective of monitoring for groundwater quality impacts caused by GSP PMAs.

In addition to the regular monitoring of groundwater quality using the selected sustainability indicator wells, ongoing assessment of groundwater quality conditions for the ILRP is also occurring and involves annual sampling of a regional network of relatively shallow wells, evaluation of trends in groundwater quality related to irrigated agricultural practices, and also includes additional compilation and analysis of groundwater quality trends and conditions at five-year intervals based on readily available public data. Under the ILRP Waste Discharge Requirements for the East San Joaquin Water Quality Coalition (Coalition), growers in the Plan Area also must sample and report groundwater quality domestic wells on parcels enrolled in the Coalition. Data and reports on groundwater quality conditions developed through the ILRP will be considered and evaluated as part of assessing the groundwater quality sustainability indicator and relationships with GSP PMAs. Additionally, many more public water supply wells exist with recent groundwater quality monitoring for the three key constituents of interest. Some of these wells are incorporated as part of the representative groundwater quality monitoring network; however, data for other wells will also be considered in evaluating any potential groundwater quality impacts from GSP PMAs.

It is worth noting that ~~Groundwater~~ groundwater quality impacts from activities unrelated to specific GSP PMAs are under the purview of separate regulatory programs including the ILRP or other regulatory programs overseeing waste discharges to groundwater and groundwater contamination sites.

3.5.1.5 Interconnected Surface Water Monitoring Program

The sustainability indicator for interconnected surface water is evaluated by monitoring groundwater levels at a network of wells screened in the Upper Aquifer near the San Joaquin River. Streamflow data from gaging stations is also collected and will be used in future studies and evaluations of interconnected surface water.

The objectives of the groundwater level and streamflow monitoring programs related to interconnected surface water include the following:

- Improve the understanding of the occurrence and movement of shallow groundwater; monitor groundwater levels relative to the nearby stream thalweg to evaluate the percent of time groundwater levels are above vs. below the thalweg;
- Track and improve understanding of streamflows, including seasonal and year to year variability, and potential changes to the hydrologic regime related to the San Joaquin River Restoration Program;
- Detect the occurrence of, and factors attributable to surface water seepage to groundwater in the San Joaquin River where it forms the southern boundary of the ~~Madera~~ Subbasin; and
- Generate data to better estimate groundwater basin conditions related to interconnected surface water; update analyses as additional data become available.

For the purpose of monitoring interconnected surface water conditions and potential impacts from GSP PMAs and groundwater pumping, a network of representative monitoring sites was selected from among existing RMS wells screened in the Upper Aquifer and located near the San Joaquin River. The representative monitoring sites for interconnected surface water include a combination of irrigation and monitoring wells to be monitored by the Subbasin GSAs. The selected RMS for interconnected surface water are listed in Table 3-14~~2~~ and shown on **Figure 3-5~~4~~**. Information on well construction and historical groundwater levels for each of the indicator wells is included in **Appendix 3.A**.

3.5.2 Monitoring Protocols for Data Collection and Monitoring *(23 CCR § 352.2)*

This section is intended to provide a description of technical standards, methods, and procedures/protocols to ensure comparable data and methodologies for data collection and monitoring. All field monitoring activities will follow established Standard Operating Procedures (SOPs) for the Plan Area, which will be developed to reflect the standards, methods, and procedures described below.

3.5.2.1 Groundwater Level Monitoring Program

The protocols for measuring groundwater levels include the following:

- Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot (or at least to the nearest 0.1 foot at a minimum) relative to the Reference Point (RP). Measurements and RPs should not be recorded in feet and inches.
- For measuring wells that are under pressure, allow a period of time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. In the event that a well is artesian, site specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in the well. Record the dimension of the extension and document measurements and configuration.
- The groundwater elevation should be calculated using the following equation.

  GWE= RPE−DTW

  Where:

GWE = Groundwater Elevation in NAVD88 datum
RPE = Reference Point Elevation in NAVD88 datum
DTW = Depth to Water

- The well caps or plugs should be secured following depth to water measurement.
- Groundwater level measurements are to be made on a semi-annual basis at a minimum during periods which will capture seasonal highs and lows.
- The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, oil in the well, nearby irrigation, flooding, or well condition. Of particular concern may be pumping of nearby irrigation wells or time since pumping stopped in the well being monitored; such conditions should be specifically identified and noted to the extent possible. If there is a questionable measurement or the measurement cannot be obtained, it should be noted. Standardized field forms will be used for all data collection.
- The sampler should have a record of previous measurements in the field for each well to compare with the current measurements being recorded. If a current measurement appears anomalous compared to previous measurements it should be checked again and verified.
- All data should be entered into the GSP data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person.

3.5.2.2 Installing Pressure Transducers and Downloading Data

The following procedures will be followed in the installation of a pressure transducer and periodic data downloads:

- The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.
- The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.
- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment will be exercised to ensure that the data being collected is meeting the data quality objectives (DQO) and that the instrument is capable of meeting DQO. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.
- The sampler must note whether the pressure transducer uses a vented or non-vented cable for barometric compensation. Non-vented units are preferred (generally less expensive, require less maintenance than vented units, and are less prone to failure) and provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.
- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.
- Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.

- The transducer data should be periodically checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually to maintain data integrity.
- The data should be downloaded as necessary to ensure no data is lost and subsequently entered into the Subbasin's DMS following the QA/QC program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.

3.5.2.3 Groundwater Storage Reduction Monitoring Program

The monitoring protocols for evaluating change in groundwater storage are the same as the protocols described above for groundwater levels.

3.5.2.4 Land Subsidence Monitoring Program

Subsidence monitoring will include the following protocols:

- Download and review subsidence data collected by the USGS, DWR, the SJRRP, and other entities. This data will be input into the DMS following QA/QC.
- Groundwater level data collected as part of the subsidence monitoring program will follow the same protocols as described above for groundwater level monitoring.

3.5.2.5 Groundwater Quality Monitoring Program

Annual monitoring of groundwater quality will include sampling and laboratory analysis of key parameters of interest as indicated on Table 3-2017 to be conducted by GSAs as presented in Tables 3-65, 3-76, and 3-121. Additional groundwater quality results reported by monitoring entities to DDW (in accordance with DDW testing requirements) for indicator public supply wells (and also wells monitored for the IRLP) will be obtained for evaluation as part of the groundwater quality monitoring program, although the sampling of these wells will not necessarily be performed by the GSAs. Water quality parameters may be added to the groundwater quality monitoring program in the future, if appropriate. During sampling events conducted by the GSAs, measurement of select water quality parameters will take place in the field. These field parameters should be measured at an annual frequency and include specific conductance at 25 °C (SC) in µS/cm, pH, temperature (in °C), oxidation-reduction potential (ORP) in millivolts, and dissolved oxygen (DO) in mg/L. The annual testing is summarized in Table 3-20187.

3.5.2.6 Interconnected Surface Water Monitoring Program

The protocols for measuring groundwater levels are described above in Section 3.5.2.1. Streamflow monitoring protocols would be addressed by the various agencies monitoring streamflow in the Subbasin.

Table 3-20~~187~~. Summary of Groundwater Quality Monitoring Constituents and Measurement Frequency for Representative Monitoring Sites.

Well ID	Responsible Monitoring Entity	Well Type	Field Measurements					Laboratory Measurements										
			Specific Conductance	pH	Dissolved Oxygen	ORP	Temperature	Nitrate (as nitrogen)	Arsenic	Total dissolved solids (TDS)	Carbonate	Bicarbonate	Chloride	Sulfate	Calcium	Sodium	Magnesium	Potassium
Wells Monitored by GSP Entities: Existing																		
MCE RMS-3	GSP Entities	Unknown	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MID RMS-4	GSP Entities	Irrigation	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MID RMS-5B	GSP Entities	Irrigation	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MID RMS-6	GSP Entities	Industrial	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MID RMS-7	GSP Entities	Irrigation	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MID RMS-13	GSP Entities	Irrigation	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MWD RMS-1	GSP Entities	Irrigation	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
~~MCW RMS-1~~	~~GSP Entities~~	~~Other~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-4~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-5~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-6~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-7~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MCE RMS-1~~	~~GSP Entities~~	~~Other~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MCE RMS-3~~	~~GSP Entities~~	~~Unknown~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MCW RMS-2~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-9~~	~~GSP Entities~~	~~Unknown~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MCW RMS-4~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MID RMS-13~~	~~GSP Entities~~	~~Irrigation~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
~~MWD RMS-1~~	~~GSP Entities~~	~~Unknown~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Annual~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~	~~Five-Year~~
Wells Monitored by GSP Entities: Future Monitoring Wells																		
MSB06A	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB06B	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB06C	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB09A	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB09B	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB09C	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB10B	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB10C	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB11C	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB13A	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year

Well ID	Responsible Monitoring Entity	Well Type	Field Measurements					Laboratory Measurements										
			Specific Conductance	pH	Dissolved Oxygen	ORP	Temperature	Nitrate (as nitrogen)	Arsenic	Total dissolved solids (TDS)	Carbonate	Bicarbonate	Chloride	Sulfate	Calcium	Sodium	Magnesium	Potassium
MSB13B	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
MSB13C	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Lavina MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Lavina MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Lavina MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 3 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 3 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 3 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 4 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 4 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 4 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 5 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 5 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 5 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 6 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 6 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 6 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 10 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 10 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 10 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 11 MW - Shallow	ILRP/GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 11 MW - Middle	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Site 11 MW - Deep	GSP Entities	Monitoring	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Wells Monitored for Other Programs																		
2000507-001	DDW	Public Supply	Frequency and schedule for constituent testing in public supply wells being monitored by non-GSA entities will be in accordance with monitoring entity and DDW schedule and requirements.															
2000553-001	DDW	Public Supply																
2000682-002	DDW	Public Supply																

Well ID	Responsible Monitoring Entity	Well Type	Field Measurements					Laboratory Measurements										
			Specific Conductance	pH	Dissolved Oxygen	ORP	Temperature	Nitrate (as nitrogen)	Arsenic	Total dissolved solids (TDS)	Carbonate	Bicarbonate	Chloride	Sulfate	Calcium	Sodium	Magnesium	Potassium
2000727-001	DDW	Public Supply																
2000938-001	DDW	Public Supply																
2010002-014	DDW	Public Supply																
2010002-032	DDW	Public Supply																
2010008-005	DDW	Public Supply																
2010009-002	DDW	Public Supply																
2010010-007	DDW	Public Supply																
2010801-001	DDW	Public Supply																
2801077-001	DDW	Public Supply																
ESJ12	ILRP	Domestic	Annual	Annual	Annual		Annual	Annual	Not tested*	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
ESJ17	ILRP	Domestic	Annual	Annual	Annual		Annual	Annual	Not tested*	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year

* Arsenic is not among the constituents required for the ILRP.

The GSP monitoring program will utilize the following protocols for collecting groundwater quality samples.

- Prior to sampling, the analytical laboratory will be contacted to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.
- Each well used for groundwater quality monitoring will have a unique identifier. This identifier will appear on the well housing or the well casing to verify well identification.
- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead following purging.
- Prior to sampling, the sampling port and sampling equipment will be cleaned of any contaminants. The equipment will be decontaminated after purging and collection of water samples at each site to avoid any cross-contamination between wells.
- The groundwater elevation in the well should be measured following appropriate protocols described above in the groundwater level measuring protocols.
- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling.
- Field parameters of pH, electrical conductivity, pH, temperature, and turbidity should be collected periodically during purging and prior to the collection of each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to collection of the water sampling. Measurements of pH values should occur in the field since the short hold times for laboratory pH analysis are typically unachievable. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO) (in situ measurements preferable), or turbidity, may also be useful for assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.
- Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.
- Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection. Alternatively, the flow rate from the sampling tap should correspond to laminar flow conditions when possible.
- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.

- Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.
- Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.
- Ensure the laboratory uses appropriate reporting limits that are at or below levels needed for the objectives of the monitoring.
- Groundwater quality samples are to be collected annually for key constituents and every five years for all other constituents.
- For wells monitored by other entities, obtain results and associated information on sampling activities through coordination and communication directly with the monitoring entity or through public databases such as SWRCB Geotracker where these data are available.

All groundwater quality data and other information from sampling activities should be entered into the DMS as soon as possible and in accordance with established QA/QC procedures. Care should be taken during any data entry to avoid mistakes and data entered into the database should be checked for accuracy and completeness.

3.5.2.7 GDE Monitoring Program

The GDE monitoring program will include monitoring of groundwater levels and biological monitoring. Groundwater level monitoring being conducted for the overall GSP includes three RMS wells adjacent to the San Joaquin River Riparian potential GDE Unit along the San Joaquin River in the southern Plan Area~~, and one RMS well near the Madera Canal Equalization Reservoir in close proximity to the Fresno River Riparian GDE Unit~~. Reconnaissance-level biological surveys were conducted in May 2019 and additional monitoring will be conducted as necessary in future Plan Amendments and Periodic Evaluations~~every five years~~ to document ecological condition of each GDE unit, including the Sumner Hill potential GDE Unit. Biological data will be analyzed in conjunction with hydrological data, where available, to assess potential ecological effects related to changes in groundwater levels and the relative degree of influence on GDE conditions exerted by stream flows and groundwater levels associated with each potential GDE.

3.5.3 Representative Monitoring *(23 CCR § 354.36)*

This section of Chapter 3 is intended to provide the following:

- Description of representative sites
- Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators
- Adequate evidence demonstrating the representative monitoring sites reflect general conditions in the area

Groundwater level data are collected from a large network of CASGEM,~~ and~~ USBR wells, and dedicated monitoring wells (**Appendices 3.A and 3.J**). Representative monitoring sites (RMS) are defined in the SGMA regulations as a subset of monitoring sites that are representative of conditions in the Plan Area. All the monitoring sites in this section are considered RMS utilizing methods of selection consistent with best management practices described above under the groundwater level protocols. Groundwater level monitoring will be used to determine changes in groundwater storage and ~~to assist in monitoring~~ for comparison to the rate of subsidence measurements. As previously stated, reduction in groundwater storage is directly dependent on measuring changes in groundwater levels. In the case of subsidence, there are various entities monitoring for subsidence adjacent to and within the Plan Area. ~~Although land subsidence has not yet been identified to cause significant impacts to infrastructure in the Plan Area and no specific land subsidence MTs have initially been set, w~~Water level monitoring well~~s~~ data are being utilized to supplement review ~~of ongoing~~ subsidence surveys ~~to determine if adaptive management is needed in the future to address land subsidence~~ (although installation of nested monitoring wells in this area at two locations includes shallow completions that are currently dry)~~,~~. Changes in water levels can be used in combination with subsidence surveys to develop the relationship/correlation between groundwater levels and amount/rate of subsidence.

3.5.4 Assessment and Improvement of Monitoring Network *(23 CCR § 354.38)*

This section of the GSP is intended to provide the following:

- 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

As described in 23 CCR § 354.38, the monitoring network is required to be analyzed for improvements as follows:

- Review the monitoring network and include an evaluation in the GSP and each ~~five-year assessment~~Periodic Evaluation, including a determination of uncertainty and whether there are data gaps that could affect the ability of the GSP to achieve the sustainability goal for the Subbasin.
- Identify data gaps wherever the Subbasin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the GSP.
- If the monitoring network contains data gaps, the GSP shall include a description of the following:
  - The location and reason for data gaps in the monitoring network
  - Local issues and circumstances that limit or prevent monitoring.
- The GSP shall describe steps that will be taken to fill data gaps before the next Periodic Evaluation~~five-year assessment~~, including the location and purpose of newly added or installed monitoring sites.
- The GSP shall adjust the monitoring frequency and distribution of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:
  - MT exceedances
  - Highly variable spatial or temporal conditions
  - Adverse impacts to beneficial uses and users of groundwater
- The potential to adversely affect the ability of an adjacent subbasin to implement its GSP or impede achievement of sustainability goals in an adjacent subbasin.

3.5.4.1 Review and Evaluation of the Monitoring Network

The monitoring networks described above for each of the applicable sustainability indicators will be evaluated ~~on a yearly basis~~the Annual Reports and Periodic Evaluation process, consistent with SGMA. The~~is~~ evaluation in the Annual Reports will involve a review of the described MTs and MOs and their comparison to observed trends in the networks. ~~Furthermore, a~~A more comprehensive review of the monitoring networks will be conducted every five years in the Periodic Evaluation. During this review, management actions and projects will be evaluated and the monitoring networks will be assessed for their efficacy in tracking progress based on the actions and projects. These evaluations and assessments will also highlight any additional data gaps and recommended changes to the monitoring networks. Documentation of these evaluations are found in the Annual Reports and Periodic Evaluation.

3.5.4.2 Identification and Description of Data Gaps

Identification and description of data gaps for the monitoring networks described above for each of the applicable sustainability indicators are described below. Updates related to data gaps are documented in the Annual Reports and Periodic Evaluation.

Groundwater Elevation

Groundwater elevation data has been extensively collected within the Plan Area over the past several decades. However, despite this data collection effort, spatial data gaps still exist. Specifically, in the Upper Aquifer in the northern portion of the Plan Area (although installation of nested monitoring wells in this area at two locations includes shallow completions that are currently dry),, and the Lower Aquifer in the south central (although one nested monitoring well has been added since 2019 in this area) and extreme eastern (two new nested monitoring wells added in 2022) and western portions of the Plan Area are lacking in monitoring wells. These gaps are evident in the designed monitoring network as limited~~no~~ existing wells represent the areas described. In addition to these spatial gaps, temporal data collection gaps also exist at some of the monitoring network sites. Many times the lack of measurements is due to the inaccessibility of the monitoring wells or active pumping, or relatively recent inclusion in a monitoring program. Some of the spatial data gaps were~~will be~~ filled with installation of the nested monitoring wells since 2019~~by 2020~~ - particularly for the Upper Aquifer and extreme western portion of the Lower Aquifer. Temporal data gaps will begin to be filled by more regular collection of data as part of the GSP (the groundwater level RMS monitoring network was updated and revised in this Plan Amendment to replace RMS with inconsistent measurements), and installation of transducers in new nested monitoring wells.

Data gaps relative to GDEs can be characterized as incomplete information on the extent to which the vegetation composing the Fresno River Riparian and San Joaquin River Riparian GDE units may be impacted by occurrence of temporary short-term declines in shallow groundwater levels below historical lows. Additionally, uncertainty exists with respect to the source of shallow groundwater supporting the wetlands and vegetation composing the Sumner Hill potential GDE Unit and its potential to be affected by changes in future groundwater conditions. Biological monitoring, recommended every five years, will be used to evaluate potential beneficial or adverse effects on GDEs that may be related to changes in future groundwater conditions during the implementation and sustainability periods.

Groundwater Storage

Groundwater storage data gaps are described in the groundwater elevation section as water levels are being used as a proxy for groundwater storage.

Subsidence

Subsidence monitoring has been conducted benchmark survey stations since 2012 at six locations and since 2017 at two additional locations. There is also one continuous subsidence monitoring station with data since 2005. While subsidence monitoring density is good in the extreme western portion of the Subbasin, along Highway 99, and in the southeast portion of the Subbasin, data gaps in benchmark station subsidence monitoring are present southwest of Highway 99 and in the northeast portion of the Subbasin. ~~a~~ A Subsidence w~~W~~orkplan has been developed and is included with this GSP (see **Appendix 3.H**) to help develop a more robust subsidence benchmark monitoring program. In addition, the subsidence benchmark monitoring is supplemented by InSAR based subsidence measurements throughout the Subbasin dating back to 2015.

Groundwater Quality

Considerable historical groundwater quality data exist for the Plan Area although the spatial distribution and association of well construction information with groundwater quality observations present limitations. ~~Some~~ Many of the wells in the proposed groundwater quality sustainability indicator monitoring network ~~have~~ had not historically been monitored for groundwater quality prior to 2020. The ~~addition of these wells and~~ establishment of a groundwater quality monitoring network for this GSP, which includes the monitoring wells ~~currently being~~ constructed since 2019 together with other groundwater quality monitoring being conducted for public supply wells and the ILRP help provide a sufficient network for monitoring of groundwater quality and impacts from GSP projects and managements actions. Extensive groundwater quality sampling for this network started in 2020. As GSP PMAs are implemented and the planned locations for these activities are better known, the groundwater quality monitoring network ~~should~~ will be reviewed and modified as~~if~~ needed to provide sufficient groundwater quality monitoring to meet the stated objectives. The first comprehensive review of the groundwater quality RMS monitoring network was conducted for this Plan Amendment, and the network was updated and revised to replace RMS with inconsistent measurements.

3.5.4.3 Interconnected Surface Water

Significant data gaps exist for adequately characterizing interconnected surface water along the San Joaquin River along the southern boundary of Subbasin. The relationships between occurrence of shallow groundwater levels, streamflow, and pumping need an improved understanding. Whether or not (and to what degree) shallow groundwater levels that occur along the San Joaquin River may be impacted by regional groundwater pumping is yet to be determined, and requires an improved understanding of shallow subsurface stratigraphy, groundwater elevations in various depth zones, and potential variations in streamflow along this reach of the San Joaquin River. While interim SMC for ISW have been established, an ISW Workplan was developed to improve understanding of surface water – groundwater interactions and support subsequent refinement of interim SMC.

3.5.4.4 Description of Steps to Fill Data Gaps

Data gaps have been presented in the groundwater level, groundwater storage, land subsidence, ~~and~~ groundwater quality, and ISW monitoring networks. The following steps have been or will be taken to address these data gaps:

- Since initial GSP development, the GSAs in the ~~Madera~~ Subbasin applied for and were awarded a Proposition 68 grant from DWR to install ~~six~~ four new monitoring wells at two sites in the Subbasin, among other efforts. The new nested monitoring wells were successfully installed in 2022 and ~~are expected to be~~have been incorporated into the monitoring network ~~once sufficient data is collected.~~ The monitoring wells installed in 2022 supplement the 21 new monitoring wells installed at seven sites in 2019-2020. Data collected from these new wells will address many of the data gaps described in the Upper and Lower Aquifers for groundwater level and quality data ~~(**Figures 3-1** and **3-3**)~~. Madera County GSA is currently working with DWR on plans for another nested monitoring well site anticipated for installation in 2025.
- ~~The GSAs will install sampling taps (as needed) on groundwater level wells designated for groundwater quality monitoring. These wells will then be sampled for both groundwater elevation data and groundwater quality data.~~

- Sampling events are beingwill be coordinated with well owners to prevent pumping and access issues to the extent possible.

In addition to these steps, the monitoring networks will be evaluated on a yearly and five-year basis as part of the Annual Reports and Periodic Evaluation, consistent with SGMA. Other updates related to data gaps are documented in the Annual Reports and Periodic Evaluation.

If additional data gaps arise, the GSA will consider the implications of these gaps, associated costs, and importance to the continued implementation of the GSP and take appropriate actions to address the gaps.

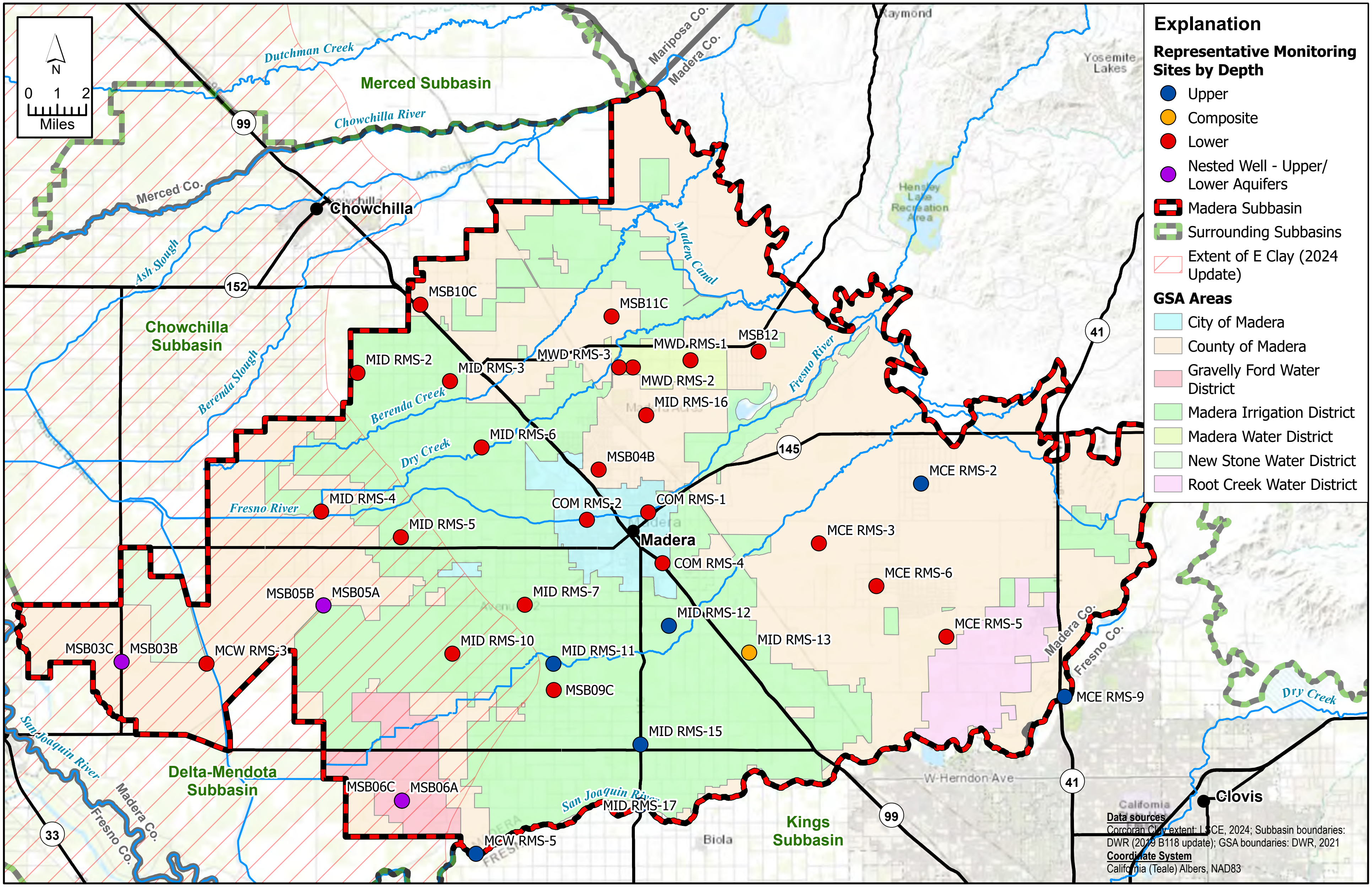
3.5.4.5 Description of Monitoring Frequency and Density of Sites

Monitoring frequency and density of sites for all sustainability indicators are described in previous sections in Chapter 3 of this report.

CHAPTER 3 SUSTAINABLE MANAGEMENT CRITERIA

Selected Figures

The following figures can be found after this page: Figures 3-1 to 3-110



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_WL

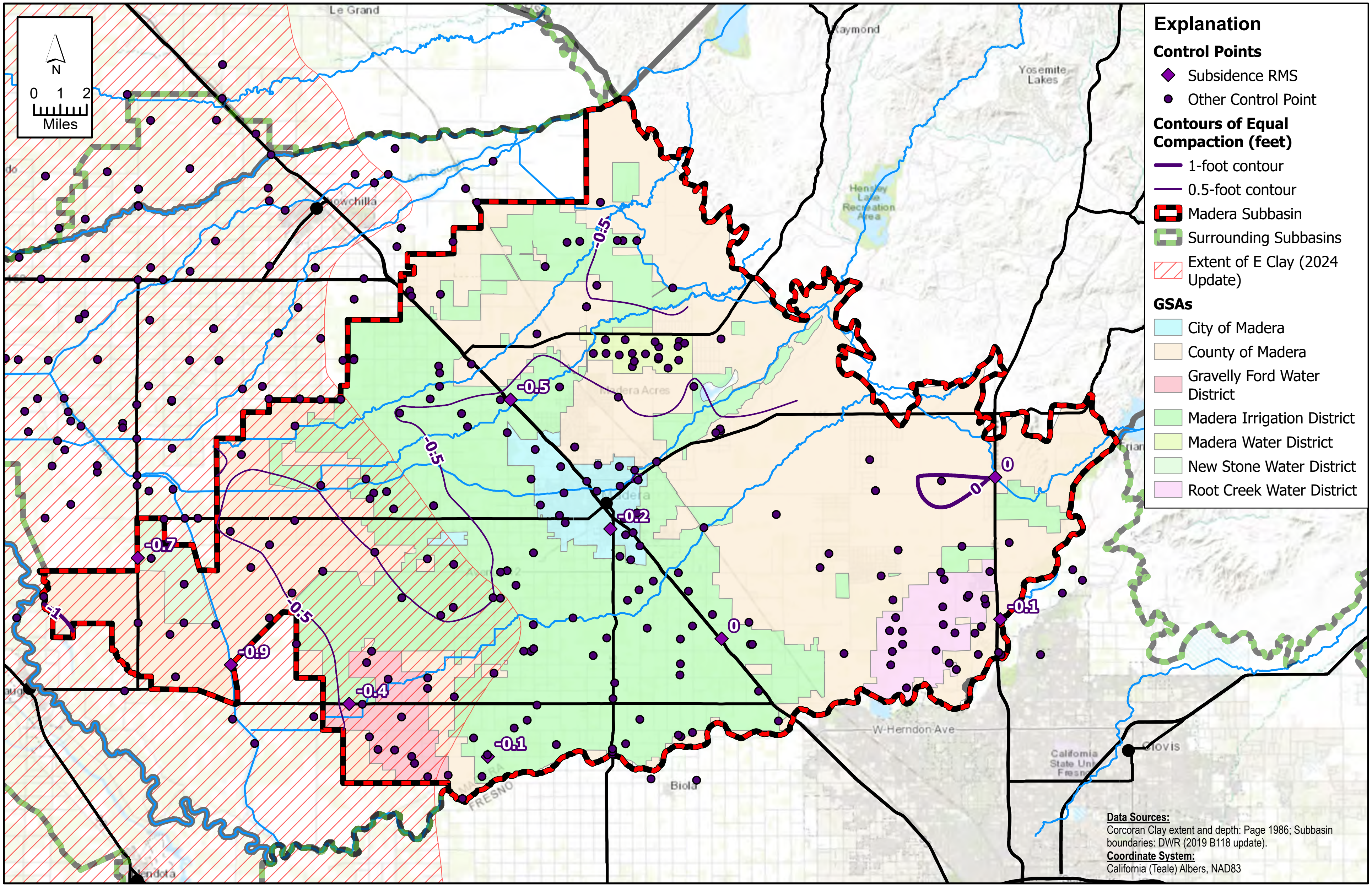
DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-1

Proposed Groundwater Level Representative Monitoring Sites

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\MODEL\MCSim_v2_GIS_20231101\MCSim_v2_20231101.aprx; SUBS_September 2030

DAVIDS ENGINEERING, INC

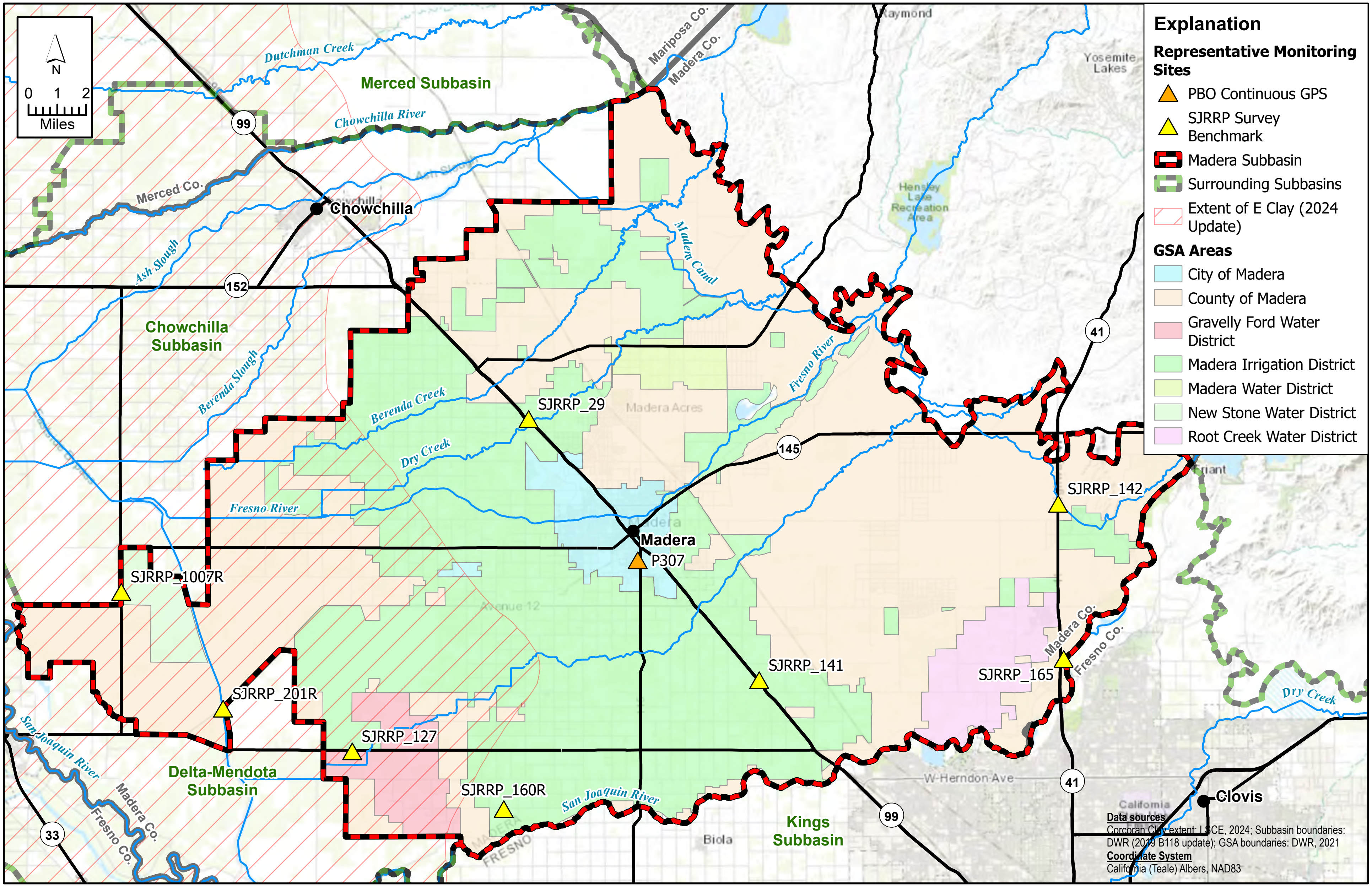
Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-2

Simulated Contours of Equal Compaction: September 2023 through September 2030

Madera Subbasin

Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_SUBS

DAVIDS ENGINEERING, INC

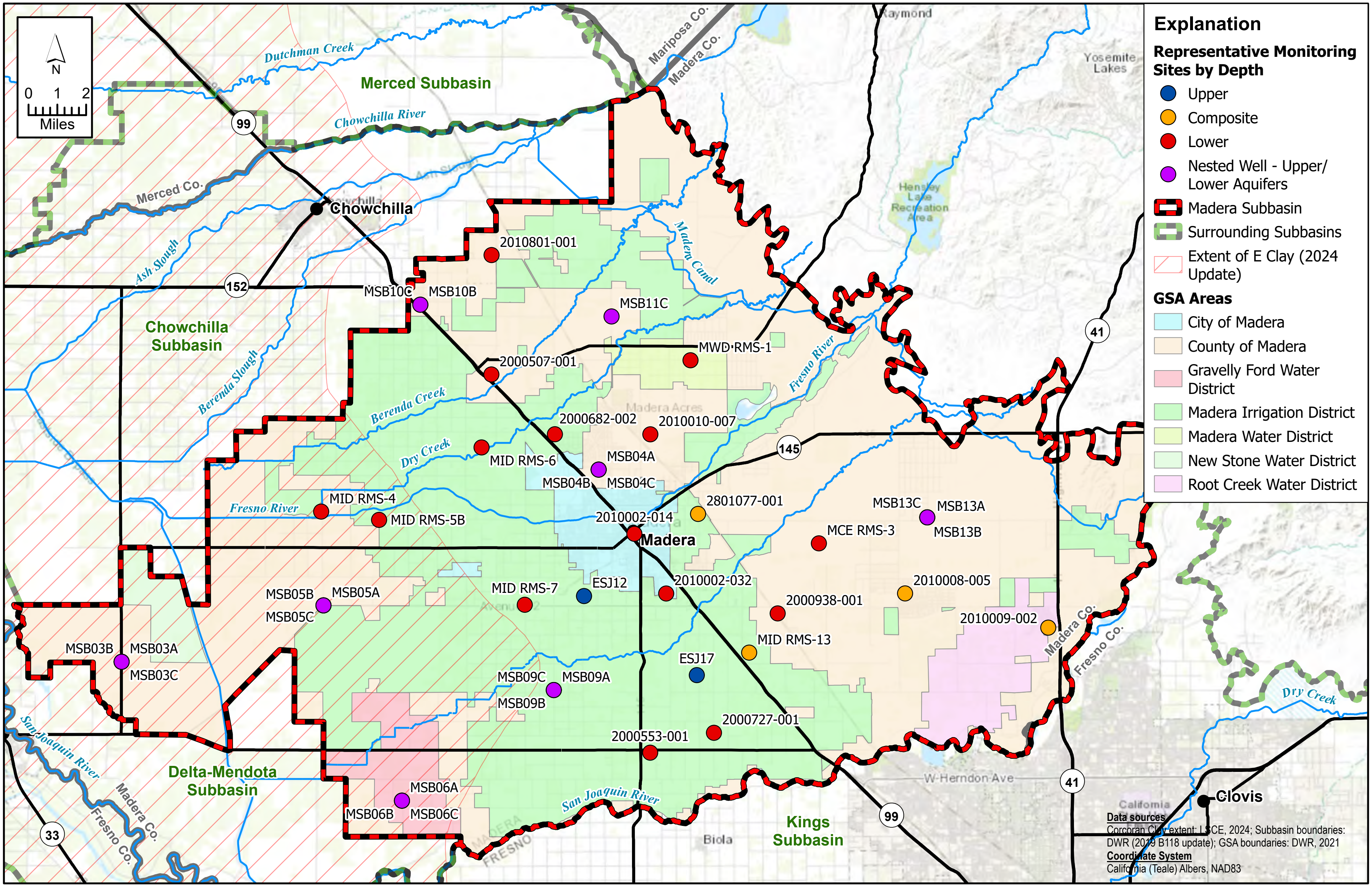
Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-3

Proposed Subsidence Sustainability Indicator Representative Monitoring Sites

Madera Subbasin

Groundwater Sustainability Plan - First Plan Amendment



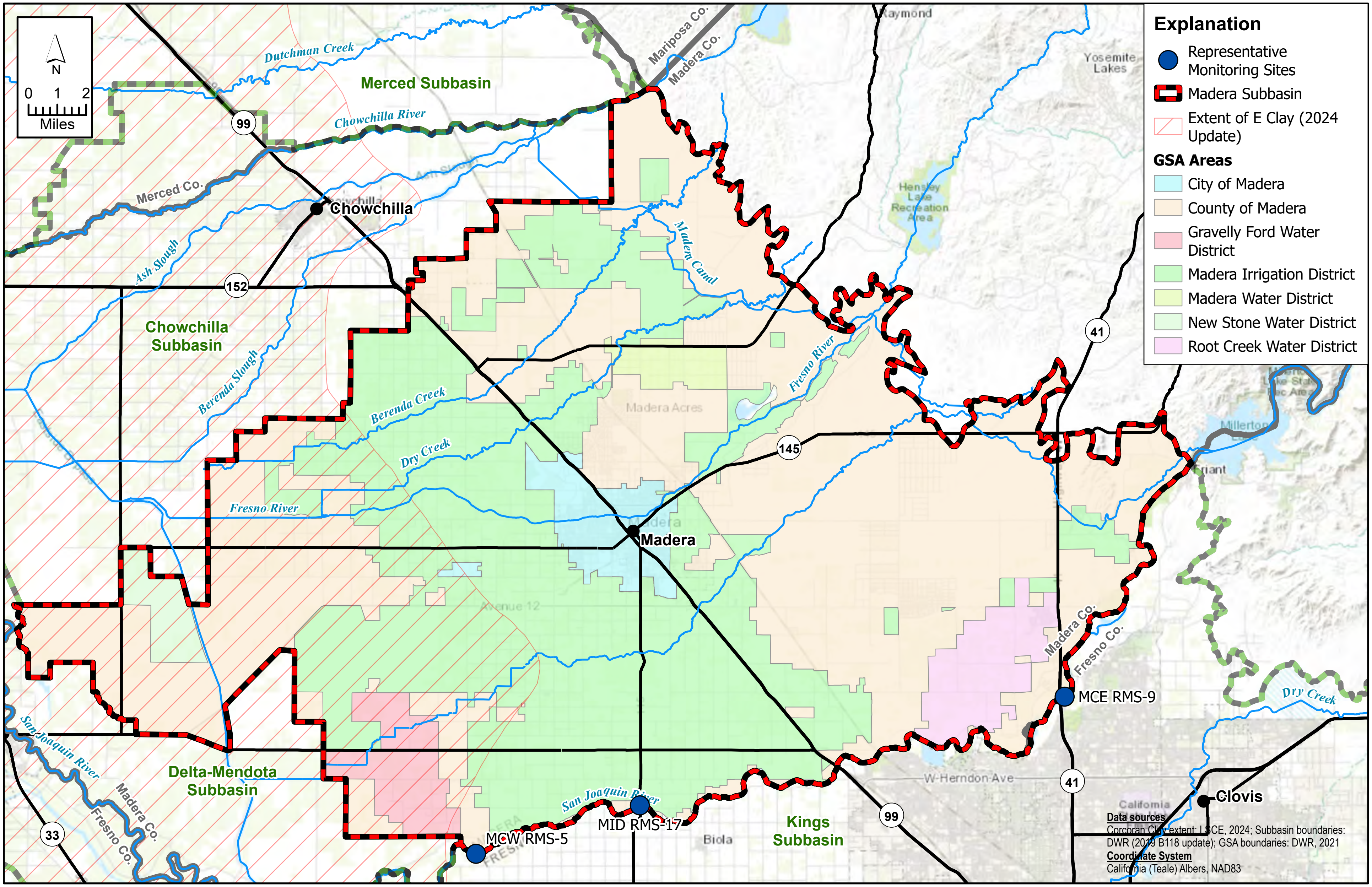
X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_WQ

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-4
Proposed Groundwater Quality Sustainable Indicator Representative Monitoring Sites

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



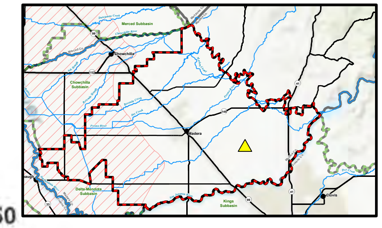
X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_ISW

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

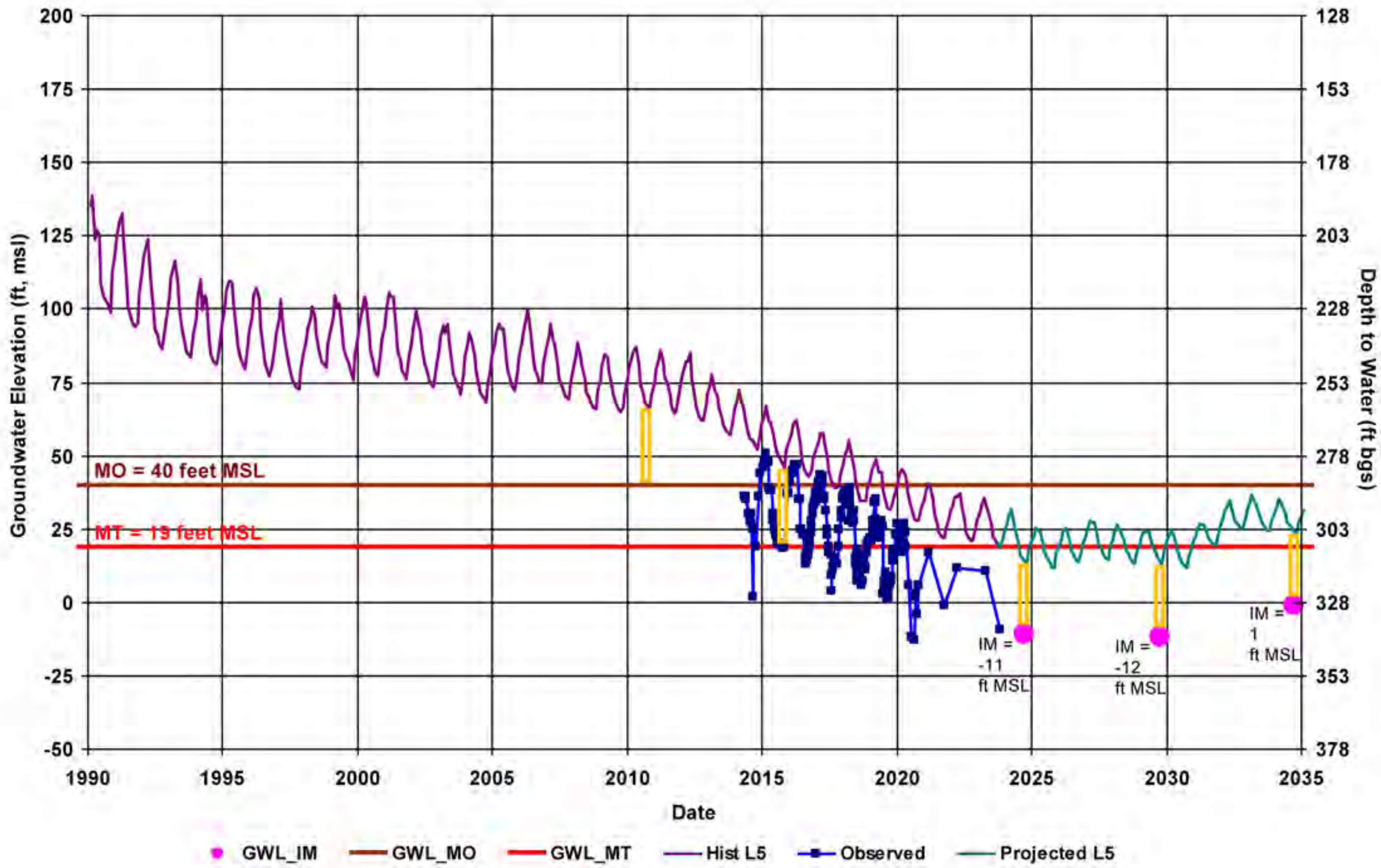
FIGURE 3-5
Proposed Interconnected Surface Water Sustainability Indicator Representative Monitoring Sites

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



Well Name: MCE RMS-6
Depth Zone: Lower
Subbasin: Madera
GSE (ft, msl): 328
GSA: County of Madera

Total Depth (ft): 550
Perf Top (ft): 450
Perf Bottom (ft): 550
Top Model Layer: 5
Bottom Model Layer: 5



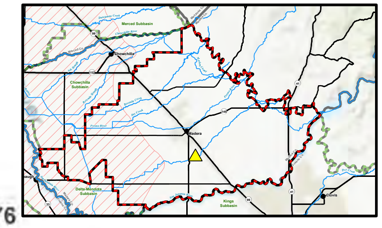
X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; GWL_SMC_MCE RMS-6

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

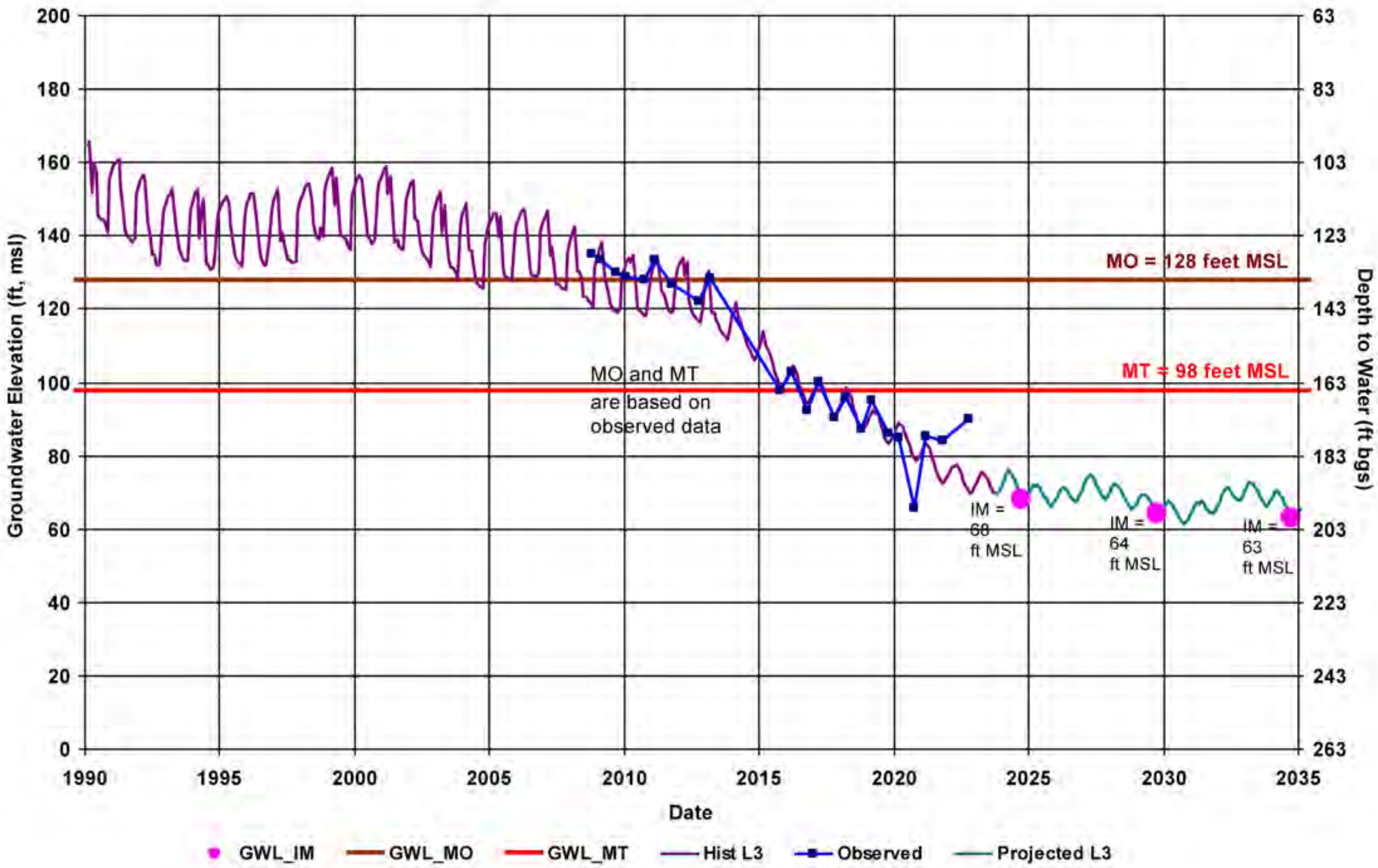
FIGURE 3-6A
Example Groundwater Level Hydrograph with Observed Fall 2015 Data - MCE RMS-6

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



Well Name: MID RMS-12
Depth Zone: Upper
Subbasin: Madera
GSE (ft, msl): 263
GSA: Madera Irrigation District

Total Depth (ft): 176
Perf Top (ft):
Perf Bottom (ft):
Top Model Layer: 3
Bottom Model Layer: 3

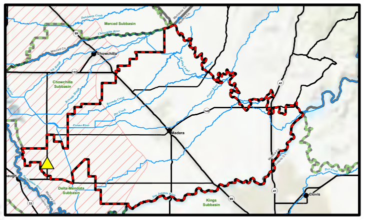


X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; GWL_SMC_MID RMS-12

DAVIDS ENGINEERING, INC
Luhdorff & Scalmanini Consulting Engineers

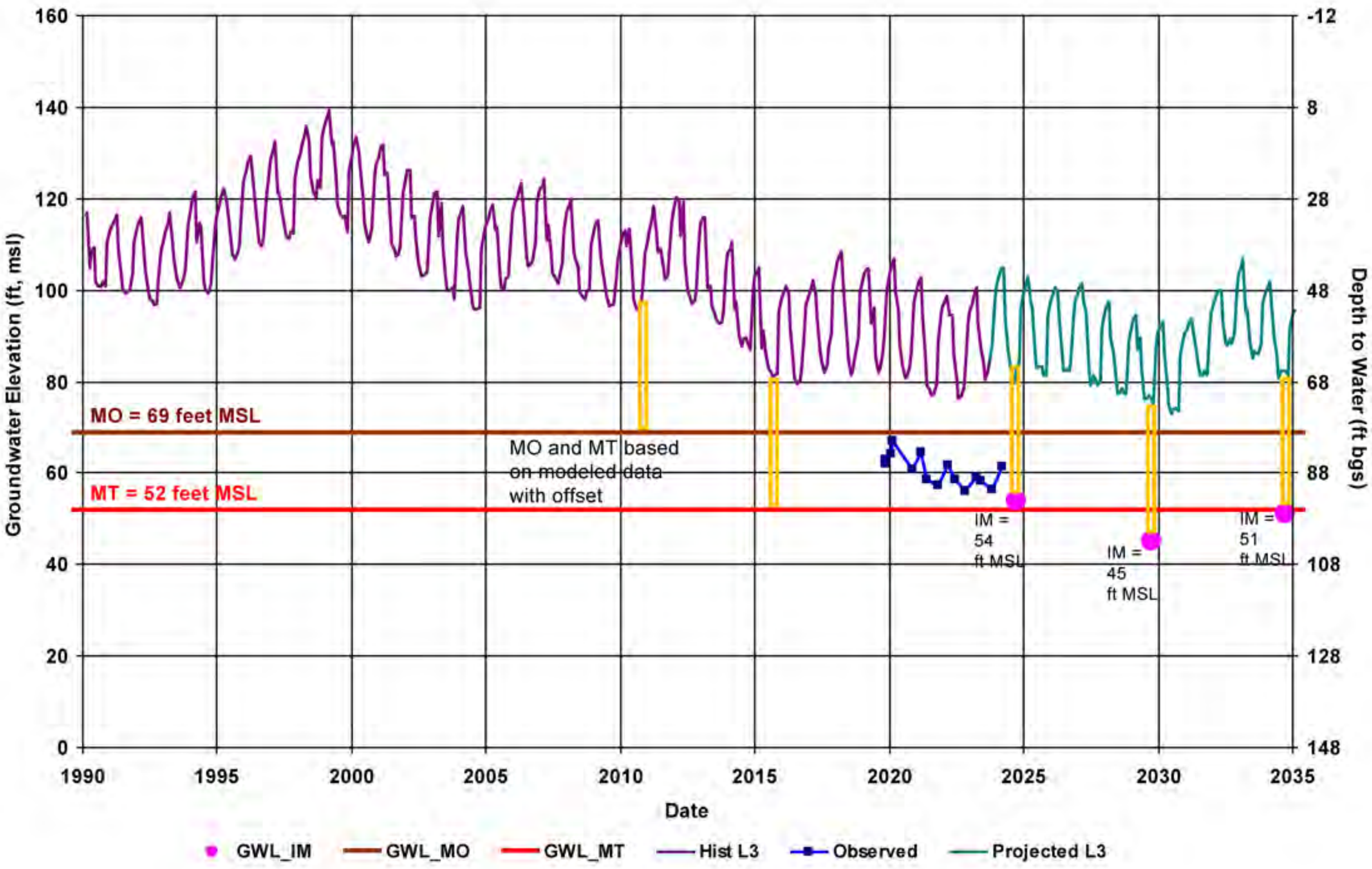
FIGURE 3-6B
Example Groundwater Level Hydrograph with Observed Fall 2015 Data - MID RMS-12

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



Well Name: MSB03B
Depth Zone: Upper
Subbasin: Madera
GSE (ft, msl): 148
GSA: County of Madera

Total Depth (ft): 295
Perf Top (ft): 215
Perf Bottom (ft): 285
Top Model Layer: 3
Bottom Model Layer: 3



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; GWL_SMC_MSB03B

DAVIDS ENGINEERING, INC

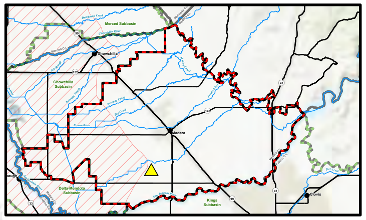
Luhdorff & Scalmanini Consulting Engineers

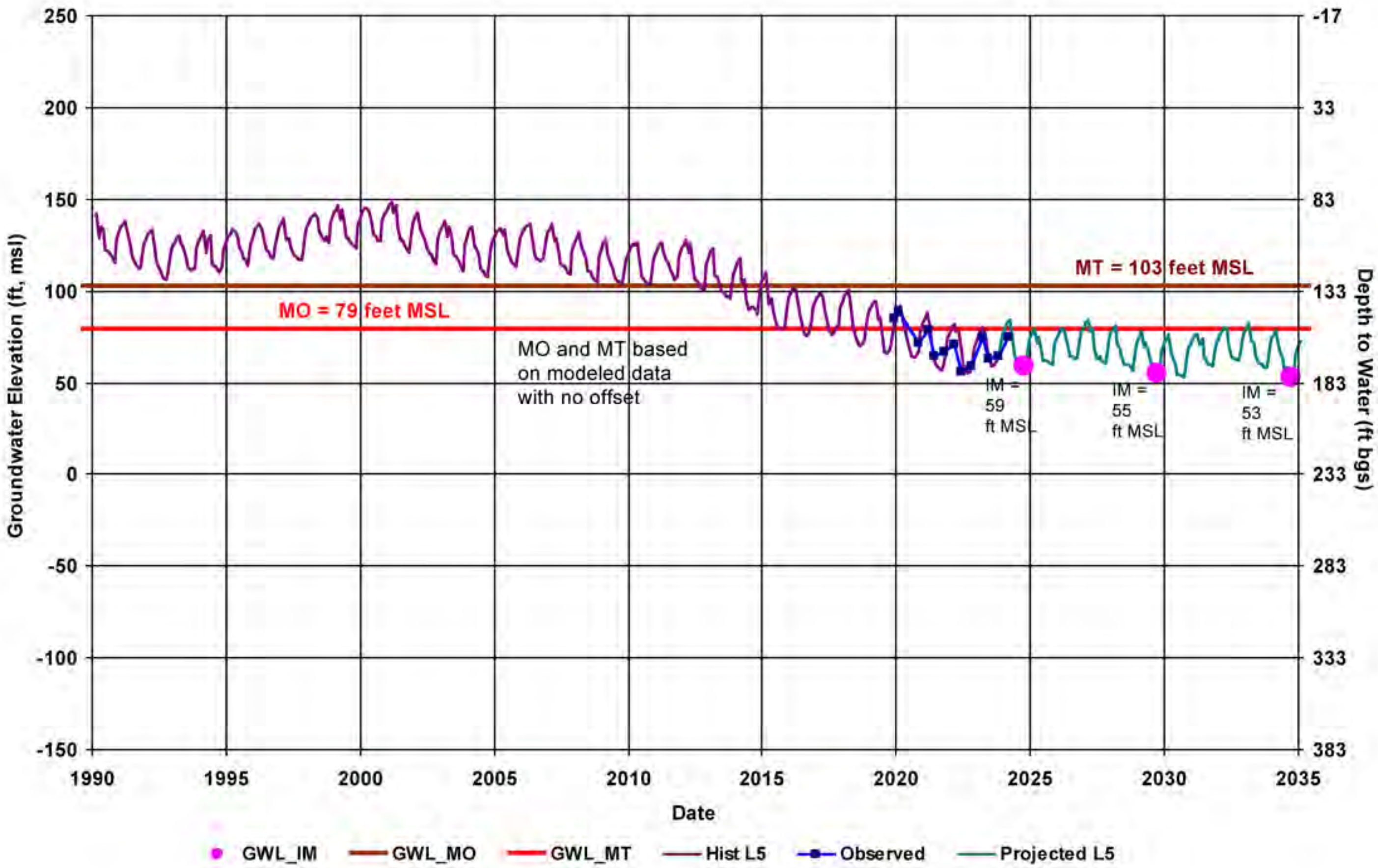
FIGURE 3-7A
Example Groundwater Level Hydrograph without Observed Fall 2015 Data - MSB03B

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment

Well Name: MSB09C
Depth Zone: Lower
Subbasin: Madera
GSE (ft, msl): 233
GSA: Madera Irrigation District

Total Depth (ft): 955
Perf Top (ft): 880
Perf Bottom (ft): 945
Top Model Layer: 5
Bottom Model Layer: 5

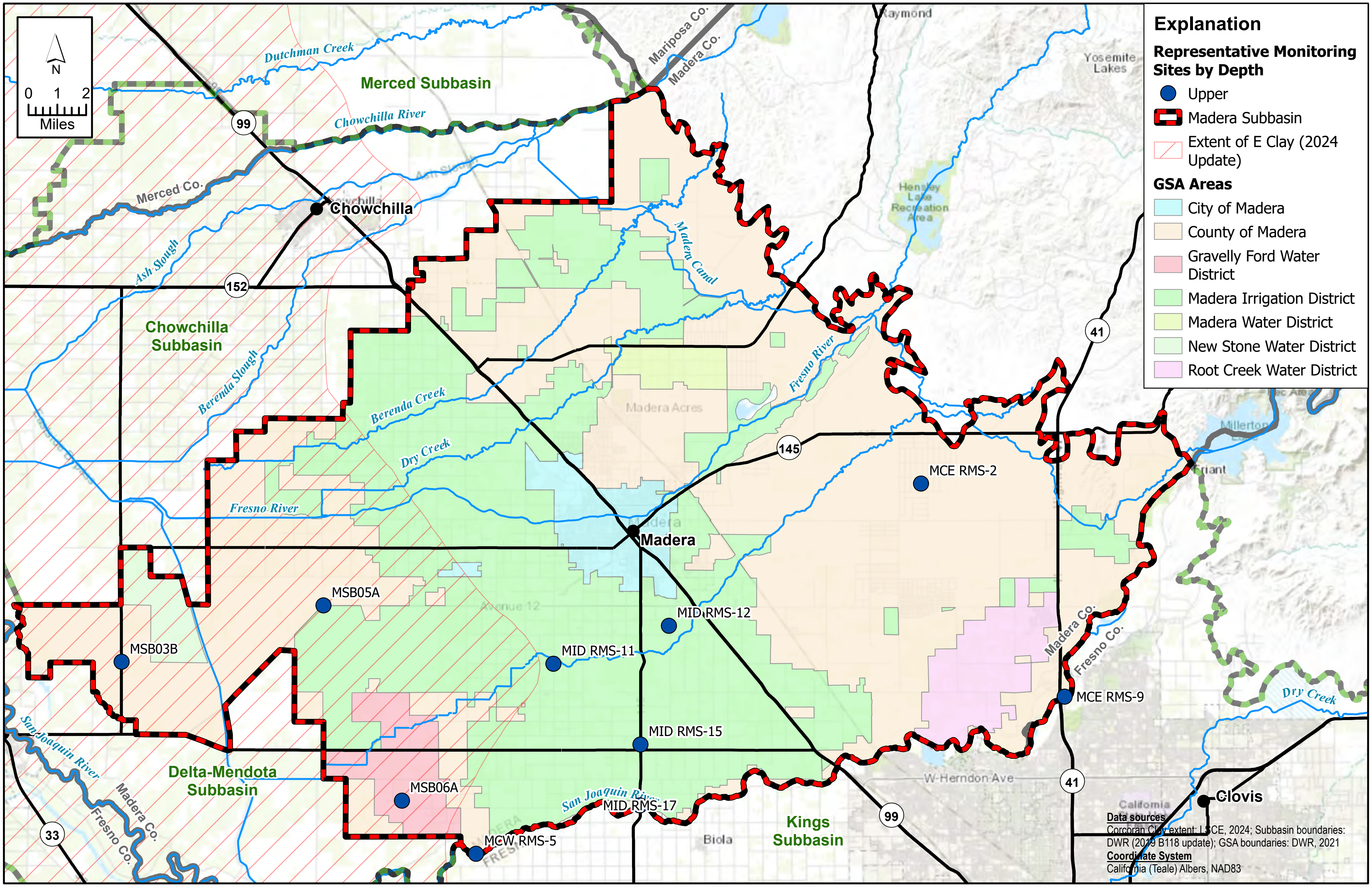




X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; GWL_SMC_MSB09C

FIGURE 3-7B
Example Groundwater Level Hydrograph without Observed Fall 2015 Data - MSB09C

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_WL_Upper

DAVIDS ENGINEERING, INC

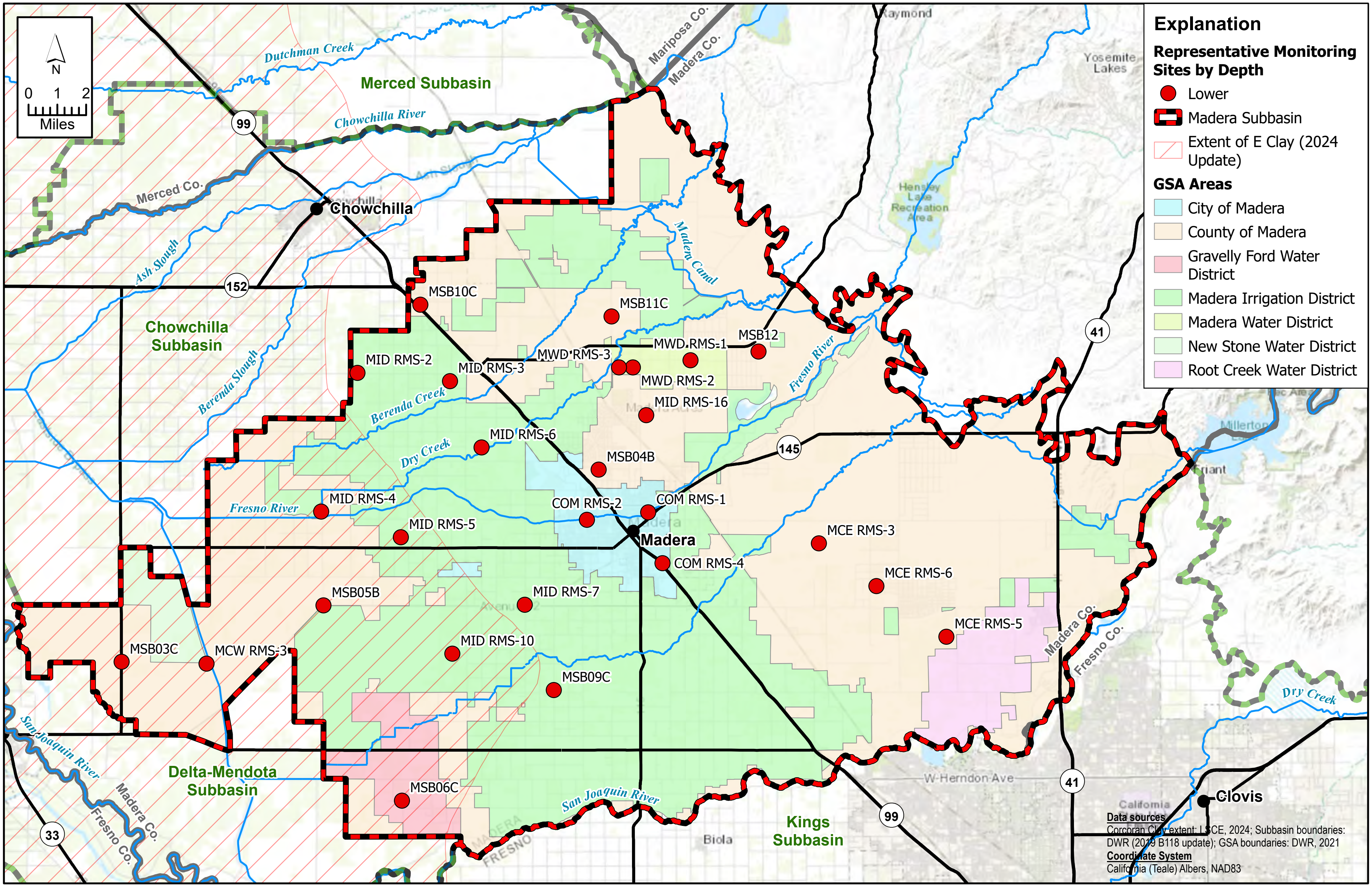
Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-8

Proposed Groundwater Level Sustainable Indicator Representative Monitoring Sites - Upper Aquifer

Madera Subbasin

Groundwater Sustainability Plan - First Plan Amendment



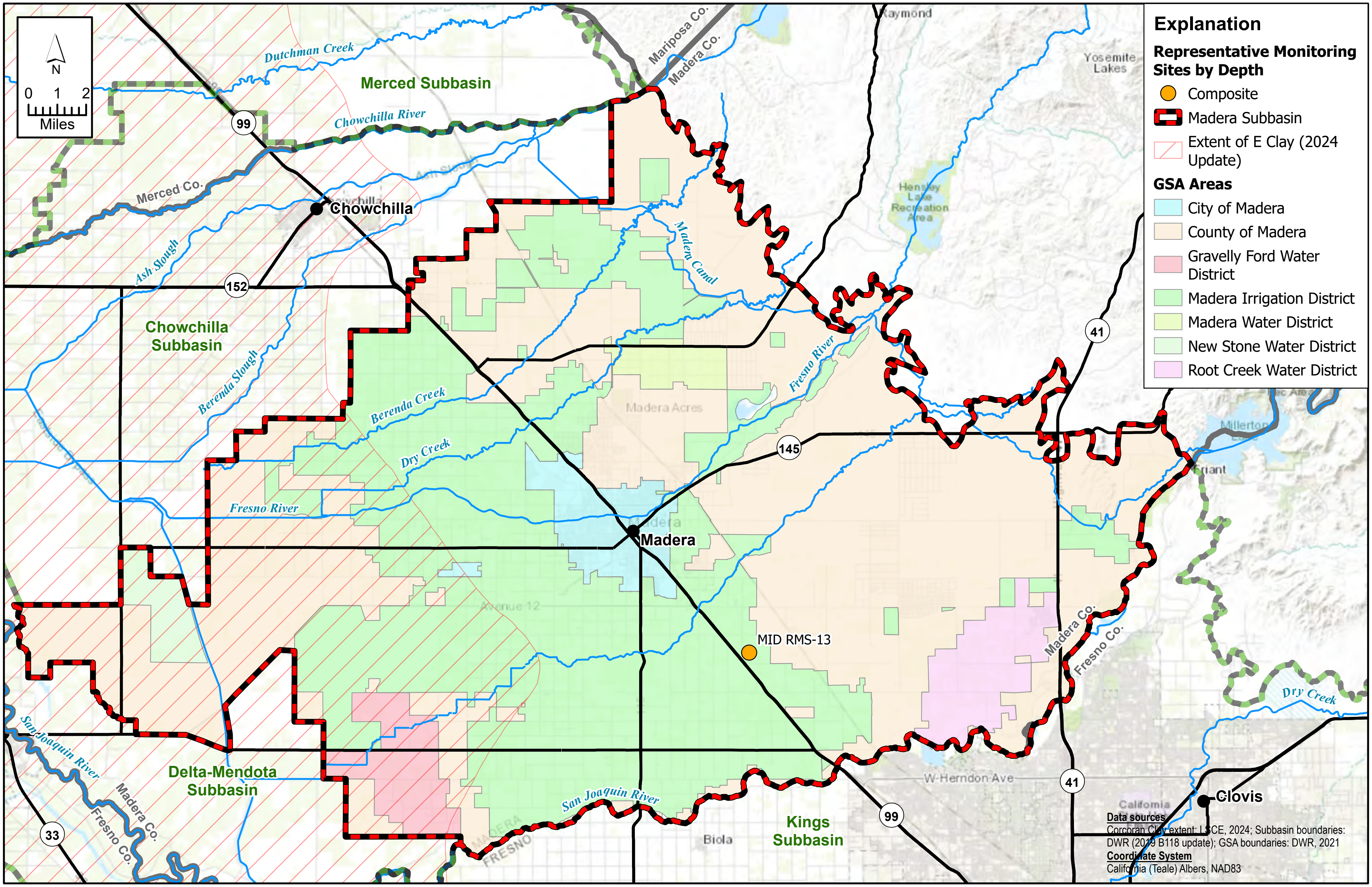
X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_WL_Lower

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-9
Proposed Groundwater Level Sustainable Indicator Representative Monitoring Sites - Lower Aquifer

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; RMS_WL_Composite

DAVIDS ENGINEERING, INC

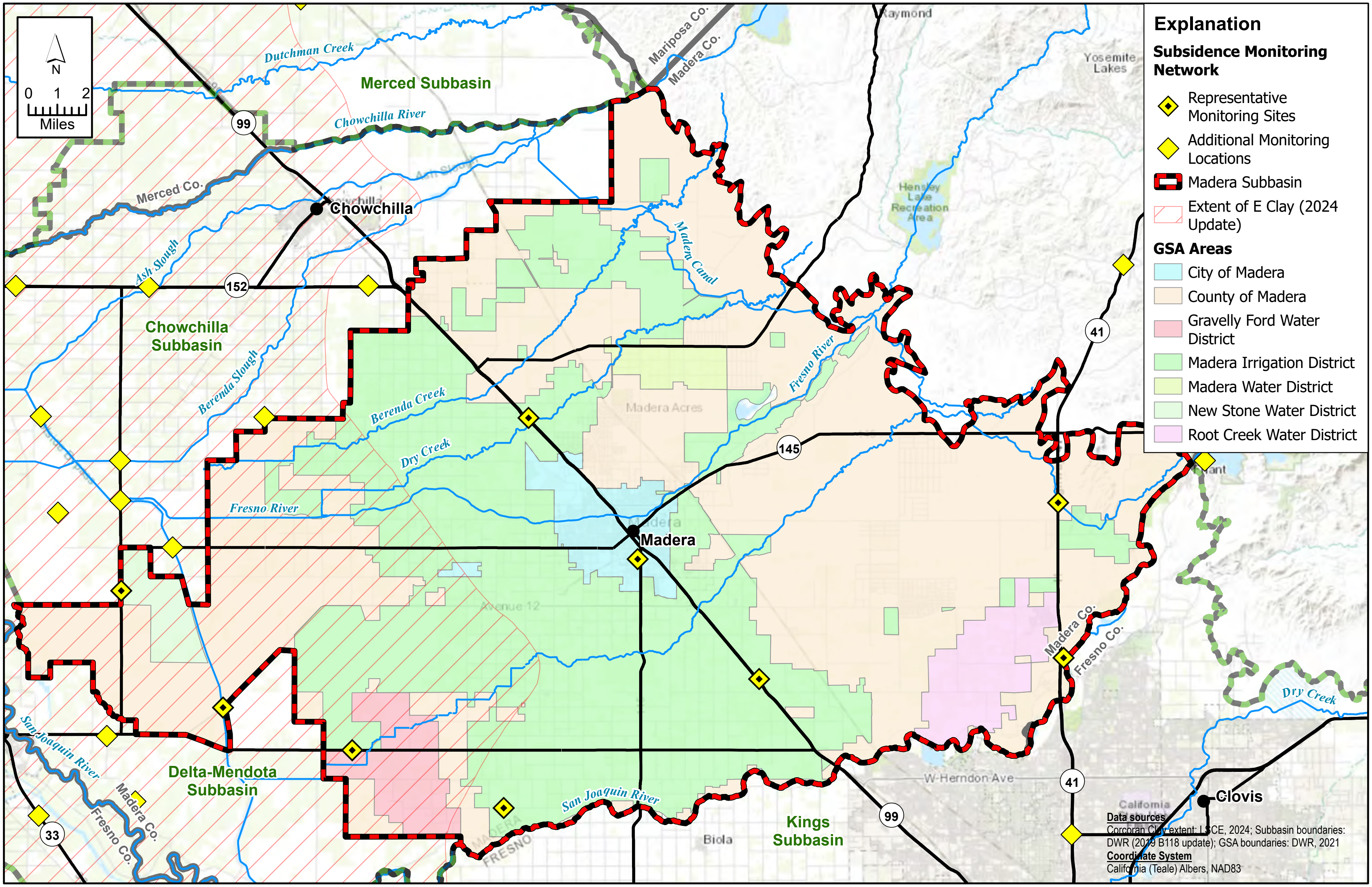
Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-10

Proposed Groundwater Level Sustainable Indicator Representative Monitoring Sites - Composite

Madera Subbasin

Groundwater Sustainability Plan - First Plan Amendment



X:\2024\24-010 (1) Davids Eng. - Madera Subbasin 5-Year GSP Update\GIS\MAD_Five_Year_Update\MAD_Five_Year_Update.aprx; SUBS_MONIT_NETWORK

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 3-11

Proposed Subsidence Monitoring Network

Madera Subbasin
Groundwater Sustainability Plan - First Plan Amendment

4 SUBBASIN PROJECTS AND MANAGEMENT ACTIONS

To achieve the ~~Madera~~ Subbasin sustainability goal by 2040 and continue to manage sustainably to 2090, as required by the GSP regulations, various projects and management actions (PMAs) have been developed and will be implemented by the GSAs between 2020 and 2040. This chapter describes the types of PMAs that have been and are expected to be implemented by each GSA in the ~~Madera~~ Subbasin to meet sustainability objectives. "Projects" generally refer to structural features that supplement and expand available water supplies, whereas "management actions" are typically programs or policies designed to reduce groundwater use – with both integrated into the Subbasin's sustainable water management.

Subbasin PMAs are described in accordance with 23 CCR § 354.42 and § 354.44 of the GSP regulations. For projects, the estimated groundwater recharge benefit along with capital, operating, and maintenance costs for each project is shown. Project cost information is limited for many projects because a detailed feasibility assessment has not been completed. Other projects have cost estimates that were developed several years ago and may not reflect current conditions. To the extent possible, project costs are adjusted and reported on a consistent basis. For example, a consistent water purchase price is applied across all projects that would purchase and import water from other Subbasins (unless a specific cost is already provided in an existing agreement). All costs are indexed using an appropriate index (the Implicit Price Deflator or Engineering News Report Construction Cost Index) and reported in 2019 dollars. GSAs will further develop PMAs during the GSP implementation period and refine estimated costs.

Costs to acquire water for projects are based on the following assumptions. Water available as local surplus or flood flow has no direct acquisition cost[79]. Water received as CVP Section 215 delivery is assumed to cost $38.54 per acre-foot, based on Reclamation's 2019 Special Water Rates for irrigation 215 water that includes charges for conveyance, water marketing, restoration fund, and Friant surcharge. The cost to purchase water from other water users or from new projects elsewhere in the Central Valley assumes market purchase prices. These acquisition costs per acre-foot, by water year type and region, were developed in the Technical Reference for the Water Storage Investment Program (California Water Commission, 2016) and range from $270 per acre-foot in wet years to over $1,100 in critical years. Cost to deliver water using existing district facilities is assumed to be $25 per acre-foot[80]. For water delivered to farms for recharge on fields (On-Farm Recharge, or Flood-MAR), a cost of $25 per acre-foot is assumed for farmers to manage the water.

GSAs will identify sources of funding to cover project development, capital, and operating costs, including but not limited to, groundwater extraction fees/penalties, increasing water rates, grants, low interest loans, private/public partnerships, private landowner contributions, and other assessments. The exact funding mechanism will vary by project and the legal authority of each GSA. A general description of how each GSA expects to cover the cost of all PMAs it will implement is presented after the description of PMAs for each GSA.

The GSAs have prioritized implementation of projects that provide additional surface water supplies to the Subbasin, thereby reducing groundwater pumping. However, recognizing that access to surface water

[79] Surplus water can have costs associated with it, depending on the timing and source of the supply. These costs will be assessed in detail as part of future GSA project planning.

[80] Actual delivery costs vary by GSA and will be assessed as part of future project planning. For example, MID's current wheeling rate is around $160 per acre-foot.

supplies is variable, the GSAs are also planning demand management to directly reduce groundwater pumping to achieve sustainability. The GSAs are also committed to an adaptive management approach to implementing PMAs that is informed by continued monitoring of groundwater conditions using the monitoring networks. As PMAs are implemented and Subbasin conditions are monitored, the GSAs will review PMA timelines, benefits, and the volume of demand management that may be necessary to achieve sustainability. If the GSAs find that adjustments are needed to meet the sustainability goal, the GSAs will evaluate and adjust plans for project implementation and, to the extent necessary, demand management. Any adjustments will be reported in future Periodic Evaluations, and Annual Reports. subsequent annual reports and/or the five-year periodic evaluation and GSP updates. A proposed timeline for the 2025 Joint GSP Periodic Evaluation and associated Plan Amendment is provided in **Appendix 5.A**. This timeline includes evaluation of projects and management actions to ensure that the Subbasin will be managed sustainably and without undesirable results by 2040. A similar timeline is anticipated for the 2030 and 2035 Joint GSP Periodic Evaluations (and any associated Plan Amendments).

A proposed timeline for the 2025 GSP updatefuture Joint GSP pPeriodic eEvaluations and associated Plan aAmendments is provided in **Appendix 5.A**. This timeline includes evaluation of projects and management actions to ensure that the Subbasin will be managed sustainably and without undesirable results by 2040.

This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports. A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

PMAs are summarized for all GSAs in the Subbasin. This Joint GSP covers Madera Irrigation District (MID) GSA, Madera County (MC) GSA, City of Madera (CM) GSA, and Madera Water District (MWD) GSA. The PMAs for these GSAs are described in accordance with 23 CCR § 354.42 and § 354.44 of the GSP regulations. Gravelly Ford Water District (GFWD) GSA, Root Creek Water District (RCWD) GSA, and New Stone Water District (NSWD) GSA are preparing separate GSPs. The operation and gross benefit of PMAs for these GSAs are summarized in this chapter because the sustainability of the Subbasin depends in part on these PMAs. More detailed project descriptions, costs, and uncertainties are described in each of those GSA's respective GSP.

Two main types of projects are included for implementation in the Joint GSP: recharge and conveyance (Table 4-1). Recharge projects are designed to support sustainability by diverting floodwater or other available surface water for direct infiltration in constructed basins or spreading onto fields. Conveyance projects facilitate the delivery of additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping (in-lieu recharge). Conveyance projects may include structural improvements, operational changes, or both. Section 4.8 describes and quantifies available water from the potential sources, as well as implications for water supplies available to recharge projects since the issuance of Executive Order N-4-23 in March 2023.

In addition to projects, several GSAs in the Madera Subbasin have developed and will implement management actions. Gravelly Ford Water DistrictGFWD will implement a program to monitor groundwater extractions and use that data to more efficiently manage its water supply. MID Madera Irrigation District will develop incentive structures to encourage its growers to use more surface water and reduce groundwater pumping. Madera CountyMC GSA is also in the process of implementing a demand management program that will reduce demand by placing restrictions on groundwater pumping, among other actions. The MC Madera County GSA's planned program will provide groundwater users a flexible way to meet any future pumping restrictions. Other GSAs within the Subbasin may also implement similar programs if needed to attain sustainability. Together, the PMAs have been developed and planned to achieve the Subbasin sustainability goal by 2040.

The cost, timing, and groundwater benefit (yield) of the PMAs included in the GSP vary by GSA. Table 4-2 lists all the PMAs planned at the time of initial GSP development, summarized by GSA or implementing entity, and the estimated implementation timeline, capital cost, operating cost, and gross benefit of the projects. Recharge basins, a common project, may also provide environmental benefits that are not quantified in the table. Table 4-3 further summarizes the total benefits and costs of all PMAs developed for each GSA or implementing entity. Updates and new PMAs implemented since initial GSP development are documented in Section 4.9.5. As noted above, costs have not been updated since initial Joint GSP development and are reported in 2019 dollars.

Table 4-1. Projects and Management Actions and Water Sources Considered in the Madera Subbasin.

GSA	PMA type	PMA Mechanism	Water Source			
			Fresno River Flood Releases	Millerton Flood Release and 215 water	Chowchilla Bypass flows	Purchase
Recharge						
All	Recharge Basins	Increase Recharge	X	X	X	X
All	On-Farm Recharge (Flood-MAR)	Increase Recharge	X	X	X	X
Conveyance						
MID	MID Pipeline Project, Main I-Road 23 Project	Reduces evaporation and GW Pumping				
MID	WaterSMART Pipeline Project	Reduces evaporation and GW Pumping				
MID	WaterSMART SCADA Project	Reduces evaporation and GW Pumping				
MID, MC, MWD	Water Supply Development-Partnerships	Purchase water from willing partners outside of the basin to increase recharge or reduce GW pumping	X	X	X	X
MWD, RCWD	Water Supply Development-Partnerships	Purchase water from willing partners in the basin to reduce GW pumping				X
NSWD	Water Right Utilization	Divert flood flow from Chowchilla Bypass, under existing water right			X	
Management Actions						
GFWD	Groundwater monitoring and well meters	Collect, analyze, and report data on conditions and use to improve management.				
MC	Demand Management	Reduce demand by limiting groundwater pumping				
MID	Explore new fee structures and incentive-based programs to use surface water	Encourage more use of district SW; reduce GW pumping				

Table 4-2. Madera Subbasin Projects and Management Actions (As of January 2020).

GSA	PMA	First Year of Implementation	Average Annual Gross Benefit at Full Implementation (AFY)	Estimated Capital Cost ($ millions)	Estimated Average Annual Operating Cost ($ millions/year)
MWD	Expanded Surface Water Purchase	2023	2,810	14.90	0.90
MID	Rehab Recharge Basins	2016	5,030	0.06	0.43
MID	Ellis Basin	2016	240	0.02	0.02
MID/City of Madera	Berry Basin	2018	20	0.02	0.00
MID	Allende Basin	2019	1,050	0.20	0.07
MID	Additional Recharge Basins Phase 1	2030	5,470	1.00	0.24
MID	Additional Recharge Basins Phase 2	2040	21,890	14.20	3.75
MID	On-Farm Recharge	2015	510	0.00	0.05
MID	Phase 2 On-Farm Recharge	2025	1,690	0.00	0.19
MID	MID Pipeline	2016	420	0.56	0.00
MID	WaterSMART Pipeline	2019	880	1.30	0.00
MID	WaterSMART SCADA	2019	1,230	1.20	0.00
MID	Water Supply Partnerships	2025	3,990	0.00	2.50
MID	Incentive Program	2022	5,010	0.00	3.08
City of Madera	Meters and Volumetric Pricing	2015	3,350	11.00	0.00
City of Madera/MID	Berry Basin	2018	20	0.02	0.00
Madera County	Water Imports Purchase	2025	3,610	0.30	2.49
Madera County	Millerton Flood Release Imports	2025	7,060	31.90	0.45
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 1	2025	12,710	67.00	0.32
Madera County	Chowchilla Bypass Flood Flow Recharge Phase 2	2040	26,470	118.90	1.16
Madera County	Demand Management	2020	90,000	0.00	53.90
GFWD	Recharge Basin and Canals	2020	2,620	*See GFWD GSP*	
NSWD	Water Right Utilization	2020	5,540	*See NSWD GSP*	
RCWD	Purchased Water for In-Lieu Storage	2019	4,380	*See RCWD GSP*	
RCWD	Holding Contracts	2020	9,840	*See RCWD GSP*	
Total			215,840	262.58	69.55

Note: ~~estimated~~ Estimated project benefit values and costs are rounded. Costs are presented in 2019 dollars. This represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.

Table 4-3. Summary of Madera Subbasin Projects and Management Actions by GSA (As of January 2020[1]).

GSA	Average Annual Gross Benefit at Full Implementation (AFY)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
MWD	2,810	14.90	0.90
MID	47,430	18.56	10.33
City of Madera	3,370	11.02	0.00
Madera County	139,850	218.10	58.32[1 2]
GFWD	2,620	*See GFWD GSP*	
NSWD	5,540	*See NSWD GSP*	
RCWD	14,220	*See RCWD GSP*	
Total	215,840	262.58	69.55

[1] This represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports

[2] Costs of demand management include reduced economic activities in the county, this includes approximately $53.9 million per year in direct economic impacts alone (excluding multiplier effects). Costs are presented in 2019 dollars.

The gross yield across all projects at full implementation (2040) is estimated to generate an average annual yield of over 200,000 acre-feet (AF). This includes the Madera County demand management program implemented by the ~~Madera County~~MC GSA that reduces net groundwater pumping by about 90,000 acre-feet per year (AFY) by 2040, based on current pumping estimates. The gross yield is larger than the projected shortfall primarily due to changes in other water budget elements when flood flows are directed to recharge.

The remaining subsections of this chapter provide additional details about:

- Plans for implementation of PMAs by each GSA or agency, including anticipated costs and benefits.
- The amount of water available for recharge by projects, and
- Actual PMA implementation efforts that have been completed as of the latest GSP Annual Report (water year 2022).

4.1 Madera Water District GSA

The ~~Madera Water District~~MWD GSA ~~(MWD)~~ has identified one project to include in the GSP to help the Subbasin meet sustainability goals. The project is an expanded surface water purchase program where MWD would secure new surface water supplies for use in its service area. Although expanded surface water purchases are considered one project, to obtain those additional deliveries, there will be various infrastructure components implemented by MWD.

At the time of initial GSP development, project planning was still in development, so complete information on project planning, operations, costs, and other details were not finalized. **This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.** A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

4.1.1 MWD Surface Water Purchase Program

The MWD surface water purchase program provides in-lieu recharge benefits by providing growers with additional surface water supplies imported from inside or outside of the Subbasin. The program is an extension of current MWD practices of purchasing surface water when it is available, but access to surface water has been limited by the diversion facilities currently available to MWD. As part of the GSP development process, MWD has been investigating the ability to access additional surface water supplies.

4.1.1.1 Project Overview

The surface water purchase program includes a series of improvements to expand MWD's ability to purchase additional surface water supply. Improvements include upgrades to the Dry Creek turnout and pump stations, and additional conveyance capacity from the installation of a new pipeline connecting Madera Lake, both MID facilities, to the MWD's existing distribution system. To maximize the use of surface supplies, storage reservoirs will be constructed to store water for later delivery as irrigation demands occur. These improvements will enable MWD to purchase higher quantities of water in Wet and Above Normal years than it has been able to purchase historically. By expanding its ability to access additional surface water supplies, MWD expects to increase its in-lieu recharge volumes when supplies are available, which is typically in wetter years. However, even in extremely dry years MWD has often been able to purchase water from Madera Irrigation District (MID) for delivery out of Dry Creek.

4.1.1.2 Implementation

MWD will expand water purchases, particularly in Wet and Above Normal years. In addition, it has identified a set of facilities that will allow greater purchases. These facilities include:

- Improvements to the MWD Dry Creek Pump Station to support flow increases of about 2,000 gpm (4.5 cfs), from 10,500 (23.4 cfs) to 12,500 gpm (27.8 cfs),
- A new pipeline connection to Madera Lake sized for 6,000 gpm (13.4 cfs) with 4,000 gpm (8.9 cfs) capacity to Madera Water District,
- The construction of storage reservoirs within or near the District with capacity of 3,000 AF or more.

Permitting and environmental studies are expected to begin in late 2019 or 2020, with construction to begin in 2021. The new facilities will be operational in 2023.

Table 4-4. MWD Surface Water Purchase Program Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2019 for Madera Lake pipeline; 2020 for other projects	2023
Financing	2019	2025
Construction	2021	2023
Operation	2023	2075

Construction activities and requirements

As described under Project Overview and Implementation, MWD will construct a new turnout, pump stations, pipeline, and storage reservoirs. Specific construction activities, scheduling, and more detailed cost estimation will be developed as part of final design of the project.

Water source

MWD intends to purchase surface water from CVP Friant Division contractors within or outside the Subbasin to the extent available. If surface water is not available from these partners, then MWD will seek supplies from other CVP contractors. Since any purchased water will need to be wheeled through MID's system, MWD will coordinate with MID to evaluate and address potential capacity limitations.

Conditions or constraints on implementation

Continued and expanded water purchases by MWD will depend on the cost and availability of water from willing sellers.

Permitting process and agencies with potential permitting and regulatory control

Potential permitting and regulatory control over the various projects will include the U.S. Bureau of Reclamation, Madera County, MID, DWR's Division of Safety of Dams, California Department of Fish and Wildlife, and the U.S. Fish and Wildlife Service.

MWD has already contacted many of these agencies for preliminary permit review as part of its due diligence on the various facilities. MWD will obtain needed permits for construction of new reservoirs, including grading permits from Madera County. Water transfer agreements will need to be developed along with any related California Environmental Quality Act (CEQA)/National Environmental Policy Act (NEPA) documentation for anticipated water purchases. However, since most water transfers will be on a year-to-year basis and/or involve flood or excess waters, the environmental documentation is anticipated to be minimal.

4.1.1.3 Project Operations and Monitoring

With the exception of one private domestic well, all the wells in MWD are owned by MWD, under its control and metered. Groundwater extractions will continue to be metered and managed by MWD as directed by the Board of Directors. Surface water supplies that are brought into MWD are also metered and under the direct management of MWD.

4.1.1.4 Project Benefits

There is limited recharge potential within the MWD service area. Therefore, surface water would be stored in reservoirs and delivered to meet crop demand in lieu of groundwater pumping, providing in-lieu recharge benefits. The in-lieu recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by increasing surface water use and reducing groundwater pumping.

The hydrologic time series selected to establish benefits is 1993-2014. Table 4-5 shows the planned delivery schedule based on this hydrologic series for the additional surface water supplies that are proposed to be purchased and brought into the District. These amounts are in addition to historical purchases which are presumed to be able to continue in the future. Surface water will be purchased in any water year type that it is available, though supplies are likely only in Below Normal (BN), Above Normal (AN), or Wet (W) years. MID may have capacity constraints in both the Madera Canal and Dry Creek during the peak months of June, July, and August depending on the status of improvements to its diversion facilities, the water year type, and the weather. The proposed Madera Lake pipeline could provide deliveries during these summer months.

The construction of additional turnout pumping capacity to increase Dry Creek deliveries would increase MWD's ability to import surface water via Dry Creek from about 10,000/10,500 gpm to 12,500 gpm (when MID is able to provide capacity). In addition, improvements are proposed to be made to Dry Creek to allow for reliable flow delivery to meet increased turnout capacity. These improvements will require regulatory approvals.

Table 4-5. Estimated Average Additional Surface Water Purchased, by Year Type.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	6,000	35%	2,118
AN	4,500	14%	618
BN	1,000	8%	78
D	0	16%	0
C	0	27%	0
Avg. Annual			2,814

MWD also intends to evaluate the construction of reservoirs within or adjacent to MWD's boundaries and the installation of additional water lines connecting the reservoirs to MWD's current distribution system. Initial plans are to construct up to six 500-AF reservoirs for total storage of 3,000 AF, along with pipeline connections to the existing distribution system. Water purchased and stored in the reservoirs would be used throughout the entire District. The District's plan is to fill the reservoirs during the fall and winter months, so the water is available to be used during the summer months when capacity issues restrict flows.

Figure 4-1 illustrates the expected schedule for delivering and storing water from surface water and groundwater, including planned new supplies, for a wet and above normal water year. Crop demand is based on a total irrigated area of 3,486 acres with an average applied water rate of about 2.68 AF/acre, resulting in an average demand of 9,338 AFY (for year 1989 to 2014). The assumed native groundwater yield is 0.5 AF/acre per year for 1,875 AFY. In a wet and above normal water supply year, the cumulative storage at the end of the year In storage reservoirs is positive and would be available (minus losses) for the next crop year.

Based on the planned additional surface water supply projects and associated infrastructure, charts for the 2020 – 2040 (Figure 4-2) and 2020 – 2070 (Figure 4-3) projected water budget periods have been created. The projected water budgets are described in Section 2.2.3 of the GSP and were prepared for 2020 – 2090 based on historical hydrologic data from 1965 – 2015, historical water supply data from 1965 – 2015 (with adjustment of CVP supplies based on projected Friant Releases under SJRRP), and projected land use. The running balance trend for both water budgets shows positive slope, with Figure 4-2 showing the GSA being sustainable in 2040. The groundwater trend line is positive in Figure 4-2 and Figure 4-3.

The reliability of the surface water purchase program will depend on how much excess water is available to purchase and the price of the surface water. However, MWD has historically been able to purchase surface water supplies from MID even in dry years such as 2015. Since MWD has only permanent crops, fallowing on a year to year basis is not practicable. However, MWD's Board of Directors has discussed the potential for land retirement as trees planted within MWD are removed due to aging/low yields or parcels are available for sale.

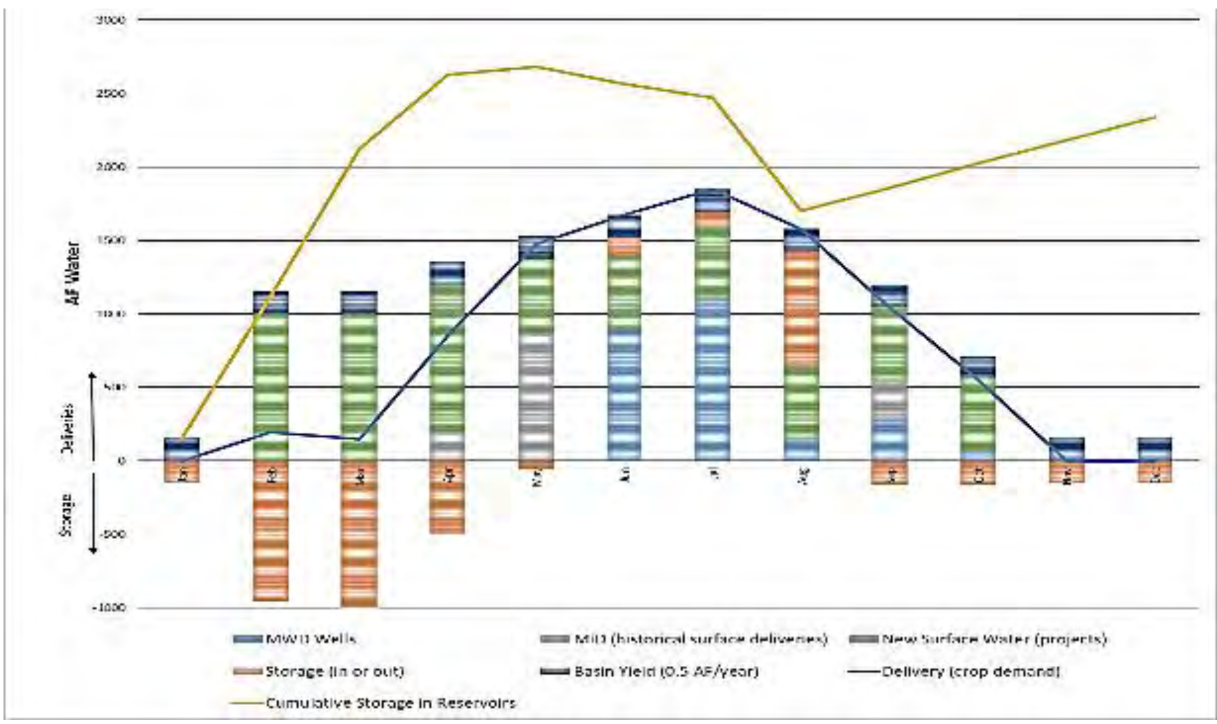


Figure 4-1. MWD Wet and Above Normal Year Water Supply Plan.

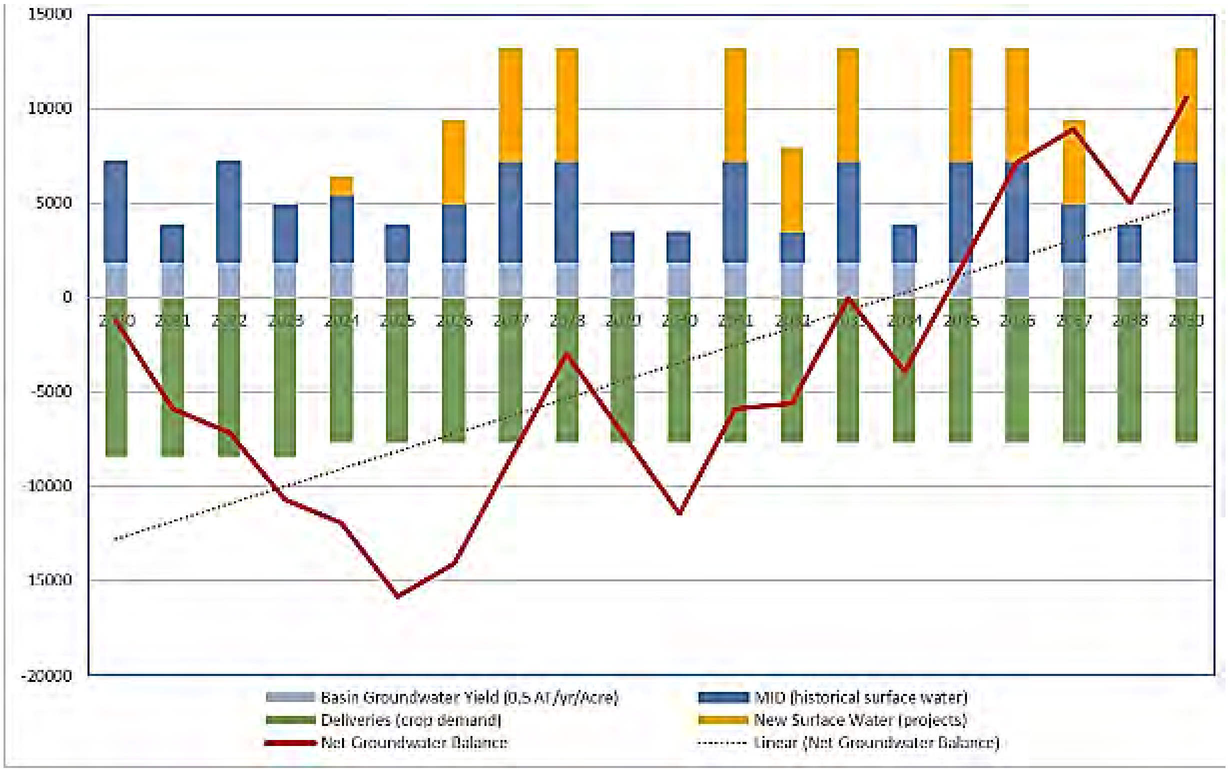


Figure 4-2. Madera Water District Water Budget, 2020 - —2040.

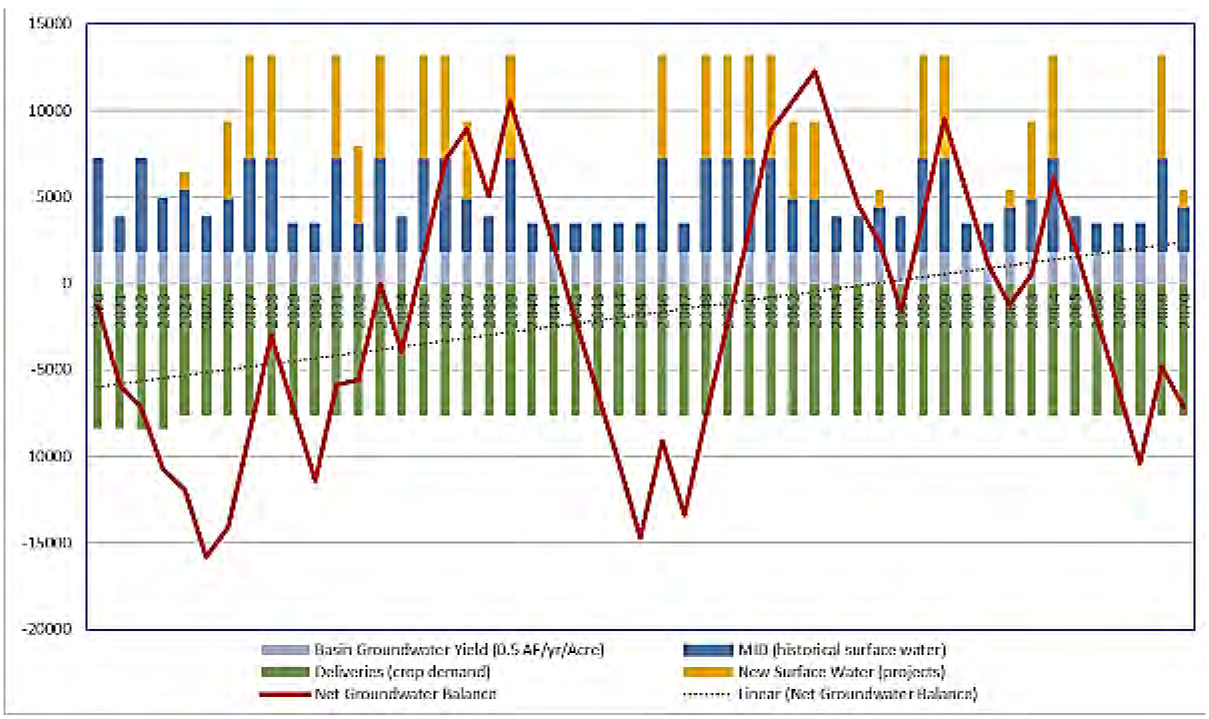


Figure 4-3. Madera Water District Water Budget, 2020 - —2070.

4.1.1.5 Project Costs

Table 4-6 summarizes estimated project costs. Capital costs are estimated by MWD and include land acquisition, planning, permitting, and construction. Annual costs will be incurred to acquire water from other water suppliers, so the cost reflects estimated market prices averaged over the year types in which water is acquired.

Table 4-6. Project Cost Summary Table (2019 Dollars).

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project planning and development	$14.9 million	Start of project	
O&M Costs			
Water supply cost	$825,000	Annual average	Average annual water purchase cost to acquire water in W, AN, and BN years; costs are incurred in years when water is available.
Other O&M cost	$70,500	Annual average	Conveyance O&M assumed to be $25 per acre-foot; costs are incurred in years when water is available.

4.1.2 Project Financing

MWD will finance capital costs of the projects using available grant funds, cash reserves and, as needed, borrowing. Debt service on any borrowed funds plus ongoing O&M will be paid by MWD landowners. MWD imposes an annual assessment and charges its growers volumetrically for water. MWD holds a public hearing each year to set the annual water rate. MWD has also been building its cash reserves to pay for the cost of physical improvements to MWD facilities. If needed, MWD will also go through the Proposition 218 process to request an increase in land-based assessments.

4.1.3 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the ~~Madera~~ Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA). ~~A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation.~~A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation.

MID has historically conveyed water to Subordinate MID landowners in MWD. MID and MWD have been coordinating on the development of long-term projects to improve surface deliveries to MWD such as a new water supply agreement and the Madera Lake pipeline. MWD is continuing to discuss new water supply agreements with MID, including wheeling agreements, water purchase agreements, and the cost of water available for purchase.

4.2 Madera Irrigation District GSA

The Madera Irrigation District GSA (MID) has identified several projects to include in the GSP to help MID achieve sustainability. These include new or expanded recharge capacity, increased operational flexibility, additional capacity to move water available from other areas, incentives to encourage MID growers to reduce groundwater pumping, and other management actions to bring the Subbasin into sustainability.

MID invested in several projects after passage of the SGMA legislation but prior to GSP development that help to bring MID into sustainability. Full implementation of these projects was achieved after 2015, the end of the historical hydrologic sequence used to develop the GSP, so the effects of implementing these projects are not included in the baseline MID water budgets described in Chapter 2. MID will continue to operate and pay for these projects and they are included as part of its PMAs.

The MID project descriptions are based on information available during the initial Joint GSP development process from MID and, where applicable, other studies. Water available for these projects is evaluated in combination with other projects in the Subbasin.

At the time of initial GSP development, planning for the PMAs was at varying stages of development, so complete information on construction requirements, operations, costs, permitting requirements, and other details are not uniformly available. **This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.** A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

4.2.1 Groundwater Recharge Basins

Recharge basins are artificial ponds of varying size that are filled with water supply that would have otherwise left the Subbasin, which instead percolates into the groundwater system. The size, location, and performance of a recharge basin depends on site-specific characteristics that will be assessed by MID and its partners in the process of developing recharge basin projects.

The following subsections describe multiple[81] groundwater recharge basin projects that have been or will be implemented by MID to generate groundwater recharge benefits.

4.2.1.1 Project Overview

MID has identified five (5) individual groundwater recharge projects that it has already developed or will develop under the GSP. This includes one rehabilitation project where MID refurbished existing recharge basins that have been underutilized and were in a state of disrepair. MID developed three new recharge basins, including the Ellis Basin, Berry Basin, and Allende Basin. Finally, MID will acquire land and develop approximately 90 acres of new recharge basins by 2030 and another 260 acres by 2040, if needed. Locations and sizes of these new basins will be selected based on land uses, access to delivery facilities, and soils having appropriate percolation rates. Recharge basins are generally distributed throughout the MID service area.

[81] MID recharge basins include the Berry Basin project, which is a joint project with the City of Madera GSA and the Ellis Basin project, which is a joint project with Madera County. Project benefits are split with the City of Madera (Section 4.3) and Madera County (Section 4.4), respectively.

MID recharge projects are similar in operation and implementation. A general description of the projects is provided. Detailed expected recharge benefits, operational descriptions, and estimated costs are provided for each individual project.

Recharge Basin Rehabilitation

MID rehabilitated and upgraded six (6) of its recharge facilities in 2015 and 2016. The facilities were underutilized by MID for many years. The upgrades included facility connections and metering for managing groundwater recharge purposes. The basins range in size from 3 acres to 220 acres with capacity of 20 to 2,300 AF.

Ellis Basin

MID and Madera County worked cooperatively to construct a 180-ft. pipeline to connect MID's Lateral 24.2 canal to the County's Ellis Street Basin in early 2016 for recharge purposes. When water is available, a lift pump is used to convey the water through a meter to Madera County's basin. The benefits are shared equally by MID and Madera County at a 50:50 ratio.

Berry Basin

The Berry Basin project conveys surface water from an existing MID canal to an existing City of Madera stormwater basin to increase opportunities for groundwater recharge in the ~~Madera~~ Subbasin. The project installed approximately 120 feet of 15-inch pipeline from the MID facilities, Lateral 24.2-14.2 Canal, to the City of Madera facilities, a City-owned and operated storm water basin located on parcels APN 006-380-006 and 006-380-011. The project was completed in 2018. The benefits are shared equally by MID and City of Madera at a 50:50 ratio.

Allende Basin

MID purchased the Allende Basin, APN 047-310-039, in 2018 for the purposes of increasing recharge benefits. MID estimates that the basin storage equals 250 AF. MID will manage the parcel as a permanent basin because of the benefits it provides for MID canal operations and regional groundwater recharge. By utilizing multiple MID surface water supplies, irrigation and flood water can be conveyed to the Allende Basin through the adjacent canal and existing basin turnout structure.

New Recharge Basin Development

MID will evaluate and acquire additional land for groundwater recharge basin development. This includes two additional projects: approximately 90 acres of recharge basins developed by 2030, and an additional 260 acres developed by 2040, if needed. Land suitable for recharge will be strategically located throughout the MID service area to maximize regional groundwater recharge benefits and district operations.

4.2.1.2 Implementation

Implementation will be staged based on the existing development of each groundwater recharge basin or new recharge basin, since 2015 and continuing through 2040 (Table 4-7). Implementation for each of the MID recharge projects is as follows:

- **Recharge Basin Rehabilitation**. Upgrades to existing recharge basins were completed by the end of 2016.
- **Ellis Basin**. The Ellis Basin project was developed in 2016 and is currently operational.
- **Berry Basin**. The Berry Basin project was developed in 2018 and is currently operational.
- **Allende Basin**. The Allende Basin parcel was acquired by MID in 2018 and is currently operational

- **New Recharge Basin Development**. MID will continue to identify additional sites that are good locations for construction of groundwater recharge ponds. Permitting and environmental documentation will be initiated, and financing will be identified and secured for the recharge basins. Construction of the first 90 acres of basins will be complete by 2030, and if necessary, an additional 260 acres of basins will be completed by 2040, if needed.

Table 4-7. MID Groundwater Recharge Basins Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2015	2040
Financing	2015	2040
Construction	2015	2040
Operation	2016	On going

Construction activities and requirements

Construction activities include acquiring land suitable for recharge, developing that land for recharge, and acquiring and/or delivering water supplies to that land for recharge benefits. Construction activities vary by recharge basin site. General activities include survey, initial feasibility assessment, permitting, environmental review, land purchase, earthwork, site development, water supply development, and operating infrastructure. Details on construction activities, schedule, and project costs will be developed as part of final project design for each recharge basin developed by MID.

Water source

Water for recharge is expected to be available from one or more of the following sources:

- MID has a contract for CVP Class 1 and Class 2 water, and it can receive CVP surplus flows when available.
- Fresno River flood releases from Hensley Lake.
- Other water supplies that MID currently has access to or may be available in the future, including potential via exchange through the larger Friant system and delivered by Madera Canal.

The analysis of benefits below considers the source of water for each recharge project specified by MID. It does not account for other potential sources nor for any changes in operations elsewhere in the CVP system that might affect availability of surplus water. Water sources for each recharge project include:

- **Recharge Basin Rehabilitation**. MID diverts flood flows and other available water supplies in Wet, Above Normal, and Below Normal water years to the rehabilitated recharge basins.
- **Ellis Basin**. MID delivers flood flows and other available water supplies to the Ellis Basin project in Wet, Above Normal, and Below Normal water year conditions.
- **Berry Basin**. MID delivers flood flows and other available water supplies to the Berry Basin project in Wet, Above Normal, and Below Normal water year conditions.
- **Allende Basin**. MID delivers flood flows and other available water supplies to the Allende Basin project in Wet, Above Normal, and Below Normal water year conditions.
- **New Recharge Basin Development**. MID will deliver flood flows and other available water supplies to newly developed groundwater recharge basins in Wet, Above Normal, and Below Normal water year conditions. Depending on future conditions in MID, it may also purchase

additional supplies from partners that will be identified to increase recharge benefits in other water year conditions.

Conditions or constraints on implementation

The groundwater recharge basins implemented by MID are planned projects of the GSP. MID groundwater recharge basin development does not depend on the performance of other projects or activities. However, MID may develop additional recharge basins if the yield of other projects is lower than anticipated in order to meet its sustainability objectives.

Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting roles for the project: Madera County and Reclamation

Some recharge basin projects may require an environmental review process under CEQA. This would require either an Environmental Impact Report, and Negative Declaration, or a Mitigated Negative Declaration.

Depending on the source of water, projects may require coordination with Reclamation for scheduling the storage and delivery of water within Millerton or to facilitate exchanges of water acquired from other Federal Contractors.

4.2.1.3 Project Operations and Monitoring

Recharge will be conducted by MID in groundwater recharge basins. Extraction of recharged groundwater will be done by water users in MID through individual, private wells.

MID expects that water will be available for recharge in all W, AN, and BN years, to be delivered using existing canals and laterals. Water may be available in other years depending on water supply conditions in the region and MID's ability to purchase additional supplies from partners. Delivery to rehabilitated recharge basins, as well as the Ellis, Berry, and Allende basins has already begun. During years in which water is available for recharge, MID expects to deliver sufficient water to recharge the basins for most of the year. Operation of new recharge basins developed by MID will start in 2030 and 2040, or potentially before, and patterns of recharge will be dictated by water availability but are expected to be generally similar to existing recharge basins.

4.2.1.4 Project Benefits

Groundwater recharge provided by the recharge basins will contribute to groundwater sustainability in the Subbasin by replenishing groundwater supplies. The direct recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, recharge basins are also expected to both reduce the rate of active subsidence and minimize or prevent continuing subsidence in the project areas.

Based on a hydrologic and operations analysis covering the historical period, 1989-2014, and the resulting frequency and amount of recharge, the average annual gross recharge benefits for each of the recharge projects that will be implemented by MID is as follows:

- **Recharge Basin Rehabilitation**. 5,029 AF.
- **Ellis Basin**. 243 AF.
- **Berry Basin**. 48 AF (24 AF credited to MID and 24 AF credited to City of Madera).
- **Allende Basin**. 1,045 AF.

- **New Recharge Basin Development**. 5,474 AF by 2030 and another 21,894 AF by 2040 if necessary.

Tables 4-8 through 4-13 below summarize the average annual water supply benefits, shown as the average delivery year type. The average annual benefit of each project is the water year-type probability weighted average. Wet, Above Normal, Below Normal, Dry, and Critical year types have historically occurred with a probability of 35%, 14%, 8%, 16%, and 27%, respectively.

The reliability of the source water is based on historical hydrology being a good projection of future hydrology. In addition, the reliability depends on future water supply management, including changes to the CVP system and the San Joaquin River Restoration Program, as well as diversions of other flood flows or sources of water by other GSAs or other entities with rights to that water.

Table 4-8. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – Recharge Basin Rehabilitation Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	11,000	35%	3,882
AN	5,500	14%	755
BN	1,500	8%	118
D	0	16%	0
C	1,000	27%	275
Avg. Annual			5,029

Table 4-9. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – Ellis Basin Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	550	35%	194
AN	300	14%	41
BN	100	8%	8
D	0	16%	0
C	0	27%	0
Avg. Annual			243

Table 4-10. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – Berry Basin Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	55	35%	19
AN	30	14%	4
BN	10	8%	1
D	0	16%	0
C	0	27%	0
Avg. Annual			24

Table 4-11. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – Allende Basin Acquisition.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	2,365	35%	835
AN	1,290	14%	177
BN	430	8%	34
D	0	16%	0
C	0	27%	0
Avg. Annual			1,045

Table 4-12. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – New Recharge Basins Constructed by 2030.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	12,650	35%	4,465
AN	6,350	14%	872
BN	1,750	8%	137
D	0	16%	0
C	0	27%	0
Avg. Annual			5,474

Table 4-13. MID Estimated Average Deliveries by Year Type, in Acre-Feet per Year – New Recharge Basins Constructed in 2040.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	50,600	35%	17,859
AN	25,400	14%	3,486
BN	7,000	8%	549
D	0	16%	0
C	0	27%	0
Avg. Annual			21,894

Recharge basins may also provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals. Groundwater that may be flowing laterally from recharge basins to nearby rivers, particularly the San Joaquin River, may also support beneficial uses by providing an additional source of relatively cold water to support riparian vegetation and both cold and warmwater aquatic habitat including migration habitat for special-status salmonids.

4.2.1.5 Project Costs

Estimated project costs are based on actual costs (for projects that were already developed) and estimated costs for development of a typical recharge basin (Table 4-14). Costs for each basin will vary based on site characteristics and market conditions affecting land, construction, and material costs at that time. Capital costs include site survey, soil sampling, land purchase costs, earthwork, pumps, fencing, and power connection. Additional development costs include project administration, legal, permitting, and environmental review. Actual project costs may be lower than estimated costs if some of these activities are not required. O&M costs are expressed as annual averages but will vary annually according to year type and water availability. Estimated project costs do not include groundwater extraction costs (which would be borne by private pumpers in MID). All costs are reported in ~~current~~ 2019 dollars.

Table 4-14. MID Groundwater Recharge Basin Project Costs (2019 Dollars).

Item	Total Cost	Year Incurred	Notes[1]
Recharge Basin Rehabilitation			
Capital Costs	$64,000	Complete	Cost to rehab existing basin
O&M costs			
Purchase Water	$308,500 per year	Annual average	$38.54 per AF, incurred when water is available
Conveyance O&M	$126,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available;
Ellis Basin			
Capital Costs	$24,000	Complete	Does not include land acquisition
O&M costs			
Purchase Water	$9,500 per year	Annual average	$38.54 per AF, incurred when water is available
Conveyance O&M	$6,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available
Berry Basin			
Capital Costs	$15,000	Complete	Does not include land acquisition
O&M costs			
Purchase Water	$950 per year	Annual average	$38.54 per AF, incurred when water is available
Conveyance O&M	$600 per year	Annual average	$25 per AF cost to convey, incurred when water is available
Allende Basin Acquisition			
Capital Costs	$200,000	Complete	Does not include land acquisition
O&M costs			
Purchase Water	$40,500 per year	Annual average	$38.54 per AF, incurred when water is available
Conveyance O&M	$26,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available
New Recharge Basins Constructed in 2030			
Capital Costs	$1.0 million	2028-2029	For basins to recharge up to 1,150 AF per month
O&M costs			
Purchase Water	$105,500 per year	Annual average	Assume half is CVP 215, half is other flood flow, incurred when water is available
Conveyance O&M	$137,000 per year	Annual average after 2040	$25 per AF cost to convey, incurred when water is available
New Recharge Basins Constructed in 2040			
Capital Costs	$14.2 million	2038-2039	For basins to recharge up to 12,000 AF per month
O&M costs			
Purchase Water	$3.2 million per year	Annual average	Assume half is acquired from other users, half is other flood flow, incurred when water is available
Conveyance O&M	$547,500 per year	Annual average after 2040	$25 per AF cost to convey, incurred when water is available

Notes: (1) MID O&M costs will be greater than $25 per AF and will be assessed as part of more detailed project development.

4.2.2 On-Farm Recharge (Flood-MAR)

MID is developing an On-Farm Recharge Program (referred to as Flood Managed Aquifer Recharge, Flood-MAR, by DWR). This program diverts flows that would have otherwise left the Subbasin onto farms and fields of willing participants (growers) to percolate into the aquifer and provide recharge benefits for the Subbasin. It requires that the GSA has capacity to capture and divert water to growers and requires willing growers to participate in the program. The MID On-Farm Recharge project assumes that growers would operate existing irrigation systems on their fields when MID is able to provide water.

On-Farm Recharge imposes additional management costs on the GSA and additional operating costs on the grower to divert water, manage fields, and operate irrigation systems. MID will evaluate incentive structures to encourage growers to participate in the program.

MID has been and will implement two On-Farm Recharge projects in its service area to increase groundwater recharge. This includes a Phase 1 project that is already operating and a Phase 2, enhanced, project, where MID will also explore incentives to encourage more growers to participate in the program.

4.2.2.1 Project Overview

MID's On-Farm Recharge program would deliver available flood water to agricultural or other suitable land for percolation to groundwater. The project is distinct from dedicated recharge basins (Section 4.1.1) because existing land uses would be maintained, no basins would be constructed, and existing delivery facilities would be used.

MID, in cooperation with Sustainable Conservation, has been researching and implementing the Phase 1 program since 2015. Preliminary feedback indicated that the program could be an affordable and practical water management tool that can assist in moving groundwater basins, including the ~~Madera~~ Subbasin, toward a sustainable balance. Since 2015, interest among MID landowners has continued. MID has signed up close to 150 landowners in the program, many of which own multiple parcels in MID.

MID has been evaluating grower reluctance to participate in the program, including concerns about crop damage and costs, and is evaluating ways to incentivize more growers to participate in the program. Once these incentives are defined MID will implement the Phase 2 program in which additional acres will participate in the program.

4.2.2.2 Implementation

The implementation timeline for MID's On-Farm Recharge program is provided in Table 4-15. Because new facilities are not needed, the project can be implemented relatively quickly. MID implemented the program initially in 2015 and has signed up close to 150 landowners, many of which own multiple parcels throughout MID. The Phase 2 program ~~will be~~was originally scheduled to be implemented starting in 2025 as of the January 2020 GSP, ~~or as soon as~~but additional incentives and mechanisms ~~are~~ were developed by MID ahead of schedule.

Construction activities and requirements

On-Farm Recharge requires MID to secure water supply and manage deliveries. Growers make the decision to participate and are required to manage their own fields and operate their own irrigation systems. However, no large-scale construction projects or significant capital outlays are required.

Table 4-15. MID On-Farm Recharge Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2015	2025
Financing	NA	NA
Construction	NA	NA
Operation	2015	2040

Water source

Water for recharge is expected to be available from one or more of the following sources:

- Fresno River supplies from Hensley Lake
- CVP supplies from Millerton Lake
- Other water available to MID or purchased by MID

The analysis of benefits below does not account for other potential sources nor for any changes in operations elsewhere in the CVP system that might affect availability of surplus water.

The Phase 1 and Phase 2 projects will compete for water with recharge basins developed by MID, and potentially, other GSAs. However, a preliminary assessment indicates that in very high runoff years water is available for all recharge projects. The GSP analysis of potential yield (benefit) to the entire Subbasin includes the joint effect of all proposed GSA PMAs and therefore already accounts for these interactions.

Conditions or constraints on implementation

On-Farm Recharge requires MID to secure water supply and manage deliveries. Growers are required to manage fields and operate irrigation systems. However, no large-scale construction projects or significant capital outlays are required. Deliveries of flood flows will need to be coordinated with maintenance activities on canals and other delivery facilities, both within MID and, if applicable, Madera Canal operations. The diversions are expected to occur during periods when flow exceeds beneficial or environmental uses.

The Phase 2 program will explore incentives to encourage additional participation. The general incentive structure would need to provide a greater benefit to the landowner than the total cost (including risk) to the grower. MID will evaluate options as it further develops the Phase 2 program.

Permitting process and agencies with potential permitting and regulatory control

MID has legal authority to deliver water to its customers. It could develop additional incentive structures and agreements (Phase 2).

Additional percolation of water on agricultural lands can affect movement of nitrates or other constituents into groundwater.

Project Operations and Monitoring

It is anticipated that the water will be delivered to participating lands that have high percolation rates in the initial program. The Phase 2 program will deliver water to additional acres of suitable farmland. The program can be scaled based on grower interest, water availability, and Subbasin needs for sustainability.

4.2.2.3 Project Benefits

On-farm groundwater recharge will contribute to groundwater sustainability in the Subbasin by replenishing groundwater supplies. The direct recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, on-farm groundwater recharge is also expected to both reduce the rate of active subsidence and minimize or prevent continuing subsidence in the project areas.

Groundwater recharge benefits are estimated using available flood flow over the historical water balance period of 1989-2014. This period is representative of long-term average hydrologic conditions in the Subbasin. Based on the analysis, flood releases are expected to occur in approximately 1 out of 3 years. MID may be able to encourage grower participation in the program in drier year conditions, depending on the availability of water supplies and district operations. The average annual benefit is the water year-type probability weighted average. Based on the probabilities, the expected average annual delivery of water is 510 AF in the Phase 1 program (Table 4-16).

Table 4-16. MID Estimated Average Deliveries by Year Type for Phase 1 On-Farm Recharge Project, in Acre-Feet per Year.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	1,250	35%	441
AN	500	14%	69
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			510

MID will increase grower participation ~~in~~ as part of the Phase 2 program. The program will scale-up the current On-Farm Recharge initiative and ~~is~~ was expected to be implemented around 2025, but is being implemented ahead of schedule. The average annual benefit is the water year-type probability weighted average. Wet, Above Normal, Below Normal, Dry, and Critical year types have historically occurred with a probability of 35%, 14%, 8%, 16%, and 27%, respectively. The average annual yield of the Phase 2 program equals 1,686 AF (Table 4-17).

Based on the historical hydrology and assuming no other changes to system operations, the average annual yield of the Phase 1 program equals 510 AF. The average annual yield of the Phase 2 program equals 1,686 AF. The combined MID On-Farm Recharge program will generate an additional 2,196 AFY starting in 2025 and continuing through the GSP implementation timeline. As described below in Section 4.9, the program has already produced estimated yields higher than those shown here.

Table 4-17. MID Estimated Average Deliveries by Year Type for Phase 2 On-Farm Recharge Project, in Acre-Feet per Year.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	4,000	35%	1,412
AN	2,000	14%	275
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			1,686

4.2.2.4 Project Costs

Estimated project costs for Phase 1 and Phase 2 of the MID On-Farm Recharge program are summarized in Table 4-18. Capital costs of the MID On-Farm Recharge program are expected to be minimal because the project uses existing MID facilities and grower irrigation systems. No construction or land acquisition costs are currently anticipated. It is also assumed that no additional permitting costs would be incurred.

Recharge volumes are estimated using existing delivery facilities. Operating costs anticipated with this project are the cost of the water, pumping costs, and labor to irrigate. Table 4-18 provides estimates of these costs for the Phase 1 and Phase 2 projects. Water costs in the table represent CVP 215 water costs, though the programs will likely acquire a mix of CVP 215 water, other flood flow at a potentially low acquisition cost, and water acquired from other water suppliers at much higher market prices.

Table 4-18. Estimated Project Costs for MID On-Farm Recharge Project (2019 Dollars).

Item	Total Cost	Year Incurred	Notes[1]
Phase 1 Project			
Capital Costs	none	NA	Project uses existing district facilities and grower systems
O&M Costs			
Purchase Water	$20,000 per year	Annual average.	Assume cost of CVP 215 water, though water may be a mix of sources; incurred when water is available
District conveyance and grower costs	$25,500	Annual average	$25 per AF District charge to convey, plus $25 per AF to compensate for grower costs, incurred when water is available
Phase 2 Project			
Capital Costs	none	NA	Project uses existing district facilities and grower systems
O&M Costs			
Purchase Water	$65,000 per year	Annual average.	Assume cost of CVP 215 water, though water may be a mix of sources; incurred when water is available
District conveyance and grower incentive	$126,500 per year	Annual average	$25 per AF District charge to convey, plus $50 per AF incentive payment to compensate for grower costs, incurred when water is available

Notes: (1) MID O&M costs will be greater than $25 per AF and will be assessed as part of more detailed project development.

For the Phase 1 program, costs include an assumed $25 per acre-foot for district conveyance, pumping, and maintenance, plus $25 per acre-foot incurred by growers to manage the water on their fields. MID will assess actual O&M and water purchases costs as the program is more fully developed. This may include additional incentives under the Phase 2 Flood-MAR program.

4.2.3 MID System Improvements and Programs

MID will implement a series of projects to improve operations and better manage ground and surface water supply within its service area. This includes capital projects, some of which are partially funded through grants and many of which are completed or are currently under development, as well as new programs to evaluate incentives and other changes to better manage surface water within MID.

4.2.3.1 Project Overview

The MID system improvements and programs project includes five separate activities that MID will implement as part of the GSP:

- **MID Pipeline Project**. Rehabilitate aging pipelines to reduce losses.
- **WaterSMART Pipeline Project**. Rehabilitate additional pipelines to reduce losses and allow MID to deliver water later in the irrigation season.
- **WaterSMART SCADA Project**. Improve MID water management, reduce losses, and allow MID to deliver water later in the irrigation season.
- **Water Supply Partnerships Project**. MID will identify and purchase or exchange additional water supplies from partnering districts.
- **Increase MID grower utilization of surface water supplies**. MID will explore incentives to encourage more MID growers to take district surface water and reduce groundwater pumping.

MID system improvement projects and programs are similar in operation and implementation. A general description of the projects is provided. Detailed expected benefits, operational descriptions, and estimated costs are provided for each individual project.

MID Pipeline Project

MID Main I Canal crossings at Road 23, Avenue 11, Avenue 10-1/2, and Avenue 10 were originally constructed in the early 1970s and have been patched numerous times over the years due to excessive cracks and leaking. These Techite pipe crossings have reached the end of their service lives and needed replacement. The project provides benefits to the Subbasin by reducing system losses.

Historically, the tail end of the Main I Canal, which conveys most of the City of Madera stormwater, had been subject to multiple canal breaks during the flood season because of the close proximity to Cottonwood Creek, Road 23 shoulder, and the Lateral 24.2 spill pipeline. The canal also had operational issues and constraints related to MID deliveries and created unnecessary losses. The 36-inch pipeline replaced the four failing road crossings, two check structures, and eliminated the risk of canal breaks and improved operations between Avenues 10 and 11. The pipeline design and construction were completed in-house by MID staff in 2016.

WaterSMART Pipeline Project

In January 2016, MID staff prepared an application for two projects under the ~~U.S. Bureau of Reclamation (~~USBR~~)~~ WaterSMART: Water and Energy Efficiency grant program. One project was titled "Lateral 24.2-17.0 Pipeline Improvement Project." MID was awarded funding for the project.

The project redeveloped approximately 6,500 feet of the existing Lateral 24.2-17.0 canal into a 36-inch pipeline to reduce losses and improve operational efficiency. The project extends the irrigation season for growers and prevents spills leaving the Subbasin, which allows growers to utilize more surface water thereby pumping less groundwater.

WaterSMART SCADA Project

In January 2016, MID staff prepared an application for two projects under the ~~U.S. Bureau of Reclamation (~~USBR~~)~~ WaterSMART: Water and Energy Efficiency grant program. One project was titled "Irrigation Water Conservation and Canal Automation Improvement Project." MID was awarded funding for the project.

The project expands the District's existing Supervisory Control and Data Acquisition (SCADA) system by installing 14 new solar-powered automated gates and meters throughout the District. The gates and meters can be remotely monitored and controlled by smart phones and are programmed to automatically open and close to maintain a constant flow within +/- 2.5% accuracy, regardless of varying upstream water level. The project extends the irrigation season for growers and prevents spills leaving the Subbasin, which allows growers to utilize more surface water thereby pumping less groundwater.

Water Supply Partnerships

MID will obtain additional water through win-win exchanges and partnerships both within and outside of the Subbasin. MID is continually evaluating potential partnership opportunities. This will provide benefits by increasing water supply in the MID service area, both for direct irrigation use and groundwater recharge. MID recognizes that competition for water supply partnerships will increase as GSPs are implemented by its partner agencies. MID will continue to monitor the market to assess partnerships and increasing water purchase costs.

Incentive Programs

MID will evaluate programs to encourage more MID growers to utilize surface water supplies instead of groundwater. MID will be conducting studies to identify potential incentive structures and assess the relative costs and benefits of different alternatives. The project benefits MID by reducing groundwater pumping.

4.2.3.2 Implementation

Implementation will be staged based on the existing development of each of the projects, having already begun and continuing through 2030. Implementation for each of the MID operation and incentive projects is as follows:

- **MID Pipeline**. Upgrade of crossing and canal completed 2016.
- **WaterSMART Pipeline**. The WaterSMART pipeline upgrade completed in 2019.
- **WaterSMART SCADA**. SCADA upgrades, funded in part with the WaterSMART grant, completed in 2019.
- **Supply Partnerships**. MID has started working with partners to bring new water supply into the Subbasin. MID will expand this program in the future.
- **Incentive Programs**. MID will conduct a study to identify appropriate incentive structures to encourage more growers to utilize surface water. Findings of the study will be implemented immediately thereafter, and Subbasin water supply benefits will be realized starting in 2022.

Timeline

Table 4-19 summarizes the implementation timeline for all operation and incentive projects implemented by MID. Acquisition, permitting, and documentation started in 2016 or earlier will continue through 2022.

MID pipeline upgrades have been operational since 2016. WaterSMART system upgrades to pipelines and SCADA were completed in 2019. Additional water purchases will start in 2020 and the MID incentive program will start in 2022.

Table 4-19. MID System Improvements and Programs Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2016	2040
Financing	2016	2040
Construction	2016	2040
Operation	2016	2040

Construction activities and requirements

Construction activities vary by project. General activities include initial feasibility assessment, permitting, environmental review, earthwork, pipes, and installation. Details on construction activities, schedule, and project costs will be developed as part of final project design for each project by MID.

MID does not anticipate construction activities under the partnership project and incentive program beyond standard maintenance of existing facilities.

Water source

Additional water for the pipeline and SCADA projects, as well as the grower incentive initiative, is expected to be available from existing MID sources. MID has a contract for CVP Class 1 and Class 2 water, and it can receive CVP surplus flows when available, along with other supplies available to MID. Partnership opportunities will increase purchases from other water suppliers across the state. Water sources for each recharge project include:

- **MID Pipeline**. During the irrigation season the project will reduce losses and provide additional water to fields by lengthening the season, increasing the use of available water supplies. MID expects the project will provide water in all year types.
- **WaterSMART Pipeline**. During irrigation season the project will reduce losses and provide additional water to fields by lengthening the season, increasing the use of available water supplies. MID expects the project will provide water in all year types.
- **WaterSMART SCADA**. During irrigation season the project would lead to longer season by allowing growers to receive more water than before, reducing losses and spill which leaves the Subbasin. MID expects the project will provide water in all year types, increasing the use of available water supplies.
- **Supply Partnerships**. Purchases from partner agencies will be identified by MID. Supplies are generally available under all water year conditions, although the cost can increase significantly in Dry and Critically Dry years.
- **Incentive Programs**. MID anticipates that water supply for the incentive program would be available under all water year types. MID estimates that even in Dry and Critically Dry years its growers could pump less groundwater and use more MID surface water.

Conditions or constraints on implementation

All the operations and incentive projects implemented by MID are planned to be implemented by 2040. Implementation of this set of projects does not depend on the performance of other projects or activities. However, the water supply source for each project does depend on the performance of other MID projects or activities. For example, purchased water may be used for recharge or additional surface water deliveries under a MID incentive program.

Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting roles for different projects: Madera County, US Bureau of Reclamation, other entities depending on agencies with authority over water supply available to MID trading partners. Water transfers with willing partners will require satisfying requirements to transfer water which will depend on the source of the supply and nature of the transfer. Incentive programs may require a rate study to justify any fees or financial incentives offered by MID.

4.2.3.3 Project Operations and Monitoring

MID will operate and monitor the MID Pipeline, WaterSMART Pipeline, and WaterSMART SCADA projects within existing district operations. The three projects provide additional operational flexibility to MID, allowing it to deliver surface water to growers longer into the season and preventing losses. MID will operate the projects in coordination with the rest of its system to maximize surface water supply deliveries to growers. In turn, growers will pump less groundwater, and this results in a benefit to the Subbasin. MID will not monitor the specific performance of the projects but will continue to monitor and manage its water supplies with these integrated projects. MID expects these projects to provide water supply benefits in all water year types.

Incentive programs to encourage growers to use MID surface water in lieu of pumping groundwater will be developed by MID. MID will initiate studies in 2020 and implement programs as they are developed. Incentive programs could include pricing mechanisms to make MID surface water less expensive or other financial incentives. MID will identify, implement, and monitor any programs that it develops. The incentive program will be designed to provide water under all year types.

MID is planning to identify and purchase water from willing partners under all water year types. Water purchase costs are expected to be significantly higher in Dry and Critically Dry years. MID will provide any purchased water supplies directly to growers (in lieu of groundwater pumping), or depending on the timing and availability, use the purchased water for groundwater recharge. MID will monitor the program by tracking and reporting how water purchased from willing partners is used within the District.

4.2.3.4 Project Benefits

MID's system improvements and program projects provide groundwater benefits in different ways. Pipeline projects provide in-lieu recharge benefits by allowing MID to deliver surface water to growers longer into the season, and by reducing losses of available surface water. The SCADA project also provides in-lieu recharge benefits by improving MID's operational flexibility and allowing MID to deliver more surface water to growers. MID incentive programs will encourage growers to use more surface water and pump less groundwater. The in-lieu recharge benefits of these projects are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by increasing surface water use and reducing groundwater pumping.

Based on an analysis of MID operations and project implementation developed by MID, the average annual gross benefit of each operation and incentive project is as follows:

- **MID Pipeline**. 420 AF.
- **WaterSMART Pipeline**. 875 AF.
- **WaterSMART SCADA**. 1,225 AF.
- **Supply Partnerships**. 3,990 AF (1,995 AF by 2020 and another 1,995 by 2025).
- **Incentive Programs**. 5,005 AF.

These expected values are averages over all year types (Wet, Above Normal, Below Normal, Dry, and Critical), weighted by the probability of each year type. Tables 4-20 through 4-24 below summarize average annual water supply benefits, shown as the average delivery by year type. The reliability of the source water is based on historical hydrology being a good projection of future hydrology. In addition, the reliability depends on future water supply management, including changes to the CVP system and the San Joaquin River Restoration Program that may affect MID operations.

Table 4-20. MID Estimated Average Yield by Year Type, in Acre-Feet per Year — MID Pipeline Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	420	35%	148
AN	420	14%	58
BN	420	8%	33
D	420	16%	66
C	420	27%	115
Avg. Annual			420

Table 4-21. MID Estimated Average Yield by Year Type, in Acre-Feet per Year — WaterSMART Pipeline Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	875	35%	309
AN	875	14%	120
BN	875	8%	69
D	875	16%	137
C	875	27%	240
Avg. Annual			875

Table 4-22. MID Estimated Average Yield by Year Type, in Acre-Feet per Year — WaterSMART SCADA Project.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	1,225	35%	432
AN	1,225	14%	168
BN	1,225	8%	96
D	1,225	16%	192
C	1,225	27%	336
Avg. Annual			1,225

Table 4-23. MID Estimated Average Supply by Year Type, in Acre-Feet per Year — Water Supply Development-Partnerships.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
Completed by 2020			
W	1,995	35%	704
AN	1,995	14%	274
BN	1,995	8%	156
D	1,995	16%	313
C	1,995	27%	548
Avg. Annual			1,995
Additional Completed by 2025			
W	1,995	35%	704
AN	1,995	14%	274
BN	1,995	8%	156
D	1,995	16%	313
C	1,995	27%	548
Avg. Annual			1,995

Table 4-24. MID Estimated Average Yield by Year Type, in Acre-Feet per Year — Incentive Programs.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	5,005	35%	1,766
AN	5,005	14%	687
BN	5,005	8%	393
D	5,005	16%	785
C	5,005	27%	1,374
Avg. Annual			5,005

4.2.3.5 Project Costs

Estimated project costs for MID system improvements and program projects are shown in Table 4-25. MID is continuing to develop many of these projects. Costs will be refined under ongoing development efforts. All project costs have been indexed to ~~current (~~2019~~)~~ dollars for consistency of comparison.

The pipeline and SCADA projects are complete or nearly complete. Capital costs shown for these projects reflect estimated material costs (pipeline) and total project costs (including Reclamation cost share) for both WaterSMART projects (pipeline and SCADA).

The water supply partnerships and incentive programs will deliver additional water acquired from willing sellers. MID does not anticipate any capital expenditures under these projects. Costs include MID O&M to deliver the water plus the cost to acquire the water at market prices that vary by year type. The water prices paid are averages weighted by year type. Future market conditions and the terms of agreements that MID can reach with its partners will determine the actual cost. MID will continue to work with partners to identify opportunities.

Table 4-25. MID System Improvements and Programs Costs (2019 Dollars).

Item	Total Cost	Year Incurred	Notes[1]
MID Pipeline Project			
Capital Costs	$556,000	2016-2020	The project is complete
O&M costs	none		No additional O&M cost
WaterSMART Pipeline Project			
Capital Costs	$1.3 million	Complete	Operation to begin in 2019; Includes Reclamation and MID costs
O&M costs	none		No additional O&M cost
WaterSMART SCADA Project			
Capital Costs	$1.2 million	Complete	Operation to begin in 2019; Includes Reclamation and MID costs
O&M costs	none		No additional O&M cost
Water Supply Partnerships Completed by 2020			
Capital Costs	none		
O&M costs			
Purchase Water	$1.2 million per year	Annual average	Include water purchase cost from willing sellers, weighted by year type
Conveyance O&M	$50,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available
Water Supply Partnerships Completed by 2025			
Capital Costs	none		
O&M costs			
Purchase Water	$1.2 million per year	Annual average	Include water purchase cost from willing sellers, weighted by year type
Conveyance O&M	$50,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available
Incentive Programs			
Capital Costs	none		
O&M costs			
Purchase Water	$2.95 million per year	Annual average	$590 per AF acquired from willing sellers, weighted by year type
Conveyance O&M	$125,000 per year	Annual average	$25 per AF cost to convey, incurred when water is available

Notes: (1) MID O&M costs will be greater than $25 per AF and will be assessed as part of more detailed project development.

4.2.4 Project Financing

Pursuant to 23 CCR §354.44 and §354.6, MID has evaluated and described the ability to cover project costs. Some projects are complete and other projects are still being assessed, and feasibility studies are being refined or developed, a general description of how MID will cover project costs is presented. MID will conduct economic and fiscal feasibility studies as part of its ongoing planning efforts to better understand willingness and ability to pay for the projects included in the GSP.

MID will pursue available state and federal grants or loans to help construct projects. This may include grant funding for planning studies to support the development of proposed management actions, including its On-Farm Recharge program and incentives to increase surface water deliveries within the district. Operation and maintenance costs will be paid using revenues raised through water rates and/or fees and assessments. MID will conduct the necessary studies and decision processes (including Proposition 218 elections if necessary) to approve rates, fees, or assessments to provide the required funding. MID water users have, in the past, approved assessments to fund projects.

4.2.5 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the Madera Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA). A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation. A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation.

In addition, MID works cooperatively with other districts to develop, provide, and manage water supply. For example, MID and MWD have been coordinating on the development of long-term projects to improve surface deliveries to MWD such as a new water supply agreement and the Madera Lake pipeline (see Section 4.1).

4.2.6 MID Projects Already Implemented: Madera Ranch Annexation

MID has been proactive in developing projects to help sustainably manage groundwater within the MID service area. All the projects that MID has already implemented were completed after the historical base period used in the GSP to develop the historical and current water budgets (post 2015), thus provide additional groundwater benefit to MID. One project that does not provide any new water to the Subbasin but is important to acknowledge is the Madera Ranch Annexation.

In 2015, MID annexed 18 parcels, totaling 10,485 acres, owned by the District since 2005 within the area known as Madera Ranch. The annexation provided MID with jurisdiction over the parcels.

The Madera Ranch is located in Madera County, approximately 5 miles southwest of the City of Madera and 10 miles northwest of the City of Fresno. The Fresno River is located to the north and the San Joaquin River is located to the south of the project site. The subject property is located east of Firebaugh Boulevard and south of Avenue 12. The subject property adjoins the existing boundaries of the MID and Gravelly Ford Water District. Adjacent land uses surrounding the property are agricultural with various agricultural zoning designations. Currently, the project site is used for cattle grazing and the project maintains the existing, non-irrigated land use and zoning designations. The project has helped to limit groundwater demand in the Subbasin by retaining non-irrigated land uses on the project site. By limiting groundwater demand, the project provides benefits to groundwater levels, groundwater storage, and subsidence.

4.3 City of Madera GSA

The City of Madera GSA has developed two projects for the GSP, one that is already complete and another that is currently being implemented. The project that is fully complete, Berry Basin, is a recharge basin implemented in cooperation with Madera Irrigation District. The project involves delivering water to the basin in wet, above normal, and below normal years. The expected recharge averaged over all years is 48 AFY, with half credited to the City of Madera and half to MID.

A detailed description of the project, pursuant to 23 CCR § 354.44 and § 354.6, is provided above under MID projects (Section 4.2). Table 4-26 summarizes the expected annual benefit of the project that accrues to the City of Madera.

At the time of initial GSP development, project planning was still in development, so complete information on project planning, operations, costs, and other details were not finalized. **This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.** A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

Table 4-26. City of Madera Estimated Average Recharge in Berry Basin by Year Type, in Acre-Feet per Year.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	55	35%	19
AN	30	14%	4
BN	10	8%	1
D	0	16%	0
C	0	27%	0
Avg. Annual			24

4.3.1 Installation of Water Meters and Volumetric Billing

The City of Madera GSA installed water meters between 2011 and 2018 and implemented a volumetric billing process for single-family users in 2015. The City of Madera water deliveries on a per capita basis for 2017 compared to average per capita water deliveries from 1999 through 2012 are significantly less for both inside and outside uses (Table 4-27).

Table 4-27. City of Madera Water Deliveries.

Days	Month	Gallons per Day per Capita (GPDC)					Gallons (2017 pop.)		AF (2017 pop.)	
		Baseline (1999-2012)	Future (2017-2018)	Savings	Savings Indoor	Savings Outdoor	Savings Indoor	Savings Outdoor	Savings Indoor	Savings Outdoor
31	1	115	74	41	41	0	82,884,157	0	254	0
28	2	115	79	36	36	0	65,666,360	0	202	0
31	3	140	78	62	40	22	81,361,654	42,997,652	250	132
30	4	185	99	86	40	46	78,737,084	89,152,185	242	274
31	5	254	148	106	40	66	81,361,654	134,039,273	250	411
30	6	312	160	152	40	112	78,737,084	217,696,436	242	668
31	7	338	183	155	40	115	81,361,654	231,704,936	250	711
31	8	324	167	157	40	117	81,361,654	235,380,469	250	722
30	9	284	146	138	40	98	78,737,084	190,677,719	242	585
31	10	214	119	95	40	55	81,361,654	109,179,746	250	335
30	11	152	95	57	40	17	78,737,084	33,233,600	242	102
31	12	121	78	44	44	0	88,498,763	0	272	0
Avg/Total		213	119	94	40	54	958,805,886	1,284,062,016	2,946	3,940
Ratio Indoor/Outdoor									43%	57%

The City of Madera has installed approximately 13,000 meters, with an additional 250 that will be installed over the coming years. The total cost of the project equals $11 million. The City of Madera expects to complete installation of meters on unmetered services including City medians, parks, facilities and landscape districts. This includes up to 200 private accounts and approximately 50 public water services. Many older parcels have cross connections that will also be addressed thereby increasing individual accountability for water usage and ideally leading to lower water usage. Cost estimates range from $400,000 to $600,000 for the additional meters. Costs are provided in 2019 dollars.

The outdoor savings in applied water includes reductions in turf consumptive use and deep percolation. Assuming 85 percent efficiency, 591 AF of the applied water savings is reduced deep percolation. The remaining 3,350 AF is reduction in consumptive use, or a reduction in the water that leaves the Subbasin.

The project provides in-lieu recharge benefits by reducing consumptive use, and consequently reducing demand for groundwater – the water supply source used within the City of Madera. The in-lieu recharge benefits of the project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by reducing demand for additional groundwater pumping.

4.4 Madera County GSA

Madera County GSA (Madera County) has identified four projects and a substantial demand management program that it will implement as part of the GSP.

A water purchase program would seek to acquire water from outside Madera County and provide direct or in-lieu recharge benefits to the Subbasin. A second project would use flood flows from Millerton releases to spread onto participating lands for flood managed aquifer recharge (Flood-MAR). Two additional projects would construct basins to recharge winter floodwater diverted from the Chowchilla Bypass. For purposes of evaluating the timing of the projects, one would be constructed in 2025 and the other in 2040.

As a primary element of its efforts to become sustainable, Madera County will implement a demand management program that would oversee a managed reduction in the volume of groundwater consumed by irrigated agriculture during the 20-year GSP implementation period – terminating in about a 50% reduction from estimated current consumptive use quantities. This will be achieved through programs that will be developed and implemented during the first year following adoption of the GSP, and may impose groundwater pumping limits, allocate pumping credits to parties based on those limits, and potentially allow groundwater users to buy, sell, or carry over pumping credits. This section provides a general overview of demand management and how it could be implemented by Madera County GSA and potentially by other GSAs in the Subbasin to achieve sustainability objectives. Madera County is currently working with stakeholders to develop program-specific parameters.

The PMA descriptions are based on information developed during the initial GSP development process and, where applicable, other studies. Water available for these PMAs is evaluated in combination with other projects in the GSP.

At the time of initial GSP development, planning for the PMAs was at varying stages of development, so complete information on construction requirements, operations, costs, permitting requirements, and other details were not available. **This section represents the planned PMAs at the time of initial Joint GSP development in January 2020. Section 4.9 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023). PMA updates are also discussed in the Periodic Evaluation and Annual Reports.** A description of how all the PMAs operate as part of the overall Joint GSP as envisioned in the January 2020 Joint GSP is provided in Chapter 5, Plan Implementation.

4.4.1 Water Purchase for Direct or In-Lieu Recharge

Madera County will develop partnerships and import additional water into Madera County for direct or in-lieu recharge. The project would purchase additional water supplies that would be delivered to Madera County parcels near existing Reclamation and Madera Irrigation District (MID) facilities. Madera County will work with Reclamation, MID, and other potential partners to identify sources of supply, costs, and wheeling agreements.

4.4.1.1 Project Overview

Madera County would directly acquire or facilitate the acquisition of new surface water supplies that would be available for diversion from Millerton Lake or other sources during the irrigation season. Madera County estimates that 3,500 to 9,000 AF could be acquired in one year, but on average the project would provide about 3,600 AFY in in-lieu recharge.

The project water would be acquired from a water supplier with rights/contracts for water from Millerton, or from another water supplier whose supply can be exchanged with water from Millerton. The water would be conveyed to Madera County parcels that are near an existing major water delivery system (e.g. Madera Canal, MID delivery system, natural stream course). Water would be conveyed to the various locations under a conveyance agreement, as may be appropriate. Diversion and conveyance facilities would be constructed to serve the lands not currently within the delivery system of a district.

4.4.1.2 Implementation

The County will contact (either directly or in coordination with MID) potential sellers of water delivered from Millerton and, if necessary, with other sellers of water that can be delivered from Millerton via exchange agreements. Diversion and conveyance facilities would be constructed to serve the lands. The County will negotiate operation and conveyance agreements to deliver the water to parcels within the Madera County area east of Highway 99. The exact parcels to receive the water have yet to be identified. To minimize costs, Madera County intends to serve parcels with irrigation systems accessible within ¼ mile of a conveyance pathway (e.g. Madera Canal, MID channel, or natural stream course).

The implementation timeline for this project is summarized in Table 4-28. Madera County has already started working with partners to identify potential purchases. Implementation of the project would start immediately in 2020 and continue through full development of the project by 2025.

Table 4-28. Water Purchase for Direct or In-Lieu Recharge Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2022
Financing	2022	2023
Construction	2023	2024
Operation	2025	On going

Construction activities and requirements

Construction would be required to divert water from existing canals or streams and convey the water to served lands. Depending on the expected frequency and duration of diversions, both temporary and permanent diversion structures could be used. Madera County will work with MID to identify parcels that are located near existing MID facilities and build necessary infrastructure to serve each parcel. This would include conveyance and all other necessary agreements. Madera County will also work directly with Reclamation to identify and potentially convey to parcels directly adjoining Reclamation owned facilities.

Water source

The project intends to acquire water from Millerton by agreement with an existing CVP contractor, or from other sources that could result in water supplies available in Millerton for delivery. This could include any water that can be conveyed to the County via exchange agreements, including water from potential new projects such as Sites Reservoir.

Conditions or constraints on implementation

A necessary requirement for this project is the availability of water for purchase. Construction of the diversion facilities would not be justified without reasonable access to water. The cost of the water to growers receiving the water could also be an impediment to participation. Delivery of acquired water must be within the capability of existing facilities and reasonably assured by conveyance agreements.

Permitting process and agencies with potential permitting and regulatory control

The project will require conveyance and other agreements to allow the use of facilities to route the water to the new diversion locations. The project will require coordination with Reclamation for scheduling the storage and delivery of water within Millerton or to facilitate exchanges of water acquired from more distant parts of the Central Valley.

The following agencies have potential permitting roles for the project: Madera County, Madera Irrigation District, and US Bureau of Reclamation. Depending on construction requirements for needed delivery infrastructure, an environmental review process under CEQA and/or NEPA could be required. Water transfers with willing partners will require satisfying requirements to transfer water which will depend on the source of the supply and nature of the transfer.

4.4.1.3 Project Operations and Monitoring

Between 3,500 and 9,000 AF would be targeted for acquisition in all year types except wet years, adjusted as appropriate for hydrologic conditions that affect water supply availability. The water would be delivered during the irrigation season using existing conveyance facilities, focusing on the early and later portions of the season when capacity in conveyance facilities may be more available. To minimize costs, Madera County intends to serve irrigated lands accessible within ¼ or ½ mile of a conveyance pathway (e.g. Madera Canal, MID facilities, or natural stream course). The surface water would be provided directly for irrigation, thereby providing in-lieu recharge of groundwater that would otherwise have been pumped. Future extraction of the in-lieu recharged groundwater will be done by water users within Madera County. If allocation of the in-lieu recharged groundwater is determined to be necessary, groundwater extraction will be monitored and enforced by Madera County with meters installed on individual wells.

4.4.1.4 Project Benefits

Table 4-29 summarizes the expected water purchases by year type. Expected average annual water purchases equal 3,608 AF. To the extent the delivered water substitutes for groundwater, it provides in-lieu recharge equal to the net amount of avoided pumping (gross pumping minus return percolation from the pumped water) plus the percolation from applying the surface water. Therefore, the total recharge (in-lieu plus direct percolation) is equal to the amount of surface water purchased and delivered. The in-lieu recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by increasing surface water use and reducing groundwater pumping. By replenishing groundwater supplies in the Subbasin, the direct or in-lieu recharge from this project is also expected to both reduce the rate of active subsidence and minimize or prevent continuing subsidence in the project areas.

Table 4-29. Madera County Estimated Average Deliveries by Year Type for Water Purchases, in Acre-Feet per Year.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	0	35%	0
AN	5,000	14%	686
BN	7,000	8%	549
D	9,000	16%	1,412
C	3,500	27%	961
Avg. Annual			3,608

4.4.1.5 Project Costs

The estimated costs of this project are summarized in Table 4-30. Project capital costs will include the cost of delivery infrastructure to Madera County parcels. It is assumed that the turnout consists of a canal gate and an open flow propeller meter. If it is necessary to pump water to the field, capital costs may include an in-line propeller meter or mag meter. Madera County is working with partners to define the specific parameters of the project and refine initial project cost estimates. An estimated capital cost of $300,000 for a total of six turnouts and limited conveyance infrastructure is assumed for initial planning purposes.

Annual operating costs of the water purchase project include wheeling agreement cost, other delivery costs (if pumping water is required), and the water purchase cost. The value of water supply is high in this region, especially in critical years. Current estimates of water purchased from existing users under SGMA implementation range from $270 per acre-foot in wet years to over $1,100 in critical years. The weighted average water purchase cost equals $2.4 million per year. An additional cost of $25 per acre-foot is included to convey the water to the fields. All costs are reported in ~~current~~ 2019 dollars.

Table 4-30. Estimated Project Costs for Madera County Water Purchases for Direct or In-Lieu Recharge (2019 Dollars).

Item	Total Cost	Year Incurred	Notes
Capital Costs	$300,000		Assuming six turnouts and limited conveyance infrastructure
O&M Costs			
Purchase Water	$2.4 million	Annually	Water purchase cost averaged over different year types.
Conveyance O&M	$90,000	Annually	Assume $25 per AF charge to convey including wheeling and delivery

4.4.2 Madera County Import and Recharge of Millerton Flood Releases

The import and recharge of Millerton flood releases project is similar to the Madera County water purchase project (Section 4.4.1), except Madera County would target water (CVP Section 215 supply) that is less expensive than direct transfer agreements with partners, and the water would likely be used for direct recharge, rather than in-lieu of pumped groundwater for direct irrigation events.

4.4.2.1 Project Overview

Through modifications to its existing CVP contract, Madera County would request CVP Section 215 flood water when available, either on its own or partnered with another contractor (Reclamation has previously indicated 215 water would be available in 10,000 acre-foot blocks). Between 2,000 and 10,000 AF per month would be targeted for acquisition when available in wet and above normal years. A total of 20,000 AF would be targeted during wet years, and the expected benefit, averaged over all year types, is about 7,000 AFY.

The water would be conveyed to Madera County recharge basins or irrigated parcels (Flood-MAR) that are near an existing major water delivery system (e.g. Madera Canal, MID delivery system, natural stream course). Water would be conveyed to the various locations under a conveyance agreement, as may be appropriate. Turnouts and conveyance facilities would be constructed to deliver water to these parcels, potentially using the same facilities that serve surface water during the irrigation season (see prior project).

4.4.2.2 Implementation

Project implementation includes securing water supply, partnerships, wheeling agreements, and building delivery facilities and recharge ponds (where necessary). Madera County will negotiate operation and conveyance agreements to deliver the water to parcels. The exact parcels to receive the water have yet to be identified. To minimize costs, Madera County intends to serve parcels within ¼ or ½ mile of a conveyance pathway (e.g. Madera Canal, MID channel, or natural stream course) that can either construct recharge basins or participate in Flood-MAR programs.

The timeline for implementation of this project is summarized in Table 4-31. Madera County would construct necessary basins, dry-wells, and conveyance facilities to deliver the water for recharge. The exact mix of facilities used for recharge will be determined during project planning in 2020 and 2021. The project will be fully operational by 2025.

Table 4-31. Import and Recharge of Millerton Flood Releases Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2022
Financing	2022	2023
Construction	2023	2024
Operation	2025	On going

Construction activities and requirements

Construction would be required to divert water from an existing canal and convey the water to served lands, basins, or recharge wells. Construction of recharge basins and appurtenant facilities would be required to the extent those are determined to be incorporated into the project. The project description and costs presented herein assume that Madera County would construct dedicated recharge basins for the water.

Water source

Water will be Section 215 CVP water from Millerton, obtained through the County's CVP contract with Reclamation, or through partnership with another CVP Contractor, and delivered through existing facilities utilizing necessary conveyance agreements with MID or others.

Conditions or constraints on implementation

A requirement for this project is the availability of Section 215 water for Madera County. Madera County will use its existing contract with Reclamation and/or an agreement with a contractor willing and able to deliver Section 215 water. Delivery of acquired water must be within the capability of existing facilities and reasonably assured by conveyance agreements.

Permitting process and agencies with potential permitting and regulatory control

Reclamation will have authority over the sale of the Section 215 water, and MID or other parties will require conveyance agreements to allow delivery, in addition to all other necessary agreements. Coordination with the State Water Board may be needed to verify the right to divert the water and avoid potential third-party impacts. Additional percolation of water on agricultural lands can affect movement of nitrates or other constituents into groundwater. Coordination with the Central Valley RWQCB's Irrigated Lands Regulatory Program (ILRP) may be needed. The project may require an environmental review process under CEQA and would require compliance with NEPA prior to Reclamation selling the water to the County.

4.4.2.3 Project Operations and Monitoring

Between 2,000 and 10,000 AF per month would be targeted for acquisition when water is available in wet and above normal years. For purposes of estimating the benefit this project may provide to the overall Subbasin sustainability goal, water is assumed to be available only in wet years. The water would be conveyed to recharge facilities using existing channels and facilities to the extent feasible. New conveyance would be constructed where needed.

4.4.2.4 Project Benefits

Table 4-32 summarizes the results of an integrated hydrologic analysis of water potentially available by year type and month for this project. All deliveries represent new supplies. Over time, the average delivery, weighted by the probability of different year types, would be about 7,000 AFY.

Surface water supplies made available through this project would provide in-lieu and direct recharge benefits. The recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by increasing surface water use, reducing groundwater pumping, and enhancing groundwater recharge.

Recharge basins may also provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals.

Table 4-32. Madera County Estimated Average Deliveries by Year Type for CVP Section 215 Purchases, in Acre-Feet per Year.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	20,000	35%	7,059
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			7,059

4.4.2.5 Project Costs

The estimated costs of this project are summarized in Table 4-33. Project capital costs will include the cost of a turnout and other conveyance required to deliver the water to Madera County parcels, in addition to recharge basins that would in total be able to handle up to 10,000 AF per month. Madera County is working with partners to define the specific parameters of the project and refine initial project cost estimates. Project capital costs may be lower if Madera County is able to identify existing recharge areas or find sites suitable for Flood-MAR closer to existing conveyance systems.

Annual operating costs of the Millerton flood release project include wheeling agreement cost, other delivery costs (if pumping water is required), and the water purchase cost. Project O&M costs are shown as annual averages. Costs will vary annually according to year type and availability of water in those years. All costs are reported in 2019 dollars.

Table 4-33. Estimated Project Costs for Recharge of Millerton Flood Releases (2019 Dollars).

Item	Total Cost	Year Incurred	Notes
Capital Costs	$31.9 million	2023	Basins to recharge up to 10,000 AF per month
O&M Costs			
Purchase Water	$272,000 per year for CVP Section 215 water	Annual average	$38.40 per AF for CVP 215, incurred when water is available
Conveyance O&M	$176,500	Annual average	$25 per AF District charge to convey, incurred when water is available

4.4.3 Madera County Chowchilla Bypass Flood Water Recharge Basins

Madera County will construct additional recharge basins or work with landowners to develop a Flood-MAR program to divert flood flows from the Chowchilla Bypass (Bypass) onto lands in western portions of Madera County. The project will provide benefits by increasing recharge in this area of Madera County.

4.4.3.1 Project Overview

Madera County will divert water from the Bypass into recharge basins, primarily during wet years but also in other years when water is available. The project proceeds in two phases.

The first phase of the project will develop recharge ponds that would be operational by 2025. Basins would have a capacity to recharge up to 36,000 AF in a wet year (12,000 AF per month from February through April). Madera County would construct diversions, delivery facilities, and recharge basins sized to accommodate this recharge rate. The average annual recharge produced will be about 12,700 AF.

The second phase of the project will develop recharge ponds that would be operational by 2040. Basins would be sized to recharge up to 75,000 AF in a wet year (25,000 AF per month from February through April). The average annual recharge produced by the second set of facilities will be about 26,500 AF.

4.4.3.2 Implementation

Implementation for the first set of basins will be staged over a five-year period, beginning in 2020 (Table 4-34). Madera County will conduct a study to identify appropriate recharge sites. Permitting and environmental documentation will be initiated in 2020, and financing for construction will be identified and secured. Construction will occur in 2023 and 2024.

The second set of recharge basins will follow a similar implementation pattern, beginning in 2035. Construction of facilities will begin in 2038. Basins will be operational by 2040.

Table 4-34. Basins to Recharge Floodwater Implementation Timeline.

Phase	First Set of Basins (2030)		Second Set of Basins (2040)	
	Start	End	Start	End
Permitting and environmental documentation	2020	2022	2035	2037
Financing	2022	2023	2037	2038
Construction	2023	2024	2038	2039
Operation	2025	On going	2040	On going

Construction activities and requirements

Construction activities will include building diversions from the Bypass, conveyance to recharge basins, and the recharge basins themselves. The initial set of basins will be in operation by 2025. The second set of basins will begin operation in 2040. Land used for the basins will be selected based on location and suitability for recharge and will likely include land that is currently farmed.

Water source

Flood flow from the Bypass will be diverted during wet years or other periods of high excess flow. This may require new water rights to allow diversion during high flow conditions.

Conditions or constraints on implementation

The projects rely on the availability of flood flow in the Bypass and the availability of suitable land to construct recharge basins. The second set of recharge basins are planned for operation beginning in 2040.

This lead time will provide substantial new information on groundwater conditions and trends, allowing for possible re-evaluation of the need for, scale, and best location of future basins.

Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting or partnership roles for the project: Madera County, the Regional Water Quality Control Board, U.S. Bureau of Reclamation, and other partner agencies. It will be necessary to obtain grading permits for construction of the recharge basins. Madera County will coordinate with others to apply for permits required from the State Water Board for diversion of water into the recharge basins.

4.4.3.3 Project Operations and Monitoring

During periods of winter flood flow, water will be diverted into recharge basins or onto lands participating in Flood-MAR. Based on hydrologic analysis, the initial basins will recharge up to 36,000 AF in wet years, about one out of three years. The second set of basins will recharge up to 75,000 AF in wet years, also about one out of three years. Delivery would typically occur during the winter and early spring but could occur any time that surplus water is available.

Extraction of recharged groundwater will be done by water users within Madera County. If allocation of groundwater recharge credits is determined to be necessary, groundwater extraction will be monitored and enforced by Madera County.

4.4.3.4 Project Benefits

Groundwater recharge provided by the project will contribute to groundwater sustainability in the Subbasin by replenishing groundwater supplies. The direct recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, recharge basins and/or Flood-MAR are also expected to both reduce the rate of active subsidence and minimize or prevent continuing subsidence in the project areas.

Based on a hydrologic and operations analysis covering the historical period, the gross yield would average about 12,700 AFY for the first basins and about another 26,500 AFY from the second set of basins (Table 4-35).

Table 4-35. Madera County Estimated Average Deliveries by Year Type for Recharge Basins, in Acre-Feet per Year.

First Set of Basins			
Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	36,000	35%	12,706
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			12,706
Second Set of Basins			
Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	75,000	35%	26,471
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			26,471

Recharge basins may also provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals.

The reliability of source water is based on the use of historical hydrology as an indicator of future hydrology. In addition, the reliability depends on future water supply management, including changes to the CVP system and the San Joaquin River Restoration Program, as well as diversions of other flood flows or sources of water by other GSAs or other entities with rights to that water.

4.4.3.5 Project Costs

The estimated costs of this project are summarized in Table 4-36. Project capital costs will include the cost of a turnout and other conveyance required to deliver the water to Madera County parcels. Details regarding the development of these capital costs are provided in **Appendix 4.A**. Recharge basins would require permitting, land acquisition, earthwork, and site development to connect to the conveyance. Madera County is working with partners to define the specific parameters of the project and refine initial project cost estimates. An estimated capital cost of $67 million for the first phase of recharge basins and $119 million for the second phase of recharge basins (in ~~current~~ 2019 dollars) is used for initial planning purposes.

Annual operating costs include the cost to deliver water to recharge basins and maintain the system. O&M costs may be lower if limited energy costs are required to move water to recharge basins. Madera County is evaluating options and will continue to refine O&M cost estimates.

Table 4-36. Estimated Project Costs for Basins to Recharge Flood Water from Chowchilla Bypass (2019 Dollars).

Item	Total Cost	Year Incurred	Notes
First Set of Basins			
Capital Costs	$67 million	2023-2024	For diversion and conveyance facilities and basins to recharge up to 12,000 AF per month
O&M costs			
Conveyance O&M	$318,000 per year	Annual average after 2025	$25 per AF cost to convey, incurred when water is available
Second Set of Basins			
Capital Costs	$118.9 million	2038-2039	For diversion and conveyance facilities and basins to recharge up to 25,000 AF per month
O&M costs			
Conveyance O&M	$1,160,000 per year	Annual average after 2040	$25 per AF cost to convey plus contingency costs, incurred when water is available

4.4.4 Management Action: Demand Management

Madera County has determined that its potential projects are unlikely to generate enough new water to offset the estimated current and projected future overdraft conditions in its GSA. It has decided to implement a management action to gradually reduce groundwater pumping over the GSP implementation period, achieving significant reductions in the consumptive use of groundwater by 2040.

The management action is a demand management (water use reduction) program. In broad terms, demand management can include any water management activity that reduces the diversion, conveyance, or use of irrigation water. However, to be effective for purposes of sustainable groundwater management, demand management must result in a decline in the consumptive use of groundwater pumped and applied for irrigation (pumping net of recharge). Activities that, for example, reduce canal seepage or reduce deep percolation from irrigation will not be effective. They may decrease quantity of water diverted or applied but they also reduce recharge to usable groundwater, so do not improve the net pumping from the aquifer.

Madera County is continuing to work with stakeholders to develop the specific details of the program. A general overview of the proposed program and summary of decisions that had been made as of late May 2019 are summarized in this section.

4.4.4.1 Program Overview

The Madera County demand management program will reduce consumptive water use (measured as evapotranspiration, ET) over the GSP implementation period. Demand management actions that reduce consumptive use can include changing to lower water-using crops, water-stressing crops (providing less water than the crop would normally consume for full yield), reducing evaporation losses, and reducing irrigated acreage. However, Madera County will not dictate which of those reduction methods growers would implement. Madera County's primary approach to demand management is to set demand reduction targets for the GSA service area as a whole, based on conditions in the Subbasin. Achieving the targets can be approached through a variety of methods, including groundwater allocations, internal groundwater markets (e.g. limited to within the GSA), fee structures, and fallowing programs. The County seeks a balance of individual flexibility and GSA-wide accountability. The Madera County GSA is considering various methods, including satellite observations, to monitor and enforce pumping limits to ensure compliance with the demand reduction targets and sustainability objectives. California Water Code §10726.4 (a)(2) provides the Madera County GSA with the authority to control groundwater extractions by regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate.

The following principles are guiding development of the demand management program. These are in no order of preference and Madera County recognizes tradeoffs exist among these principles.

- Minimize the economic impacts of any demand management required in Madera County
- Maintain established water rights
- Incentivize investment in water supply infrastructure
- Incentivize economically efficient water use
- Incentivize recharge in aggregate, and in specific regions
- Allow sufficient program flexibility for groundwater pumpers to adjust over time
- Ensure access to domestic water supply (de minimis domestic use as defined by SGMA is less than 2 AF annually per user)

4.4.4.2 Implementation

At the time the initial Joint GSP was prepared (January 2020), the estimated total quantity of native groundwater for the MC GSA area was 90,000 AFY. At the same time, it was estimated that current land use conditions (at that time) in the MC GSA resulted in approximately 111,000 AFY of overdraft.[82]

The initial Joint GSP identified five potential PMAs that it would pursue as part of Joint GSP implementation. The potential PMAs included: water purchase, flood flow recharge from Millerton releases, and two basins to recharge floodwater from the Chowchilla Bypass. Additionally, the initial Joint GSP identified a demand management program would be developed and implemented to serve as the largest benefit to the Subbasin on behalf of MC GSA. The initial Joint GSP discussed a number of possible approaches for the demand management program, with a goal of reducing annual average extractions in the MC GSA area by 90,000 AFY by 2040.[83] *The five projects combined—reducing extractions and adding recharge—were intended to eliminate the 111,000 AFY overdraft in the MC GSA area.*

The MC GSA adopted a fee to fund implementation of the projects. However, a lawsuit and subsequent injunction has prevented the MC GSA from collecting the fee and beginning to implement those projects.

The MC GSA also adopted a demand management program that is designed to slowly reduce extractions, eventually completely eliminating the entire overdraft. Although the initial Joint GSP contemplated the MC GSA's demand management program reducing extractions by 90,000 AFY by 2040, in fact, as currently existing, the program will reduce extractions by the full 111,000 AFY overdraft.

[82] Initial Joint GSP Appendix A2.F.b-31.

[83] Initial Joint GSP pages 4-31 to 4-46.

Although the MC GSA has not been able to make much progress on the other projects it intended to implement to increase recharge in its area, its demand management program is designed to meet the sustainability goal by 2040, without those projects. If projects are implemented in the future, the MC GSA can revisit the demand management program, and analyze whether extractions in addition to those planned may be appropriate.

The remaining text in this section comes from the initial Joint GSP (January 2020).

Madera County is currently evaluating a range of demand management program options. All options impose a limit on groundwater pumping that will initiate upon adoption of the GSP. Madera County is continuing to work with stakeholders to develop a program that is implementable, is consistent with the guiding principles, and achieves sustainability objectives in the Subbasin. The demand management program may include one or more of the following approaches:

- **Allocations**. Madera County would implement a groundwater allocation program that would directly relate to the overall demand reduction goals necessary to achieve anticipated reductions by 2040. Allocations could be tied to a crop-type or historic use, or could be evenly distributed among existing irrigators or over all lands. Various approaches have differing effects on grower flexibility, County management and administration, and perceptions of equality.
- **Water trading program (water market, cap and trade)**. Madera County would establish a local groundwater credit system and allow trading of those credits among groundwater users. The program would establish a full accounting of available groundwater supply, allocation of that water supply to local stakeholders, and a record-keeping system that facilitates and records all trades. Additional conditions on location and timing of the use of traded credits may be needed, and in fact, are likely to be required in many areas.
- **Easements**. Madera County would identify potential easement programs and other sources of funding to incentivize fallowing of irrigated lands.

The Madera County demand management program may impose groundwater pumping limits starting in 2020 (Table 4-37). At this time, based on the expected yield of the projects identified under Section 4.2.1 and 4.2.2, the Madera County demand management program will, by 2040, reduce average annual groundwater pumping by 90,000 AF. However, if Madera County project yields are lower than initially estimated, Madera County will increase the level of demand management.

Madera County plans to gradually phase-in demand management between now and 2040. Starting in 2020 and continuing through 2025, average annual groundwater pumping will be reduced by 2% (of the total demand reduction amount) per year, for a total cumulative reduction of 10% by 2025. Groundwater pumping will be reduced by 6% per year starting in 2026 and continuing through 2040. Figure 4-4 illustrates the annual reduction in pumping by year between 2020 and 2040. The annual reduction in pumping in Madera County will equal 90,000 AF by 2040. The second axis on the right shows the corresponding reduction in crop ET_{aw}, consumptive use, under the demand management program. Crop ET_{aw} will be reduced to about 64% of the current ET_{aw} in the Madera County area by 2040.

Table 4-37. Madera County Demand Management Program Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	On going
Financing	2020	On going
Construction	N/A	N/A
Operation	2020	On going

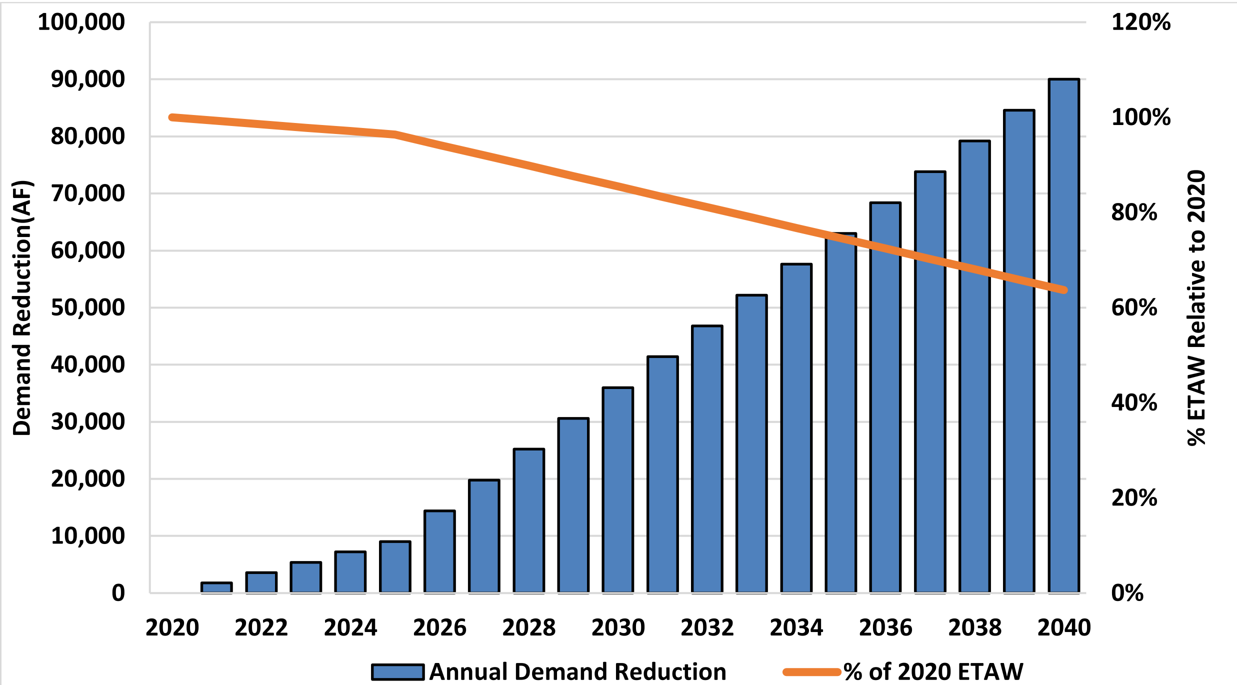


Figure 4-4. Madera County Demand Management Program.

The fundamental requirements of any demand management program include establishing a full accounting of available groundwater supply, a method for allocating the supply, and a system for monitoring and enforcement to ensure that the allocation is not exceeded by any individual or in the aggregate. Madera County is currently working with stakeholders to develop the initial guidelines of the demand management program. Important events and preliminary decisions relevant to the demand management program include:

- June 27 – 29, 2018 – The County of Madera met with representatives in Ventura County to tour recharge facilities and discuss Fox Canyon Groundwater Management Agency water market approaches that could apply to Madera County.
- July 17, 2018 – Following several weeks of development, the County of Madera submitted a proposal for a US Bureau of Reclamation WaterSMART grant to fund a study to evaluate water trading strategies.

- September 24, 2018 – The County of Madera met with the Pajaro Valley Groundwater Management Agency to discuss groundwater management options that may apply to Madera County.
- October 5, 2018 – The County of Madera was notified that it received funding for its US Bureau of Reclamation WaterSMART proposal to develop a groundwater marketing strategy for Madera County.
- November 11, 2018 – The County of Madera held a water marketing workshop to allow stakeholders to discuss water trading approaches that could be implemented under the demand management program.
- December 17, 2018 – The County of Madera held a second water marketing workshop to allow stakeholders to discuss water trading approaches that could be implemented under the demand management program, and test alternative market rules.
- February 12, 2019 – The Madera County Advisory Committee for GSAs recommended that as part of the GSP, native groundwater should be allocated equally across irrigated and unirrigated land within the County GSAs. The vote was 10-1.
- March 7, 2019 – The Madera County Advisory Committee for GSAs recommended that as part of the initial modeling efforts, groundwater pumping in the County GSAs decrease over time decreased at approximately 2% a year from 2020 to 2040 (see Figure 4-4 for example implementation schedule). The vote was 11-0.
- April 12, 2019 – The Madera County Advisory Committee for GSAs recommended that credits be given only for activities that introduce new water into the Subbasin (new water is water that would not otherwise be part of the Subbasin water supplies). The vote was 8-0.
- April 12, 2019 – The Madera County Advisory Committee for GSAs recommended that credits be evaluated by an outside entity to establish the quantity of water to be credited. The vote was 8-0.

Madera County will continue to work with stakeholders to further develop the demand management program. Implementation will start immediately and continue indefinitely.

The following subsections describe the demand management program activities and costs assuming that the Madera County demand management program includes groundwater trading.

Construction activities and requirements

No new physical water storage or conveyance facilities are required to operate a demand management program. The program could require investment in well meters or other monitoring approaches (e.g. remote sensing) to ensure pumpers comply with pumping limits.

The demand management program will require significant outreach, planning, and strategy development efforts. A groundwater market, if established, would require measurement of groundwater pumping and development of accounting software to manage trades and pumping credits. Individual water users may incur costs to manage their demand and participate in trading, but such costs are borne by individual users, may include voluntary activities, and do not require funding by the GSA.

Water source

No new water is provided. The existing groundwater use is capped, and annual reductions are managed under the demand management program.

Conditions or constraints on implementation

The demand management program is a mandatory program for Madera County groundwater users. If Madera County implements a groundwater market, participation in the market (trading) would be voluntary. Successful implementation of a trading program does not depend on all users participating, but the success of the program does depend on other factors, including:

- Any trading program must establish definitive limits on groundwater pumping and be able to enforce conditions.
- Any trading program must have an accounting mechanism to monitor pumping (or allocate credits) and an acceptable method for reviewing and ensuring compliance with the program.
- Any trading program must implement rules and constraints to ensure that the program is consistent with the GSP goals.

Permitting process and agencies with potential permitting and regulatory control

The County will likely have the primary and only regulatory control for the GSA's demand management program.

Additional regulatory or permitting processes or control are not anticipated to be necessary under this component of the Madera County GSA's sustainability program.

4.4.4.3 Program Operations and Monitoring

Madera County is currently working with GSA stakeholders and other GSAs in the Subbasin to define the demand management program, including the potential for a within-GSA groundwater market. The County has recently received a U.S. Bureau of Reclamation WaterSMART grant to investigate the functionality and viability of a groundwater market, anticipating results from that effort to further inform development of the demand management program.

Tasks that are funded by the WaterSMART grant include:

1. Defining opportunities with potential partners
2. Obtaining input from potential partners regarding concerns and priorities
3. Assessing economic, social, and environmental impacts of a water marketing strategy
4. Analyzing legal opportunities and constraints regarding a water marketing system
5. Developing monitoring, quantification, mitigation and standards for assessment of future needs
6. Developing finalized water marketing strategy framework through the grant program
7. Conducting a pilot water market demonstration

The County recognizes a critical element of success for this program will be on-going monitoring of groundwater use across the entire GSA management area. Madera County is currently evaluating potential measurement methods including:

- Meters on wells.
- Water use based on established crop factors.
- Remote-sensing measures of ET with additional analysis to determine ET_{aw}.

4.4.4.4 Program Benefits

The demand management program allows Madera County GSA and groundwater users to achieve the sustainability targets in a flexible and cost-effective way. Coupled with the Madera County projects to augment supplies, demand must be reduced to meet the sustainability goals.

The program will provide in-lieu recharge benefits by reducing consumptive use, and consequently reducing demand for groundwater pumping. The in-lieu recharge benefits of the demand management program are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by reducing demand for additional groundwater pumping.

4.4.4.5 Program Costs

Madera County is currently developing the demand management program and assessing potential costs. Since the details are still under development, project costs cannot be estimated at this time, but demand management is anticipated to require substantial County administration and implementation budgets.

Costs to measure pumping and monitor groundwater conditions are part of overall GSP management and not imposed by this program.

The most significant cost of the demand management program falls on agricultural groundwater pumpers (growers) and the regional economy. An economic impact analysis of the demand management program has estimated average annual direct economic costs at $53.9 million per year (2019 dollars). This represents reduced net returns to crop production resulting from demand management. It does not include indirect and induced economic impacts to other businesses, employees, and the Madera County regional economy.

4.4.5 Other Potential Projects

Three other projects have been identified by Madera County to either increase recharge or reduce consumptive use of water. These ideas are in early stages of discussion, so complete details about project features, yields, and costs have not yet been developed. Potential project yields are not included in the GSP.

4.4.5.1 Arundo Removal

Madera County has identified areas within the ~~Madera~~ Subbasin where an invasive plant called *Arundo donax* (Arundo) could be controlled or removed, potentially saving a significant amount of consumptive water use. Arundo is a non-native, fast growing, and dense reed that purportedly has high water consumption. It currently grows primarily in stream channels. The Nature Conservancy (TNC) has provided a literature review of Arundo's consumptive use and other impacts on native ecosystems (TNC, 2019). Studies of its consumptive use show an extremely wide range of estimates, from 1 acre-foot per acre per year to as much as 48 AF per acre per year, depending on how consumptive use is estimated and the plants' location, size, and access to water. In the ~~Madera~~ Subbasin, consumptive use is likely on the lower end of the range of estimates because the water courses where Arundo grows are often dry for much of the year.

Based on preliminary estimates, approximately 500 acres of Arundo exists in concentrated stretches of Berenda, Cottonwood, and Dry Creeks. Details on acreage of infestation, water use, the potential for reduction, and the cost would be developed before a removal/control plan is prepared.

4.4.5.2 Private, Small-Scale Recharge Projects

Several private, direct or in-lieu groundwater recharge projects have been implemented or proposed by landowners. These projects are similar to Madera County GSA recharge projects, though much smaller in scale. Up to 20 AF per day would be recharged. The water would either be used in lieu of groundwater pumping for irrigation or be recharged through drywells.

Typical project components would include permits and environmental documents, planning and design, and construction of the diversion structure, pump, and conveyance.

4.4.5.3 Dry Well Groundwater Recharge

Drywells have been installed in various areas of Madera County. Located on private residential property, dry wells are typically constructed 2 feet in diameter and 50 feet in depth and have served to recharge areas with running and standing water. In recent tests, the drywell size was increased to 3 feet in diameter by 75 feet deep in order to increase the recharge capacity and potentially reduce the unit cost of recharge.

Test results are still being evaluated and potential groundwater recharge volumes resulting from dry well installation has yet to be evaluated. Thus, the evaluation of dry wells as a potential groundwater recharge program is still in the early stages of evaluation and discussion.

Projects that comply with the existing Madera County Dry Well detail located on residential parcels may be permitted through the Madera County Environmental Health Department. Drywells that are larger than the 2-foot diameter, 50-foot depth are registered with the Environmental Protection Agency (EPA) as a Class V Injection well.

Because drinking water quality is of critical importance, Madera County is working with the Regional Water Quality Control Board to develop a process for evaluating the potential of deeper injection wells.

To be useful in meeting the sustainability goals, any dry well project would need to demonstrate a right to the water source and that the source is new to the Subbasin (e.g. not just recharging water already present that would otherwise recharge through other means).

4.4.6 Project Financing

Pursuant to 23 CCR §354.44 and §354.6, Madera County has evaluated and described the ability to cover project costs. Since most projects are still being assessed, and feasibility studies are being refined or developed, a general description of how Madera County will cover project costs is presented. Madera County will conduct economic and fiscal feasibility studies as part of its ongoing planning efforts to better understand willingness and ability to pay for the projects included in the GSP. Demand management program costs will likely be covered through fees on groundwater pumpers.

To help with projected costs for projects and demand management, Madera County will continue to pursue available state and federal grants or loans for actions such as planning studies, construction projects, fallowing easements, and monitoring. Generally, construction costs will be financed through issuance of bonds, to be repaid from revenues raised through water fees and other assessments. Operation and maintenance costs will be paid using revenues raised through water fees and other assessments. Madera County will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve fees or assessments to provide the required funding.

4.4.7 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the Madera Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA. A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation.). A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation.

At this time, no trading of pumping credits across GSA boundaries is anticipated. To the extent that trading within Madera County GSA may affect groundwater conditions at the boundary between it and a neighboring GSA, additional coordination may be needed.

4.5 Gravelly Ford Water District GSA

Gravelly Ford Water District GSA (GFWD) is developing its own GSP. However, it falls within the Madera Subbasin, so its projects are included here to describe their effects on the groundwater and overall water balance of the Subbasin. Additional details are provided in the GFWD GSP.

GFWD has identified three PMAs for its GSP implementation. One is a recharge project that will provide additional groundwater recharge and two projects provide improved measurement of pumping and monitoring of groundwater conditions. All three projects support the goals of groundwater sustainability and improved overall water management in GFWD.

This section represents the planned PMAs at the time of initial GSP development in January 2020. PMA updates are discussed in the Periodic Evaluation and Annual Reports. A description of how all the PMAs operate as part of the overall Plan for the Subbasin, as envisioned in January 2020, is provided in Chapter 5, Plan Implementation.

4.5.1 Recharge in Canals and Basin

GFWD will develop recharge basins. Water will be diverted from Cottonwood Creek into basins where it will percolate into the deep aquifer. The size, location, and performance of the recharge basins depends on site-specific characteristics that are currently being assessed by GFWD.

The project will use an existing basin to recharge water either purchased or available as excess flow. The basin is in the northern half of GFWD, just south of Cottonwood Creek and west of the Gravelly Ford Canal. Historically, flood and storm flows have been routed through Cottonwood Creek or GFWD facilities and discharged from the District. Instead, this water will be held in the recharge basin or distribution canals in order to recharge the groundwater. In addition, water may be purchased and delivered to the basin for recharge.

The project will also implement improved measurement of the flood and storm flows through the District and the incidental recharge associated with them.

4.5.1.1 Implementation

GFWD is responsible for developing and implementing the recharge project. It will modify its operations as needed beginning in 2020 to divert available flood flows or storm water flows into the basin or hold them in the distribution system for recharge (Table 4-38). Purchased water would be delivered to the basin if and when it is available.

The recharge basin and other needed conveyance facilities are in place, so the project can start immediately. No additional permitting or construction is needed. Actual operation will begin when flood or storm water (or purchased water) is available.

The primary water source will be flood flows in the San Joaquin River or in Cottonwood Creek. Purchased water will also be recharged when available. GFWD will coordinate with Reclamation and the State Water Board for any pumping of water from the two natural channels. No additional permitting requirements are expected. The District currently receives or purchases water through its permitted facilities on the San Joaquin River and Cottonwood Creek. The project will modify operations of existing facilities to capture and recharge flood and stormwater flows and, when available, purchased water.

Table 4-38. GFWD Recharge in Canals and Basin Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	Not applicable (NA)	NA
Financing	NA	NA
Construction	NA	NA
Operation	2020	On going

4.5.1.2 Project Benefits

The water diverted into the basin will percolate and recharge groundwater. Surplus winter and spring flows are expected to be available in some wet, above normal, and below normal years. Purchased water, if and when available, could be delivered during any year and month. The project will contribute to groundwater sustainability in the Subbasin by replenishing groundwater supplies. The direct recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies in the Subbasin.

The recharge benefits of the project will vary annually depending on the available flood flows. Table 4-39 summarizes the expected average amounts available by year type and month. See GFWD's GSP for description of benefits, how the project works with other projects, and costs.

Recharge basins may also provide environmental benefits by creating seasonal or perennial habitat for wildlife including waterfowl, amphibians, and reptiles and serve as drinking water sources and foraging habitat for mammals.

Table 4-39. GFWD Recharge Basins Estimated Average Annual Additional Flood Flow Available, by Year Type.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	4,956	35%	1,749
AN	4,956	14%	680
BN	2,478	8%	194
D	0	16%	0
C	0	27%	0
Avg. Annual			2,624

The expected flood flows shown in the table are based on available winter flows during the period October – March over the historical period 1965-2015. Expected monthly benefits by water year type are changes in stored groundwater (or reduced groundwater overdraft). Initial volumes will be determined based on results from pilot testing or percolation testing. On-going measurement of benefits to groundwater storage will be integrated into the overall GSP monitoring and measurement program.

4.5.2 Groundwater Pumping Measurement

GFWD staff will assist landowners/customers (owners) to install flow meters on groundwater wells used for crop production within the District. Various wells in the District already have meters and those that do not will be outfitted with the new meters, at the owner's expense. The owner will provide monthly and annual pumping volumes from the well. GFWD will collect and process the data and report the aggregate (not specific to individual wells) annual volume pumped from the local aquifer.

The project's first measurements and evaluations of the proposed 24 wells in the GFWD boundary will start this year (2019). The project will be reviewed by the Board of Directors and notice sent out to the owners in the GFWD service area.

Installation of new meters will be the responsibility of the owners. GFWD staff will assist those that currently do not have a flow meter, to assure that it is installed correctly. Staff will provide a standard reporting form for the monthly and annual report to GFWD.

No permitting is required from other agencies for this effort. The District will receive permission from each owner for the reporting of the well flow data.

The project will not provide new water supply, but it will allow GFWD to measure groundwater use, monitor conditions, and better understand the overall water balance within the District. It will support GFWD's efforts to manage groundwater sustainably as part of the ~~Madera~~ Subbasin GSP. The meters will also assist the growers to make more informed irrigation management decisions.

4.5.3 Groundwater Monitoring Program

GFWD's hydrogeologist has selected 24 wells to measure and record the standing water level. Measurements would be taken twice a year, one in the spring (February or March) prior to the irrigation season and another measurement in the fall (October or November). These levels will be tracked, and the data will be charted and analyzed to determine long-term trends and annual patterns related to water year types.

The project's first measurements and evaluations of the proposed 24 wells in the District boundary will start this year. The project will be implemented by the Hydrogeologist for the District and will continue under his direction. The Hydrogeologists' staff will take the measurements or train District staff to take the measurement.

No permitting is required from other agencies for this effort. GFWD will receive permission from owners for access to wells and reporting of the monitoring data.

The project will not provide new water supply, but it will allow GFWD to measure groundwater levels and better understand the overall condition and trends in levels within its boundaries. It will support GFWD's efforts to manage groundwater sustainably as part of the ~~Madera~~ Subbasin GSP. GFWD will use this data to improve the distribution and application of water to properties in its service area.

4.5.4 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the ~~Madera~~ Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA). A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation.~~A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation.~~

GFWD is preparing its own GSP, and it has cooperated with the coordinating GSAs in developing this ~~Madera~~ Subbasin GSP. The ~~Madera~~ Subbasin GSP establishes the requirements and process for monitoring groundwater conditions, and GFWD will comply with these requirements. Data collected from individual wells will be used to verify consistency with the sustainability goal~~s of the GSP~~for the Subbasin. No other coordination agreements are needed to implement these projects.

4.6 New Stone Water District GSA

New Stone Water District GSA (NSWD) is developing its own GSP. However, it falls within the ~~Madera~~ Subbasin, so its projects are included here to explain their effects on the groundwater and overall water balance of the Subbasin. Additional details can be found in the NSWD GSP.

This section represents the planned PMAs at the time of initial GSP development in January 2020. PMA updates are discussed in the Periodic Evaluation and Annual Reports. A description of how all the PMAs operate as part of the overall Plan for the Subbasin, as envisioned in January 2020, is provided in Chapter 5, Plan Implementation.

4.6.1 Water Right Utilization

NSWD GSA has an appropriative water right along the Chowchilla Bypass (referred to as Eastside Bypass/Chowchilla Canal in its water rights permit number 19615) of 15,700 AFY. Currently, NSWD does not use this water right. With the implementation of SGMA, NSWD intends to fully use the water right and bring 15,700 AF of surface water into NSWD. The water is expected to be available during times of flood flows in the Chowchilla Bypass, about one year out of three. The water may be recharged directly or used for irrigation, thereby providing in-lieu groundwater recharge.

4.6.1.1 Implementation

NSWD intends to begin diverting water as soon as it is available (Table 4-40). NSWD already has the water rights permit and diversion facilities, so no further documentation or permitting requirements are anticipated.

Table 4-40. NSWD Water Right Utilization Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2019	2020
Financing	Not applicable (NA)	NA
Construction	NA	NA
Operation	2020	On going

Water will be diverted from the Chowchilla Bypass during times of available flood flow. NSWD will coordinate as needed with the State Water Board and local agencies as needed when it is diverting water.

4.6.1.2 Project Benefits

The water diverted into the basin will percolate and recharge groundwater. Surplus winter and spring flows are expected to be available in some wet, above normal, and below normal years. Purchased water, if and when available, could be delivered during any year and month. The project will contribute to groundwater sustainability in the Subbasin by replenishing groundwater supplies. The direct recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies in the Subbasin.

The quantity will vary from year to year depending on the available flood flows. Table 4-41 summarizes the expected average amounts available by year type and month.

The expected available flood flows are based on winter flows in the Chowchilla Bypass during the period January – June over the historical period 1965-2015. Expected monthly benefits by water year type are changes in stored groundwater (or reduced groundwater overdraft).

Benefits to groundwater will be determined based on measured diversions from the Bypass and monitoring of groundwater conditions as part of GSP implementation.

4.6.2 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the ~~Madera~~ Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA). A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation. ~~A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation.~~ NSWD is preparing its own GSP for its portion of the Subbasin but is participating in the broader SGMA planning efforts for the Subbasin.

4.7 Root Creek Water District GSA

Root Creek Water District GSA (RCWD) is developing its own GSP. However, it falls within the ~~Madera~~ Subbasin, so its projects are included here to explain their effects on the groundwater and overall water balance of the Subbasin. Additional details can be found in the RCWD GSP.

This section represents the planned PMAs at the time of initial GSP development in January 2020. PMA updates are discussed in the Periodic Evaluation and Annual Reports. A description of how all the PMAs operate as part of the overall Plan for the Subbasin, as envisioned in January 2020, is provided in Chapter 5, Plan Implementation.

Table 4-41. NSWD Estimated Average Flood Flow Available, in AF by Year Type.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	15,700	35%	5,541
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			5,541

4.7.1 Distribution of Purchased Water for In-Lieu Storage

In 2014, RCWD received a grant to help pay for a turnout and pipeline from MID Lateral 6.2 to bring surface water supplies into the north side of RCWD. The purpose of the pipeline is to mitigate groundwater overdraft by using surface water, when available, in place of groundwater in the 3,000-acre service area. This project will enable RCWD to utilize its surface water contracts with MID, Westside Mutual, and Reclamation, thus decreasing groundwater pumping. Since project completion, about 8,000 AF of surface supplies have been brought into the District. Existing facilities include a 48-inch diameter main line that runs south for about 2.7 miles and has approximately 5.4 miles of laterals. The design maximum capacity of the system is approximately 50 cfs with 17.6 cfs discharge into Root Creek.

Some agricultural land in the northeast corner of the District that is currently served by the pipeline and laterals is planned for a housing development. Therefore, as that land is taken out of production, this project will expand the distribution system to replace the acreage.

4.7.1.1 Implementation

RCWD is responsible for developing and implementing the project. It will modify its operations as needed to bring in additional surface water supplies. Project construction is already complete and RCWD expects the project to be operational starting in 2019 (Table 4-42).

Table 4-42. RCWD Purchased Water Project Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	Not applicable (NA)	NA
Financing	NA	NA
Construction	2014	2014 (already complete)
Operation	2019	On going

4.7.1.2 Project Benefits

RCWD has contracts with MID, Westside Mutual, and Reclamation for surface water. The contract with MID states that RCWD may purchase water in excess of MID water demands, up to 10,000 AF in any one year. Since this water is dependent on how much water MID receives based on their CVP Class I and Class II allocation, it will likely only be seen by Root Creek in wet years at a much lower volume. The agreement with USBR will allow RCWD to use Section 215 water, or flood flow, when available. The ability of RCWD to take the water will depend on time of year for irrigation demand and capacity of Lateral 6.2 to carry the water. Lastly, the contract with Westside Mutual is a dependable supply, up to 7,000 AFY. However, this is the most expensive source of water and will likely only be used in dry years when other sources are not available. All contract water mentioned above will come from the San Joaquin River and Millerton Lake.

This project has been completed with the intent of bringing RCWD into a condition of sustainable groundwater management. Conditions for implementation included the recognition of continued overdraft, as mentioned in the 2012 update of the Groundwater Management Plan and a funding opportunity.

The project will use existing facilities that include a 48-inch diameter main line that runs south for about 2.7 miles and has approximately 5.4 miles of laterals. In addition, new distribution laterals will be built to replace service area that is expected to be lost to new development. Water acquired from one or more of the sources described above will be delivered as irrigation water via MID Lateral 6.2, pipeline, and distribution laterals, thereby providing in-lieu recharge. The in-lieu recharge benefits of the project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by increasing surface water use and reducing groundwater pumping.

Water supply may be provided in all year types, but benefits are generally expected in non-critical years. Up to 9,100 AF could be delivered when water is available in wet years (Table 4-43). On average, the project is expected to provide about 4,400 AFY of surface supply, resulting in reduced pumping and increased recharge from percolation of the surface water.

Table 4-43. RCWD Estimated Average Water Purchase, in AF by Year Type.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	9,100	35%	3,212
AN	5,100	14%	700
BN	3,000	8%	235
D	1,500	16%	235
C	0	27%	0
Avg. Annual			4,400

4.7.2 RCWD Holding Contracts

RCWD holds a historical right to divert water from the San Joaquin River to irrigate 3,000 acres. It has diverted water under this holding contract in the past and intends to make greater use of it to increase its surface water supply. RCWD intends to establish this as a permanent water source, diverting an average of 9,840 AFY in every year type.

4.7.3 Coordination with Other GSAs and Planning Agencies

This Joint GSP is the coordinated GSP for the four Joint GSP GSAs in the ~~Madera~~ Subbasin (City of Madera GSA, Madera Irrigation District GSA, Madera County GSA, and Madera Water District GSA). A Coordination Agreement (**Appendix 1.J**) has been signed by all GSAs in the Subbasin detailing required GSA and GSP cooperation.~~A coordination agreement will be executed by the coordinating GSAs with the other three GSAs in the Subbasin (Gravelly Ford Water District GSA, New Stone Water District GSA, and Root Creek Water District GSA) detailing required GSA and GSP cooperation.~~ RCWD is preparing its own GSP for its portion of the Subbasin but is participating in the broader SGMA planning efforts for the Subbasin.

4.8 Subbasin Water Available for Recharge Used by Projects

Four primary sources of water are available for the projects: flood releases and 215 water from Millerton Lake, Chowchilla Bypass flows, Fresno River Flood Releases from Hensley Lake, and water purchases. A summary of the total projected water available, the projected water committed to projects, and the expected water remaining after the projects recharge or use the water committed is provided below for each water source.

Following the issuance of Executive Order (EO) N-4-23 in March 2023, certain restrictions for diverting flood flows were waived with the goal of accelerating groundwater recharge and reducing the risks of local and regional catastrophic flooding. As a result of EO N-4-23, additional surface water has been made available for recharge projects in the Subbasin in water year 2023. To the extent that similar waivers are made in the future, additional surface water could be made available and used to similarly streamline water rights permitting for recharge projects during GSP implementation.

4.8.1 Flood Releases and 215 Water from Millerton Lake

The first source of water available for projects in the Madera Subbasin is the flood releases and 215 water from Millerton. Table 4-44 summarizes the volume of flood releases and 215 water released from Millerton Lake along Madera Canal and the San Joaquin River that is potentially available for recharge projects in the Madera Subbasin.

Table 4-44. Average Flood Releases and 215 Water from Millerton Lake Committed to Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	85,400	35%	29,900
AN	47,600	14%	6,700
BN	21,500	8%	1,700
D	8,000	16%	1,300
C	8,100	27%	2,200
Avg. Annual			41,700

4.8.2 Chowchilla Bypass

The second source of water available for projects in the Madera Subbasin is flows along Chowchilla Bypass. Table 4-45 summarizes the average water available to projects by water year type. Table 4-46 summarizes the volume of water along Chowchilla Bypass that is potentially available for recharge projects in the Madera Subbasin. Table 4-47 summarizes the volume of water estimated to be remaining in the Chowchilla Bypass after the projects have taken water.

Table 4-45. Average Projected Chowchilla Bypass Water Available to Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	404,100	35%	141,400
AN	47,900	14%	6,700
BN	4,600	8%	400
D	6,500	16%	1,000
C	6,200	27%	1,700
Avg. Annual			151,200

Table 4-46. Average Chowchilla Bypass Water Committed to Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	99,100	35%	34,700
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			41,700

Table 4-47. Average Available Chowchilla Bypass Water Remaining After Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	305,000	35%	106,700
AN	47,900	14%	6,700
BN	4,600	8%	400
D	6,500	16%	1,000
C	6,200	27%	1,700
Avg. Annual			116,500

4.8.3 Fresno River Flood Releases

The third source of water available for projects in the ~~Madera~~ Subbasin is flood releases from Hensley Lake along Fresno River. Table 4-48 summarizes the volume of flood releases along Fresno River that is potentially available for recharge projects in the ~~Madera~~ Subbasin.

Table 4-48. Average Fresno River Flood Releases Committed to Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	28,600	35%	10,000
AN	22,100	14%	3,100
BN	8,000	8%	600
D	0	16%	0
C	2,500	27%	700
Avg. Annual			14,400

4.8.4 Water Purchases

The fourth source of water available for projects is water acquired from willing sellers. This supply is constrained by the capacity to move it from its source to a location of use in Madera County, via existing natural channels or the Madera Canal. Imported water could be purchased from any willing seller anywhere in the Central Valley provided the water can be delivered to Madera County using existing or proposed conveyance facilities, including via exchanges involving three or more parties. For example, water offered for sale from the Sites JPA could be imported via exchanges through CVP contractors and facilities. Beyond this, purchases are also limited by other factors including market considerations of availability and price.

Table 4-49 summarizes the average water purchases and additional CVP diversions committed to recharge projects in the ~~Madera~~ Subbasin by water year type.

Table 4-49. Average New Water Purchases Committed to Madera Subbasin Recharge Projects, by Water Year Type (2019-2090).

Year Type	Total Annual Volume (AF)	% of Years	Weighted Avg. Volume (AF)
W	26,200	35%	9,200
AN	26,200	14%	3,700
BN	22,600	8%	1,800
D	22,000	16%	3,500
C	15,100	27%	4,100
Avg. Annual			22,200

4.9 Implementation of Projects and Management Actions Since Initial GSP Development

The implementation of PMAs is critical for achieving and maintaining groundwater sustainability. Since the development of the initial Joint GSP, the Joint GSP GSAs have made substantial progress toward implementing the PMAs, as described in the sections abovebelow. Updates to these on implementation of PMAs are also summarized in each of the Joint GSP Annual Reports.

Sections 4.9.1 through 4.9.4 below summarize the PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2023) for the Joint GSP GSAs. Please see the other GSPs and Annual Reports in the Subbasin through water year 2023 for updates on their PMA implementation.

Section 4.9.5Implementation of all describes PMAs PMAs described below that will be jointly implemented by the GSAs and provides benefits to all GSAs and applicable sustainability indicators in the Subbasin by providing groundwater recharge, supporting in-lieu recharge, improving understanding of Subbasin conditions, or otherwise reducing demand and contributing to groundwater sustainability.The sections below summarize the PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2022)

4.9.1 Madera Water District GSA

Updates to the implementation of PMAs proposed and planned by the MWD GSA are summarized below through water year 2023.

4.9.1.1 Updates in the 2020 Annual Report (Water Year 2019)

4.9.1.1.1 *Surface Water Purchase Program*

- MWD had an opportunity to substantially increase its purchase of surface water to preserve groundwater supplies. MWD's per acre groundwater demand was substantially reduced compared to previous years.
- Approximately one acre of pistachio trees within MWD was removed to build a new small reservoir, providing for water regulation and storage.
- MWD continued to move forward on the Madera Lake Project by obtaining an easement for the proposed MWD facilities; contracting with a consultant for environmental, permitting, and design; and initiating discussions with applicable regulatory and permitting agencies.

4.9.1.2 Updates in the 2021 Annual Report (Water Year 2020)

4.9.1.2.1 *Surface Water Purchase Program*

- MWD was able to purchase surface water as part of their efforts to preserve groundwater supplies. MWD's per acre groundwater demand was reduced compared to previous years.
- MWD continued to move forward on the Madera Lake Project by initiating necessary permitting and regulatory processes and preparing preliminary level engineering designs.

4.9.1.2.2 *Miscellaneous Activities*

- MWD performed an elevation survey of the reference points and surrounding ground to a known vertical datum on each of the RMS wells in the MWD GSA.

4.9.1.3 Updates in the 2022 Annual Report (Water Year 2021)

4.9.1.3.1 *Surface Water Purchase Program*

- Despite dry conditions, MWD was able to purchase and deliver nearly 800 AF of surface water for in-lieu recharge as part of their efforts to preserve groundwater supplies.
- MWD continued to move forward on the Madera Lake Project. Since the last Annual Report, the project plans progressed to a 60% level of design and administrative drafts of required CEQA documents were prepared.
- In early 2022, the MWD GSA applied for and was awarded Proposition 68 funding to support further development and construction of the Madera Lake Project by 2025.

4.9.1.4 Updates in the 2023 Annual Report (Water Year 2022)

4.9.1.4.1 *Surface Water Purchase Program*

- Despite dry conditions, MWD was able to purchase and deliver nearly 1,300 AF of surface water to its customers for in-lieu recharge as part of their efforts to preserve groundwater supplies.
- MWD continued to move forward on the Madera Lake Project. Since the last Annual Report, MWD circulated CEQA documents and started the various permitting processes required for project implementation through the USACE, the Regional Water Quality Control Board, and the California Department of Fish & Wildlife.
- In 2022, MWD was awarded approximately $3.7 million in grant funding for the Madera Lake Project through DWR's SGM Grant Program.

4.9.1.5 Updates in the 2024 Annual Report (Water Year 2023)

4.9.1.5.1 *Surface Water Purchase Program*

- In 2023, MWD purchased and delivered more than 6,400 AF of surface water to its customers to facilitate in-lieu recharge and preserve groundwater supplies.
- MWD continued to move forward on the Madera Lake Project and the various permitting processes required for project implementation.

4.9.2 Madera Irrigation District GSA

Updates to the implementation of PMAs proposed and planned by the MID GSA are summarized below through water year 2023.

4.9.2.1 Updates in the 2020 Annual Report (Water Year 2019)

4.9.2.1.1 *Groundwater Recharge Basins*

- MID operated Ellis Basin in partnership with MC, with a total recharge benefit of 306 AF in 2019.
- MID operated Berry Basin in partnership with CM, with a total recharge benefit of 929 AF in 2019.
- MID operated Allende Basin intensively to recharge 3,088 AF in 2019.

- MID operated an additional six dedicated recharge facilities that were recently rehabilitated and upgraded, with a total recharge benefit of 3,683 AF in 2019.

4.9.2.1.2 *On-Farm Recharge (Flood-MAR)*

- MID administered an on-farm recharge program, resulting in 3,000 AF of recharge in 2019.

4.9.2.1.3 *MID System Improvements and Programs*

- MID continued to upgrade infrastructure (pipelines and SCADA systems) to reduce conveyance losses, with cumulative average annual benefits of 2,530 AF as of 2019.
- 2019 MID utilized nearly 250,000 AF of surface water through grower deliveries and groundwater recharge, including making water available free of charge and at a reduced rate for specific periods during the year to encourage surface water use.

4.9.2.2 Updates in the 2021 Annual Report (Water Year 2020)

4.9.2.2.1 *Groundwater Recharge Basins*

- MID continued operating the Ellis Basin in partnership with MC, although no surface water was delivered for recharge in 2020.
- MID continued operating the Berry Basin in partnership with CM, although no surface water was delivered for recharge in 2020.
- MID continued operating Allende Basin to recharge 31 AF in 2020.
- MID continued operating an additional six dedicated recharge facilities that were recently rehabilitated and upgraded, with a total recharge benefit of 269 AF in 2020.

4.9.2.2.2 *On-Farm Recharge (Flood-MAR)*

- MID administered an on-farm recharge program, resulting in 3,000 AF of recharge in 2020.

4.9.2.2.3 *MID System Improvements and Programs*

- MID continued to upgrade infrastructure (pipelines and SCADA systems) to reduce conveyance losses.
- 2020 MID utilized approximately 100,000 AF of surface water through grower deliveries and groundwater recharge.

4.9.2.3 Updates in the 2022 Annual Report (Water Year 2021)

4.9.2.3.1 *Groundwater Recharge Basins*

- MID continued operating the Ellis Basin in partnership with MC, although no surface water was delivered for recharge in 2021 due to drought conditions.
- MID continued operating the Berry Basin in partnership with CM, although no surface water was delivered for recharge in 2021 due to drought conditions.
- MID continued operating Allende Basin and six other dedicated recharge facilities, although no surface water was delivered for recharge in 2021 due to drought conditions.
- MID worked to expand the existing recharge basins by approximately 60,000 cubic yards, expanding their overall capacity by approximately 40 AF. This additional capacity results in much higher recharge potential for the basins in future years.

- MID began work on the phase 1 project to construct additional recharge basins. MID acquired three (3) parcels in 2021 as sites for future recharge basins, and took 73 acres out of irrigated agricultural production.
- MID and CM worked cooperatively to develop the Golf Course Basin.

4.9.2.3.2 *MID System Improvements and Programs*

- MID continued to upgrade infrastructure (pipelines and SCADA systems) to reduce conveyance losses.
- In 2021, MID submitted a WaterSMART grant application intended to fund installation of additional SCADA equipment, automated gates, and new meters.
- MID began work to develop water supply partnerships with partners outside of the Subbasin through coordination with other agencies with contracts for supplies from Friant Dam.
- MID implemented an intensive groundwater use policy that supports the goals of the incentive program and the overall Subbasin sustainability goal.

4.9.2.4 Updates in the 2023 Annual Report (Water Year 2022)

4.9.2.4.1 *Groundwater Recharge Basins*

- MID continued operating the Ellis Basin in partnership with MC, although no surface water was delivered for recharge in 2022 due to drought conditions.
- MID continued operating the Berry Basin in partnership with CM, although no surface water was delivered for recharge in 2022 due to drought conditions.
- MID continued operating nine other dedicated recharge facilities, including two new recharge basins. Approximately 50 AF of surface water was delivered to these basins for recharge in 2022.
- MID worked to expand the existing recharge basins by approximately 70,000 cubic yards, expanding their overall basin capacity by approximately 43 AF. This additional capacity results in much higher recharge potential for the basins in future years.
- As part of MID's phase 1 project to construct additional recharge basins, MID completed construction of two new recharge basins in 2022 on the three (3) parcels acquired and taken out of production in 2021.
- MID and CM worked cooperatively to develop the Golf Course Basin and Airport Basin.

4.9.2.4.2 *On-Farm Recharge (Flood-MAR)*

- MID has also partnered with the Natural Resources Conservation Service (NRCS), which has made pilot program funds available in MID for recharge projects such as on-farm recharge, recharge basins, or other supporting practices, $1.5 million in funding was made available to MID landowners for projects that conserve water and promote the use of surface water.

4.9.2.4.3 *MID System Improvements and Programs*

- MID continued to upgrade infrastructure (pipelines and SCADA systems) to reduce conveyance losses.
- In early 2023, the WaterSMART Initiative announced $1.5 million in funding for MID landowners to support conservation practices and infrastructure improvements such as irrigation water management, irrigation pipelines, structures for water control, pumps, micro irrigation systems, cover crops, and other practices.

- In 2022, MID partnered with the NRCS and was selected as a pilot program area for investigating the benefits of implementing new recharge practices. MID conducted public outreach and workshops to promote program participation within MID. MID also offered an additional financial incentive of 15% of the project costs as a future water purchase offset to incentivize landowners to participate and utilize surface water in the future. The program has been a success, with more than 25 parcels in MID participating in recharge activities. Approximately $62,000 in program costs have been incurred thus far.

4.9.2.5 Updates in the 2024 Annual Report (Water Year 2023)

4.9.2.5.1 *Groundwater Recharge Basins*

- In 2023, MID acquired two parcels for a new recharge facility. The parcels total approximately 45 acres and are to be components in MID's "Additional Recharge Basins Phase 2" project, which is beginning to be implemented ahead of schedule (expected implementation was by 2040 in the initial Joint GSP).
- 2023's wet conditions facilitated a substantial amount of recharge for fifteen of the recharge basins. A total of 18,700 AF of surface water was delivered to the basins. This included 1,705 AF delivered to CM-partner basins (benefits are equally split between MID GSA and CM GSA).

4.9.2.5.2 *On-Farm Recharge (Flood-MAR)*

- MID offered landowners on-farm recharge opportunities throughout 2023. Water was available at $10/AF and $0/AF to promote on-farm recharge. The estimated benefits of on-farm recharge in 2023 were approximately 38,000 AF. MID has already begun implementation of phase 2 of the on-farm recharge program ahead of schedule (expected implementation was to begin in 2025 in the initial Joint GSP).
- The MID and NRCS partnership, which made pilot program funds available in MID for recharge, is two years ahead of schedule. $2.4 million was made available in fall 2023 for projects that conserve water and promote the use of surface water.

4.9.2.5.3 *MID System Improvements and Programs*

- MID's WaterSMART SCADA and WaterSMART pipeline projects continued to be implemented in 2023. Both projects are helping to improve MID's water management, reduce system losses, and enhance flexibility of surface water deliveries to growers who would otherwise use groundwater.
- Since 2021, MID has benefitted from the replacement of 5,350 feet of aging pipelines within the district's system. Infrastructure improvements have resulted in cumulative average annual benefits to date of more than 2,500 AF per year.
- MID has also continued its partnership with the NRCS and U.S. Department of Interior's WaterSMART Initiative, which designated MID as a priority area in the western U.S. Funding has been made available to MID landowners through the program, including $1.5 million in 2022 and another $2.4 million in fall 2023.
- MID has also continued work to develop water supply partnerships with partners outside of the Madera Subbasin. Efforts to import surface water supplies are being coordinated with other districts that have contracts for supplies from Friant Dam.
- MID has also continued its support of the program by offering an additional financial incentive of 15% of the project costs for basins as a future water purchase offset to incentivize landowners to participate and utilize surface water in the future. The program

has been a success, with more than 25 parcels in MID participating in recharge activities. Approximately $89,000 in program costs have been incurred by MID.

- In 2023, MID continued implementing the intensive groundwater use policy that supports the goals of the incentive program and the overall sustainability goal established in the Joint GSP.

4.9.3 City of Madera GSA

Updates to the implementation of PMAs proposed and planned by the CM GSA are summarized below through water year 2023.

4.9.3.1 Updates in the 2020 Annual Report (Water Year 2019)

4.9.3.1.1 *Installation of Water Meters and Volumetric Billing*

- CM continued implementing a project to install water meters and a volumetric billing process. As of 2019, the installation of water meters was roughly 98% complete and the average annual benefits were 3,350 AFY.

4.9.3.1.2 *Groundwater Recharge Basins*

- CM operated Berry Basin in partnership with MID, with a total recharge benefit of 929 AF in 2019.

4.9.3.2 Updates in the 2021 Annual Report (Water Year 2020)

4.9.3.2.1 *Installation of Water Meters and Volumetric Billing*

- CM continued implementing a project to install water meters and a volumetric billing process. As of 2020, the installation of water meters remained roughly 98% complete and the average annual benefits were 3,350 AFY.
- CM applied as a Local Project Sponsor in cooperation with Madera's Proposition 1 Round 1 IRWM grant for funding to install meters on the remaining unmetered services and to replace failing meters on higher volume services.

4.9.3.2.2 *Groundwater Recharge Basins*

- CM continued operating the Berry Basin in partnership with MID, although no surface water was delivered for recharge in 2020.

4.9.3.3 Updates in the 2022 Annual Report (Water Year 2021)

4.9.3.3.1 *Installation of Water Meters and Volumetric Billing*

- CM continued implementing the water metering and a volumetric billing project. As of 2021, the installation of water meters remained roughly 98% complete and the average annual benefits were 3,350 AFY.
- CM applied as a Local Project Sponsor in cooperation with Madera's Proposition 1 Round 1 IRWM grant for funding to install meters on the remaining unmetered services and to replace failing meters on higher volume services. The final grant agreement was approved in 2021, and the CM began moving forward with investigation and installation of remaining missing meter locations.

4.9.3.3.2 *Groundwater Recharge Basins*

- CM continued operating the Berry Basin in partnership with MID, although no surface water was delivered for recharge in 2021 due to drought conditions.
- CM and MID worked cooperatively to develop the Golf Course Basin.

4.9.3.4 Updates in the 2023 Annual Report (Water Year 2022)

4.9.3.4.1 *Installation of Water Meters and Volumetric Billing*

- CM continued implementing the water metering and a volumetric billing project. As of 2022, the installation of water meters remained roughly 98% complete and the average annual benefits were 3,350 AFY.
- Through funding from Madera's Proposition 1 Round 1 IRWM grant, CM investigated and identified 646 residential, industrial, commercial, and institutional locations to be metered. Plans, specifications, and estimates were prepared in 2022 for planned installation in 2023.

4.9.3.4.2 *Groundwater Recharge Basins*

- CM continued operating the Berry Basin in partnership with MID, although no surface water was delivered for recharge in 2022 due to drought conditions.
- CM and MID worked cooperatively to develop the Golf Course Basin and Airport Basin.

4.9.3.5 Updates in the 2024 Annual Report (Water Year 2023)

4.9.3.5.1 *Installation of Water Meters and Volumetric Billing*

- The CM GSA has continued efforts on a project to install water meters and implement a volumetric billing process for single-family users to promote water conservation. In 2023, the CM GSA proceeded with installation of 46 automatic meter reading (AMR) meters ranging from 3 to 10 inches. In addition to the average annual project benefits to the Madera Subbasin of 3,350 AF per year, project implementation in 2023 has achieved an estimated 250 AF of additional benefits, resulting in total estimated benefits of 3,600 AF. The capital cost incurred for project implementation in 2023 was approximately $972,000.

4.9.3.5.2 *Groundwater Recharge Basins*

- 2023's wet conditions facilitated a substantial amount of recharge which included 1,705 AF delivered to CM-partner basins (benefits are equally split between CM GSA and MID GSA).

4.9.4 Madera County GSA

Updates to the implementation of PMAs proposed and planned by the MC GSA are summarized below through water year 2023.

4.9.4.1 Updates in the 2020 Annual Report (Water Year 2019)

4.9.4.1.1 *Water Purchase for Direct or In-Lieu Recharge*

- MC coordinated with USBR to modify its CVP contract to enable access to additional CVP supplies (e.g., Section 215 water). Also, as part of the Millerton Flood Release Import project, MC also requested a change in place of use and had multiple meetings with USBR to discuss.

4.9.4.1.2 *Chowchilla Bypass Flood Water Recharge Basins*

- Chowchilla Bypass Flood Flow Recharge Phase 1: MC began work to initiate recharge projects in the western portion of the Subbasin along the Chowchilla Bypass and Fresno River through discussions with local landowners and DWR's Flood MAR project team.

4.9.4.1.3 *Other Groundwater Recharge Basins*

- MC operated Ellis Basin in partnership with MID, with a total recharge benefit of 306 AF in 2019.

4.9.4.1.4 *Demand Management*

- MC GSA received grant funding to explore the feasibility of adopting an agricultural easement process within Madera County. The project was formerly referred to as the Sustainable Agricultural Lands Conservation (SALC) project but is currently referred to as the Voluntary Land Repurposing Program (VLRP). MC issued a request for proposals (RFP) to obtain a consultant to assist with the work.
- MC GSA applied for a grant to inventory domestic wells in the Subbasin to better understand how to protect and mitigate potential undesirable effects on disadvantaged communities during GSP implementation.
- MC GSA applied for and was awarded a grant from USBR to develop a comprehensive water marketing strategy. An RFP was issued, a contractor was selected, and the contractor initiated an economic analysis to support development of a comprehensive water marketing strategy, in coordination with MC, stakeholders, and technical experts.

4.9.4.2 Updates in the 2021 Annual Report (Water Year 2020)

4.9.4.2.1 *Water Purchase for Direct or In-Lieu Recharge*

- MC continued coordination and discussion with USBR on CVP contract modifications and place of use changes.

4.9.4.2.2 *Chowchilla Bypass Flood Water Recharge Basins*

- Chowchilla Bypass Flood Flow Recharge Phase 1: MC conducted additional planning and coordination with a group of farmers and other agencies in the western Madera subbasin that have applied for water rights on the Chowchilla Bypass.

4.9.4.2.3 *Other Groundwater Recharge Basins*

- MC continued operating the Ellis Basin in partnership with MID, although no surface water was delivered for recharge in 2020.

4.9.4.2.4 *Demand Management*

- MC continued work on the VLRP planning project to explore the feasibility of adopting a sustainable agricultural conservation easement program. In 2020, MC conducted stakeholder interviews to provide feedback on the structure of the VLRP. Feedback was summarized, presented at a stakeholder meeting in January 2021. Feedback has been used to inform GSA and County decisions about the timing, flexibility, incentives, and areas for the VLRP.

- MC applied for and was awarded a Proposition 68 DWR grant to conduct a domestic well inventory and install 6 new monitoring wells at two sites in the Subbasin.
- MC continued work to develop a comprehensive water marketing strategy. In 2020, three partner workshops were held to define opportunities, understand concerns, and develop solutions. Interviews were conducted with local stakeholders to voice opinions and concerns. Legal frameworks were also developed. In January 2021, a virtual pilot water market was initiated, with the goal of testing the effectiveness and implications of the potential market rules over a multi-year time period. Sixty local landowners from the Madera and Chowchilla Subbasin signed up for the virtual pilot program.
- MC initiated a demand measurement program in 2020. MC selected the IrriWatch program to measure consumptive water use on irrigated acres. MC hosted trainings to inform growers about the program. On January 1, 2021, IrriWatch began calculating and making data available to the MC GSA and growers who signed up for the program.
- MC developed a groundwater allocation framework through a series of public meetings with the Madera County GSA Advisory Committee. The MC GSA Board of Directors adopted the allocation framework at their December 2020 meeting.

4.9.4.3 Updates in the 2022 Annual Report (Water Year 2021)

4.9.4.3.1 *Water Purchase for Direct or In-Lieu Recharge*

- MC continued coordination and discussion with USBR on CVP contract modifications and place of use changes.

4.9.4.3.2 *Chowchilla Bypass Flood Water Recharge Basins*

- Chowchilla Bypass Flood Flow Recharge Phase 1: MC has conducted additional planning and coordination with a group of farmers and other agencies in western Madera Subbasin that have applied for a water right on the Chowchilla Bypass. MC applied for and was awarded DWR Grant funding in 2021 and 2022 to fund development and construction of the first and second phases of project development.
- Chowchilla Bypass Flood Flow Recharge Phase 2: MC has begun early planning of Phase 2 resulting in refined cost and benefits that have been considered as part of the rate study.

4.9.4.3.3 *Other Groundwater Recharge Basins*

- MC continued operating the Ellis Basin in partnership with MID, although no surface water was delivered for recharge in 2021.

4.9.4.3.4 *Demand Management*

- MC continued work on the VLRP planning project. In 2021, MC continued stakeholder outreach to gain feedback on the structure of the VLRP. Feedback has been used to inform GSA and County decisions about the timing, flexibility, incentives, and areas for the VLRP.
- MC continued work to develop a comprehensive water marketing strategy. A virtual pilot water market simulation occurred between January 2021 and November 2021, with the goal of testing the effectiveness and implications of the potential market rules over a multi-year time period. The simulation was jointly implemented by the MC GSA in both the Madera and Chowchilla Subbasins. A total of 57 unique participants from the Madera

and Chowchilla Subbasins were enrolled in the overall simulation, with about 25 regular participants each month.

- MC continued work on the demand measurement program. Growers completed a test year with IrriWatch in 2021. To date, all irrigated parcels in the Madera County GSA have been auto-enrolled in the program, representing nearly 120,000 irrigated acres across the Chowchilla, Madera, and Delta-Mendota Subbasins.
- MC continued work to develop a groundwater allocation framework through a series of public meetings with the Madera County GSA Advisory Committee. The MC GSA Board of Directors adopted resolutions in December 2020, June 2021, and August 2021 that describe "per-acre" allocations and rules for credits.

4.9.4.4 Updates in the 2023 Annual Report (Water Year 2022)

4.9.4.4.1 *Water Purchase for Direct or In-Lieu Recharge*

- MC continued coordination and discussion with USBR on CVP contract modifications and place of use changes.

4.9.4.4.2 *Chowchilla Bypass Flood Water Recharge Basins*

- Chowchilla Bypass Flood Flow Recharge Phase 1: MC applied for and was awarded a DWR grant to fund the first phase of project development. In 2022 sites were surveyed, 60% designs were completed, and permitting efforts were initiated. This project has been developed in close coordination with RCWD and participating landowners.
- Chowchilla Bypass Flood Flow Recharge Phase 2: MC applied for and was awarded grant funding for DWR in 2022 to fund the second phase of project development and work on site surveys and initial designs was initiated. This project has been developed in close coordination with participating landowners.

4.9.4.4.3 *Other Groundwater Recharge Basins*

- MC continued operating the Ellis Basin in partnership with MID, although no surface water was delivered for recharge in 2022.

4.9.4.4.4 *Demand Management*

- MC continued work on the VLRP planning project. In 2022, MC GSA conducted four public workshops and meetings to review the VLRP development process as well as eligibility criteria, monitoring strategies, contracting processes, incentives, land management strategies, and other planned contract provisions. Rules and criteria for implementing the VLRP were approved by the MC GSA in December 2022. The MC GSA in the Madera Subbasin was awarded a $9.3 million grant from DWR for LandFlex, in coordination with the California Department of Food and Agriculture.
- MC completed work on a WaterSMART-funded project to develop a comprehensive water marketing strategy. A final report describing the water market development process, findings, and conclusions was completed in December 2021.
- MC continued work on the demand measurement program. Growers completed a second test year with IrriWatch in 2022. The MC GSA conducted the Madera Verification Project in 2022 to analyze the consistency of applied water measurements from flowmeters to the evapotranspiration of applied water estimates developed from the IrriWatch remote sensing measurements. Findings and conclusions from the Madera Verification Project are provided in a final report completed in spring 2023.

- MC continued work to develop and enforce a groundwater allocation. In 2022, the MC GSA Board of Directors approved penalties for groundwater use in excess of approved allocations through Resolution 2022-145. Beginning in calendar year 2023, the penalties are being enforced in the MC GSA (within the Chowchilla, Madera, and Delta-Mendota Subbasins) through measurements of groundwater use by approved measurement methods.

4.9.4.5 Updates in the 2024 Annual Report (Water Year 2023)

4.9.4.5.1 *Water Purchase for Direct or In-Lieu Recharge*

- MC continued coordination and discussion with USBR on CVP contract modifications and place of use changes.

4.9.4.5.2 *Chowchilla Bypass Flood Water Recharge Basins*

- Chowchilla Bypass Flood Flow Recharge Phase 1: In 2023, design and permitting efforts continued. This project has been developed in close coordination with RCWD and participating landowners.
- Chowchilla Bypass Flood Flow Recharge Phase 2: In 2023, site survey and design efforts were continued, with conceptual plans being developed. This project has been developed in close coordination with participating landowners.

4.9.4.5.3 *Other Groundwater Recharge Basins*

- CM conducted maintenance for Ellis Basin in 2023 to remove sediment and improve drainage. Site improvements are ongoing, and MC plans to continue operation of the Ellis Basin project for recharge, although no recharge occurred in 2023.
- MC GSA is working on the Fairmead Groundwater Resilience Project and has received approximately $180,000 in grant funding as part of the California Resilience Challenge to support that effort. Concept plans for recharge projects have been developed, including options for direct recharge, in-lieu recharge, and a multi-benefit recharge project incorporating a recharge basin into community recreational facilities. MC GSA has held several meetings with the community throughout this process to collect feedback and to guide project development.

4.9.4.5.4 *Demand Management*

- MC approved rules and criteria for implementing the VLRP in December 2022 and continued planning and implementation of the VLRP using the $9.3 million grant received from DWR in 2022 for LandFlex, in coordination with the California Department of Food and Agriculture. This funding resulted in the removal of approximately 70 acres of irrigated agricultural land from production.
- Beginning in calendar year 2023, the allocations and associated penalties are being enforced in the MC GSA. MC included certain refinements to the framework, allowing "farm units" (i.e., fields irrigated from the same well that are grouped and considered together in enforcement of the allocation) to be changed at the end of the calendar year, and allowing never-irrigated lands to opt-in in November of each year.
- MC began development of recharge policies that would credit recharge benefits to the allocation of areas where recharge occurred. As of early 2024, MC has approved and is implementing these recharge policies. Two policies were developed and approved: one related to recharge with surface water that is purchased, and one related to recharge

with water taken under EO N-4-23. Both policies have a “floor” of a 75% recharge credit and a "ceiling" of 90% recharge credit depending on data specific to the land on which the recharge occurred.

- MC GSA continued to implement the demand measurement program. The MC GSA conducted the Madera Verification Project for a second year in 2023 to analyze the consistency of applied water measurements from flowmeters to the evapotranspiration of applied water estimates developed from IrriWatch, Land IQ, and Open ET data. Findings and conclusions from the Madera Verification Project are provided in a final report completed in spring 2024.
- MC GSA has observed landowner responses to the demand management program thus far, and initial data is showing promising reductions in ETAW from actions in 2023.

4.9.5 Jointly Implemented Projects and Management Actions

The sections below describe PMAs that will be jointly implemented by the GSAs and provide benefits to all GSAs and applicable sustainability indicators in the Subbasin.

~~4.9.1.1~~4.9.5.1 Domestic Well Mitigation Program

A key element of the Joint GSP is a proposed Domestic Well Mitigation Program to mitigate undesirable results for domestic well users that are significantly and adversely impacted by groundwater levels during the GSP implementation period while the GSAs implement other projects and management actions to achieve and maintain sustainability.

Between 2019-2022, the GSAs successfully completed an inventory of the domestic wells in the Subbasin as a first step toward development of the Domestic Well Mitigation Program. The GSAs applied for and were awarded a Proposition 68 grant from DWR to conduct a domestic well inventory and install six new monitoring wells at two sites in the Subbasin. The MC GSA applied for the grant on behalf of the ~~Madera~~ Subbasin and has led the project since its inception. After issuing an RFP and selecting a consultant, the domestic well inventory was conducted in 2021-2022 and final documentation of the inventory was completed in spring 2022 (**Appendix 2.G**). The new nested monitoring wells were installed in 2022. In addition to an updated and more accurate domestic well inventory, information collected during this project from the drilling, geologic and geophysical logging, groundwater quality sampling, and automated groundwater level monitoring will continue to aid the GSAs in filling data gaps in the monitoring and conceptualization of the ~~Madera~~ Subbasin hydrogeology. The project will also improve understanding and management of groundwater in the ~~Madera~~ Subbasin.

During 2022-2023, the GSAs continued to meet to develop the Domestic Well Mitigation Program for implementation, as needed. To date, the GSAs have developed a memorandum of understanding (MOU) that describes, among other things, the responsibilities and principles that will guide administration of the program. The MOU is included in **Appendix 3.E.** In accordance with the MOU, the Program will continue to be developed by the GSAs and will be implemented as needed.

The MC GSA has been awarded $125,000 grant from DWR that, in part, provides facilitation and related services, in connection with the Domestic Well Mitigation Program. This grant is supporting implementation of the Subbasin Program (**Appendix 4.B**). The MC GSA has contracted with David M. Ceppos to provide neutral, stakeholder engagement and consultation support to the MC GSA regarding implementation of a Program in the Madera Subbasin with a specific focus on developing rules of said Program.

Additional information about the Domestic Well Mitigation Program is described in Section 3.3.1.1.

4.9.5.2 Subsidence Workplan Development and Implementation

To address the need and interest in improving the understanding of subsidence in the Subbasin, the GSAs have developed a workplan outlining future activities related to monitoring and understanding conditions relating to subsidence in the Subbasin. One of the key objectives of the workplan is to expand the subsidence RMS network to allow for better characterization of the spatial distribution of subsidence in the subbasin, and to improve our understanding of the mechanisms and conditions causing land subsidence including development of better correlations between groundwater elevation fluctuations and rates of subsidence. In addition, another key objective is to better characterize residual land subsidence versus new/active subsidence. Key topics considered in the workplan include the following:

- Summary of existing subsidence monitoring
- Improvements to subsurface hydrogeologic characterization related to occurrence of fine-grained layers most subject to compaction, including review of results from recently completed aerial electromagnetic surveys of the area
- Refinement of our understanding of the extent and thickness of the Corcoran Clay
- Identification and instrumentation of additional existing wells to expand the monitoring network
- Expansion of the benchmark RMS network
- Drilling and installation of new monitoring wells to expand the monitoring network
- Develop an inventory of active production wells
- Technical analyses to improve understanding of the relationship between groundwater level fluctuations and subsidence, groundwater production and subsidence, and the occurrence of residual subsidence
- Groundwater and subsidence modeling
- Develop technical support for a strategy to manage groundwater pumping and recharge in the Subbasin to minimize future active subsidence

The subsidence workplan is included in **Appendix 3.H**. Following submittal of the January 2025 Plan Amendment and Periodic Evaluation, the GSAs anticipate initiating implementation of the subsidence workplan immediately. Any updates to the subsidence workplan and/or its implementation, or potential revisions to SMC, will be reported in Annual Reports, Periodic Evaluations, and/or Plan Amendments.

4.9.5.3 Interconnected Surface Water Stakeholder Coordination

As described in Section 2.2.2.7.5, the GSAs in the Subbasin coordinated and developed an ISW workplan for the Subbasin as part of prior GSP development**.** Additional coordination and planning related to ISW with the Kings Subbasin and other agencies has occurred since then and is described below; this includes updates to the ISW workplan as part of the January 2025 Plan Amendment (see **Appendix 3.I**).

Since late 2023 and as a result of individual comments received following submission of the 2020 Joint GSP, representatives from the Madera and Kings Subbasins have been meeting monthly with representatives from the USBR and FWA to better understand their issues and concerns related to Interconnected Surface Water (ISW) along the San Joaquin River (SJR) from Reach 1A to the Mendota Pool. Concurrent with meetings with USBR and FWA, representatives from both the Madera and Kings sSubbasins have had extensive communication with representatives of the San Joaquin River Restoration Program (SJRRP). As of the date of the January 2025 Plan Amendment, USBR and FWA are continuing to work to quantify total diversions, uses, and estimates of losses along the SJR. USBR is also working on a detailed analysis of the Holding Contracts and the groundwater pumping allowances and limitations that will need to be factored into any allowable groundwater pumping within proximity to the SJR. As a sign of their commitment to collaboratively working together to better understand ISW along the SJR, the Kings and Madera subbasins have developed a Memorandum of Understanding (MOU) with USBR, FWA, and SJRRP that includes a cooperative scope of work for further investigation of possible ISW from along the SJR from Reach 1A to Mendota Pool. A copy of the MOU between Kings, Madera, USBR, and FWA has been included in **Appendix 3.I**.

In addition to development of the above noted ISW workplan and MOU and the resulting cooperatively developed work products, the GSAs plan to review the additional ISW white papers by DWR that were released in September 2024. In February 2024, DWR released the first of three papers on ISW. The remaining two papers were released in late September of 2024. In addition to the aforementioned papers, the GSAs understand that DWR plans to release an ISW white papers document in Winter 2024. During subsequent Plan Amendments, the GSAs may consider revisions to the current ISW SMC based on information gleaned from the collaborative work with USBR and FWA, in addition to the additional papers issued in 2024, and guidance document to be issued in the future by DWR. Any potential revisions to SMC for ISW will be reported in Annual Reports, Periodic Evaluations, and/or Plan Amendments.

5 PLAN IMPLEMENTATION

It is noted that this section describes Plan implementation and associated costs as estimated and envisioned during initial GSP development in January 2020. Plan implementation and costs are reported as of January 2020, unless otherwise specified, and do not necessarily include changes to GSP implementation made in the 2023 Revised GSP or the 2025 Plan Amendment. Changes to GSP implementation are discussed in the Periodic Evaluation.

To achieve the Subbasin sustainability goal by 2040 and avoid undesirable results through 2090 as required by SGMA and the GSP regulations, various PMAs have been developed and will be implemented by the GSAs. Chapter 4: PMAs describes each GSAs PMAs, gross benefit, and operations. In addition, Chapter 4 provides an estimate of the project-specific capital and operating costs for the PMAs. This chapter describes:

- Costs for GSAs to administer GSP activities (not including the project-specific costs described in Chapter 4), as required by 23 CCR §354.6(e)
- Financing approaches.
- Timeline and roadmap for implementing all GSA PMAs between 2020 and 2040.
- Monitoring and reporting, including the contents of annual reports and five-year PPeriodic EEvaluations that must be provided to the California Department of Water Resources (DWR) (23 CCR § 356.2 and § 356.4)
- and dData management.

5.1 Estimate of GSA Implementation Costs

Total GSP implementation costs include both project-specific costs and costs for GSA's to administer and operate all other aspects of the GSP. The four Joint GSP GSAs implementing the Joint GSP will incur costs for managing the GSP, planning and studies, monitoring implementation, and providing general administration. Projected capital and operating costs of PMAs are summarized in Chapter 4 and are not repeated in this chapter. For the purposes of this chapter, each GSAs implementation costs are aggregated into six (6) categories including GSA administration, GSP studies, GSP implementation and updates, project planning, monitoring, and contingency to cover any unanticipated costs. The following subsections describe the general types of costs that could fall under each category. In practice, each GSA will allocate GSP implementation costs to cost categories that are consistent with its internal bookkeeping and accounting practices. **Please note that costs have not been updated since initial GSP development and costs represent 2019 dollar values.**

5.1.1 GSA Administration

Administration of the GSP will be conducted by the four Joint GSP GSAs working together and with GSAs for other GSPs under the Subbasin coordination agreement (as required under 23 CCR § 357.4). Administrative costs generally include coordination meetings, reporting, record keeping, bookkeeping, legal advice, continued outreach to stakeholders, and government relations. GSAs will also need to continue to monitor PMAs to assess their benefit, economic feasibility, and coordinate with stakeholders and other GSAs if modification of PMAs is necessary to ensure the Subbasin meets sustainability objectives.

The four Joint GSP GSAs implementing the Joint GSP anticipate that significant coordination of administrative tasks will be required. Many GSP projects require coordination between one or more GSAs, and overall Subbasin sustainability depends on continued coordination, planning, and evaluation of groundwater conditions across all seven GSAs. In general, it is anticipated that most administrative tasks will have a lead GSA. The lead GSA for each administrative task will keep the other GSAs informed through periodic updates to stakeholders and other GSAs.

Each GSA will conduct public outreach/engagement to provide timely information to stakeholders regarding GSP progress and Subbasin conditions. Most GSAs will develop and maintain a website that will be used to post data, reports, and meeting information. In addition, each GSA will conduct general business administration including record keeping, bookkeeping, and general management.

5.1.2 GSP Studies

GSP implementation will require various planning, technical, and economic/fiscal studies. These are additional costs that are not covered by the cost of specific PMAs (see Chapter 4), including for example, more detailed evaluation of proposed projects and assessment of overall cost-effectiveness of GSP implementation strategies.

Planning Studies. GSAs will continue to develop planning studies to integrate the GSP with other regional water management efforts, monitor Subbasin conditions, and update the GSP to ensure that the Subbasin meets all sustainability objectives. GSAs will continue to evaluate Subbasin conditions and adjust short- and long-term Subbasin planning efforts accordingly. Other planning studies may include evaluating projects and developing other programs to support sustainable management.

Technical Evaluations. Subbasin GSAs are required to prepare annual updates and five-year Pperiodic Eevaluations for DWR (23 CCR § 354.2 and § 354.4). These reports will require additional technical analysis. GSAs will continue to monitor groundwater levels in the Subbasin to document progress toward sustainability objectives. Additional monitoring wells may be installed, and GSAs will evaluate and report groundwater conditions, water use, and change in groundwater storage as required by DWR. GSAs will continue to evaluate data gaps and implement programs to improve data availability.

Economic/Fiscal Analyses. GSAs will develop economic and fiscal studies to support implementation of projects and management actions and the overall GSP. This may include cost-effectiveness assessments and preliminary investigations of proposed projects. Fiscal analyses are expected to include rate studies and other analysis required to implement fees or assessments, willingness to pay, and ability to pay studies. GSAs will engage legal and technical experts to help develop the required studies. Economic impact studies will be developed to evaluate GSP implementation, understand distribution of costs to different stakeholder groups, and identify methods for reducing those costs during the implementation period.

5.1.3 GSP Implementation and Updates

GSP implementation costs include internal GSA coordination, meetings, and document preparation. This cost category includes costs not covered by GSA Administration and GSP Studies, in addition to costs incurred to comply with annual updates and five-year Pperiodic Eevaluations.

Annual reports. 23 CCR § 356.2 requires GSAs to prepare and submit annual reports to DWR. GSAs will prepare any required technical analysis, data, summary material, and provide a report on sustainable management objectives. GSAs expect that annual reports will also require inter- and intra-GSA coordination as well as stakeholder outreach.

Periodic evaluations. 23 CCR § 356.4 requires GSAs to prepare and submit five-year Pperiodic Eevaluation reports. In contrast to the annual report, this the periodic evaluationreport requires additional evaluation of sustainability conditions, objectives, monitoring, and documentation of new information that is available since the last update to the GSP. GSAs expect that Ppeeriodic Eevaluations will also require significant inter- and intra-GSA coordination and stakeholder outreach.

5.1.4 Project Planning

GSAs will incur additional costs for project planning. Project capital and operating and maintenance costs for projects that are included in the GSP are already summarized in Chapter 4. However, GSAs expect to evaluate other project ideas proposed by stakeholders, assess cost-effectiveness of proposed projects, and evaluate the joint implementation of multiple projects to ensure the GSP continues to meet sustainability objectives. Technical studies may include feasibility assessments, environmental studies, water rights evaluations, coordination with permitting agencies, and other project planning efforts. GSAs may evaluate land acquisition and easements, pursue grant applications, administer grants, and engage other legal and technical services.

As needed, the GSAs will coordinate on the specific studies and analyses necessary to improve understanding of Subbasin conditions. The GSAs will use new information on Subbasin conditions to improve PMAs to achieve sustainability. Evaluations and updates will occur annually (annual report) and every five-years (Ppeeriodic Eevaluation) as required by the GSP regulations, but GSAs anticipate that planning, coordination, and studies will be continuous and ongoing during the 2020 to 2040 implementation period.

5.1.5 Monitoring

GSAs will implement programs to monitor groundwater extractions, measure elevations, and track total water use. Monitoring activities will include data management, installing and measuring monitoring wells, maintaining existing wells, and deploying other technology.

GSAs will oversee monitoring programs outlined in Chapter 3. This will include tracking Subbasin conditions and sustainability indicators. Data from the monitoring programs will be routinely evaluated to ensure progress is being made toward sustainability and to identify whether undesirable results are occurring.

5.1.6 Contingency

An additional contingency cost is included for planning purposes. This may include actions needed to respond to critically dry years or if Subbasin conditions start trending towards MT levels in any area.

5.2 GSA Implementation Costs

The following subsections summarize estimated costs for each GSA to implement non-project-specific costs of the GSP. Costs are presented for each of the six cost categories identified above**. Please note that costs have not been updated since initial GSP development and costs represent 2019 dollar values**. However, GSAs manage costs and expenses in different ways and as such may record costs in different categories. In addition, some GSAs are still developing operating budgets and expect to issue requests for proposals to engage additional consultant technical services, but these costs are not known at this time.

This Joint GSP covers the Madera County GSA, Madera Irrigation District GSA, City of Madera GSA, and Madera Water District GSA. Other GSAs in the Madera Subbasin include Gravelly Ford Water District, Root Creek Water District, and New Stone Water District. Implementation costs for these GSAs can be found in the separate GSPs being developed by these GSAs.

5.2.1 Madera Irrigation District GSA

The Madera Irrigation District GSA (MID) estimates that annual implementation costs in 2019 dollars (excluding the costs of specific projects) will be approximately $560,000 per year over the next five years (Table 5-1). Most (approximately half) of the annual budget is allocated to project planning. These costs do not include the cost of annual reports (costs for the five-year Pperiodic Eevaluation are included) or for development of additional projects or management actions that may be required if MID determines that its sustainability objectives are not being met.

MID will recover GSP implementation costs through grants and local revenues that are yet to be determined. MID is currently evaluating options. Section 5.3 provides a general description of how MID and other GSAs may recover GSP implementation costs.

Table 5-1. Madera Irrigation District GSP Implementation Costs (2019 Dollars).

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$70,000	$70,000	$70,000	$70,000	$70,000	$70,000
GSP Studies	$20,000	$150,000	$150,000	$20,000	$20,000	$20,000
GSP Implementation and Updates	$130,000	$30,000	$30,000	$30,000	$30,000	$130,000
Project Planning	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
Monitoring	$0	$20,000	$20,000	$20,000	$20,000	$20,000
Contingency	$52,000	$57,000	$57,000	$44,000	$44,000	$54,000
Total	$572,000	$627,000	$627,000	$484,000	$484,000	$594,000

5.2.2 Madera County GSA

The Madera County GSA estimates that its implementation costs for the Madera Subbasin in 2019 dollars (excluding the costs of specific projects) would total $13.3 million through 2024, or an average of about $2.2 million per year (Table 5-2). GSA administration will include administration of the GSP, Subbasin coordination, communications, and government relations. Studies will include rate studies, Proposition 218 processes, and legal and technical support. Implementation and updates will include preparing and implementing the initial GSP, internal GSA coordination, meetings, guidance document preparation, costs for periodic updates to the GSP, and coordination and agreements for future updates. Project planning would include, as needed, feasibility and environmental studies, costs to plan any new programs or projects not included in Chapter 4, and grant applications. Monitoring costs include equipment costs and maintenance for well monitoring, and data management. Contingency costs would cover cost overruns and unanticipated activities such as litigation.

Table 5-2. Madera County GSP Implementation Costs (2019 Dollars).

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$0	$456,000	$456,000	$456,000	$456,000	$456,000
GSP Studies	$0	$865,000	$472,000	$472,000	$472,000	$472,000
GSP Implementation and Updates	$1,652,000	$79,000	$79,000	$79,000	$79,000	$79,000
Project Planning	$315,000	$393,000	$393,000	$393,000	$393,000	$393,000
Monitoring	$0	$590,000	$590,000	$590,000	$590,000	$590,000
Contingency	$0	$197,000	$197,000	$197,000	$197,000	$197,000
Total	$1,967,000	$2,580,000	$2,187,000	$2,187,000	$2,187,000	$2,187,000

5.2.3 City of Madera GSA

The City of Madera GSA estimates that its implementation costs for SGMA in 2019 dollars (excluding the capital and O&M costs of specific projects discussed in Chapter 4) would total less than $1 million through 2024, with a range of about $73,000 to $180,000 per year depending on the activities anticipated to occur (Table 5-3). GSA administration will include administration of the GSP, Subbasin coordination, communications, and government relations. Studies will include engineering reports, Proposition 218 processes if needed, and legal and technical support. Implementation and updates will include preparing and implementing the initial GSP, internal GSA coordination, meetings, costs for periodic updates to the GSP, and coordination and agreements for future updates. Project planning would include, as needed, new feasibility studies to plan any new programs or projects as well as the environmental/engineering processes for existing proposed projects. Monitoring costs include setting up the monitoring systems, twice annual monitoring of groundwater levels, sensor equipment costs for well monitoring, and data management. Contingency costs would cover cost overruns and unanticipated activities that may occur.

Table 5-3. City of Madera GSP Implementation Costs (2019 Dollars).

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	20,000	20,000	20,000	20,000	20,000	20,000
GSP Studies	10,000	50,000	50,000	50,000	10,000	10,000
GSP Implementation and Updates	50,000	15,000	15,000	15,000	15,000	15,000
Project Planning	25,000	50,000	50,000	50,000	50,000	5,000
Monitoring	5,000	30,000	3,000	3,000	3,000	3,000
Contingency	20,000	20,000	20,000	20,000	20,000	20,000
Total	130,000	185,000	168,000	168,000	118,000	73,000

5.2.4 Madera Water District GSA

The Madera Water District GSA estimates that its implementation costs for SGMA in 2019 dollars (excluding the capital and O&M costs of specific projects discussed in Chapter 4) would total almost $1.1 million through 2024, with a range of about $61,000 to $250,000 per year depending on the activities anticipated to occur (Table 5-4). GSA administration will include administration of the GSP, Subbasin coordination, communications, and government relations. Studies will include engineering reports, Proposition 218 processes if needed, and legal and technical support. Implementation and updates will include preparing and implementing the initial GSP, internal GSA coordination, meetings, costs for periodic updates to the GSP, and coordination and agreements for future updates. Project planning would include, as needed, new feasibility studies to plan any new programs or projects as well as the environmental/engineering processes for existing proposed projects. Monitoring costs include setting up the monitoring systems, twice annual monitoring of groundwater levels, sensor equipment costs for well monitoring, and data management. Contingency costs would cover cost overruns and unanticipated activities that may occur (15% assumed).

Table 5-4. Madera Water District GSP Implementation Costs (2019 Dollars).

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	20,000	20,000	20,000	20,000	20,000	20,000
GSP Studies	10,000	50,000	50,000	50,000	10,000	10,000
GSP Implementation and Updates	100,000	15,000	15,000	15,000	15,000	15,000
Project Planning	25,000	100,000	100,000	100,000	100,000	5,000
Monitoring	5,000	30,000	3,000	3,000	3,000	3,000
Contingency	24,000	32,250	28,200	28,200	22,200	7,950
Total	184,000	247,250	216,200	216,200	170,200	60,950

5.3 GSP Financing

Administering the GSP and monitoring and reporting progress is projected to cost between $3 and $5 million per year across the four Joint GSP GSAs that are jointly preparing this Joint GSP. Costs are expected to be higher during years in which five-year Pperiodic Eevaluations are required, and slightly lower during years in which annual reports are required. This does not include the capital and annual operating cost of PMAs (see Chapter 4).

Development of this Joint GSP was funded through a Proposition 1 Grant, and contributions from individual GSAs (e.g. through in-kind staff time, or separately contracted consulting services). Individual GSAs are also funding additional, ancillary studies and implementation efforts. To fund GSA operations and GSP implementation, GSAs are developing a financing plan that will include one or more of the following financing approaches:

- **Grants and low-interest loans**: GSAs will continue to pursue grants and low interest loans to help fund planning studies and other GSA activities. However, grants and low-interest loans are not expected to cover most GSA operating costs for GSP implementation.
- **Groundwater extraction charge**: A charge per acre-foot pumped would be used to fund GSP implementation activities.

- **Other Fees and charges**: Other fees may include permitting fees for new wells or development, transaction fees associated with contemplated groundwater markets, or commodity-based fees, all directed at aiding with sustainability objectives. Depending on the justification and basis for a fee, it may be considered a property-related fee subject to voting requirements of Article XIII D of the California Constitution (passed by voters in 1996 as Proposition 218) or a regulatory fee exempt from such requirements.
- **Assessments:** Special benefit assessments under Proposition 218 could include a per-acre (or per-parcel) charge to cover GSA costs.
- **Taxes:** This could include general property related taxes that are not directly related to the benefits or costs of a service (ad valorem and parcel taxes), or special taxes imposed for specific purposes related to GSA activities.

GSAs are pursuing a combined approach, targeting available grants and low interest loans, and considering a combination of fees and assessments to cover operating and program-specific costs. As required by statute and the Constitution, GSAs would complete an engineer's report, rate study, and other analysis to document and justify any rate, fee, or assessment. For example, Madera County has initiated two separate rate studies in 2019. In the first-rate study, an engineering report is being produced to adequately fund an existing flood control and water conservation agency, which would allow for the agency to adequately control flood flows with existing infrastructure. In the second rate study, an engineering report is being produced for the ongoing costs associated with running the three County GSAs, which would include administration as well as sufficient planning funds for eventual project implementation.

Some cost recovery approaches will affect the cost of water for specific uses in the Subbasin. This will affect business (farm) income and incentivize changes in cropping decisions and farming practices in the Subbasin. As cropping and other land use adjusts, GSAs will monitor and adjust fees/assessments, and modify the GSP accordingly.

5.4 Schedule for Implementation

This section describes Plan implementation as envisioned during initial GSP development in January 2020. Changes to GSP implementation are discussed in the Periodic Evaluation.

The GSP implementation schedule allows time for GSAs to develop and implement PMAs and meets all sustainability objectives by 2040. While some sustainability projects began immediately after SGMA became law and are already contributing to Subbasin goals, the GSAs will begin implementing all other GSP activities in 2020, with full implementation of PMAs to achieve sustainability by 2040. Figure 5-1 illustrates the GSP implementation schedule for PMAs that have already been implemented by each GSA (including GSAs not covered under this Joint GSP but within the ~~Madera~~ Subbasin). Figure 5-2 illustrates the GSP implementation schedule for PMAs that will be implemented by each GSA. The GSP implementation schedule also shows mandatory reporting and updating for all GSAs, including annual reports and five-year P~~p~~eriodic ~~updates (~~E~~e~~valuations~~)~~ prepared and submitted to DWR. A proposed timeline for the 2025 Joint GSP Periodic Evaluation and associated Plan Amendment is provided in **Appendix 5.A**. This timeline includes evaluation of projects and management actions to ensure that the Subbasin will be managed sustainably and without undesirable results by 2040. A similar timeline is anticipated for the 2030 and 2035 Joint GSP Periodic Evaluations (and any associated Plan Amendments).

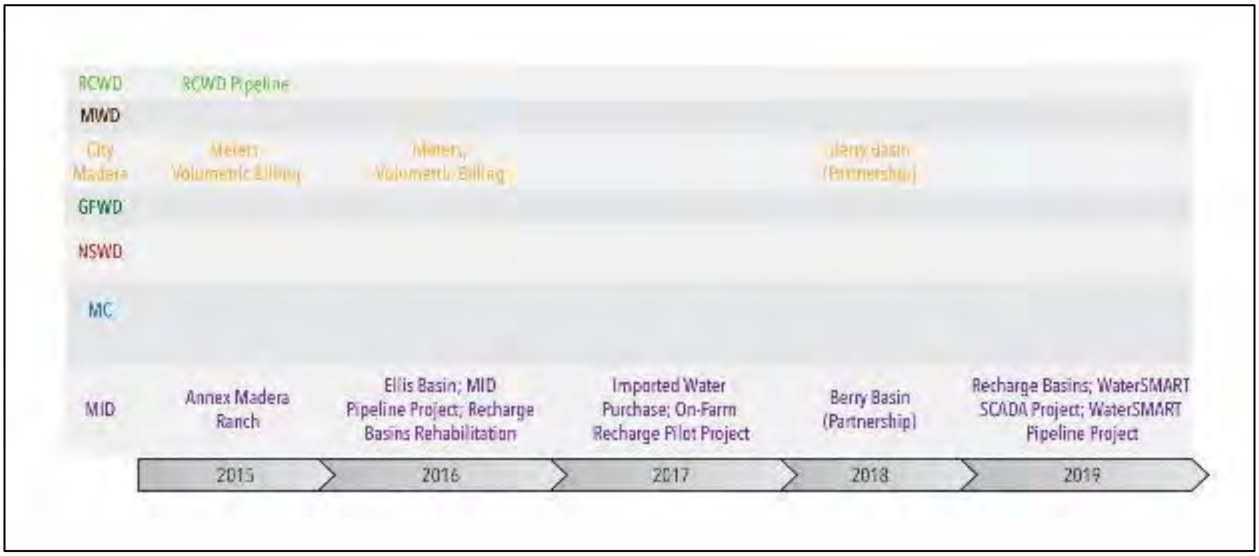


Figure 5-1. Madera Subbasin GSP Completed Projects, 2015 – 2019.[1]

[1] Implementation plans shown in this figure reflect the original design of PMAs in the initial GSP (January 2020). These plans may have changed due to various factors, as reflected in Annual Reports and the Periodic Evaluation. Please refer to the Annual Reports and Periodic Evaluation for updates on PMAs implementation, benefits, and timelines.

Figure 5-2. Madera Subbasin GSP Implementation Schedule, 2020 – 2040.[1]

[1] *Implementation plans shown in this figure reflect the original design of PMAs in the initial GSP (January 2020). These plans may have changed due to various factors, as reflected in Annual Reports and the Periodic Evaluation. Please refer to the Annual Reports and Periodic Evaluation for updates on PMAs implementation, benefits, and timelines.*

The ~~Madera~~ Subbasin GSP implementation plan for PMAs recognizes that projects will take several years to plan and develop, and ~~planned~~ demand reduction programs will incrementally expand until reaching planned targets by 2040. The Subbasin economy, which is heavily reliant on agriculture, needs time to adjust to sustainability. Important adjustments include higher water costs and limited water supplies in some areas that will result in cropping changes and land idling and affect farming, linked agricultural industries, and all residents in the county. The implementation plan is phased in order to lessen impacts to businesses, individuals, and ~~disadvantaged communities~~DACs in Madera County.

Implementing PMAs to achieve the sustainability objectives specified in the GSP will increase irrigation water costs and limit the quantity of water available for farming in some parts of the ~~Madera~~ Subbasin. This will impact agriculture and create ripple effects across all sectors of the Madera County economy, including County tax revenues and jobs that support many of the County's ~~disadvantaged communities~~DACs. The GSP implementation schedule, especially for the Madera County GSA's demand management program, allows time for the Madera County economy to adjust in order to minimize economic impacts to ~~disadvantaged communities~~DACs, businesses, and other individuals in the region.

Figure 5-3 illustrates the conceptual GSP implementation plan, showing the gross benefit (measured in average AFY) of projects and the County's demand management program to meet the Subbasin sustainability objective by 2040. Many GSAs have already started to implement PMAs. The gross annual benefit to the Subbasin from the projects described in Chapter 4 is expected to equal approximately 38,000 AF in 2020, increasing to around 200,000 AF by 2040 when the Subbasin will achieve all sustainability objectives. Gross benefit values shown in Figure 5-3 include the demand management program implemented by the Madera County GSA, which anticipates an additional 90,000 AF of benefit (demand reduction) by 2040 – nearly double the benefit of other planned PMAs.

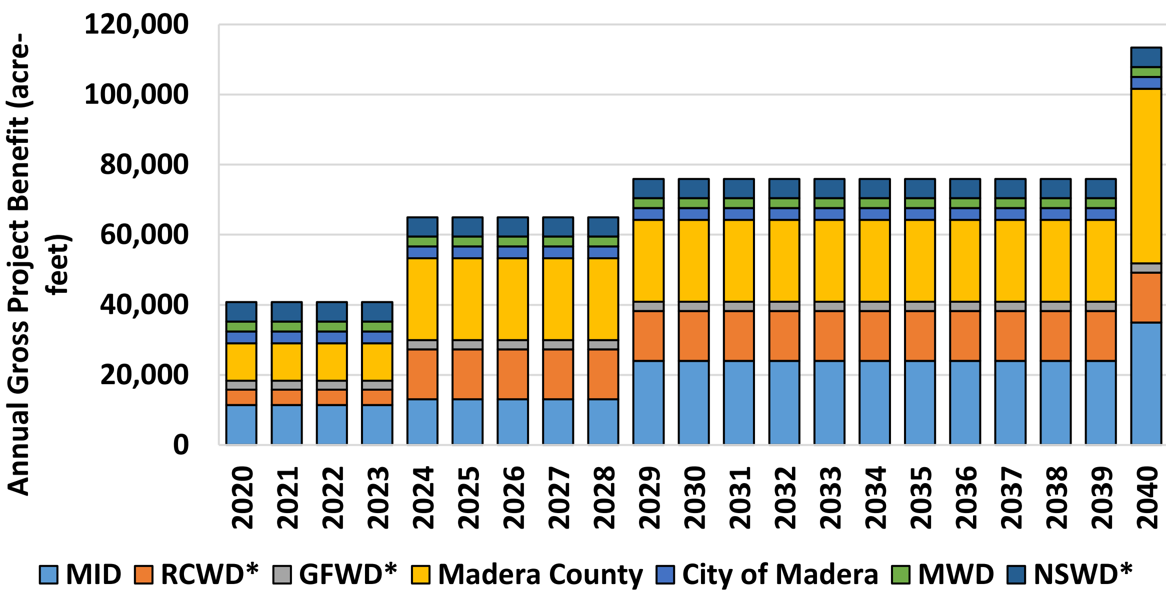


Figure 5-3. Madera Subbasin Project Gross Benefit Timeline (* indicates GSAs not covered by Joint GSP).

In addition to funding GSA activities, GSP updates, and ongoing monitoring and reporting, GSA's will develop and implement PMAs to provide groundwater benefits for the Subbasin (see Figure 5-3). The annual gross benefit increases until it nearly reaches the projected shortfall in 2039 and then in 2040 additional projects come online. Progress will be evaluated in 2035 and each following year and the additional projects adjusted to meet the sustainability objective.– Thus, the 2040 annual gross project benefit will be revised to meet the sustainability objective. –The capital cost of each project and management action is summarized in Chapter 4. Figure 5-4 illustrates the capital outlay required to implement all of the projects specified in the GSP. The figure indicates the year that the projects would be completed and begin operation, not when all the capital cost would be incurred. The total capital cost of all projects equals approximately $260 million in 2019 dollars. The GSP implementation plan includes significant outlays in 2025 and 2040, when large recharge projects are planned for development by multiple GSAs. The need for the large recharge projects planned for 2040 will be reviewed during the 2035 GSP update to determine their required size. These capital costs do not include the cost of developing the Madera County GSA demand management program or the cost to growers and the economy of demand management (economic impacts from land idling and crop switching) under that program.

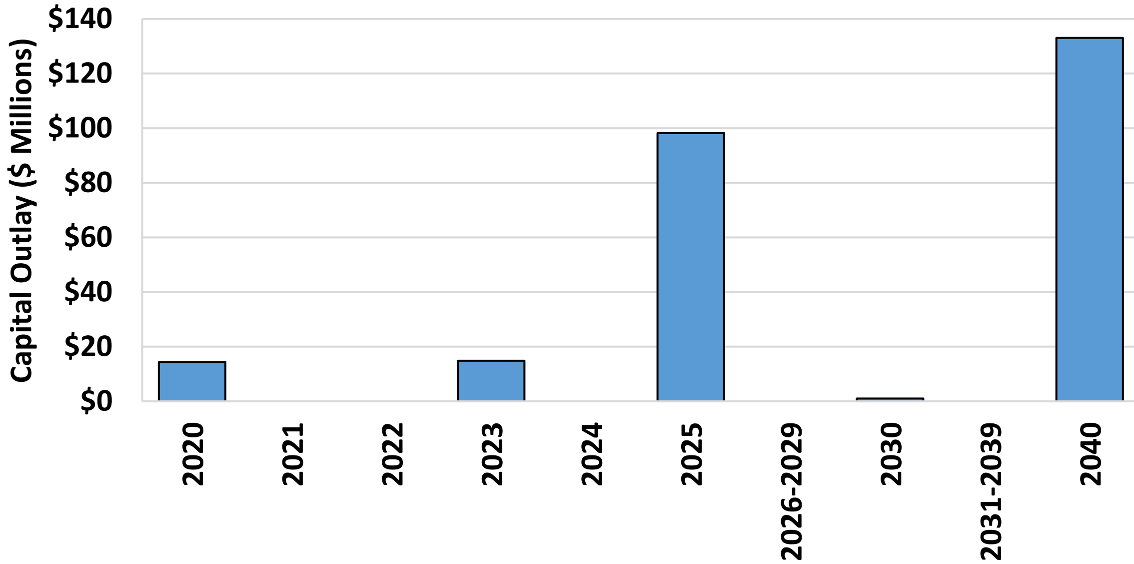


Figure 5-4. Madera Subbasin Estimated Capital Outlay for Projects Only (2019 dollars).

As projects are implemented, GSAs will incur additional operation and maintenance (O&M) costs. Figure 5-5 illustrates the estimated annual O&M costs (in current dollars) for all GSP projects described in Chapter 4 and the annual costs of GSA implementation described in Section 5.2. This figure does not include the cost that the Madera County GSA demand management program would impose on growers and the County economy. Average annual operating costs for projects increase from $0.5 million per year in 2020 to over $15 million per year by 2040. Project costs will be refined by GSAs as the GSP is implemented. GSA implementation costs total about $3.1 million per year. Please note that all PMA cost estimates noted above were created using the 2019 dollar during initial GSP development.

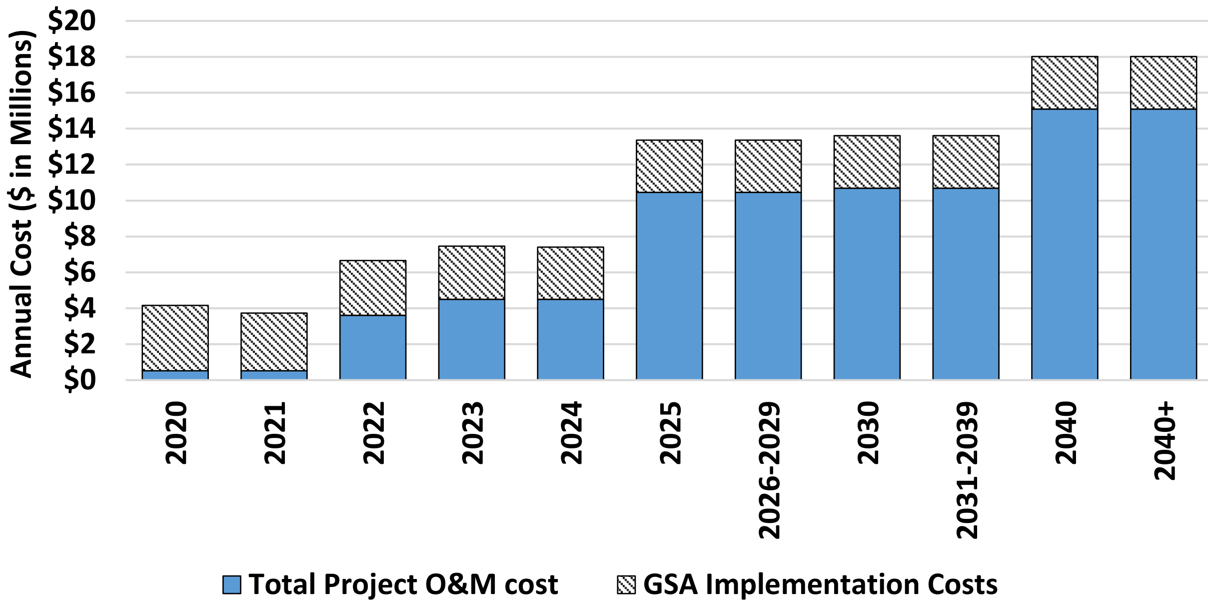


Figure 5-5. Madera Subbasin Estimated Annual Costs for Project O&M and GSA Implementation (2019 dollars).

5.5 Annual Reports

23 CCR § 356.2 requires annual reports to be submitted to DWR by April 1 of each year following the adoption of the GSP. GSAs will prepare annual reports that comply with the requirements of 23 CCR § 356.2. It is anticipated that GSAs will need to develop independent analyses and data (e.g. for surface water use by a particular GSA) as well as joint analyses (e.g. estimating the Subbasin-wide change in groundwater storage) in order to develop annual reports. GSAs will work together under the Subbasin coordination agreement to complete annual reports. Annual reports must provide basic information about the Subbasin in addition to technical information including:

- Groundwater elevation data from monitoring wells
- Hydrographs of groundwater elevations
- Total groundwater extractions for the prior year
- Surface water supply used in the prior year, including for groundwater recharge or other in-lieu uses
- Change in groundwater storage
- Progress towards implementing the GSP

In preparing the Annual Reports, the GSAs plan to review and follow guidelines provided in DWR's guidance document for Annual Reports, Periodic Evaluations, and Plan Amendments (DWR, 2023).

The following subsections provide a general outline of what information will be provided in the annual report, per the GSP Regulations. The annual report provided to DWR will fully comply with the requirements of 23 CCR § 356.2.

5.5.1 General Information (23 CCR § 356.2(a))

General information will include an executive summary that highlights the key content of the annual report. This will include a description of the sustainability goals and provide a description of GSP projects, an updated implementation schedule, and a map of the Subbasin. Any important changes or updates since the last annual report will be noted and described.

5.5.2 Subbasin Conditions (23 CCR § 356.2(b))

The Subbasin conditions section of the annual report will provide an update on groundwater and surface water conditions in the Subbasin.

Current groundwater conditions with respect to the sustainability goals in the Subbasin will be described. GSAs will summarize the groundwater monitoring network data and report current and change in groundwater elevation. This will include groundwater elevation contour maps for each aquifer in the Subbasin tailored to specific hydrogeologic conditions across the region. This will show seasonal high and low conditions within the current season and show historical data from at least January 1, 2015.

Total groundwater extractions will be summarized (in tabular and map form) by water use sector and the method of measurement will be identified (e.g. metering, satellite analysis, crop-based ET estimates, etc.). All data and methods used to characterize extractions and levels will follow best practices and be described in the annual report.

Total ET_{aw} in the Subbasin will be summarized and parsed into ET_{aw} of surface water and ET_{aw} of groundwater using the information on applied surface water. Surface water data will show whether it was used for direct or in-lieu recharge and identify all sources for each GSA.

The groundwater system balance will be used to estimate the change in groundwater storage. Change in storage will be summarized in tabular form and as a map for each aquifer in the Subbasin. A graph will show the water year type, groundwater use, change in storage, and cumulative change in storage for the Subbasin using historical data from no later than January 1, 2015.

5.5.3 Plan Implementation Progress (23 CCR § 356.2(b))

The annual report will summarize GSP implementation of PMAs and other GSA-related activities and describe progress toward established interim milestones and planned sustainability objectives. It will summarize sustainability conditions in the Subbasin.

5.6 Periodic Evaluation (Five-Year Updates)

DWR will review the GSP's progress toward meeting its sustainability goals at least every five years. GSAs will prepare the Ppperiodic Eevaluation to summarize GSP implementation, whether the GSP is meeting the sustainability goals, and summarize implementation of PMAs. An evaluation will also be made whenever the GSP is amended. A summary of the general information that will be included in the five-year Ppperiodic eEvaluation required by 23 CCR § 356.4 is provided in the following subsections. In preparing the Periodic Evaluation, the GSAs plan to review and follow guidelines provided in DWR's guidance document for Annual Reports, Periodic Evaluations, and Plan Amendments (DWR, 2023).

5.6.1 Sustainability Evaluation (23 CCR § 356.4(a) - § 356.4(d))

The evaluation will summarize current groundwater conditions for each sustainability indicator and describe overall progress towards sustainability. A summary of interim milestones and MOs will be included, along with an evaluation of groundwater elevations in relation to MTs. If any MTs are found to be exceeded, the GSAs will investigate probable causes and implement actions to correct conditions, as warranted. However, exceedance of a MT does not automatically trigger corrective action, as the exceedance may be due to factors beyond the control of the GSA.

Implementation of PMAs will be documented and used to adaptively manage the Subbasin. This will include a summary of actual implementation timelines compared to the proposed timeline (Figure 5-1 and Figure 5-2) and implementation schedule described in Chapter 4, and evaluation of the project contribution to improving conditions. If conditions are improving faster or slower than projected, the reason for the difference from the projection will be evaluated. If conditions are improving slower than projected because any projects or management actions are not implemented according to the specified timeline, the deviation from the original plan will be documented and to the extent possible, corrective actions to speed implementation will be taken. This may include imposing limits on groundwater pumping more broadly than described in Chapter 4, or at a more rapid rate. Similarly, if conditions are improving faster than projected, the scale or timeline of some projects or management actions (notably demand management) may be re-evaluated and revised.

The evaluation will analyze and describe the effect of PMAs on Subbasin sustainability indicators and compare that to the estimated gross benefits of the PMAs presented in Chapter 4. If differences are identified, these will be described in the Pperiodic Eevaluation. If projects or management actions are not performing as expected, the update will describe steps the GSAs will take to implement additional projects or reduce pumping, if warranted. Any changes to the implementation schedule of PMAs will be described in the Pperiodic eEvaluation.

As GSP PMAs are implemented, monitoring data may indicate unanticipated effects. Also, land uses and economic conditions will change in ways that cannot be anticipated at this time. For example, the GSP has not developed an economic analysis to consider the effect of higher water costs and lower water supply availability on farm profitability and regional crop mix. As such, it may be necessary to revise the GSP to account for these changes. The elements of the GSP including the basin setting, management areas, undesirable results, MTs, and MOs will be reconsidered by the GSAs during the Pperiodic Eevaluations. Any proposed revisions will be documented in the periodic evaluation.

5.6.2 Monitoring Network Description (23 CCR § 356.4(e))

Chapter 3 details the planned monitoring network and protocols. The effectiveness of the monitoring network and overall GSP implementation depends on timely, accurate, and comprehensive data. The GSP includes Data Management System (DMS) protocols, as well as expanded monitoring wells and data collection. However, as described in Chapter 3, data gaps still exist in the Subbasin that will require expanding the network. If data gaps are identified, a plan will be developed to improve the monitoring network, consistent with 23 CCR § 354.38.

GSAs expect that additional data gaps may will be identified in future Periodic EvaluationsGSP updates. The Pperiodic Eevaluations of the GSP will assess changes to the monitoring program needed to acquire additional data sources, and how the new information will be used and incorporated into any future Periodic Evaluations and Annual ReportsGSP updates. The installation of new data collection facilities and analysis of new data will be prioritized in the GSP.

5.6.3 New Information (23 CCR § 356.4(f))

GSAs are continuing to monitor Subbasin conditions and additional monitoring wells are being installed under a Proposition 1 grant. In addition, the DMS will allow GSAs to identify additional data gaps and implement procedures to secure additional data. Land use and economic incentives for farming and other water uses in the Subbasin will continue to change as the GSP is implemented. GSAs expect that new information about groundwater conditions, PMAs, and sustainability objectives will continue to be available. An adaptive management approach will be applied to identify, review, and incorporate all new information into the GSP. Periodic evaluations will indicate whether new information warrants changes to any aspect of the GSP, including the basin setting, MOs, MTs, or undesirable results.

5.6.4 GSA Actions (23 CCR § 356.4(g) - § 356.4(h))

GSAs are continuing to monitor, manage, and collaborate to meet the sustainability goal~~s~~ specified in the GSP. Within their allowed authorities, GSAs are evaluating new regulations or ordinances that could be implemented to help achieve sustainability objectives. Any changes in regulations or ordinances will be summarized in the periodic update. The effect on any aspect of the GSP, including the basin setting, MOs, MTs, or undesirable results will be described.

The five-year P~~p~~eriodic E~~e~~valuation will include a summary of state laws and regulations or local ordinances related to the GSP that have been implemented since the previous P~~p~~eriodic E~~e~~valuation and address how these may require updates to the GSP. Enforcement or legal actions taken by the GSAs in relation to the GSP will be summarized in this section along with how such actions support sustainability in the Subbasin.

5.6.5 Plan Amendments, Coordination, and Other Information (23 CCR § 356.4(i) - § 356.4(k))

Any proposed or completed amendments to the GSP will be described in the P~~p~~eriodic E~~e~~valuation. This will also include a summary of amendments that are being considered or developed at that time. This may include changes to the basin setting, MOs, MTs, or undesirable results.

Any changes to the GSA coordination agreement, or other Subbasin coordination agreements will be documented and summarized. GSAs will summarize any other information deemed appropriate to support the GSP and provide required information to DWR for review of the GSP.

5.7 Data Management System (23 CCR § 352.6)

The ~~Madera~~ Subbasin Data Management System (DMS) has been developed as an integrated network of databases and linked programs and tools. Each element is directly or indirectly linked to the central water budget database, which organizes and calculates the Subbasin water budget (Figure 5-6). Inputs to the water budget database are organized into inputs that are managed and implemented at the Subbasin-level and inputs that are managed at the GSA-level. Subbasin-level inputs include:

- **Time series**: time series data managed in a database structure and used to quantify surface water inflows/outflows and groundwater levels
    - USGS and USACE station data
    - DWR-compiled data (WDL and CDEC)

- **Weather:** weather data managed in a database structure and used to quantify reference evapotranspiration and precipitation, and to support root zone water budget calculations (crop evapotranspiration, infiltration, runoff)
    - CIMIS station data
    - NCEI (NOAA) station data
    - PRISM data
- **eWRIMS**: water rights diversions records managed publicly in a database structure and used to quantify surface water supply utilized for irrigation
- **GIS:** spatially-defined geographic data managed in GIS and used to support land use analyses and spatial water use by sector
    - DWR spatial data (Subbasin boundaries, GSA boundaries, land use survey spatial coverages, Land IQ land cover classification and analysis)
    - DWR interpolation tool results (spatial and temporal interpolation of spatial coverages, using Ag Commission reports)
    - Local land use data comparison and validation
- **IWFM IDC**: daily root zone water budget results estimated by the IWFM IDC program and used to quantify crop evapotranspiration, infiltration, runoff, and change in SWS storage (see Section 2.2.3.3)

Inputs to the Subbasin water budget that are managed at the GSA-level include:

- **Time series:** time series data relating to GSA-specific inflows that are managed in a database structure and used to quantify surface water inflows/outflows
- **Local Data:** local data managed in spreadsheets and used to quantify GSA-specific inflows/outflows (diversions and deliveries not recorded in Subbasin-level data sources)
- **Deliveries**: Water district delivery data managed in a database structure and used to quantify surface water supply utilized for irrigation

All GSAs will manage data related to GSP project implementation within their boundaries. GSAs are continually working to refine data, identify data gaps, and incorporate additional information characterizing groundwater conditions in the Subbasin.

GSAs are currently developing a Request for Proposals (RFP) to secure a database development contractor to develop a database system to store, manage, and retrieve data. This will formalize the DMS, which will be developed to meet the requirements in the GSP regulations, including 23 CCR §352.4, §352.6, and §354.4. As described previously, the data will be managed so that appropriate tables, graphs, and maps supporting the GSP annual reports and Pperiodic eEvaluations can be queried and provided to DWR.

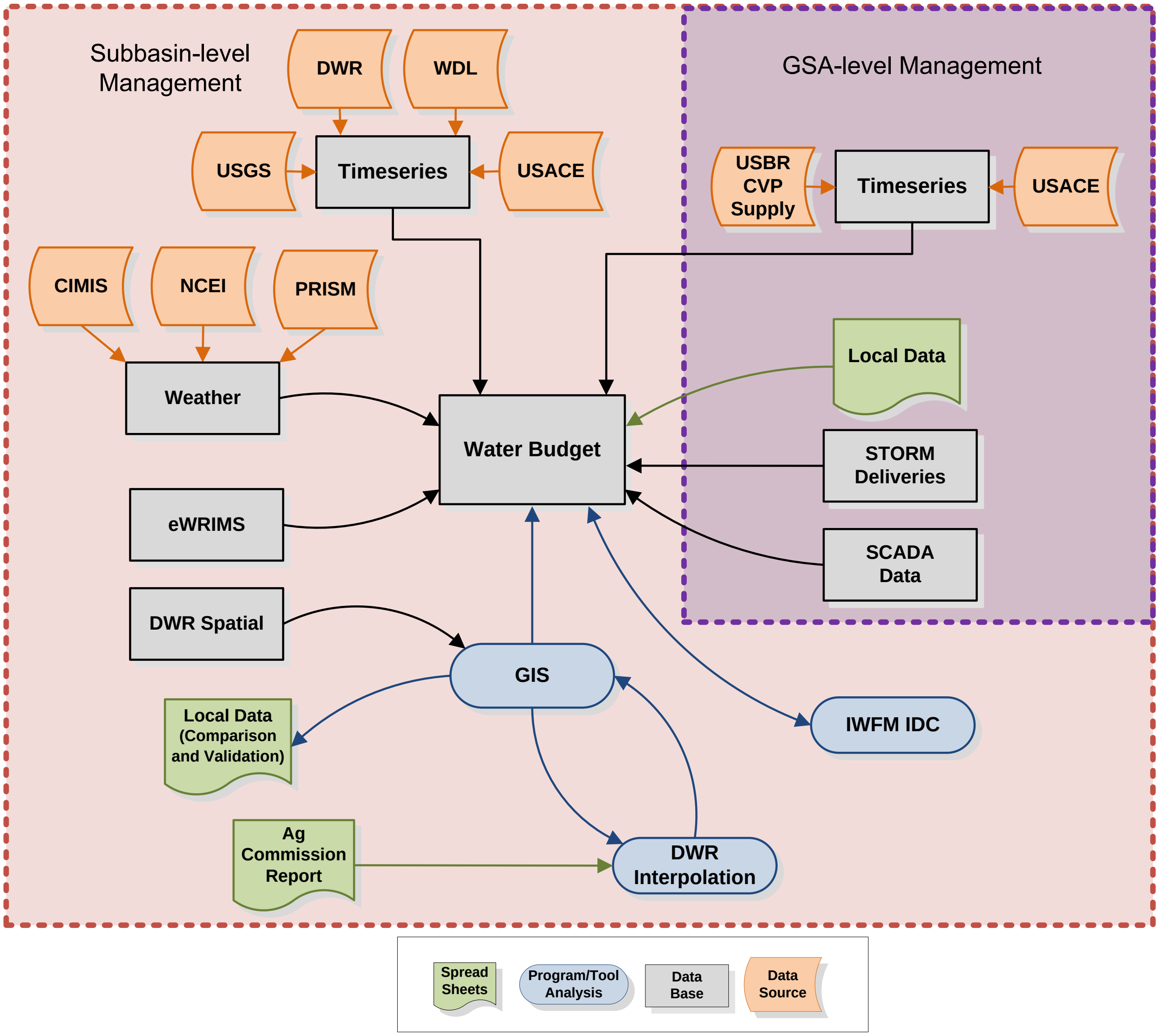


Figure 5-6. Madera Subbasin Data Management System Structure.

6 REFERENCES

Allen, R.G., Pereira, L.S., Howell, T.A., and Jensen, M.E., 2011, Evapotranspiration Information Reporting: I. Factors Governing Measurement Accuracy. Agricultural Water Management. 98(6): 899-920 pp.

Allen, R. G., M. Tasumi, A. Morse, R. Trezza, J. L. Wright, W. Bastiaanssen, W. Kramber, I. Lorite, and C. W. Robison. 2007. Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC)—Applications. J. Irrig. and Drain. Engng. 133(4): 395-406.

Allen, R., A. Irmak, R. Trezza, J. M. Hendrickx, W. Bastiaanssen, and J. Kjaersgaard. 2011. Satellite-based ET estimation in agriculture using SEBAL and METRIC. Hydrological Processes. 25(26): 4011-4027.

AKEL Engineering Group, Inc. 2014. City of Madera 2014 Water System Master Plan, September 2014. Cited in Provost & Pritchard. 2017. City of Madera Urban Water Management Plan 2015 Update.

American Society of Agricultural and Biological Engineers (ASABE). 2007. Design and Operation of Farm Irrigation Systems. G. J. Hoffman, R. G. Evans, M. E. Jensen, D. L. Martin, and R. L. Elliott (eds), ASABE, 863 pp.

American Society of Civil Engineers (ASCE). 2016. Evaporation, Evapotranspiration and Irrigation Water Requirements. Manual 70. Second Edition. M. E. Jensen and R. G. Allen (eds). Am. Soc. Civ. Engrs., 744 pp.

ASCE Environmental and Water Resources Institute (ASCE-EWRI). 2005. The ASCE standardized reference evapotranspiration equation, R. G. Allen, I. A. Walter, R. L. Elliott, T. A. Howell, D. Itenfisu, M. E. Jensen, and R. L. Snyder (eds). Task Committee on Standardization of Reference Evapotranspiration of ASCE-EWRI, Reston, VA. 173 pp.

Bastiaanssen, W. G. M., E. J. M. Noordman, H. Pelgrum, G. Davids, B. P. Thoreson, R. G. Allen. 2005. SEBAL Model with Remotely Sensed Data to Improve Water Resources Management under Actual Field Conditions. J. Irrig. Drain. Eng. 131(1): 85-93.

Blair, L.E. and Westra, J.J. 1998. Gravelly Ford Water District Groundwater Management Plan, Adopted April 13, 1998, Amended October 3, 2000.

Blaszyk, T., and J. Gorski, Ground-Water Quality Changes During Exploitation, Ground Water, Vol. 19, No. 1, pp 28-33. 1981.

Boyle Engineering Corporation. 1999. Madera Irrigation District AB3030 Groundwater Management Plan.

California Environmental Protection Agency State Water Resources Control Board (SWRCB). 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, pg. 24.

California Division of Mines and Geology. Geologic Guide to the Merced Canyon and Yosemite Valley, California. Bulletin 182, Part 1, The geology, geomorphology, and soils of the San Joaquin Valley in the vicinity of the Merced River, California, by Rodney J. Arkley, 1962.

California Department of Water Resources (DWR). 1981. Water Well Standards, Bulletin 74-81 (and draft supplemental Bulletin 74-90) (http://wdl.water.ca.gov/well_standards/well_standards_content.html). Last accessed July 2019.

DWR. 1992. San Joaquin District, Lines of Equal Elevation of Water in Wells, San Joaquin Valley, 1989 and 1993, Memorandum Report by Anthony Camoroda. Cited in Todd Engineers. 2002. AB3030 Groundwater Management Plan, Madera County, Final Draft, prepared for County of Madera Engineering and General Services.

DWR. 2003. Bulletin 118: California's Groundwater, Update 2003.

DWR. 2004. California's Groundwater, Bulletin 118, San Joaquin Valley Groundwater Basin, Chowchilla Subbasin.

DWR. 2007. California Central Valley Unimpaired Flow Data, Fourth Edition Draft. Bay-Delta Office, California Department of Water Resources. May 2007.

DWR. 2015. IWFM Demand Calculator: IDC-2015, revision 36. Theoretical Documentation and User's Manual. Central Valley Modeling Unit, Modeling Support Branch, Bay-Delta Office. Sacramento, CA.

DWR. 2015. Integrated Water Flow Model Demand Calculator (IDC), version 2015.0.0036, Retrieved from: https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model-Demand-Calculator.

DWR. 2015. Best Management Practices for the Sustainable Management of Groundwater: Water Budget BMP. California DWR Sustainable Groundwater Management Program. December 2016.

DWR. 2016. Best Management Practices for Sustainable Management of Groundwater, Hydrogeologic Conceptual Model, BMP.

DWR. 2016. Best Management Practices for Sustainable Management of Groundwater, Monitoring Networks and Identification of Data Gaps, BMP.

DWR. 2016. Best Management Practices for Sustainable Management of Groundwater, Water Budget, BMP.

DWR. 2016. California's Groundwater, Bulletin 118 Interim Update 2016.

DWR. 2017. California Aqueduct Subsidence Study. San Luis Field Division, San Joaquin Field Division, June 2017.

DWR. 2017. Best Management Practices for Sustainable Management of Groundwater, Sustainable Management Criteria, BMP.

DWR. 2017. Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria BMP (Draft). California DWR Sustainable Groundwater Management Program. November 2017.

DWR. 2019. Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices, California Cooperative Snow Surveys. Available at: http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST. Last accessed on 2/22/2019.

Castle and Cooke.2018. Central California Irrigation District Hazard Mitigation Grant Program DR-4308: Attachment 1 - Subapplication Responses. MARPRO Red Top Joint Banking.

City of Madera and PMC, 2009, City of Madera General Plan, Adopted October 7, 2009 by the Madera City Council Resolution 09-243.

Clemmens, A. J. and C. M. Burt. 1997. Accuracy of irrigation efficiency estimates. J. Irrig. and Drain. Engng. 123(6): 443-453.

County of Madera. 1995. Madera County General Plan, Adopted October 24, 1995, Updated November 3, 2015.

CPAD (California Protected Areas Database), 2019, California Protected Areas Database. Website: https://www.calands.org/cpad/ [accessed July 2019]. Prepared by GreenInfo Network.

Davids Engineering (DE) and Luhdorff and Scalmanini Consulting Engineers (LSCE). 2017. Technical Memorandum: Madera Subbasin Sustainable Groundwater Management Act, Data Collection and Analysis, prepared for Madera Subbasin Coordination Committee.

Davis, G.H., Green, J.H., Olmsted, P.H., and Brown, D.W. 1959. *Ground-Water Conditions and Storage Capacity in the San Joaquin Valley, California*, USGS Water-Supply Paper 1469.

Driscoll, F.G. 1986. Groundwater and Wells, Johnson Screens, St. Paul, Minnesota.

Englehardt, J. D., T. Wu, F. Bloetscher, Y. Deng, P. Du Pisani, S. Eilert, S. Elmir, T. Guo, J. Jacangelo, M. LeChevallier, and H. Leverenz. 2016. Net-zero Water Management: Achieving Energy-Positive Municipal Water Supply. Environmental Science: Water Research & Technology. 2(2): 250-260.

Friant Water Authority. 2018. Technical Memorandum: Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California. December 2018.

Gravelly Ford Water District. 2012. Gravelly Ford Water District 2009 Water Management Plan.

Hansen, J.A., Jurgens, B.C., and M.S. Fram. Quantifying Anthropogenic Contributions to Century-scale groundwater salinity changes, San Joaquin Valley, California, USA. Science of the Total Environment, 642, 125-136, 2018.

sHaugen, E.A., Jurgens, B.C., Arroyo-Lopez, J.A., and G.L. Bennett. Groundwater Development Leads to Decreasing Arsenic Concentrations in the San Joaquin Valley, California. Science of the Total Environment, 771, 145223, 2021.

sHarmel, R.D., Cooper, R.J., Slade, R.M., Haney, R.L., and J.G. Arnold, Cumulative Uncertainty in Measured Streamflow and Water Quality Data for Small Watersheds. Transactions of the American Society of Agricultural and Biological Engineers (ASABE), 49(3): 689-701. 2006.

Herum Crabtree Suntag Attorneys. 2017. Clayton Water District Municipal Service Review. Prepared for the Madera Local Agency Formation Commission (LAFCO). January 2017.

Hopkins, J. 1994. Explanation of the Texas Water Development Board groundwater level monitoring program and water-level measuring manual. Cited in Hopkins, J. and B. Anderson. 2016. User Manual 52: A Field Manual for Groundwater-level Monitoring at the Texas Water Development Board. 23 p. http://www.twdb.texas.gov/groundwater/docs/UMs/UM-52.pdf

Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, and A. Lyons. 2018. Mapping indicators of groundwater dependent ecosystems in California. https://data.ca.gov/dataset/natural-communities-commonly-associated-groundwater.

Lees, M., R. Knight, and R. Smith. 2022. Development and application of a 1D compaction model to understand 65 years of subsidence in the San Joaquin Valley. Water Resources Research, 58, e2021WR031390. Available at: https://doi.org/10.1029/2021WR031390.

Levy, Z.F., Jurgens, B.C., Burow, K.R., Voss, S.A., Faulkner, K.E., Arroyo-Lopez, J.A., and M.S. Fram. Critical Aquifer Overdrraft Accelerates Degradation of Groundwater Quality in California's Central Valley During Drought. AGU Research Letter, 10.1029/2021GL094398, 2021.

2Lombard, M.A., Daniel, J. Jeddy, Z. Hay, L.E., and J.D. Ayotte. Assessing the Impact of Drought on Arsenic Exposure from Private Domestic Wells in the Conterminous united States. Environmental Science & Technology, 55, 1822-1831, 2021.2Loux, J., R. Winer-Skonovd, and E. Gellerman. 2012. Evaluation of Combined Rainwater and Greywater Systems for Multiple Development Types in Mediterranean climates. Journal of Water Sustainability. 2(1): 55-77.

Luhdorff and Scalmanini Consulting Engineers (LSCE). 2014. East San Joaquin Water Quality Coalition Groundwater Quality Assessment Report.

LSCE, Borchers, J.W., and M. Carpenter. 2014. Land Subsidence form Groundwater Use in California. Prepared for California Water Foundation.

LSCE. 2015. 2014 Annual Report Mendota Pool Group Pumping and Monitoring Program, Prepared for San Joaquin River Exchange Contractors Water Authority, Wonderful Orchards, and Mendota Pool Group, August 2015. Available at: https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=41114.

~~Luhdorff and Scalmanini Consulting Engineers (~~LSCE~~)~~ and Larry Walker Associates. 2016. Region 5: Updated Groundwater Quality Analysis and High Resolution Mapping for Central Valley Salt and Nitrate Management Plan.

LSCE, Geosyntec, Brown and Caldwell, Environmental Science Associates, Dr. Jean Moran, and Farallon Geographics. 2022. Region 5: East Bay Plain Subbasin Groundwater Sustainability Plan. Prepared for East Bay Municipal Utility District GSA and City of Hayward GSA.

Madera County. 2017. Madera County Storm Water Resource Plan (SWRP). Prepared by County of Madera, Fall Creek Engineering, Sierra Watershed Progressive, and 2NDNATURE (2N). December 28, 2017.

Madera County Department of Agriculture Weights and Measures. 2017. 2017 Madera County Agricultural Crop and Livestock Report.

McBain & Trush, Inc., editors. 2002. San Joaquin River Restoration Study Background Report, prepared for Friant Water Users Authority, Lindsay, CA, and Natural Resources Defense Council, San Francisco, CA.

McMillan, H.K. Krueger, T., Freer, J.E., and I. Westerberg. Benchmarking Observational Uncertainties for Hydrology. American Geophysical Union (AGU), Abstract for Fall Meeting 2013. 2013.

Mendenhall, W.C., Dole, R.B., and H. Stabler. 1916. Ground Water in San Joaquin Valley, California, USGS Water-Supply Paper 398.

Mitten, H.T., Bertoldi, G.L., and LeBlanc. R.A. 1970. Geology, Hydrology and Quality of Water in the Madera Area, San Joaquin Valley, California, USGS Open File Report 70-228, 1970.

Montgomery, R.H., and T.G. Sanders, Uncertainty in Water Quality Data, Developments in Water Science, Vol. 27, pp. 17-29. 1986.

National Marine Fisheries Service (NMFS). 2016. California Species List. Intersection of USGS Topographic Quadrangles with NOAA Fisheries ESA Listed Species, Critical Habitat, Essential Fish Habitat, and MMPA Species Data. Google Earth (KMZ) file available at: https://www.westcoast.fisheries.noaa.gov/maps_data/california_species_list_tools.html [accessed July 2019].

Olmos, K. C. and F. J. Loge. 2013. Offsetting Water Conservation Costs to Achieve Net-Zero Water Use. Journal-American Water Works Association. 105(2): E62-E72. https://awwa.onlinelibrary.wiley.com/doi/abs/10.5942/jawwa.2013.105.0002

Page, R.W. 1973. Base of Fresh Ground Water (approximately 3,000 micromhos) in the San Joaquin Valley, California, USGS Hydrologic Investigations Atlas HA-489.

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.

Pacific Fishery Management Council (PFMC). 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by amendment 18 to the Pacific Coast Salmon Plan. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. https://www.pcouncil.org/wp-content/uploads/Salmon_EFH_Appendix_A_FINAL_September-25.pdf

Provost & Pritchard, 2012, Root Creek Water District Groundwater Management Plan, Adopted October 13, 1997, Updated January 2012.

Provost & Pritchard, Wood Rodgers, and KDSA. 2014. *Madera Regional Groundwater Management Plan*, prepared for City of Chowchilla, Chowchilla Water District, City of Madera, Madera County, Madera irrigation District, and South-Est Madera County United.

Provost & Pritchard. 2015. Madera Integrated Regional Water Management Plan, February 2015.

Provost & Pritchard. 2017. City of Madera Urban Water Management Plan 2015 Update.

Regional Water Quality Control Board (RWQCB), Central Valley Region. 2018. Amendments to the Water Quality Control Plans for the Sacramento River and San Joaquin River Basins and Tulare Lake Basin to Incorporate a Central Valley-wide Salt and Nitrate Control Program.

Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson. 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy, San Francisco, California.

San Joaquin River Restoration Program (SJRRP), 2022, Final 2022 Restoration Allocation & Default Flow Schedule, May 13, 2022, https://www.restoresjr.net/?wpfb_dl=2664.

Smith, R., Knight, R., and S. Fendorf. Overpumping Leads to California Groundwater Arsenic Threat. Nature Communications, 9:2089. 2018.

State Water Resources Control Board (SWRCB). 1995. Water Quality Control Plan for the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary. California Environmental Protection Agency SWRCB. p. 24.

Steiner, D. B. 2005. Effects to Water Supply and Friant Operations Resulting From Plaintiffs' Friant Release Requirements. Expert report prepared by Daniel B. Steiner for Friant Water Users Authority. September 16, 2005. Cited in Congressional Research Service. 2007. San Joaquin River Restoration Settlement. Report RL34237. November 9, 2007.

Todd Engineers. 2002. AB3030 Groundwater Management Plan, Madera County, Final Draft, prepared for County of Madera Engineering and General Services. Cited in Provost & Pritchard, Wood Rodgers, and KDSA. 2014. Madera Regional Groundwater Management Plan, prepared for City of Chowchilla, Chowchilla Water District, City of Madera, Madera County, Madera Irrigation District, and South-East Madera County United.

The Nature Conservancy (TNC). 2014. Groundwater and stream interaction in California's Central Valley: insights for sustainable groundwater management. Prepared by RMC Water and Environment.

Thoreson, B., B. Clark, R. Soppe, A. Keller, W. Bastiaanssen, and J. Eckhardt. 2009. Comparison of Evapotranspiration Estimates from Remote Sensing (SEBAL), Water Balance, and Crop Coefficient Approaches. Proceedings of the 2009 World Environmental & Water Resources Congress. American Society of Civil Engineers Environmental and Water Resources Institute. Kansa City, MO.

TRC. 2015. Second quarter 2015 monitoring report, Former MacGillis and Gibbs Pole Treating Facility (Trigo Site) Madera, California BNSF File No. 01002722, July 21, 2015.

University of California Cooperative Extension (UCCE). 1987. Leaflet 21427: Using reference evapotranspiration (ETo) and crop coefficients to estimate crop evapotranspiration (ETc) for agronomic crops, grasses, and vegetables, crops, University of California.

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 2004. National Engineering Handbook: Part 630—Hydrology. USDA, Natural Resources Conservation Service: Washington, DC.

USDA-NRCS. 2004. National Engineering Handbook: Part 630, Hydrology, Chapters 9 and 10. USDA, Natural Resources Conservation Service: Washington, DC.

USDA-NRCS. 2007. National Engineering Handbook. Part 630, Hydrology, Chapter 7. USDA, Natural Resources Conservation Service: Washington, DC.

U.S. Environmental Protection Agency (USEPA), 2009, National Primary Drinking Water Regulations, https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf. Last accessed July 2019.

United State Fish and Wildlife Services (USFWS). 2019. Threatened & Endangered Species Active Critical Habitat Report: online mapping tool. https://fws.maps.arcgis.com/home/webmap/viewer?webmap=9d8de5e265ad4fe09893cf75b8dbfb77 [accessed May 2019].