CHOWCHILLA SUBBASIN

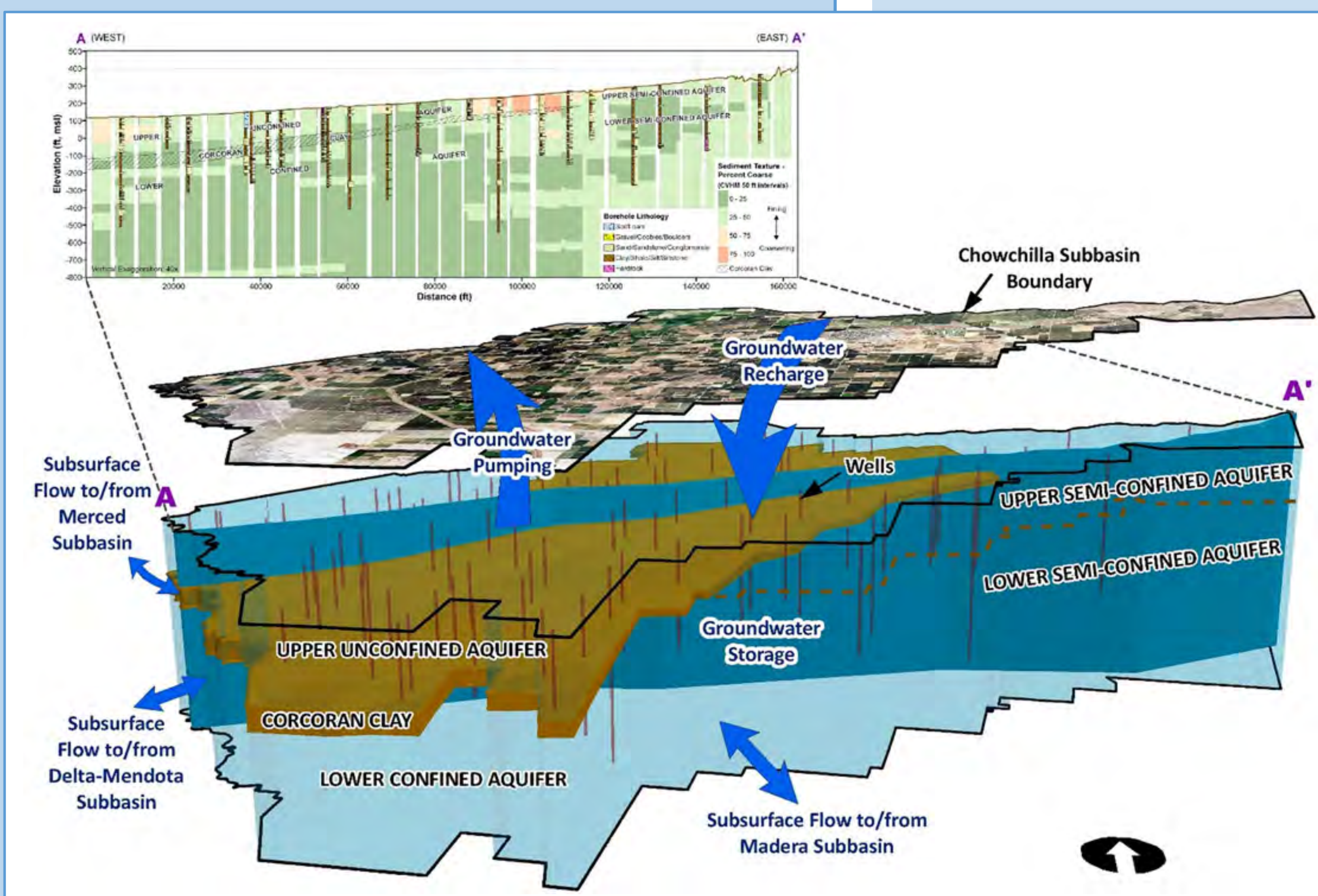
Sustainable Groundwater Management Act (SGMA)

Groundwater Sustainability Plan

January 2020
Revision 1 July 2022
Revision 2 May 2023

Prepared by

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



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Prepared For

Chowchilla Subbasin GSP Advisory Committee

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LIST OF ABBREVIATIONS

AF	acre-feet
AFY	acre-feet per year
AG	Agricultural Land
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
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
C2VSim-CG	published coarse-grid version of C2VSim, Version R374
C2VSim-FG	published fine-grid version of C2VSim
CCC	Columbia Canal Company
CCID	Central California Irrigation District
CCP	Consensus and Collaboration Program at California State University, Sacramento
CCR	California Code of Regulations
CDEC	California Data Exchange Center
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
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
DAC	Disadvantaged Community
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
EMA	Eastern Management Area
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
GAMA	Groundwater Ambient Monitoring and Assessment
GDEs	groundwater dependent ecosystems
GFWD	Gravelly Ford Water District
GIS	geographic information system

GMP	Groundwater Management Plan
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
IM	interim milestone
ISW	interconnected surface water
IWFM	Integrated Water Flow Model
K	hydraulic conductivity
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LDC	Little Dry Creek
LSCE	Luhdorff & Scalmanini Consulting Engineers
Madera Co	Madera County
Maf	millions of acre-feet
MAR	Managed aquifer recharge
MC	Madera County
MCDEH	Merced County Department of Public Health, Division of Environmental Health
MCL	maximum contaminant level
MCWPA	Madera-Chowchilla Water and Power Authority
Merced Co	Merced County
Merced ID	Merced Irrigation District
mg/L	milligrams/liter
MID	Madera Irrigation District’s
MIGR	Warm and cold migration habitat
MOs	measurable objectives
MSL	mean sea level
MTs	minimum thresholds
MUN	Municipal and domestic supply
MWELO	Model Water Efficient Landscape Ordinance
NASA-JPL	National Aeronautics and Space Administration Jet Propulsion Laboratory
NCCAG	Natural Communities Commonly Associated with Groundwater
NOAA NCEI	National Oceanic and Atmospheric Administration National Centers for Environmental Information
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
pTb	Pre-Tertiary basement complex
PV	Present Value
Qb	Quaternary flood-plain deposits
Qoa	Older Quaternary alluvium
QTc	Tertiary and Quaternary continental deposits

QTcd	Quaternary continental rocks and deposits
Qya	younger Quaternary alluvium
Reclamation	United States Bureau of Reclamation
redox	reduction-oxidation
RFP	Request for Proposals
RH	relative humidity
RMS	Representative monitoring sites
RPE	Reference Point Elevation
Rs	solar radiation
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
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
SPWN	Warmwater spawning habitat
SS	Stillwater Sciences
SVMWC	Sierra Vista Mutual Water Company
SWRCB	State Water Resources Control Board
SWS	surface water system
Sy	specific yield
T	transmissivity
Ta	air temperature
TAF	thousand acre-feet
TDS	total dissolved solids
TM	Technical Memorandum
TMWA	Truckee Meadows Water Authority
TpTu	Pre-Tertiary and Tertiary marine and continental sedimentary rocks
TTWD	Triangle T Water District
UR	Urban Land
USACE	United States Army Corps of Engineers
USBR	U.S. Bureau of Reclamation, or 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
WARM	Warm freshwater habitat
WCRs	well completion reports
WDL	Water Data Library
WILD	Wildlife habitat
WMA	Western Management Area
Ws	wind speed
WYI	Water Year Index
YCWA	Yuba County Water Agency
yield	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, or Plan) 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 Chowchilla Subbasin (Subbasin) is identified by the California Department of Water Resources (DWR) as a critically overdrafted subbasin. Therefore, the Chowchilla Subbasin GSP must be developed, adopted, and submitted to DWR by January 31, 2020. This document, the Chowchilla Subbasin GSP, satisfies these requirements and outlines the strategy by which the Chowchilla Subbasin GSAs will achieve sustainable groundwater management by 2040.

GSP Revisions

As of May 2023, the GSAs in the Chowchilla Subbasin have revised the Chowchilla Subbasin GSP on two occasions. The first revisions were completed in 2022, when the GSAs in the Chowchilla Subbasin revised the Chowchilla Subbasin GSP to resolve deficiencies identified by DWR in their January 2022 consultation letter. The second revisions were completed in 2023, when the GSAs revised certain section of the GSP to address remaining deficiencies identified by DWR in their March 2023 inadequate determination.

GSP Revisions Completed July 2022

In November 2021, the GSAs in the Chowchilla Subbasin received a letter from DWR initiating consultation for the Chowchilla Subbasin GSP. The letter described potential deficiencies identified by DWR that may preclude approval of the submitted GSP 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 after the final DWR determination was released. On January 28, 2022, the GSAs in the Chowchilla Subbasin received DWR's final incomplete determination.

In 2022, the GSAs revised the Chowchilla Subbasin GSP to:

- Address the potential deficiencies identified by DWR in their January 2022 consultation letter, and discussed during five DWR consultation meetings between December 2021 and May 2022;
- Summarize the progressive implementation actions taken by the GSAs since submission of the GSP in January 2020;
- Recognize the Chowchilla Subbasin GSAs' clear and formal commitment to fund and implement a Domestic Well Mitigation Program beginning no later than January 1, 2023, including the execution of a memorandum of understanding (MOU); and
- Reaffirm their commitment to implementing the GSP and achieving sustainable groundwater conditions by 2040.

In July 2022, revisions were made in various sections of the GSP to address these points, as well as other points of clarification learned during the GSAs' consultation meetings with DWR in January-May 2022.

GSP Revisions Completed May 2023

In March 2023, following DWR's review of the July 2022 GSP revisions, the GSAs received a letter from DWR communicating that an inadequate determination had been made for the Chowchilla Subbasin GSP. The letter described DWR's conclusions from their review and ongoing concerns that the GSP does not provide sufficient information to support the selection of the chronic lowering of groundwater levels and the land subsidence sustainable management criteria.

In 2023, the GSAs revised the Chowchilla Subbasin GSP once more to:

- Resolve the remaining deficiencies identified by DWR in their March 2023 consultation letter related to groundwater levels and subsidence through establishment of more conservative sustainable management criteria related to groundwater levels and subsidence rates in the Subbasin;
- Reaffirm their commitment to upholding the Human Right to Water (CWC § 106.3) and their commitment to sustainably manage groundwater in the Subbasin for all beneficial uses and users, including domestic well owners and owners of shallow wells that supply drinking water users;
- Provide updates to recognize the launch and current status of the Domestic Well Mitigation Program in 2023;
- Clarify the benefits of projects and management actions to all sustainability indicators;
- Provide updates on further efforts to implement projects and management actions since July 2022; and
- Reaffirm and clarify that GSP implementation will achieve sustainable groundwater conditions by 2040, in accordance with SGMA.

As of May 2023, revisions have been made in various sections of the GSP to address these points. However, some text, estimated costs and benefits, and other analyses related to GSP implementation remained unchanged from the initial GSP submitted in January 2020. The GSAs plan to reassess and update other content in the GSP, as needed, as part of future GSP updates and Annual Reports as more is known.

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 potential groundwater dependent ecosystems (GDEs).

In developing this GSP, a Hydrogeologic Conceptual Model (HCM) and water budgets were created to first characterize historical and current groundwater conditions in the Chowchilla Subbasin, 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

[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 and users of surface water.

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 Chowchilla 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 Chowchilla Subbasin). Lateral subsurface inflows/outflows from/to adjacent subbasins were not considered in these water budget calculations of net recharge or shortage.

Projects and management actions (PMAs) were then developed with the goal of bringing the current net recharge into balance. A total of 12 PMAs are proposed in this GSP. 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 GSAs practice adaptive management while they monitor and learn more about groundwater conditions in the Chowchilla 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. Any changes in the PMAs will be reported in subsequent GSP Annual Reports and/or in future GSP updates.

Importantly, this approach to developing PMAs 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. 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 Chowchilla Subbasin and adjacent subbasins all achieve sustainability by 2040.

GSP Development and Outreach

This GSP has been developed by the Chowchilla Subbasin GSAs 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 were hosted throughout GSP development, including monthly GSA meetings, Chowchilla Subbasin GSP Advisory Committee meetings, joint subbasin meetings, County Advisory Committee meetings, Madera County Farm Bureau Water Forum meetings, and Madera County Regional Water Management Group meetings (see Section 2.1.5). During the GSP revision process in 2022, the GSAs conducted further public outreach through three public GSP Advisory Committee meetings, public GSA governing body meetings, and through public notices regarding the GSP revision process. The Chowchilla Subbasin GSAs have also met multiple times with GSAs in adjacent subbasins, sharing data and information on GSP projects to ensure that this Plan will not interfere with the ability of adjacent subbasins to also achieve sustainable groundwater management.

The following sections in this Executive Summary provide a concise overview of the complete Chowchilla Subbasin GSP and changes made as part of revising the GSP in response to DWR's final incomplete determination.

ES-1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, industrial, and environmental beneficial uses and users throughout the Chowchilla Subbasin[2], which underlies approximately 146,000 acres within Madera and Merced Counties. Agriculture in the Chowchilla Subbasin has historically relied on approximately 300,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the agricultural economies of both Madera County and Merced County, which have a total combined value of over $5 billion dollars.[3] Groundwater also supports a large portion of domestic, municipal, and industrial water use in and around the City of Chowchilla. Thus, the sustainable management of groundwater in the Chowchilla Subbasin is important for long-term prosperity within Madera and Merced Counties.

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, or Plan) for the subbasin. Under this Plan, 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 Chowchilla Subbasin.

The Chowchilla 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 Section 10720.7(a)(1)).

This GSP is the coordinated Plan for four GSAs that represent the entirety of the Chowchilla Subbasin area: Chowchilla Water District (CWD) GSA, County of Madera GSA - Chowchilla Subbasin (also referred to herein as Madera County GSA), County of Merced GSA - Chowchilla Subbasin (also referred to herein as Merced County GSA), and Triangle T Water District (TTWD) GSA (**Figure ES-1**). The Chowchilla Subbasin will satisfy SGMA requirements with this single GSP that covers the entire Subbasin.

The purpose of this GSP is to characterize groundwater conditions in the Chowchilla Subbasin, to evaluate and report on conditions of overdraft, to establish sustainability goals, and to describe PMAs the GSAs will implement to achieve sustainable groundwater management by 2040.

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[2] Groundwater basin number 5-022.05, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.

[3] 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). According to the Merced County Department of Agriculture, the gross value of all agricultural commodities in the County was $3,408,866,000 (Merced County 2017 Report on Agriculture).

This GSP also serves to comply with DWR's requirements that the Chowchilla Subbasin GSAs prepare, adopt, and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan 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 Section (§) 354.24, GSAs within the Chowchilla 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 Chowchilla Subbasin will be operated within its sustainable yield by 2040, or 20 years following GSP submittal 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 Section 10721(w)).

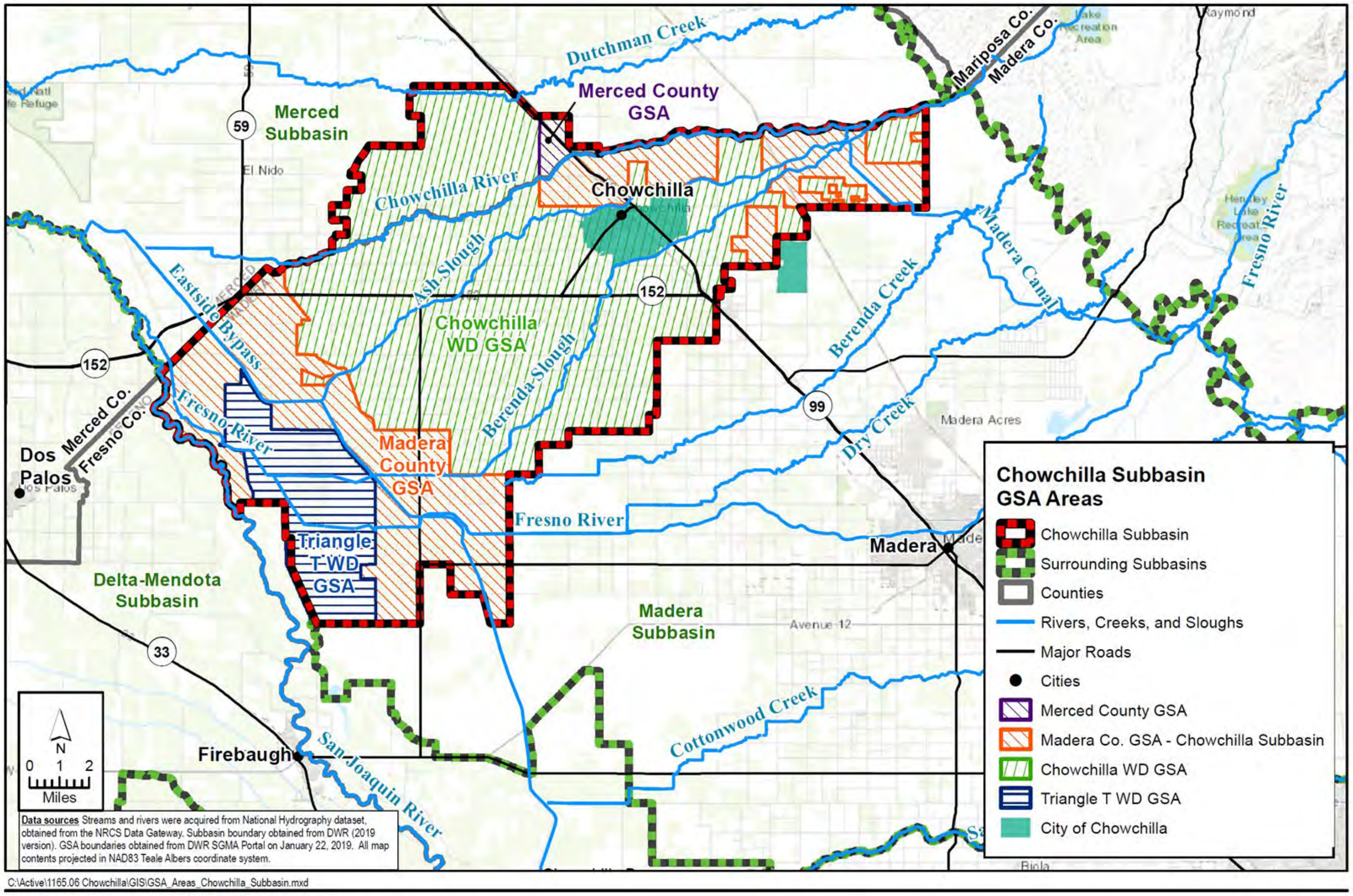

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Figure ES-1. Chowchilla Subbasin GSAs Map.[1]

[1]In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be shown in the five-year GSP update and will be reflected in future water budget updates.

ES-2 PLAN AREA AND BASIN SETTING

The Plan Area is defined as the Chowchilla Subbasin (5-022.05), part of the San Joaquin Valley Groundwater Basin, as described in Bulletin 118 (DWR, 2003) updated in 2016, with boundary updates approved in early 2019. The Subbasin is bounded in the south and east by the Madera Subbasin, in the west by the San Joaquin River and the Delta-Mendota Subbasin, and in the north by the Merced Subbasin (**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,[4] 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 Chowchilla Subbasin is underlain by the Corcoran Clay over approximately the western and central two-thirds of the Subbasin area. The depth to the top of the Corcoran Clay varies from 50 to 100 feet at its northeastern extent to in excess of 250 feet in the southwestern portion of the Subbasin. In the western portion of the Subbasin, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure ES-2**). In the central and eastern portions of the Subbasin where the Corcoran Clay is shallow or does not exist, the aquifer system is generally considered to be semi-confined with discontinuous clay layers interspersed with more permeable coarse-grained units.

The upper 800 feet of sediments are comprised of multiple layers of coarse-grained sediments. 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).

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

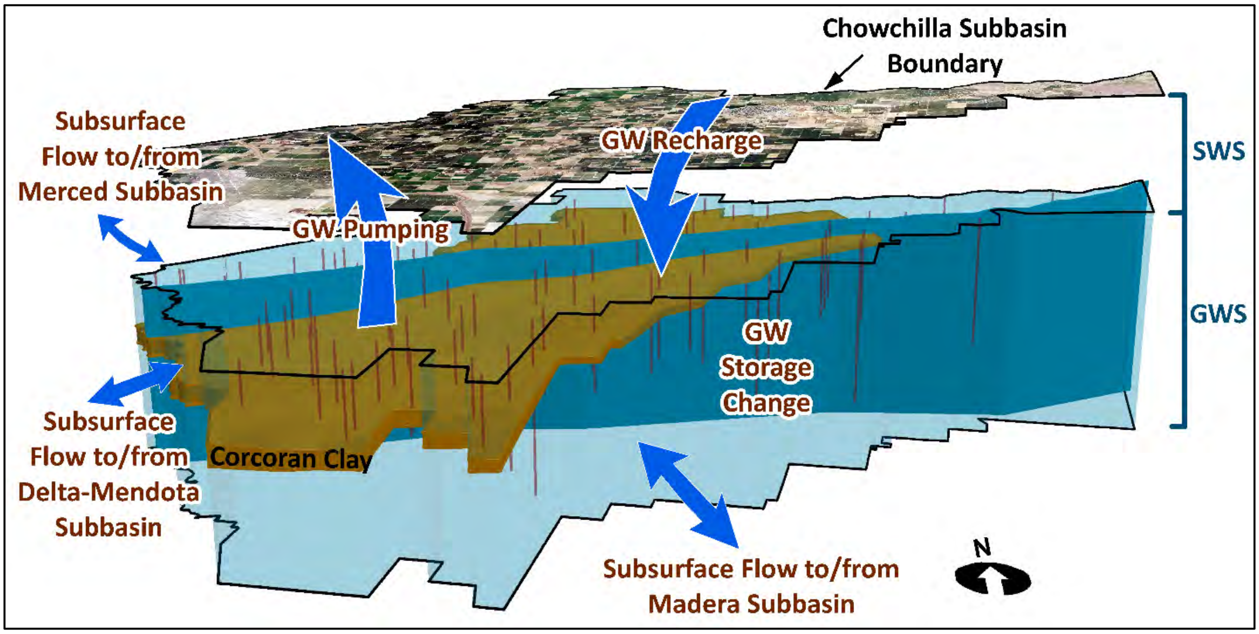


Figure ES-2. Chowchilla Subbasin Hydrogeologic Conceptual Model.

Groundwater recharge can occur throughout the Chowchilla Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources. Net subsurface inflows to the Chowchilla Subbasin from adjacent subbasins also contribute to groundwater recharge (but are not included in the water budget "net recharge" or "shortage" calculations described below); however, subsurface inflows and outflows are expected to decline as the Chowchilla Subbasin and adjacent subbasins achieve sustainability by 2040. A relatively large area of hydrologic group A and B soils with higher infiltration capacity is located in the central portion of the Subbasin from north of Chowchilla River to south of Berenda Slough, and from the City of Chowchilla on the east to Eastside Bypass on the west. This large area of hydrologic group A and B soils has soil saturated vertical hydraulic conductivity (K) from 1.1 to greater than 5 feet/day, whereas most other areas have soil saturated vertical K of less than 1 foot/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, and public supply wells are concentrated in the central to eastern portions of the Subbasin. Domestic well depths vary across the Subbasin, with the most common domestic well depth between 300 and 400 feet. Agricultural and public supply wells also vary in depth across the Subbasin, but they tend to be somewhat deeper than domestic wells with the most typical well depths in the range of 500 to 750 feet.

Groundwater Conditions

The general prevailing groundwater flow direction in the unconfined Upper Aquifer is northeast to southwest, though 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 to the south of the City of Chowchilla along the Subbasin boundary with the Madera Subbasin, and in the northwestern and southwestern portions of the Subbasin. Recent groundwater level data indicates a small area of slightly higher groundwater elevations occurs within the City of Chowchilla (180 ft msl).

Local areas of very shallow perched groundwater also exist above low-permeability (e.g., clay) layers where an unsaturated zone is present between the perching layer and the regional water table. Perched groundwater has been documented in Chowchilla Subbasin at several sites through review and comparison of local groundwater level data from regulated facility sites obtained from Geotracker and regional groundwater level data from CASGEM and other sources.

The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer indicates Lower Aquifer groundwater elevations of between -30 and -40 feet msl in the area of the Chowchilla Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 shows relatively lower groundwater elevations with some areas from -40 and -60 feet msl in the Lower Aquifer in the City of Chowchilla and in the southwestern portion of the Subbasin east of the Eastside Bypass. However, there is also an area of higher groundwater elevations than in 2014 in the middle portion of the Subbasin along Highway 152. Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in Chowchilla Subbasin is challenging.

Varying levels of groundwater level decline have been observed over the historical period across the Subbasin. Prior to the mid-1980s, trends of more stable water levels, although slightly declining, are apparent in most wells. Over the period from the mid-1980s to 2015, rates of groundwater level decline greatly increased. The calculated changes in groundwater levels from groundwater elevation contour maps translate to decreases in groundwater storage estimated to range between 27,000 and 57,500 acre-feet per year (AFY) between 1988 and 2016, assuming a range of specific yield values from 7 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.

Historical TDS concentrations in groundwater in the Chowchilla Subbasin indicate variable salinity across the Subbasin with more elevated TDS concentrations in the western portion 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.

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 central parts of the Subbasin. Several notable areas with a high density of wells with nitrate concentrations above the maximum contaminant level (MCL) of 10 mg/L (as nitrogen) are located in the more central parts of the Subbasin to the west and southwest of the City of Chowchilla and between Ash Slough and Highway 152.

Although there are a few wells with higher arsenic concentrations above 7.5 micrograms per liter (µg/L), most of the wells with data have concentrations below 5 µg/L with a considerable number having concentrations of less than 2.5 µg/L. The available groundwater quality data do not indicate any wells with arsenic concentrations above the MCL of 10 µg/L.

Recent land subsidence has been a major concern in the western portion of the Chowchilla Subbasin. Approximately 1 to 2 feet of subsidence occurred between 1926 and 1970 in the western portion of Chowchilla Subbasin. Subsidence mapping using a combination of InSAR remote sensing data and data from surveys conducted by the United States Bureau of Reclamation (USBR) for the San Joaquin River Restoration Project indicate a maximum subsidence of almost seven feet occurred from 2007 to 2021 in the northwest part of the Chowchilla Subbasin between Eastside Bypass and the western basin boundary, which reflects a recent period of subsidence re-activation in the Subbasin. Maps for the two-year period between 2015 and 2017 show one to two feet of subsidence in a large portion of the western Subbasin. Since 2017, subsidence has continued in the western part of the Subbasin, although the greatest areas of subsidence since 2017 are focused in areas farther east and south than prior to 2017. Overall, the available historical subsidence maps for the three time periods indicate up to approximately nine feet of subsidence in some areas of western Chowchilla Subbasin since 1920. The subsidence has generally been concentrated in areas of the Subbasin within the extent of the Corcoran Clay. Recent subsidence mapping indicates smaller amounts of subsidence in the central to eastern portions of the Subbasin.

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. These data suggest 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.

Review of available data for ISW indicates regional groundwater and surface water are disconnected across most of the Subbasin, with depths to regional groundwater commonly in excess of 100 feet below ground surface. Depths to regional groundwater generally increase from west to east. However, high groundwater elevations (at or above the adjacent thalweg) are periodically observed in the shallow subsurface along the San Joaquin River at the western boundary of the Subbasin. These high groundwater elevations in the shallow zone may be related to shallow clay layers causing perching/mounding conditions, and the relationship to underlying regional groundwater is not well documented. The source of water causing these high groundwater elevations in the shallow zone appears to be infiltration of San Joaquin River streamflow derived from reservoir releases or other upstream surface water contributions. A data gaps workplan for ISW has been developed to further evaluate potential interconnection between the San Joaquin River and shallow groundwater zone (**Appendix 3.I**). Extensive review and assessment of potential GDEs identified by TNC compared to depths to groundwater resulted in identification of a GDE unit along the San Joaquin River in the western portion of Chowchilla Subbasin. This GDE unit is composed of a mix of riparian forest, shrub, and herbaceous habitat totaling approximately 70 acres.

Water Budget

A water budget is defined as a complete accounting of all water flowing into and out of a defined volume[5] 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

[5] 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.

conditions. A numerical integrated groundwater flow model (MCSim) was developed based on the fine-grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSim-FG), and was utilized to support development of water budgets.

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, which was found to be representative of long-term average conditions in the Subbasin based on analysis of precipitation, unimpaired flows, and CVP supplies.

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 in the Chowchilla Subbasin is estimated to be 100,600 AF (**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/water demand conditions continued in the future under historical hydrologic conditions. PMAs described below were designed to address the current water budget shortage.

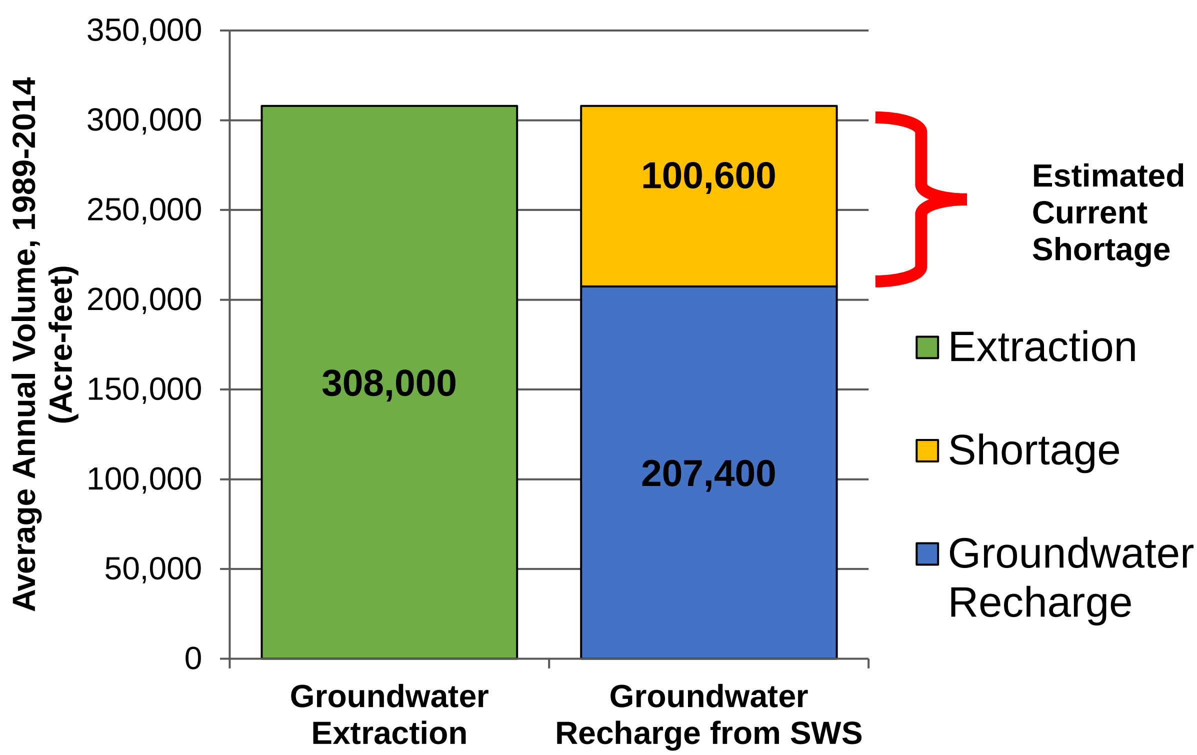


Figure ES-3. Summary Groundwater Budget for Current Subbasin Conditions (2015 Land Use).

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[6] on Subbasin conditions. Two primary projected water budget scenarios were considered: one without projects (no action), and another 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 shows 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 Chowchilla Subbasin to address the climate change scenario that actually occurs.

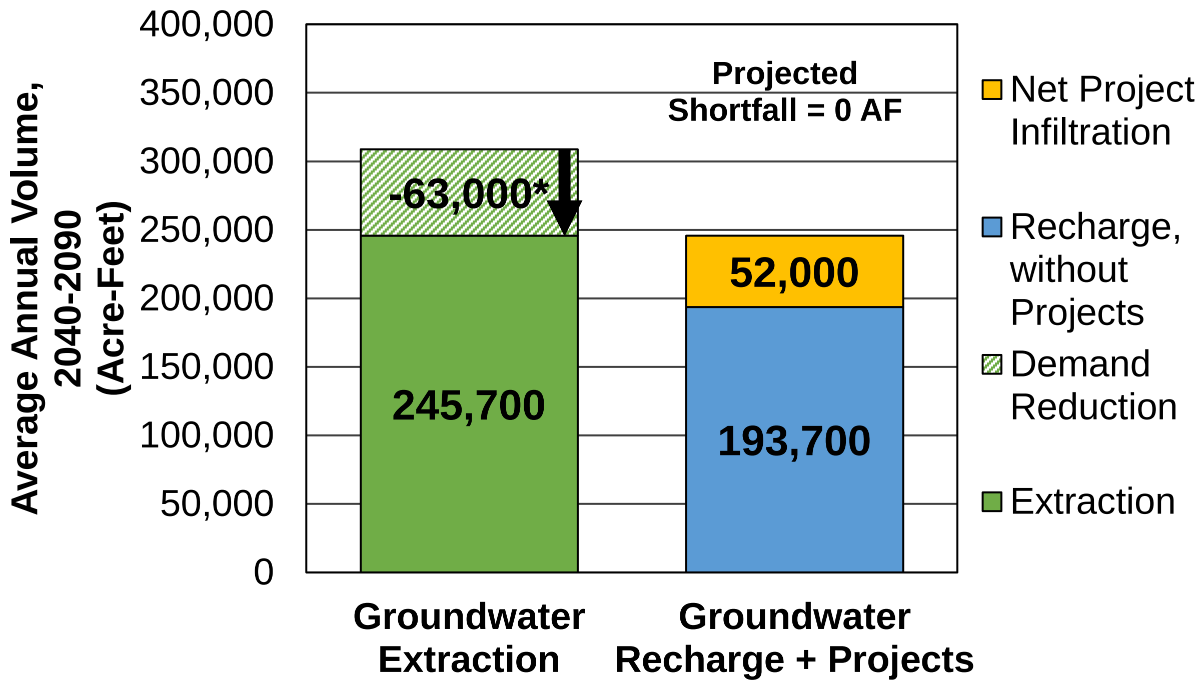
Two major time periods exist in the future projected model: the implementation period (2020-2039), during which PMAs are implemented to bring the Subbasin into sustainability, and the sustainability period (2040-2090), after which PMAs have been fully implemented. The projected with projects scenario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

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 completed. Thus, sustainable yield was only calculated for the sustainability period, after all PMAs identified in the GSP are fully implemented.

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 Section 10721(w)). In alignment with the GSP regulations and DWR's Sustainable Management Criteria BMP (DWR, 2017), the 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 was assumed to be zero over this 50-year period. Accounting for all uncertainties in groundwater system inflows and outflows, the sustainable yield is estimated to range between 184,300 AF and 307,100 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 245,700 AFY.

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



*Crop Water Use Reduction Program: County of Madera GSA-Chowchilla Subbasin 27,550 AF and TTWD GSA 1,700 AF. The balance of crop water use reduction is due to permanent recharge basins replacing irrigated area and increased use of surface water in lieu of groundwater.

Figure ES-4. Summary Groundwater Budget With Projects during Sustainability Period (2040-2090).

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	245,700	25%	184,300	307,100

[1] Confidence interval source: Professional judgment based on historical calculations.

ES-3 SUSTAINABLE MANAGEMENT CRITERIA

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 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 and depending on hydrologic conditions. DWR recognizes in the SGMA Best Management Practices (BMP) guidance documents that it may be acceptable for groundwater levels to temporarily exceed MTs during the GSP implementation period (prior to 2040) provided that the GSAs are managing groundwater and implementing PMAs as outlined in the GSP. 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.

Sustainability Indicator	Historical Period (Before 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 (Western Management Area)	Yes	Yes	Yes	No
Land Subsidence (Eastern Management Area)	No	No	Possibly	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] Surface water and groundwater are disconnected under existing conditions in most of the Subbasin. 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. A data gaps workplan for interconnected surface water (Appendix 3.I) will provide additional data to evaluate this sustainability indicator.

A summary of the sustainable management MTs, measurable objectives (MOs) and undesirable results is provided in **Table ES-3**. Locally defined undesirable results were 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. Descriptions and locations of the representative monitoring sites (RMS) for each sustainability indicator are provided in Section 3.

Table ES-3. Summary of MTs, MOs 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 elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.	Set equal to the Fall 2011 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2011 groundwater elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.	Greater than 25% of the same RMS wells below minimum threshold for two consecutive fall measurements.
Reduction of Groundwater Storage	Same as minimum thresholds for chronic lowering of groundwater levels.	Same as measurable objectives for chronic lowering of groundwater levels.	Greater than 25% of the same RMS wells 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	Subsidence rate across 75 percent 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 RMS wells above the MT for the same constituent due to GSP projects and/or management actions, 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 equal to historical conditions for a similar climatic/hydrologic period.	A percent of time surface water is connected to shallow groundwater equal to historical conditions for a similar climatic/hydrologic period.	Greater than 30 percent of RMS wells below MT 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 Chowchilla Subbasin begins after the GSP implementation period.

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 elevation at each RMS well.[7] 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 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 temporarily 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 Chowchilla Subbasin GSAs have expressed and formalized their clear commitment to fund and implement a Domestic Well Mitigation Program to provide assistance to owners of domestic wells and shallow wells that supply drinking water users (e.g., public water systems and state small water systems) adversely impacted by groundwater level declines during the GSP implementation period, prior to achieving sustainable groundwater conditions in 2040. The Domestic Well Mitigation Program will provide assistance to domestic and shallow drinking water supply wells owners adversely impacted by declining future 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. As described in Section 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved. After 2040, groundwater levels will stabilize at or above Fall 2015 levels, avoiding continued undesirable results for groundwater uses and users.

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 ISW, as described later in this 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 periodic evaluations 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,

[7] 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 elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.

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, 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 the Subbasin is tied to actions in neighboring subbasins, and the ability to meet IMs is also dependent on the successful implementation of 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 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 PMA that causes concentrations of key groundwater quality constituents to increase to concentrations exceeding 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). There are no known significant large-scale groundwater quality contamination plumes in regional groundwater aquifers within the Subbasin. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Subbasin; therefore, groundwater quality degradation is considered significant and unreasonable based on adverse impacts to this beneficial use. Significant and unreasonable degradation of water quality occurs when beneficial uses and users of 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

Regional groundwater levels have been below the stream channel bottoms in Chowchilla Subbasin for at least the last several years, and for many decades in most of the Subbasin. 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, 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 western boundary of Chowchilla 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 or other surface water conditions, interim SMC have been established for interconnected surface water (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 minimum thresholds are the same as the interim measurable objectives: 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 data (including recent data) preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Subbasin) and Lower Aquifers preferred;
- Relatively good match between observed and modeled water levels preferred for water levels monitoring wells.

The selected groundwater level indicator wells (Representative Monitoring Sites) 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. 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 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 implementing projects that provide additional surface water supply, 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 annual reports and/or the five-year periodic evaluation and GSP updates.

Three main types of projects are included in the Chowchilla Subbasin GSP: recharge, conveyance, and storage. Recharge projects are designed to support sustainability by increasing recharge. 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). Storage projects store additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping. 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 GSP includes one management action planned by the County of Madera GSA: a demand management program that will reduce demand by placing restrictions on groundwater pumping, among other actions. All PMAs are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies through recharge or reducing groundwater use. Together, the PMAs have been developed and planned to achieve the Chowchilla Subbasin sustainability goal by 2040.

The 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 well owners and shallow drinking water supply well owners (e.g., public water system and state small water systems). In their ongoing efforts to uphold these commitments, the GSAs plan, to the extent feasible, to prioritize project implementation efforts in the vicinity of public supply wells, especially Flood-MAR, on-farm recharge projects, multi-benefit projects, and voluntary land repurposing efforts that can be flexibly targeted to specific areas of need. By replenishing groundwater supplies in priority areas surrounding public supply wells, the PMAs are also expected to benefit the groundwater supplies available to the domestic well users in the Subbasin, many of whom are also located within these same priority areas.

The cost, timing, and gross groundwater benefit (yield) of the PMAs included in the GSP vary by GSA. Table ES-4 lists all of the PMAs, by GSA or implementing entity, and the estimated implementation timeline, capital cost, operating cost, and gross benefit of the projects. **Table ES-5** further summarizes the total gross benefits and costs of all PMAs developed for each GSA or implementing entity.

The gross yield across all PMAs at full implementation (2040) equals approximately 129,300 AFY. This includes the demand management program (management action) to be implemented by the Madera County GSA that will reduce net groundwater pumping by about 28,000 AFY.

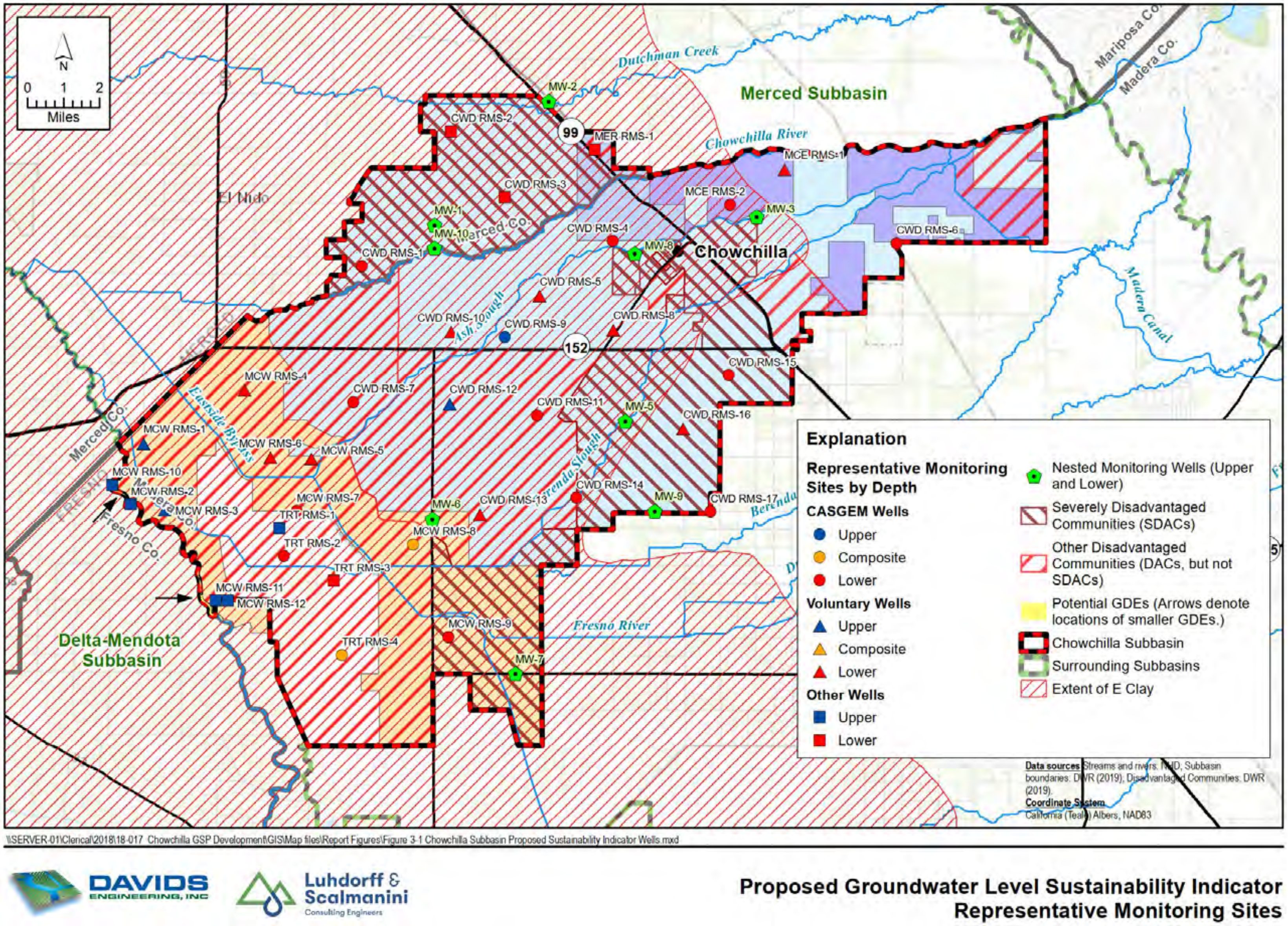


Figure ES-5. Groundwater Level Monitoring Network: CASGEM, Voluntary and Other Wells.

Table ES-4. Chowchilla Subbasin Projects and Management Actions.[1]

GSA[2]	Project	First Year of Implementation	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	Recharge Basin	2018	1,359	3.1	0.01
CWD	Flood-MAR	2020	5,836	N/A	0.2
CWD	Additional Recharge Basins (1,000 acres)	2021	10,803	38.6	0.5
CWD	Merced-Chowchilla Intertie	2035	7,350	6.7	1.5
CWD	Eastman Lake (Buchannan Dam) Enlargement	2040	8,753	49.2	0.2
Madera County (East)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	3,015	1.0	1.1
Madera County (West)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	27,953	118.0	0.7
Madera County (All)	Demand Management	2020	27,550	N/A	19.6[4]
Sierra Vista Mutual Water Company (SVMWC)[3]	SVMWC Recharge Basin	2020	4,344	7.5	0.2
TTWD	Poso Canal Pipeline / Settlement Agreement	2020	7,647	5.2	4.6
TTWD	Eastside Bypass Flood Water / Redtop Joint Banking	2021	24,657	24.5	0.7
Total			129,267	254	29.4

[1] Costs and benefits updated to remove CWD's Madera Canal Capacity Increase project from consideration. Other updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.
[2] PMAs summarized by each GSA, GSA subregion, or local agency responsible for implementation.
[3] SVMWC includes portions of both County of Madera GSA and County of Merced GSA.
[4] Costs of demand management include reduced economic activities in the County of Madera, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

Table ES-5. Summary of Chowchilla Subbasin Projects and Management Actions by GSA.[1]

GSA[2]	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	34,101	97.6	2.41
Madera County	58,518	119.0[3]	21.4[4]
SVMWC[3]	4,344	7.5	0.2
TTWD	32,304	29.7	5.3
Total	129,267	254	29.4

[1] Costs and benefits updated to remove CWD's Madera Canal Capacity Increase project from consideration. Other updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.
[2] PMAs summarized by each GSA or local agency responsible for implementation.
[3] SVMWC includes portions of both County of Madera GSA and County of Merced GSA.
[4] Costs of demand management include reduced economic activities in the County of Madera, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

ES-5 PLAN IMPLEMENTATION

As of January 2020, administering the GSP and monitoring and reporting progress was projected to cost approximately $1.2 million per year across all GSAs in the Chowchilla Subbasin. These total costs did not include:

- The costs of implementing the Domestic Well Mitigation Program, although the GSAs have expressed their clear and firm commitment to funding the Program. As of July 2022, the total annual cost of implementing the Domestic Well Mitigation Program is anticipated to range between approximately $1.18 million and $10,000 per year between 2023-2032, with higher costs expected in the first several years. Additional information is provided in **Appendix 3.D.**
- The costs of implementing the two data gaps workplans that the GSAs identified and developed in 2022-2023 (**Appendix 3.H and 3.I**). Additional information about the interconnected surface water and subsidence workplans is provided in **Section 2.2.2**.
- The capital and annual operating cost of PMAs.

The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports. The total costs are expected to be higher during years in which five-year periodic evaluations are required, and slightly lower during years in which annual reports are required.

Development of this 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 AF of groundwater pumped could 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 assessment 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 Fall 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 next 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-6**), the GSAs will begin implementing all other GSP activities in 2020, with full implementation of PMAs to achieve sustainability by 2040. **Figure ES-7** illustrates the GSP implementation schedule for PMAs implemented by each GSA (Madera County East and West correspond to the portion of the County of Madera GSA within each Management Area). The GSP implementation schedule also shows mandatory reporting and updating for all GSAs, including annual reports and five-year periodic updates (evaluations) 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 Chowchilla Subbasin to meet its sustainability goal by 2040 and comply with the SGMA regulations. During each five-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.

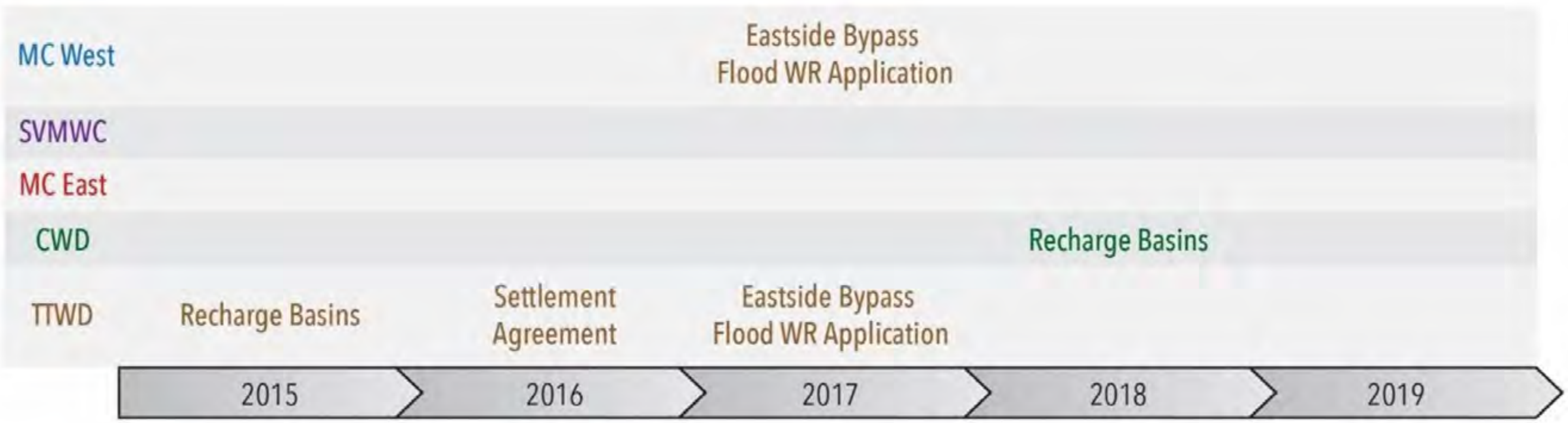


Figure ES-6. Chowchilla Subbasin Projects in Response to SGMA (2015-2019).

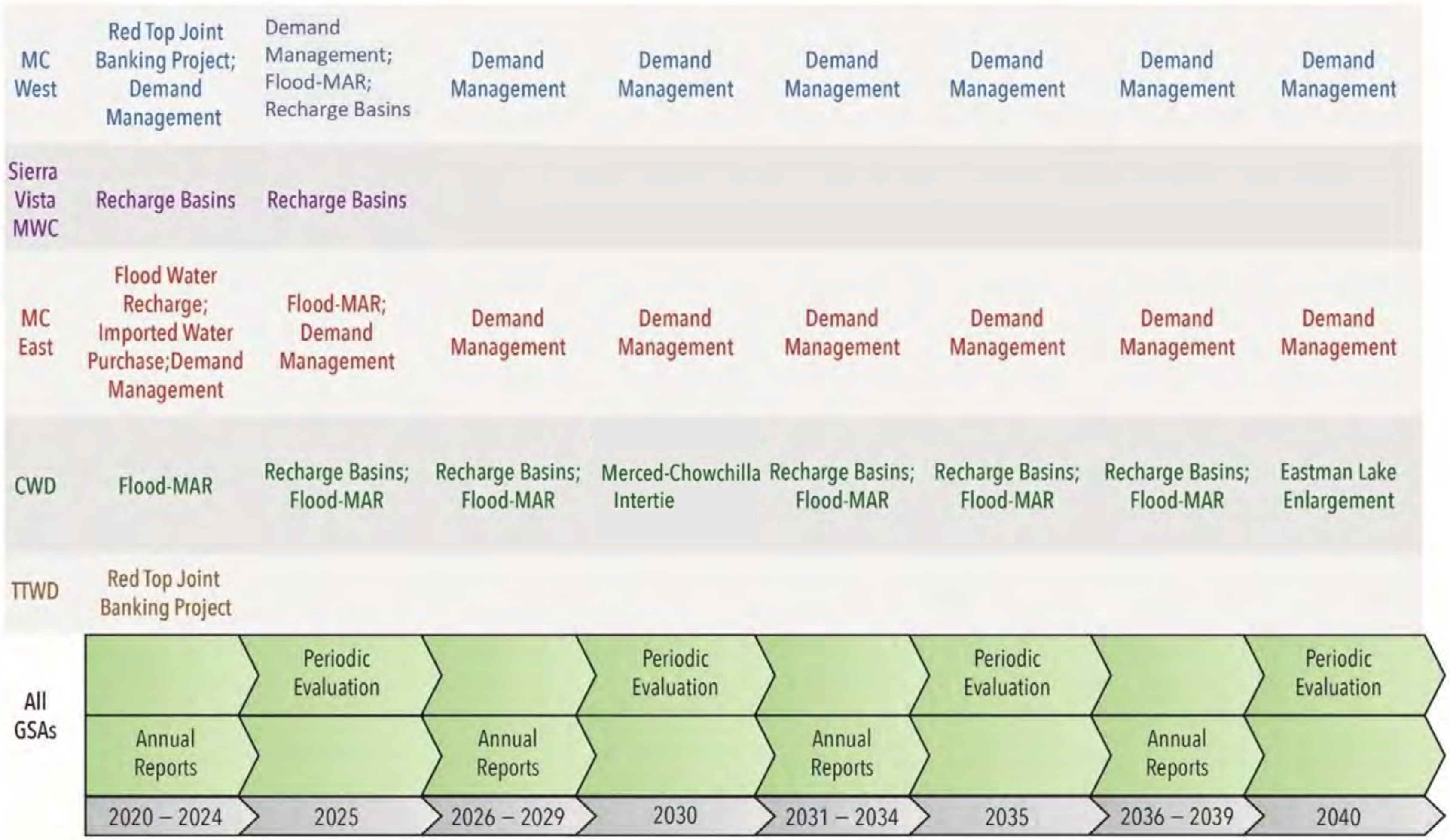


Figure ES-7. Chowchilla Subbasin Implementation Schedule (2020-2040).

1 INTRODUCTION

Groundwater serves as an important source of supply for agricultural, municipal, domestic, and industrial beneficial uses and users throughout the Chowchilla Subbasin[8], which underlies approximately 146,000 acres within Madera and Merced Counties. Agriculture in the Chowchilla Subbasin has historically relied on approximately 300,000 acre-feet (AF) of groundwater annually to produce an array of commodities that contribute to the agricultural economies of both Madera County and Merced County, which have a total combined value of over $5 billion dollars.[9] Groundwater also supports a large portion of domestic, municipal, and industrial water use in and around the City of Chowchilla. Thus, the sustainable management of groundwater in the Chowchilla Subbasin is important for long-term prosperity within Madera and Merced Counties.

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, or Plan) for the subbasin. Under this Plan, 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 Section 10721(x)[10] 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 Chowchilla Subbasin.

The Chowchilla Subbasin (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 Section 10720.7(a)(1)).

This GSP is the coordinated Plan for four GSAs that represent the entirety of the Chowchilla Subbasin area: Chowchilla Water District (CWD) GSA, County of Madera GSA – Chowchilla Subbasin (also referred to herein as Madera County GSA), County of Merced GSA – Chowchilla Subbasin (also referred to herein as Merced County GSA), and Triangle T Water District (TTWD) GSA. The Chowchilla Subbasin will satisfy

[8] Groundwater basin number 5-022.05, part of the San Joaquin Valley Groundwater Basin, as defined by DWR Bulletin 118 (DWR, 2003) and updated in 2016.

[9] 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). According to the Merced County Department of Agriculture, the gross value of all agricultural commodities in the County was $3,408,866,000 (Merced County 2017 Report on Agriculture).

[10] 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.

SGMA requirements with this single GSP that covers the entire Subbasin. The Chowchilla Subbasin is coordinating GSP development with the Madera Subbasin. An interbasin agreement was developed by all GSAs in the Chowchilla Subbasin detailing required GSP cooperation and coordination with neighboring GSAs in the Merced Subbasin.

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this GSP is to characterize groundwater conditions in the Chowchilla 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.

This GSP also serves to comply with DWR's requirements that the Chowchilla Subbasin GSAs prepare, adopt, and implement a plan "consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan 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).

1.2 Sustainability Goal

As mandated under 23 CCR Section (§) 354.24, GSAs within the Chowchilla 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 Chowchilla 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 Section 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 GSP details accounting of the Chowchilla 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 GSP's corresponding section.

1.3 Agency Information

Four local agencies have formed GSAs covering the full extent of the Chowchilla Subbasin: Chowchilla Water District (CWD) GSA, Madera County (Madera Co) GSA, County of Merced Chowchilla GSA (Merced Co), and Triangle T Water District (TTWD) GSA. **Figure 1-1** delineates the areas managed exclusively by each GSA.

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

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

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

GSA	GSA Abbreviation	GSA Area, Acres	Average Irrigated Area (2015), Acres
Chowchilla Water District GSA	CWD GSA	85,200	71,400
County of Madera GSA - Chowchilla[1]	Madera Co GSA	45,100	37,100
County of Merced GSA - Chowchilla	Merced Co GSA	1,300	1,200
Triangle T Water District GSA[1]	TTWD GSA	14,700	13,700
	Total	146,300	123,400

[1] In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.

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

Groundwater Sustainability Agency	Contact Person	Contact Title	Mailing Address	Phone Number	Email Address
Chowchilla Water District	Doug Welch[1]	General Resources Manager, Chowchilla Water District	327 S. Chowchilla Blvd., Chowchilla, CA 93610	(559) 665-3747	dwelch@cwdwater.com
County of Madera GSA - Chowchilla	Stephanie Anagnoson	Director of Water and Natural Resources, County of Madera	200 W. Fourth Street, Madera, CA 93637	(559) 598-0362	stephanie.anagnoson@maderacounty.com
County of Merced GSA - Chowchilla	Lacey McBride	Water Resources Coordinator, County of Merced	2222 M Street, Merced, CA 95340	(209) 385-7654	lacey.mcbride@countyofmerced.com
Triangle T Water District	Brad Samuelson	Water & Land Solutions, LLC GSA Manager	2941 Hwy 59 Merced, CA 95341	(559) 658-8487	bsamuelson@waterandlandsolutions.com

[1] Doug Welch is the Plan Manager (23 CCR § 354.6(c)).

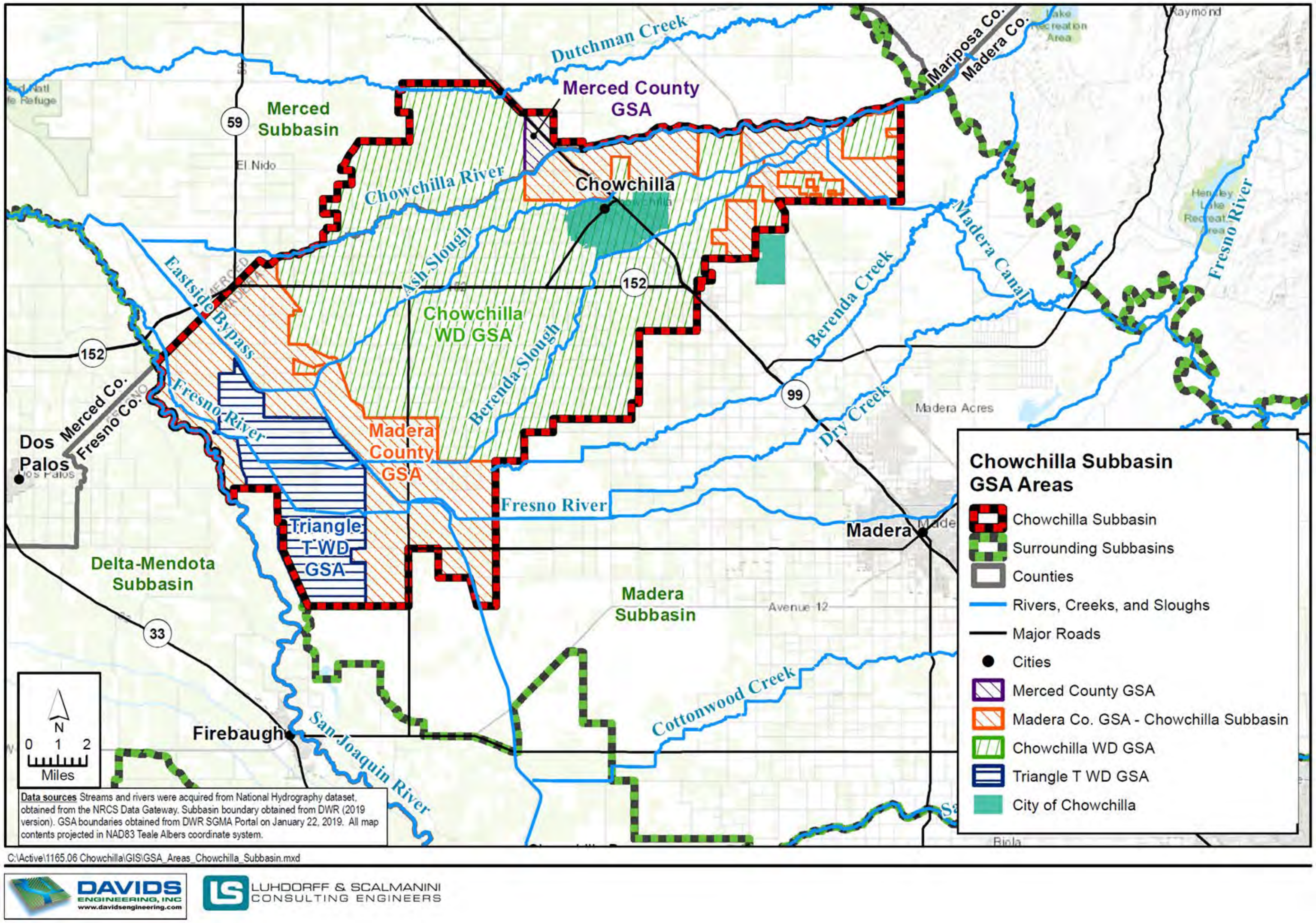


Figure 1-1. Chowchilla Subbasin GSAs Map.[1]

[1] In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.

1.3.1 Organization and Management Structure of the Groundwater Sustainability Agencies

A summary is provided below for each GSA detailing its formation date, management structure, and background regarding typical land use and water supply availability. This GSP has been developed through joint coordination between the GSAs within the Chowchilla Subbasin GSP Advisory Committee, also described below.

1.3.1.1 Chowchilla Water District GSA

Chowchilla Water District (CWD) GSA was formed on December 14, 2016 and manages approximately 85,200 acres of the Chowchilla Subbasin, representing the largest jurisdictional area in the Subbasin (**Figure 1-2**). CWD GSA includes the portion of the City of Chowchilla that falls within the District service area. As of 2015, much of the GSA area is agricultural land (85%) and developed land (11%), including urban, semi-agricultural, and industrial land. The remaining area is primarily native vegetation (3%) with some water surface (1%).

In 2015, irrigated agricultural land represented over 71,000 acres in the CWD GSA. Much of this area is used for cultivating almonds, though mixed pasture, alfalfa, corn, and grapes are also grown across substantial portions of the GSA. CWD GSA receives substantial surface water supplies to support agriculture. These include CVP supplies received under contract with Reclamation from Buchanan Dam and the Madera Canal (**Figure 1-3**). CWD also diverts water from the Chowchilla River under its appropriative water rights on the Chowchilla River System and purchases water from Merced Irrigation District. Remaining agricultural water demand in CWD GSA is met by privately owned groundwater wells.

The Board of Directors for CWD GSA is the Chowchilla Water District Board of Directors. CWD GSA Board of Directors meetings are held concurrently with the regular CWD Board of Directors meetings, which are typically scheduled on the second Wednesday of each month at 1:30 p.m. These meetings are open to the public and are held at the Chowchilla Water District offices (327 South Chowchilla Boulevard, Chowchilla, CA, 93610).

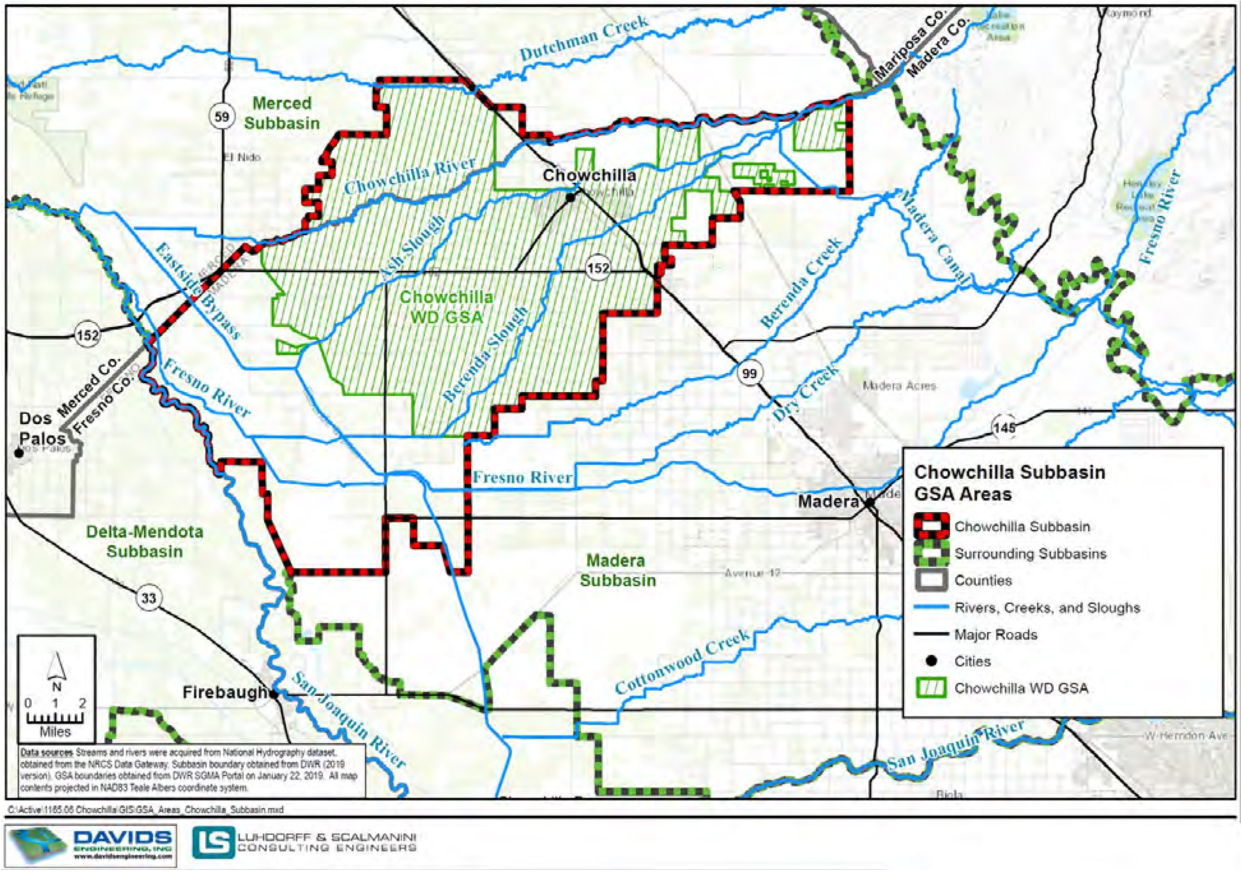


Figure 1-2. Chowchilla Water District GSA Map.

Figure 1-3. Madera Canal Mile 33.6 Deliveries to Chowchilla Water District GSA.

1.3.1.2 Madera County GSA

Madera County (Madera Co) GSA was formed on January 24, 2017 and manages approximately 45,100 acres of the Chowchilla Subbasin (**Figure 1-4**).[11] As of 2015, the majority of this area is comprised of agricultural land (82%) or native vegetation (12%). The remaining area consists of developed land (includes urban, semi-agricultural, and industrial land) and some water surface (6%).

In 2015, irrigated agricultural land represented approximately 37,100 acres in Madera Co GSA. Much of this area is used for cultivating orchard crops (primarily almonds and pistachios), corn, mixed pasture, alfalfa, and grapes (**Figure 1-5**). Surface water supplies available for agriculture in Madera Co GSA are limited to riparian and appropriative deliveries to individual water rights users along waterways within the GSA. Thus, agricultural water demand in Madera Co GSA is primarily fulfilled by groundwater.

North of the City of Chowchilla, a portion of Madera Co GSA overlaps with Sierra Vista Mutual Water Company (SVMWC). Within this GSP, the water budgets, projects, and management actions developed for SVMWC are applicable to this portion of Madera Co GSA.

The Board of Directors for Madera Co GSA is the Madera County Board of Supervisors. As the Board of Directors, the Board of Supervisors meets on the first Tuesday of each month at the end of the 10 a.m. Board of Supervisors Meeting. 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 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.

[11] In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.

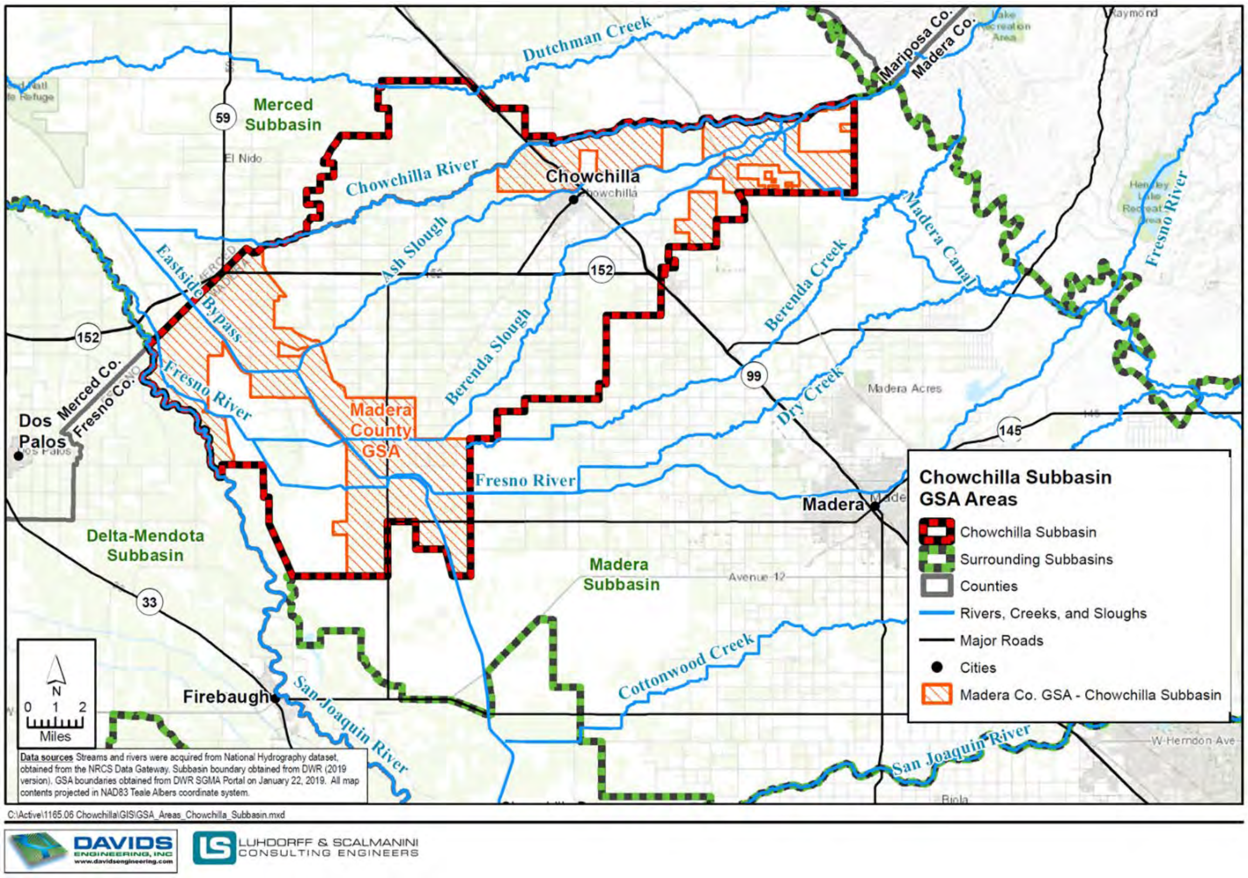


Figure 1-4. Madera County GSA Map.

Figure 1-5. Viticulture in Madera County GSA.

1.3.1.3 Merced County GSA

County of Merced Chowchilla (Merced Co) GSA was formed on February 21, 2017 and manages approximately 1,300 acres of the Chowchilla Subbasin (**Figure 1-6**). As of 2015, the majority of this area is comprised of agricultural land (89%) or developed land (10%) (urban, semi-agricultural, or industrial land). The remaining area consists of native vegetation or water surfaces (1%).

In 2015, irrigated agricultural land represented approximately 1,200 acres in Merced Co GSA. This area is used primarily for cultivating mixed pasture, alfalfa, corn, and orchard crops (**Figure 1-7**). Surface water supplies available to agriculture in Merced Co GSA include deliveries from CWD and individual water rights usage along the Chowchilla River. Remaining agricultural water demand in Merced Co GSA is fulfilled by privately owned groundwater wells.

In the Chowchilla Subbasin, Merced Co GSA lies almost entirely within the jurisdictional bounds of SVMWC. SVMWC also overlaps with a portion of Madera Co GSA. Within this GSP, the water budgets, projects, and management actions developed for SVMWC are applicable to the entirety of Merced Co GSA and the portion of Madera Co GSA overlapping SVMWC.

The Board of Directors for Merced Co GSA is the Merced County Board of Supervisors. The Merced Co GSA Board of Directors meetings are held as needed following the regular Merced County Board of Supervisors meetings. The regularly scheduled Board of Supervisors meetings are typically held on the first and third Tuesday of each month at 10:00 a.m. and are open to the public at the Merced County Administration Building (2222 M Street, 3rd Floor, Merced, CA 95340).

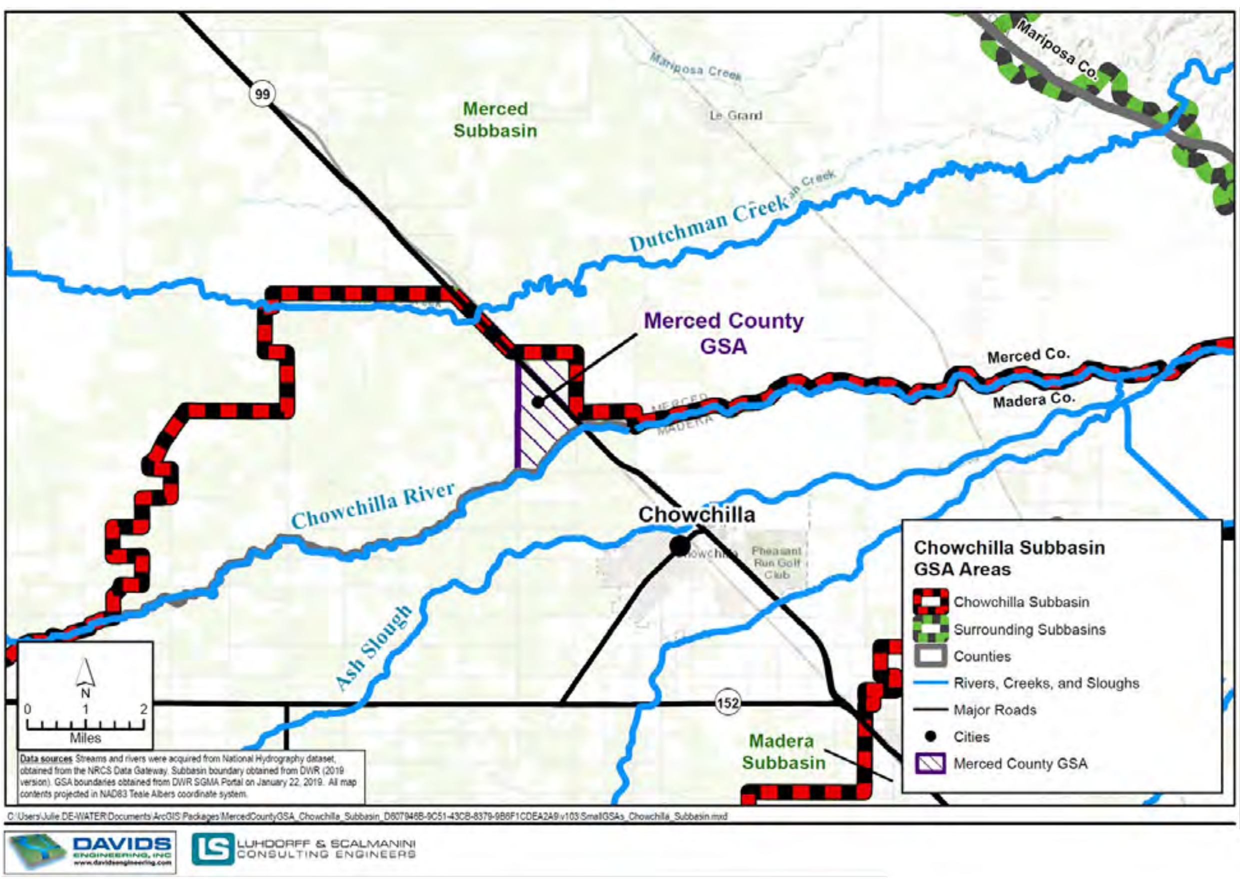


Figure 1-6. Merced County GSA Map.

Figure 1-7. Orchard in Merced County GSA.

1.3.1.4 Triangle T Water District GSA

Triangle T Water District (TTWD) GSA was formed on October 26, 2017 and manages approximately 14,700 acres of the Chowchilla Subbasin (**Figure 1-8**).[12] As of 2015, most of this area is comprised of agricultural land (94%). Small portions (6%) of the GSA are also covered by native vegetation, developed land (urban, semi-agricultural, or industrial land), and water surfaces.

In 2015, irrigated agricultural land represented approximately 13,700 acres in TTWD GSA. At present, this area is used primarily for cultivating almonds and pistachios (**Figure 1-9**). Prior to SGMA, surface water supplies available to agriculture in TTWD GSA were limited to water rights users along waterways in the district. Remaining agricultural water demand in TTWD GSA has historically been fulfilled by groundwater.

The Board of Directors for TTWD GSA is the Triangle T Water District Board of Directors. TTWD GSA Board of Directors meetings are held concurrently with the regular Triangle T Water District Board of Directors meetings on the second Thursday of each month at 1:00 pm. These meetings are open to the public and are held at Triangle T Ranch.

[12] In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.

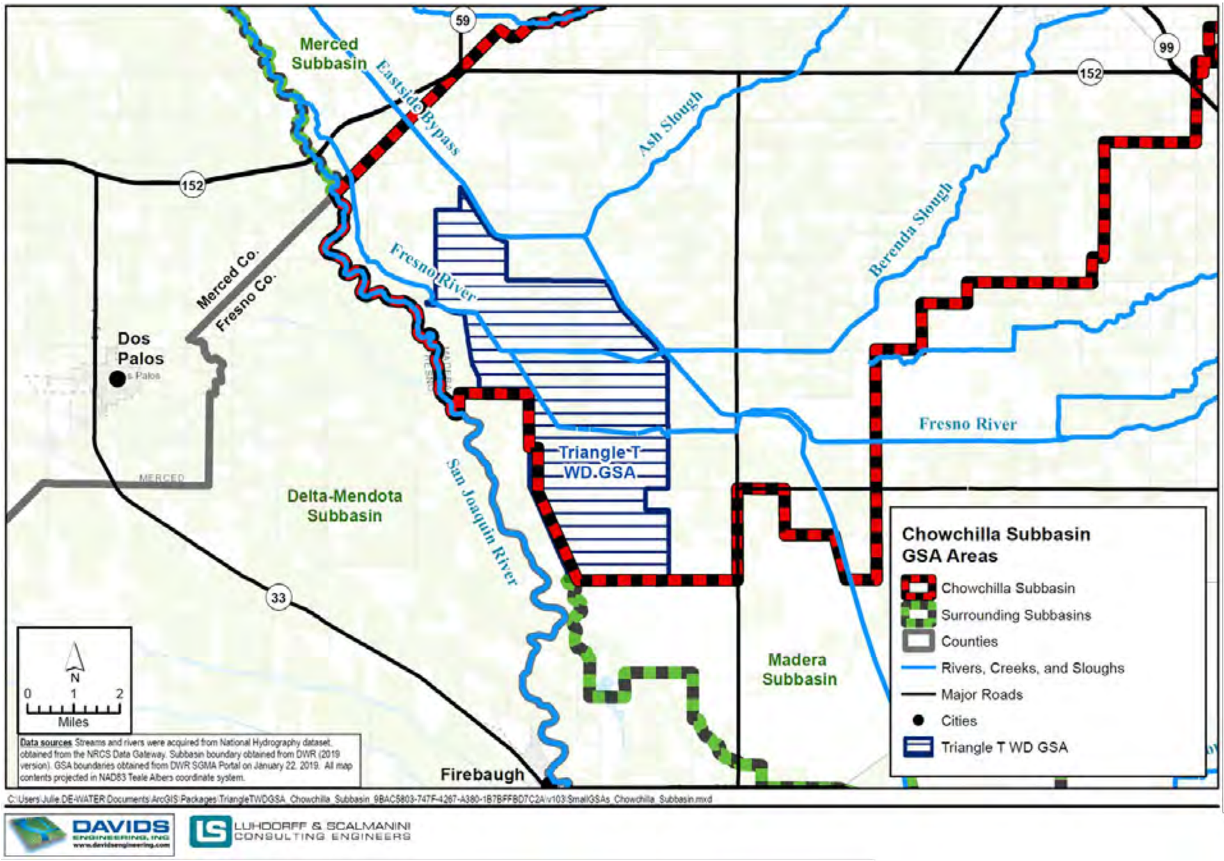


Figure 1-8. Triangle T Water District GSA Map.

Figure 1-9. Orchard Crops and Flood-MAR field in Triangle T Water District.

1.3.1.5 Chowchilla Subbasin GSP Advisory Committee

The Chowchilla Subbasin GSAs have jointly formed the Chowchilla Subbasin GSP Advisory Committee (the "Committee"). The Committee was formed in September 2017 by a memorandum of understanding (MOU) and serves as the coordinating body for guiding the Chowchilla Subbasin GSAs through development of the Chowchilla Subbasin GSP. In this role, the Committee advises the GSAs' governing bodies on GSP development, implementation, and public engagement consistent with each GSA's policies.

The aim of the Committee is to facilitate cooperation between GSAs to obtain and share costs related to consulting, administrative, and management services needed to efficiently develop a GSP, to conduct outreach to other basin agencies and private parties, and to identify mechanisms for the management and funding commitments reasonably anticipated to be necessary for the purposes of the MOU.

The Committee members and staff include at least one representative of each GSA. Committee meetings are typically held monthly and are open to the public.

1.3.2 Legal Authority of the GSA

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

Chowchilla Water District, Madera County, Merced County, and Triangle T Water District are local agencies[13] overlying the Chowchilla Subbasin as defined under SGMA and are therefore eligible to serve as separate GSAs within the Chowchilla Subbasin (CWC Section 10723(a)). Pursuant to CWC Section 10724(a), Madera County and Merced County each serve as the GSA for all areas within their respective counties in the Chowchilla Subbasin that are outside the management area of other GSAs.

Each agency held public hearings regarding the establishment of a GSA in accordance with CWC Section 10723(b). Public notice for these hearings was provided in accordance with Government Code Section 6066. After holding these hearings, the governing bodies of each agency adopted resolutions to establish the associated GSAs.

Pursuant to CWC Section 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 Estimated Cost of GSP Implementation

The estimated annual costs of GSP implementation for the four GSAs included under this GSP are shown in **Figure 1-10** (in current dollars). Additional detail is provided in Chapter 5 of this GSP. Also illustrated are the estimated annual operations and maintenance (O&M) costs (in current dollars) for all GSP PMAs described in Chapter 4. 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 $6.5 million per year in 2020 to over $12 million per year by 2040. Project costs will be refined by GSAs as the GSP is implemented. GSA implementation costs total about $1.05 million per year.

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[13] California Water Code Section 10721(n): "Local agency" means a local public agency that has water supply, water management, or land use responsibilities within a groundwater basin.

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.

Table 1-4 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 129,300 AF to Subbasin recharge with an estimated average annual operating cost of approximately $29,400,000. 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 Chowchilla Subbasin GSAs is around $254 million dollars. All costs are preliminary estimates that will be refined by the GSAs. Additional information is provided in Chapter 4 of this GSP.

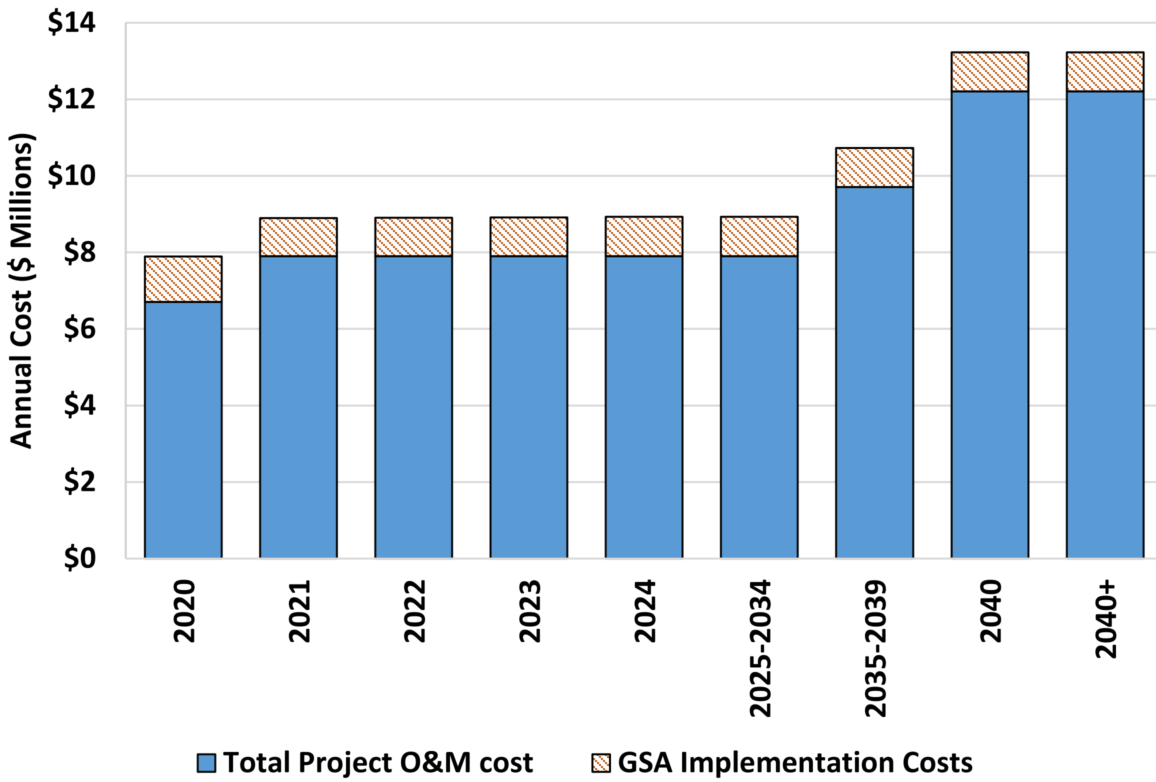

Figure 1-10. Chowchilla Subbasin Estimated Annual Costs (in current dollars) for Project O&M and GSA Implementation.[1]

[1] Costs shown do not reflect any updates or changes to projects, management actions, or planned GSP implementation activities identified since January 2020. Updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.

Table 1-4. Summary of Chowchilla Subbasin Groundwater Sustainability Plan Projects and Management Actions by GSA.[1]

GSA[2]	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	34,101	97.6	2.41
Madera County	58,518	119.0[3]	21.4[4]
SVMWC[3]	4,344	7.5	0.2
TTWD	32,304	29.7	5.3
Total	129,267	254	29.4

[1] Costs and benefits updated to remove CWD's Madera Canal Capacity Increase project from consideration. Other updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.
[2] Projects and management actions summarized by each GSA or local agency responsible for implementation.
[3] SVMWC includes portions of both Madera County GSA and Merced County GSA.
[4] The cost of the County's demand management program includes approximately $19.1 million per year in direct economic impacts (crop revenue losses), excluding any multiplier effects.

1.4 GSP Organization

This GSP has been developed by the consulting team on behalf of CWD GSA, Madera Co GSA, Merced Co GSA, and TTWD GSA. The consulting team is 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 GSP is organized in accordance with 23 CCR § 354 as follows:

- Chapter 1 of this Plan provides an introduction to the Chowchilla Subbasin GSAs and the development of this GSP.
- Chapter 2 provides a detailed summary of the 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).
- Chapter 3 establishes the Subbasin sustainability goal to be achieved through coordination among all GSAs in the Subbasin. This section also establishes MOs, 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.
- Chapter 4 proposes PMAs for achieving the Subbasin sustainability goal.
- Chapter 5 proposes the Plan implementation strategy, costs, and schedule.

To facilitate DWR review and assure compliance with all applicable GSP regulations, **Table 1-5** was prepared to cross-reference between sections of this GSP to applicable sections and the GSP regulations. Terminology in this GSP has also been used in alignment with the SGMA definitions provided in CWC Section 10721 and in 23 CCR § 351. These definitions are provided as **Appendix 1.F.** of this GSP.

Table 1-5. Cross Reference of GSP Regulations[14] 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 Section 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 Section 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
	16. Groundwater Conditions	(a)-(g)	Description of current and historical groundwater conditions including: 1. Groundwater elevation 2. Change in storage 3. Seawater intrusion	2.2.2

[14] 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
2. Basin Setting			4. Groundwater quality issues 5. Land subsidence 6. Interconnected surface water systems 7. Groundwater dependent ecosystems	
	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, MTs, MOs, 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
	28. Minimum Thresholds	(a)	Establish MTs to quantify groundwater conditions for each applicable sustainability indicator.	3.3
		(b)-(d)	Describe information and criteria to select, establish, justify, and quantitatively measure MTs.	3.3
	30. Measurable Objectives	(a)-(g)	Establish MOs, including interim milestones in increments of five years, to achieve and maintain the Subbasin sustainability goal.	3.2

Subarticle	Section	Paragraph	Requirement	GSP Section
4. Monitoring Networks	32. Introduction to Monitoring Networks	-	Description of monitoring network, monitoring objectives, monitoring protocols, and data reporting.	3.5
	34. Monitoring Network	(a), (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 Plan Area is defined as the Chowchilla Subbasin (5-022.05), part of the San Joaquin Valley Groundwater Basin, as described in Bulletin 118 (DWR, 2003) updated in 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), with boundary updates approved in late 2018. The Subbasin is bounded in the south and east by the Madera Subbasin, in the west by the San Joaquin River and the Delta-Mendota Subbasin, and in the north by the Merced Subbasin (**Figure 1-1**).

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,[15] 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**, four GSAs cover the Chowchilla Subbasin: CWD GSA, Madera Co GSA, Merced Co GSA, and TTWD GSA. These four GSAs have agreed to cooperate and develop a single GSP for the Chowchilla Subbasin.

Table 1-2 and **Figure 1-1** delineate the areas managed exclusively by each GSA in this GSP and portions of the subbasins adjacent to the Plan Area. No area in the Subbasin is covered by an alternative. The Subbasin is within the jurisdictional boundaries of Madera County and Merced County and is covered by the respective general plans of the counties. The area covered by the City of Chowchilla General Plan is contained within the CWD GSA boundaries. The Chowchilla Subbasin is not adjudicated and contains no considerable state land or federal land.[16]

2.1.1.1 Land Uses

Land in the Chowchilla Subbasin is broadly classified across three land use sectors: agricultural, urban, and native vegetation. Agricultural land use (and water use) encompasses all agricultural crops reported in the Chowchilla Subbasin, including idle agricultural land and dairies. Urban land use includes urban, industrial, and semi-agricultural land. Native vegetation land use includes all land covered by native vegetation and water surfaces.

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

[16] Federal land includes primarily rights of way along canals conveying USBR Central Valley Project water.

Figure 2-1 depicts land use in the Chowchilla Subbasin as reported in the 2011 DWR Madera County Land Use Survey and 2012 DWR Merced County Land Use Survey spatial coverages[17]. Annual land use areas within Chowchilla Subbasin were derived from the aforementioned DWR spatial land use surveys of Madera and Merced Counties, Land IQ remotely sensed land use data obtained through DWR, and Madera County and Merced 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 three sectors are summarized in **Figure 2-2** and **Table 2-1** for the entire Chowchilla Subbasin between 1989-2015. Agricultural land use categories are further detailed in **Figure 2-3** and **Table 2-2**. Average land use across each sector and category is provided for the 1989-2014 historical water budget period described below in Section 2.2.3. Land use summaries are provided for each GSA in **Appendix 2.F**.

[17] The 2011 DWR Madera County Land Use Survey and 2012 DWR Merced County Land Use Survey are 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.

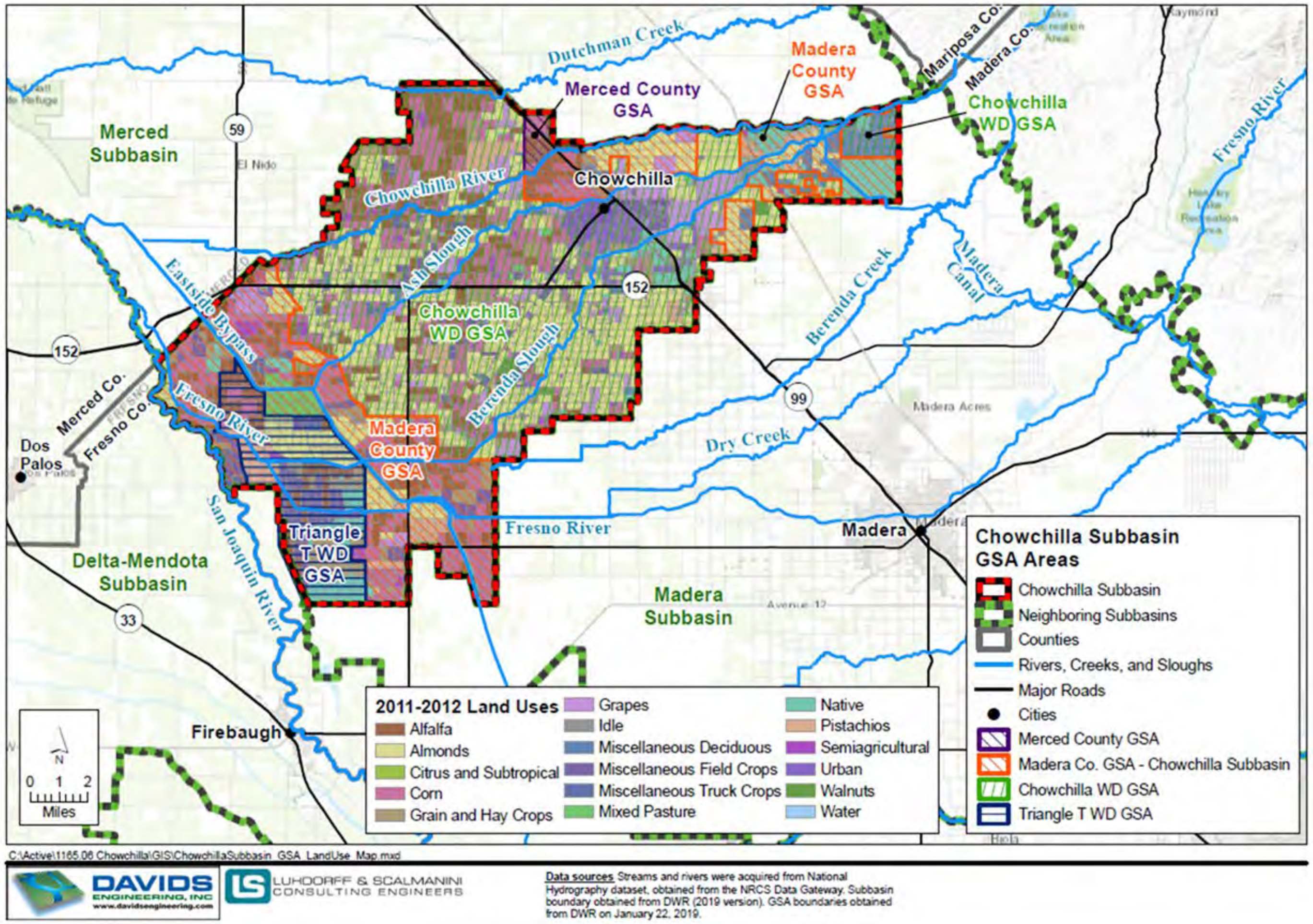

Figure 2-1. Chowchilla Subbasin Land Use Map.[18]

[18] Land uses extracted from the 2011 DWR Madera County and 2012 DWR Merced County spatial land use survey results.
Water User Sectors: Native Vegetation (Native and Water land uses), Urban (Semiagricultural and Urban land uses), and Agricultural (all other land uses).
Water Source Type: The Urban water use sector uses groundwater. The Agricultural water use sector uses a mixture of groundwater and surface water sources (CVP and local supplies are used for agriculture in Chowchilla WD GSA; local supplies are used in all other GSAs). The mixture of groundwater and surface water sources depends on the GSA (see **Appendices 2.F.a.** through **2.F.e**).

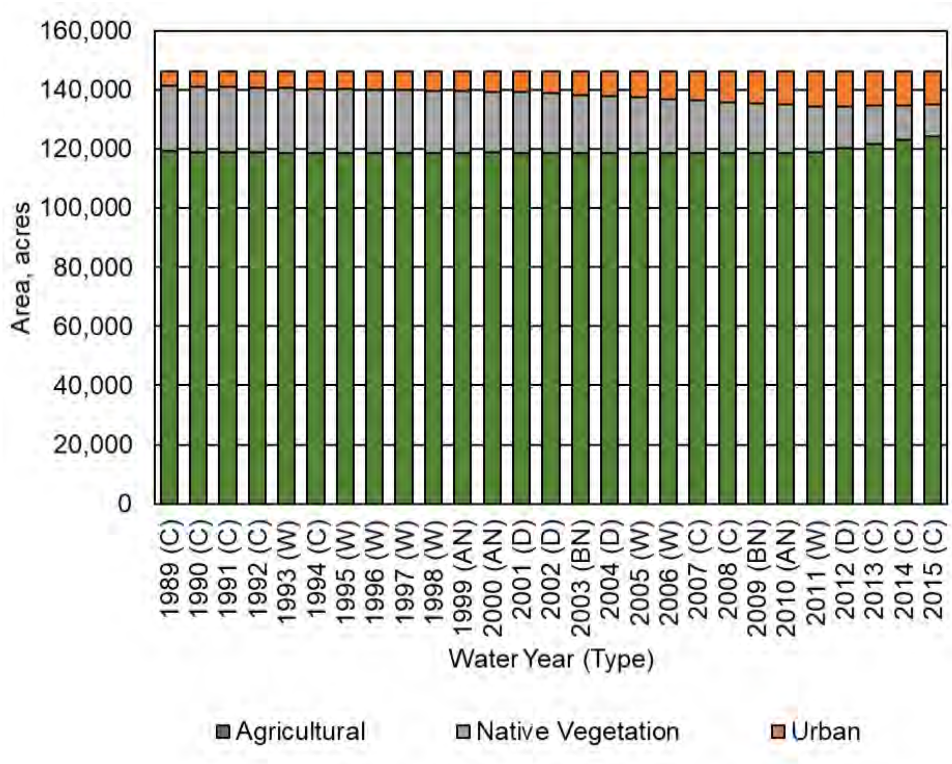

Figure 2-2. Chowchilla Subbasin Land Use Areas.

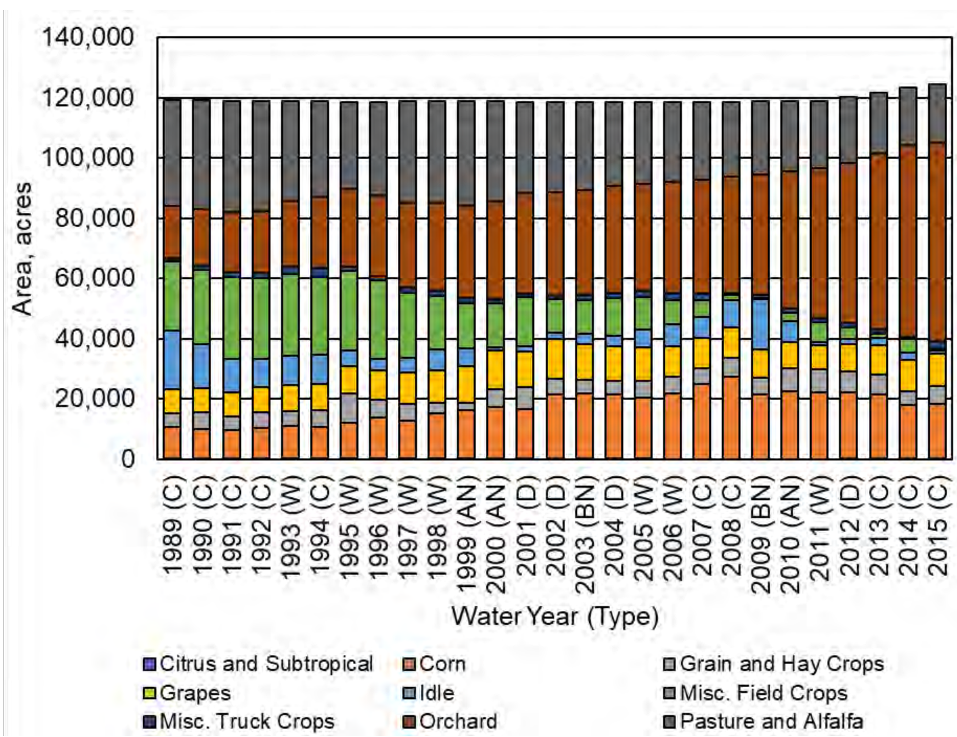

Figure 2-3. Chowchilla Subbasin Agricultural Land Use Areas.

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

Water Year (Type)	Agricultural	Native Vegetation[1]	Urban[2]	Total
1989 (C)	119,134	22,046	5,145	146,325
1990(C)	119,000	22,040	5,285	146,325
1991 (C)	118,929	21,960	5,436	146,325
1992 (C)	118,784	21,942	5,599	146,325
1993 (W)	118,737	21,824	5,764	146,325
1994 (C)	118,658	21,730	5,936	146,325
1995 (W)	118,601	21,612	6,112	146,325
1996 (W)	118,634	21,411	6,280	146,325
1997 (W)	118,667	21,210	6,448	146,325
1998 (W)	118,700	21,010	6,615	146,325
1999 (AN)	118,733	20,809	6,783	146,325
2000 (AN)	118,766	20,608	6,950	146,325
2001 (D)	118,577	20,613	7,135	146,325
2002 (D)	118,605	20,156	7,564	146,325
2003 (BN)	118,611	19,666	8,048	146,325
2004 (D)	118,616	19,177	8,531	146,325
2005 (W)	118,623	18,686	9,015	146,325
2006 (W)	118,629	18,197	9,499	146,325
2007 (C)	118,635	17,707	9,982	146,325
2008 (C)	118,641	17,219	10,465	146,325
2009 (BN)	118,648	16,727	10,949	146,325
2010 (AN)	118,653	16,238	11,433	146,325
2011 (W)	118,861	15,570	11,894	146,325
2012 (D)	120,293	14,184	11,848	146,325
2013 (C)	121,760	12,822	11,743	146,325
2014 (C)	123,247	11,425	11,653	146,325
2015 (C)	124,350	10,645	11,330	146,325
Average (1989-2014)	119,067			

[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. Chowchilla Subbasin Agricultural Land Use Areas (Acres).

Water Year (Type)	Citrus and Subtropical	Corn	Grain and Hay Crops	Grapes	Idle	Misc. Field Crops	Misc. Truck Crops	Orchard[1]	Pasture and Alfalfa	Total
1989 (C)	59	10,439	4,590	8,023	19,511	22,850	1,201	17,449	35,012	119,134
1990 (C)	64	9,875	5,545	8,033	14,688	24,528	1,521	18,680	36,065	119,000
1991 (C)	67	9,519	4,369	8,119	11,065	27,411	1,566	19,889	36,925	118,929
1992 (C)	67	10,302	5,097	8,387	9,450	26,605	1,815	20,739	36,322	118,784
1993 (W)	67	10,845	4,993	8,529	9,912	27,249	2,162	22,078	32,902	118,737
1994 (C)	64	10,691	5,287	8,823	9,761	25,913	2,834	23,832	31,454	118,658
1995 (W)	112	11,782	9,891	8,981	5,264	26,486	1,178	25,975	28,932	118,601
1996 (W)	146	13,597	5,919	9,759	3,729	26,040	1,543	26,709	31,193	118,634
1997 (W)	135	12,628	5,686	10,325	4,768	21,525	1,785	28,138	33,677	118,667
1998 (W)	34	15,211	3,462	10,753	6,930	17,799	1,530	29,306	33,674	118,700
1999 (AN)	78	16,084	2,457	12,262	5,926	14,983	1,591	30,817	34,535	118,733
2000 (AN)	83	17,212	5,730	12,941	966	14,844	1,199	32,292	33,500	118,766
2001 (D)	72	16,574	7,383	11,604	1,683	16,445	1,197	33,159	30,462	118,577
2002 (D)	85	21,273	5,408	13,044	1,983	11,156	1,240	34,368	30,049	118,605
2003 (BN)	39	21,785	4,537	11,820	3,432	11,190	1,533	35,020	29,255	118,611
2004 (D)	37	21,217	4,860	11,199	3,520	12,484	1,876	35,279	28,144	118,616
2005 (W)	33	20,227	5,845	10,846	5,927	10,907	1,980	35,569	27,288	118,623
2006 (W)	30	21,811	5,595	10,139	7,070	8,117	2,269	36,905	26,693	118,629
2007 (C)	26	25,012	5,039	10,115	6,829	5,710	2,174	37,866	25,865	118,635
2008 (C)	21	27,377	6,092	10,023	9,086	1,724	677	38,640	25,002	118,641
2009 (BN)	18	21,245	5,664	9,386	16,696	398	1,153	39,895	24,193	118,648
2010 (AN)	22	22,514	7,498	8,822	6,866	2,918	1,201	45,530	23,281	118,653
2011 (W)	17	21,979	7,679	8,133	890	6,889	1,228	49,602	22,445	118,861
2012 (D)	46	22,131	6,950	8,940	1,723	3,875	1,301	53,289	22,037	120,293
2013 (C)	87	21,465	6,605	9,755	2,307	1,254	1,426	58,411	20,449	121,760
2014 (C)	190	17,660	4,510	10,624	2,236	4,497	785	63,752	18,992	123,247
2015 (C)	130	18,117	5,805	10,934	1,085	666	2,479	65,699	19,435	124,350
Average (1989-2014)	65	17,325	5,642	9,976	6,624	14,377	1,537	34,353	29,167	119,067

[1] Orchard crops include primarily almonds and pistachios, as well as walnuts and miscellaneous deciduous crops.

2.1.1.2 Groundwater Wells

The spatial distribution of domestic wells and irrigation wells within the Chowchilla Subbasin, by well type and section, are shown in **Figures**[19] **2-4a and 2-4b.** Summaries of domestic wells in the Chowchilla Subbasin were compiled based on the best available data in DWR's Well Completion Report (WCR) dataset (DWR, 2022). Characteristics of domestic wells were summarized for WCRs of new wells constructed since 1970 and are presented in **Table 2-3**. Records for a total of 500 domestic wells exist in the WCR dataset. Total well depths for domestic wells in the WCR dataset range from 140 to 960 feet deep, with an average well depth of 377 feet. The GSAs recently completed an inventory of domestic wells in the Subbasin. As part of the Chowchilla Subbasin Domestic Well Inventory project, well permits were compared to the WCR dataset to evaluate the completeness of the WCR dataset. Comparisons were made in each year since 1990, beginning the first year that well permit data was available. A total of 439 domestic well permits were issued in the Subbasin since 1990 compared to 375 domestic well WCRs available for the same period. This suggests that the DWR WCR dataset may underrepresent the number of domestic wells in the Subbasin (ratio of 1.17 well permits to WCRs). No information on well construction characteristics (e.g., depth, screened interval) are currently available for well permits. Additional detail on domestic wells in the Chowchilla Subbasin is presented in the Domestic Well Inventory in **Appendix 2.G**.

Characteristics of agricultural wells were also summarized based on WCRs since 1970, as presented in **Figure 2-4b** and **Table 2-3**. A total of 749 agricultural well WCRs since 1970 exist in the DWR WCR dataset. Total well depths range from 130 to 1,960 feet deep with an average depth of 597 feet (**Table 2-3**). Similar to the analyses of domestic wells, well permits since 1990 for agricultural wells were compared to the WCR dataset to evaluate the completeness of the WCR dataset. A total of 557 new agricultural well permits were issued since 1990 compared to 443 agricultural well WCRs in DWR's dataset over the same period. This suggests the WCR data may underrepresent the number of agricultural wells in the Subbasin (ratio of 1.26 well permits to WCRs); however, as noted above, no information on well construction characteristics (e.g., depth, screened interval) are currently available for well permits.

A list of identified public supply wells in the Chowchilla Subbasin was compiled based on the best available data in the DWR WCR (**Figure 2-5a**) and data available through the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) (SWRCB, 2022a) and Groundwater Ambient Monitoring and Assessment Program (GAMA) (SWRCB, 2022b). **Figure 2-5b** presents the locations of public supply wells in the Subbasin, identified by activity status. **Table 2-4** presents information on public water supply wells identified in the Subbasin. A total of 45 public supply wells were initially identified in the Subbasin, with 20 wells reported as active, 19 inactive, and 6 with unknown status according to records from SWRCB DDW. Total depths of public water supply wells ranged from 280 feet to 900 feet, with an average depth of 656 feet. According to SWRCB DDW data, public water system wells were categorized into five main categories: businesses, churches, schools, community residential supply, and municipal supply. Community residential and municipal supply wells are considered community wells, meaning they have at least 15 connections serving at least 25 residents.[20] Businesses, churches, and schools are considered non-community wells, serving smaller populations.

Notably, the information on wells in the Subbasin is derived primarily from WCR data provided by DWR, supplemented by information from the SWRCB DDW and GAMA or local data sources for public water supply wells. The well information reported for the Subbasin are based mainly on new WCRs submitted

[19] Figure titles that are bolded can be found at the end of each chapter

[20] Definitions of different types of public water systems are given in Part 12, Chapter 4 of the California Health and Safety Code § 116275 (part of the California Safe Drinking Water Act).

to DWR for the period 1970 through 2021 and may not reflect the total number of existing or active wells in the Subbasin. The highest concentrations of domestic wells are centered primarily along the southern side of the City of Chowchilla. Irrigation wells are generally less concentrated and more evenly distributed across the entirety of the Subbasin, though slightly higher concentrations are found in sectors within the western portions of Madera Co GSA and CWD GSA. **Figure 2-6a** presents comparisons of the number of wells constructed by decade within the Subbasin and **Figure 2-6b** presents typical well depths by well type.

Table 2-3. Summary of DWR Well Completion Report (WCR) Dataset (1970-2021).

	Well Type		
	Agriculture/ Irrigation	Domestic	Municipal/ Public Supply
Count of Wells	749	507	14
Minimum Total Well Depth (feet)	130	140	280
Maximum Total Well Depth (feet)	1,960	960	900
Average Total Well Depth (feet)	597	377	591
Minimum Top of Perforations (feet)	20	100	150
Maximum Top of Perforations (feet)	1,180	604	775
Average Top of Perforations (feet)	313	250	387
Minimum Bottom of Perforations (feet)	20	40	280
Maximum Bottom of Perforations (feet)	1,960	940	900
Average Bottom of Perforations (feet)	548	371	560

NOTE:
bgs = below ground surface
WCR dataset includes new constructions since 1970

Table 2-4. Summary of Public Supply Wells in Chowchilla Subbasin.

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
City of Chowchilla	WELL 01 – INACTIVE	2010001-001	Inactive	Municipal Supply Well		556	825		DDW
City of Chowchilla	WELL NO. 1A	2010001-023	Active	Municipal Supply Well	800		800	WCR2018-004564	DDW
City of Chowchilla	WELL 02 – DESTROYED	2010001-002	Inactive	Municipal Supply Well	754		754	WCR2019-006868	DDW
City of Chowchilla	WELL 03 – RAW	2010001-003	Active	Municipal Supply Well	900	506	832	WCR0081513	DDW
City of Chowchilla	WELL 04 – RAW	2010001-004	Inactive	Municipal Supply Well	610	500	628	WCR0183879?	DDW
City of Chowchilla	WELL 05 – DESTROYED	2010001-005	Inactive	Municipal Supply Well					DDW
City of Chowchilla	WELL 05A – RAW	2010001-019	Active	Municipal Supply Well	795	775	795	WCR0120517	DDW
City of Chowchilla	WELL 06 – INACTIVE – RAW	2010001-006	Inactive	Municipal Supply Well	790	218	548		DDW
City of Chowchilla	WELL 07 – DESTROYED – 2004	2010001-007	Inactive	Municipal Supply Well		506	618	WCR0303277	DDW
City of Chowchilla	WELL 08 – RAW	2010001-008	Active	Municipal Supply Well	396	242	297	WCR0288824	DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
City of Chowchilla	WELL 09 – INACTIVE	2010001-009	Inactive	Municipal Supply Well	640				DDW
City of Chowchilla	WELL 10 – RAW	2010001-010	Active	Municipal Supply Well	470	358	474		DDW
City of Chowchilla	WELL 11 – RAW	2010001-011	Active	Municipal Supply Well	608.1	310	393		DDW
City of Chowchilla	WELL 14 – RAW	2010001-020	Active	Municipal Supply Well					DDW
MD #85 Valeta	SOURCE WELL 1 – DEEPEN 2009	2000511-001	Active	Community Residential Supply Well					DDW
Wagon Wheel Super Market	SOURCE WELL 1	2000514-001	Active	Business				WCR2017-000511	DDW
Dairyland School	SOURCE WELL 1	2000597-001	Active	School					DDW
Alview School	SOURCE WELL 1	2000598-001	Inactive	School					DDW
Alview School	SOURCE WELL 5 2015	2000598-002	Active	School				WCR2015-008230	DDW
Alview School	NEW WELL 3 (DRILLED 2011) INACTIVE	2000598-004	Inactive	School					DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
Alview School	NEW WELL 3 (DRILLED 2011)	2000598-006	Active	School					DDW
Howard Elementary School	WELL 1 – ABANDONED	2000600-001	Inactive	School					DDW
Alview School	WELL 01 – INACTIVE	2000604-001	Inactive	School					DDW
Red Top Market	SOURCE MARKET WELL – INACTIVE	2000609-001	Inactive	Business					DDW
Red Top Market	COTTON GIN WELL – INACTIVE	2000609-002	Inactive	Business					DDW
Red Top Market	NEW WELL 2014	2000609-005	Active	Business					DDW
North Fork Union School	SOURCE RADIAL WELL	2000612-002	Inactive	School					DDW
Bowles Farming Co. – Forced To Picme	WELL 01 – INACTIVE	2000676-001	Inactive	Business					DDW
Bowles Farming Co. – Forced To Picme	WELL 02 – INACTIVE	2000677-001	Inactive	Business					DDW
CertainTeed	SOURCE WELL 1 – EMERGENCY	2000681-001	Active	Business					DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
CertainTeed	SOURCE WELL 6 FRONT WELL	2000681-002	Active	Business					DDW
CertainTeed	WELL 100	2000681-003	Active	Business					DDW
United Park Inc	SOURCE WELL 1	2000790-001	Inactive	Business		300	360	WCR0195493	DDW
United Park Inc	SOURCE WELL #2	2000790-002	Active	Business				WCR2019-006638	DDW
Pioneer Market	SOURCE WELL 1 – DESTROYED 2011	2000823-001	Inactive	Business					DDW
Pioneer Market	WELL 2 – DRILLED 2011	2000823-005	Active	Business					DDW
Solis Water System	SOURCE WELL 1	2000833-001	Unknown	Business					DDW
Chowchilla Cong. Of JWS	SOURCE WELL #2	2000942-002	Active	Church				WCR2017-005311	DDW
Merced RV and Truck Stop-Closed	WELL #1 – SE CORNER OF PRPRTY – DESTROYED	2400100-001	Inactive	Business					DDW
CalTrans CHP Chowchilla River Facility	WELL 1 – S END OF FACILITY	2400216-001	Active	Business		400	460		DDW

System Name	Well Name	Well ID	Well Status	Supply Type	Well Depth (feet)	Screen Top (feet)	Screen Bottom (feet)	WCR No.	Dataset
Unknown	WCR0220448	00151057	Unknown	Unknown	280	150	280	WCR0220448	WCR
Unknown	WCR2016-011638	E0322799	Unknown	Unknown	660	330	610	WCR2016-011638	WCR
Unknown	WCR2017-000468		Unknown	Unknown	600		600	WCR2017-000468	WCR
Unknown	WCR0168864	00550225	Unknown	Unknown	670		495	WCR0168864	WCR
Unknown	WCR2017-008608	E0338392	Unknown	Unknown				WCR2017-008608	WCR

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 Chowchilla 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 Chowchilla Subbasin's GSAs have prepared and adopted several water planning documents. These 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 two currently organized as GSAs in the Chowchilla Subbasin (CWD and Madera Co). 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 two currently organized as GSAs in the Chowchilla Subbasin (CWD and Madera Co). The objectives of the plan are to establish collaborative governance, stabilize and recover groundwater levels, mitigate subsidence, improve public awareness, and maintain and improve the economic viability of the Madera region.
- Water Management Plans
    - Chowchilla Water District Water Management Plan (2017)
- Groundwater Management Plans
    - Chowchilla-Red Top Resource Conservation District Joint Powers Authority Groundwater Management Plan (1997)
    - Madera County Groundwater Management Plan (2002)
- Other Plans
    - General Plans:
        - City of Chowchilla General Plan (updated 2017)
        - Madera County General Plan (updated 2015)
        - Merced County General Plan (updated 2016)
    - Municipal Service Reviews:
        - City of Chowchilla Sphere of Influence Expansion and Municipal Service Review (2011)
        - Clayton Water District Municipal Service Review (2017)
        - Triangle T Water District Municipal Service Review (2017)

- Other:
  - City of Chowchilla Urban Water Management Plan (2017)
  - Madera County Storm Water Resource Plan (2017)
  - Madera County SB 552 Drought Plan (in development)
  - PG&E San Joaquin Valley Operations & Maintenance Habitat Conservation Plan (HCP) (2006, permit issues 2007)[21]

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

GSP implementation will support all HCP goals to minimize and avoid adverse effects to threatened and endangered species in the Chowchilla Subbasin. No Natural Community Conservation Plans overlap with the Chowchilla Subbasin.

Development and implementation of this 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), groundwater dependent ecosystems (GDEs), and other stakeholders.

Implementation of this 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[22]: Identification of the water service needs of DUCs in Madera County.
- Merced County General Plan, SB 244 Analysis[23]: Identification of water service needs of DUCs in Merced County.
- PG&E San Joaquin Valley Operations and Maintenance HCP: Establishes goals to minimize and avoid adverse effects to threatened and endangered species in the Chowchilla Subbasin.

2.1.2.2 Surface Water Monitoring and Management Programs

Surface water flows into and within the Chowchilla 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 GSP to support water budget development, per 23 CCR § 354.18.

These sources and the data they provide are summarized below.

2.1.2.2.1 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)

[21] 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 potential ISW habitats.

[22] This GSP 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.

[23] This GSP considers the water service and supply needs of other DACs in the subbasin not discussed in the Merced County General Plan, SB 244 Analysis.

- 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)[24]
- San Luis Delta-Mendota Water Authority (SLDMWA)
- 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 2-5**. In the Chowchilla Subbasin, Chowchilla Bypass and San Joaquin River inflows are compiled from CDEC and WDL data, Chowchilla River inflows are measured and reported by USACE, Fresno River inflows are measured by the MID recorder network (this is also the Fresno River outflow from the Madera Subbasin), and Madera Canal inflows are recorded and reported by Reclamation. These monitoring stations are important for monitoring surface water available to potential interconnected surface water (ISW) habitats and groundwater dependent ecosystems (GDEs).

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

2.1.2.2.2 Local Programs

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

- The City of Chowchilla's SCADA system and records of monthly volumes pumped from groundwater supply wells (available since 2003).
- CWD's SCADA system and records of canal flows and conveyance system spillage (available since 1995).
- CWD's records of monthly water supply from Madera Canal (Class 1, Class 2, 215, URF, RWA, Free Water, Flood Releases), Buchanan Dam (Irrigation Releases, Flood Releases), Legrand, and transfers.
- CWD's records of grower deliveries in their STORM[25] database (available since 2000).
- CWD's records of riparian deliveries to white areas (available since 1996)
- CWD's records of riparian deliveries to Roduner Ranch (available since 1994)

[24] 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/.

[25] The water ordering and delivery management software used by Chowchilla Water District and Madera Irrigation District.

- CWD's records of prescriptive water rights deliveries to growers along Chowchilla River (available since 1981)
- Madera County's requirement to include a flow measurement device on new wells and the resulting groundwater pumping records.
- Madera Irrigation District's (MID) recorders network with records of Fresno inflows to the Chowchilla Subbasin (available since the 1950s).
- Triangle T Ranch well reports (available since 2011) and water level reports (available since 2016).

Table 2-5. 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	
Chowchilla River	USACE	Buchanan Reservoir	Buchanan Reservoir, Chowchilla River, California	1981-2017	
Fresno River	MID	Recorder 24	Rd. 9 at Fresno River	2005-2013	
Madera Canal	Reclamation	Indicated by Mile	Miles 33.6, 35.6	1978-2018	CVP water deliveries to CWD reported by Mile
San Joaquin River	WDL	B07610	San Joaquin River near Dos Palos	1980-2018	

Streamflow monitoring stations and MID recorders along waterways were used to prepare time series datasets for Subbasin surface water inflows and outflows, as applicable. CWD SCADA records at spillage sites were used to prepare time series datasets for CWD 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**.

2.1.2.2.3 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 as well as 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.

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 Chowchilla Subbasin related to groundwater levels, groundwater quality, and land subsidence. Each monitoring category is described in more detail in the sections below.

2.1.2.3.1 Groundwater Level Monitoring

Groundwater level monitoring has been conducted historically by variety of entities in the Subbasin including Chowchilla Water District, Madera County, Triangle T Water District, 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 Chowchilla Water District and the County, along with other entities in Madera 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.

2.1.2.3.2 Groundwater Quality Monitoring

Groundwater quality monitoring has historically been conducted by a variety of entities in the Subbasin including the City of Chowchilla 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 Chowchilla Subbasin is identified as a Priority 1 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 issue notices to comply within a short time period, which will start the clock on requirements of the Nitrate Control Program. As a Priority 1 Subbasin identified by CV-SALTS, dischargers in the Chowchilla Subbasin will be among the first required to comply with the program and 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.

2.1.2.3.3 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 date for historical land subsidence monitoring conducted in the Subbasin and 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. Since initial GSP development, the GSAs have created a subsidence workplan to help develop a more robust subsidence monitoring program and fill data gaps (**Appendix 3.H**).

2.1.2.4 Conjunctive Use Programs

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

CWD receives surface water supplies from Millerton Reservoir (along Madera Canal) and Eastman Lake (along Chowchilla River) that is delivered to customers in CWD, Madera Co, and Sierra Vista Mutual Water Company (SVMWC). The districts practice conjunctive use of these surface water supplies through policies to encourage grower use of surface water when available. These practices reduce groundwater pumping and increase groundwater recharge in wet years, providing increased groundwater supplies available for use by private groundwater wells in dry years. For growers, the historical advantages of groundwater 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.

Domestic water users in the City of Chowchilla rely solely on groundwater, while some agricultural water users within the City limits use groundwater to supplement surface water supplies from CWD. The domestic water system infrastructure includes seven active groundwater wells and with two additional off-line wells, that together supply up to 6,000 gpm of water to 37 miles of main distribution pipelines and over 3,700 connections.[26] The Central California Women's Facility and the Valley State Prison for Women in Chowchilla each operate their own separate water systems.

Conjunctive use programs in the Subbasin include indirect reuse and recharge of surface water supplies, treated wastewater, and/or stormwater in CWD, City of Chowchilla, and Madera County.

In addition to encouraging growers to use surface water when available, CWD provides or facilitates groundwater recharge through infiltration of surface water along 150 miles of unlined canals, local sloughs, and nearby stream channels (Chowchilla River, Dutchman Creek, Ash Slough and Berenda Slough).[27] Recharge is also provided through two surface water retention reservoirs, eight recharge

[26] Madera Regional Groundwater Management Plan, December 2014. Pg. 130-131.
[27] Madera Regional Groundwater Management Plan, December 2014. Pg. 119, 132.

basins, and the City of Chowchilla stormwater basins.[28] CWD also utilizes various water management techniques to enhance water delivery efficiency, including measurement weirs, water meters, rated canal gates, regulating reservoirs and ponds, long-crested weirs, flap gates, and a SCADA system.[29]

The City of Chowchilla provides groundwater recharge through incidental infiltration of secondary treated wastewater released from the city's wastewater treatment plant.[30] The wastewater treatment plant collects approximately 1.8 MGD of wastewater from Chowchilla's population of over 19,000 people along 26 miles of sanitary sewers, and discharges approximately 1.0 MGD to percolation ponds.[31]

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

The Chowchilla Subbasin lies primarily within Madera County, though a small portion lies within Merced County. Thus, both the Madera County General Plan and Merced County General Plan are applicable to the Subbasin. Additionally, the City of Chowchilla General Plan is applicable to land in CWD GSA defined by the boundaries of City of Chowchilla.

Implementation of this GSP will support all goals and policies established in these plans, consistent with SGMA and GSP regulations. Development and implementation of this 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), groundwater dependent ecosystems (GDEs), and other stakeholders.

2.1.3.1 Madera County General Plan

In the Madera County General Plan updated in 2015[32], 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). Madera 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 (Policy 5.E.11).

[28] Madera Regional Groundwater Management Plan, December 2014. Pg. 119, 133.
[29] Madera Regional Groundwater Management Plan, December 2014. Pg. 132.
[30] Madera Regional Groundwater Management Plan, December 2014. Pg. 119.
[31] Madera Regional Groundwater Management Plan, December 2014. Pg. 131.
[32] Madera County General, Plan Policy Document Adopted October 1995, housing element updated November 2015.

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).

2.1.3.1.1 Implementation Effects on Water Demands and Sustainability

Implementation of proposed land use developments under this general plan is not expected to shift water demands, in part due to the County’s ordinance for large developments to not exceed available sustainable yield (e.g. equivalent to a ‘net zero’ impact policy). Furthermore, the 2009 remote sensing ET results developed as part of this GSP indicate that medium and high-density housing consume less water on a per-acre basis than the agricultural uses replaced. Thus, even though domestic water demand is met entirely by groundwater, urban growth is estimated to slightly reduce overall water consumption.

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 potential ISW habitats and GDEs. This 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 Chowchilla Subbasin. Consistent with GSP regulations, the minimum thresholds (MTs) established by this GSP and the measurable objectives (MOs) monitored throughout GSP implementation will confirm the protection of wetlands, aquatic resources, and other GDEs identified in the Subbasin.

2.1.3.1.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla 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 (see Chapter 4). 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 currently irrigated agricultural land and, because new urban developments consume less water per acre, will lower water use compared to the agricultural consumption. New development and retrofitted landscape water efficiency standards are governed by numerous state statutory requirements, such as the Model Water Efficient Landscape Ordinance (MWELO) and the Urban Water Management Planning Act. 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), Engelhardt 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, native vegetation, and open spaces are in alignment with GSP planning efforts and are expected to support achievement of Subbasin sustainability.

2.1.3.2 Merced County General Plan

In the Merced County General Plan adopted in December 2013 and amended in July 2016[33], Merced County affirms its countywide growth and development goal to shape land use patterns that "enhance the integrity of both urban and rural areas" by limiting urban sprawl and protecting agricultural and wetland habitat areas (Goal LU-1). To achieve this, Merced County has established policies to promote compact development of existing or well-planned new urban communities established apart from productive agricultural land, to limit growth in rural centers, and to forbid development adjacent to wetland habitat (Policies LU-1.1-5,7,9-10,13).

With regard to agricultural land, Merced County maintains policies that would "preserve, promote, and expand the agricultural industry" (Goal LU-2) by limiting land use activities in designated agricultural and foothill pasture land use areas to agricultural crop production, grazing, and related ancillary uses that directly support farm operations or produce renewable energy without interfering with agriculture or natural resources (Policies LU-2.1-7). These policies stipulate that ancillary agricultural land uses "shall not have a detrimental effect on surface or groundwater resources" (Policy LU-2.5(h)).

With regard to water resources, Merced County's goals are to ensure the reliability and quality of surface and groundwater resources to meet the existing and future needs of users (Goals W-1-2). Toward these goals, policies have been established to support water management planning (Policies W-1.1,3), to require demonstration of sufficient water supply for new development (Policies W-1.2,7), to support surface water storage and groundwater recharge projects (Policies W-1.4,6), to develop guidelines for new well construction (Policy W-1.5), to encourage conjunctive use of groundwater and surface water supplies (Policy W-1.10), and to develop regulations and/or promote practices that reduce point source and non-point source water pollution (Policies W-2.2-8)

Merced County also promotes maximizing water use efficiency through policies that support conservation, reuse and recycling, and public education programs (Policies W-3.1-15)

2.1.3.2.1 Implementation Effects on Water Demands and Sustainability

Implementation of proposed land use developments under this general plan is not expected to increase water demands in the Subbasin because the County's policies require that new developments demonstrate sufficient water supply and because, as described above, medium and high density housing consumes less water than the agricultural uses replaced. Implementation of policies to promote surface water storage, groundwater recharge, conjunctive use, water conservation, and recycling will all benefit Subbasin sustainability by enhancing surface water supplies and groundwater recharge.

The general plan's policies forbidding urban development adjacent to wetland habitat and forbidding agricultural land uses from detrimentally affecting surface water or groundwater resources provides for the protection of wetlands, aquatic resources, and other potential ISW habitats and GDEs. This 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 Chowchilla Subbasin. Consistent with GSP regulations, the MTs established by this GSP and the MOs monitored

[33] 2030 Merced County General Plan, Adopted December 10, 2013 and Amended July 12, 2016.

throughout GSP implementation will confirm the protection of wetlands, aquatic resources, and other GDEs identified in the Subbasin.

2.1.3.2.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla 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. As described above, new development is governed by the MWELO, which increases water efficiency standards and encourages more efficient irrigation systems, graywater usage, and onsite storm water capture, while limiting the portion of landscapes that can be covered in turf. Such measures will result in lower water use.

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

2.1.3.3 City of Chowchilla General Plan

In the City of Chowchilla General Plan[34], City of Chowchilla establishes a vision for future development that would, among other goals, support contiguous urban development, even into agricultural land when necessary, within and around the existing city bounds.

In the plan, City of Chowchilla identifies critical growth challenges, including managing urban expansion efficiently, resisting premature conversion of agricultural land, and discouraging urban encroachment on prime agricultural land. For future growth into 2040, City of Chowchilla's projected planning area would absorb approximately 8,000 acres for residential, commercial, and industrial uses between 2020 and 2040, including land within and outside the existing city limits.[35] Much of this would go into expanding high and medium density housing and mixed use land[36], reflecting City policies to develop a mixture of residential types and densities (Policies LU 2.1-4, 3.1-2, 4.1).

While the plan allows conversion of agricultural lands to urban uses, it establishes growth management policies to resist premature conversion, to require contiguous urban expansion within the City, and to seek an agreement with Madera County to regulate eastward growth and maintain agricultural buffer zones (Policies LU 17.1-2, 4-6).

Finally, the City of Chowchilla General Plan maintains a policy to support Madera County's General Plan goals, objectives, and policies for land outside the City limits (Policies LU 19.1).

2.1.3.3.1 Implementation Effects on Water Demands and Sustainability

Similar to the Madera County and Merced County General Plans, implementation of proposed land use developments under the City of Chowchilla General Plan is expected to reduce water demands because new developments are required to follow the MWELO and because, as described above, medium and high density housing consumes less water than the agricultural uses replaced.

[34] City of Chowchilla 2040 General Plan.

[35] City of Chowchilla 2040 General Plan, Land Use Element Table LU-1, pg. LU-5.

[36] City of Chowchilla 2040 General Plan, Land Use Element Figures LU-2 and LU-3, pg. LU-7.

2.1.3.3.2 GSP Implementation Effects on Water Supply Assumptions

Implementation of the GSP will require the Chowchilla 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 Chowchilla does not have surface water rights and does not currently import surface water from other sources, larger urban communities will require additional groundwater extraction. However, urban development would extend partly into agricultural lands, which also consume significant groundwater resources. Thus, water use requirements are projected to decrease slightly due to urban expansion, benefiting Subbasin sustainability.

Implementation of the GSP will also provide for recharge projects to achieve Subbasin sustainability. Within the bounds of CWD GSA, City of Chowchilla has opportunities to recharge stormwater and flood flows, which will benefit sustainability and help to offset potential increases in water use associated with urban development.

2.1.3.4 Permitting Process for Wells in Chowchilla Subbasin

The well permitting processes in Madera and Merced Counties are described below. GSAs in the Chowchilla Subbasin will work with the counties to ensure that future well permitting aligns with the Subbasin sustainability goal established under this 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 order.

2.1.3.4.1 Permitting Process for Wells in Madera County

Within Madera County, including much of the Chowchilla 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.

2.1.3.4.2 Permitting Process for Wells in Merced County

Within Merced County, including a portion of CWD GSA and the entirety of Merced Co GSA, the permitting process for all well construction and destruction is managed by the Merced County Department of Public Health, Division of Environmental Health (MCDEH). Wells under their oversight include, but are not limited to, agricultural/irrigation wells, domestic private wells, industrial wells, municipal wells, test wells, and monitoring wells.

The process for well permits is detailed on the MCDEH Well Systems website: https://www.co.merced.ca.us/2247/Well-Systems. MCDEH restricts work on all water wells to be performed only by those possessing an active C-57 Water Well Contractors License.

2.1.3.5 *Effects of Land Use Plans Outside Subbasin*

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

The subbasins underlying City of Merced, City of Madera, and Fresno County 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 Section 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 Chowchilla Subbasin. Provided that these subbasins are managed to achieve sustainability, these land use plans are not expected to affect the ability of the Chowchilla 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 Chowchilla 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 Chowchilla Subbasin, 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 Chowchilla 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 Chowchilla.

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). 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. Merced County Department of Public Health manages well destruction for Merced County portions of Chowchilla Subbasin as described under Section 2.1.3.4.

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 projects and management actions (PMAs) for this GSP are described in detail in Chapter 4.

2.1.4.6 Conjunctive Use and Underground Storage

Historical and current conjunctive use operations in the Subbasin have primarily been conducted by Chowchilla Water District. CWD 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 Triangle T Water District and Chowchilla Water District, along with some private landowners, to conduct recharge for underground storage during wet years in 2016-17 and 2018-19. 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 2.1.3.4 (Well Permitting Process for Wells in Chowchilla 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 Chowchilla 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 spray and flood irrigation.

2.1.4.10 Relationships with State and Federal Agencies

The GSAs in Chowchilla Subbasin have relationships with a number of State and Federal agencies related to surface water supply, water quality, and water management. Chowchilla Water 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 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.[37] 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

[37] 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/.

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 GSP, including in Chapter 5 (Plan Implementation).

2.1.4.10.1 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).

2.1.4.10.2 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 Groundwater Sustainability Plans (GSPs) for groundwater basins around the state, including the Chowchilla Subbasin. The intent of SGMA is to ensure successful, sustainable management of groundwater resources at the local level. Success will require cooperation by all beneficial users (defined below), and cooperation is far more likely if beneficial users 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 Communication and Engagement Plan (**Appendix 2.C**) was created for the GSAs in the Chowchilla Subbasin to:

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

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 Chowchilla 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 Chowchilla Subbasin, the Communications and Engagement Plan included a Stakeholder Engagement chart (**Table 2-6**).

Table 2-6. Stakeholder Engagement Chart for GSP Development.

Category of Interest	Examples of Stakeholder Groups [38]	Engagement purpose
General Public	• Citizens groups • Community leaders	Inform to improve public awareness of sustainable groundwater management
Land Use	• Municipalities (City, County planning departments): City of Chowchilla • Regional land use agencies	Consult and involve to ensure land use policies are supporting GSPs
Private users	• Private pumpers • Domestic users • School systems: Chowchilla Elementary School District • Hospitals: Chowchilla Memorial Health Care District	Inform and involve to minimize negative impact to these users
Urban/ Agriculture users	• Water agencies • Irrigation districts • Mutual water companies • Resource conservation districts: Madera/Chowchilla RCD (formerly the Chowchilla Red Top RCD) • Farm Bureau: Merced Farm Bureau, Madera County Farm Bureau	Collaborate to ensure sustainable management of groundwater
Industrial users	• Commercial and industrial self-supplier • Local trade association or group	Inform and involve to avoid negative impact to these users
Environmental and Ecosystem	• Federal and State agencies: CDFW • Environmental groups: The Nature Conservancy, Audubon California, American Rivers, Clean Water Action/Clean Water Fund	Inform and involve to sustain a vital ecosystem
Economic Development	• Chambers of commerce: Chowchilla District Chamber 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
Human right to water	• Disadvantaged Communities • Small community systems • Environmental Justice Groups: Leadership Council for Justice and Accountability, Self-Help Enterprises, Community Water Center	Inform and involve to provide a safe and secure groundwater supplies to all communities reliant on groundwater

[38] 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 [38]	Engagement purpose
Tribes	• Federally Recognized Tribes and non-federally recognized Tribes with Lands or potential interests in Chowchilla Subbasin	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 (IRWM regions) • Flood agencies	Inform, involve and collaborate to improve regional sustainability

2.1.5.3 Communications

2.1.5.3.1 Decision-making Processes

As noted above, the Chowchilla Subbasin is divided among four GSAs for GSP development. The four GSAs have jointly developed this coordinated GSP.

GSA Boards are the final decision-makers for the Chowchilla Subbasin. To assist in GSP development, the GSAs convened a Chowchilla Subbasin GSP Advisory Committee (Advisory Committee) in 2018 to bring together local agencies and related parties vested with the authority and/or ability to support implementation of SGMA in the Chowchilla Subbasin. Representatives from Merced County, Merced Irrigation District, Madera County, CWD, Madera Farm Bureau, Triangle T Water District, Sierra Vista Mutual Water Company, Clayton Water District and City of Chowchilla regularly attend the Advisory Committee meetings. The Advisory Committee has been meeting approximately monthly since its formation.

Generally, the representatives attending the Advisory Committee are technical experts associated with the various Subbasin GSAs and water districts. In addition to coordinating between the GSAs, the Advisory Committee developed recommendations for GSP development which were presented to the GSA boards in public meetings as well as at Subbasin-wide public meetings.

2.1.5.3.2 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 GSAs in the Chowchilla Subbasin held regular public meetings, generally on a monthly schedule and in many cases in conjunction with standing board meetings.
- **Joint Subbasin meetings:** The intent of the Joint Subbasin meetings was to provide a forum for representatives from the Chowchilla Subbasin and the adjacent Madera Subbasin to share perspectives and information about GSP development and SGMA implementation.
- **Subbasin-wide Technical meetings:** Subbasin-wide technical meetings 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 meetings 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 Plan.

- **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 County Advisory Committee provided feedback on GSP development to the board 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.
- **Madera County Farm Bureau Water Forum**: The Chowchilla and Madera Subbasins made a joint presentation on SGMA efforts by the Subbasin GSAs.
- **City of Chowchilla**: The Chowchilla GSA gave a SGMA presentation in the City of Chowchilla City Council Chambers.
- **Madera County Regional Water Management Group:** Updates on Chowchilla Subbasin GSP activities were given at the monthly meetings of the Madera County Regional Water Management Group.

Figure 2-7 describes the GSP process steps, including topic development, technical review, and public meetings both at the Subbasin and individual level.

2.1.5.3.3 Encouraging Active Involvement

There were also activities related to encouraging involvement and building capacity for engagement. Madera County worked with Self-Help Enterprises and the Leadership Counsel for Justice and Accountability, organizations that represent DAC communities, to inform DAC members about the plan and encourage their involvement. 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.
- **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.

2.1.5.3.4 Soliciting Written Comments

In addition to soliciting feedback at GSA meetings, an opportunity was provided to offer written comments on the plan via an online comment form or letter. An 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 5, 2019, and continued through November 5, 2019. In addition, a special GSP Advisory Committee meeting was held on October 23, 2019 to solicit written comments. All comments received via the comment form or a letter were circulated to the GSAs.

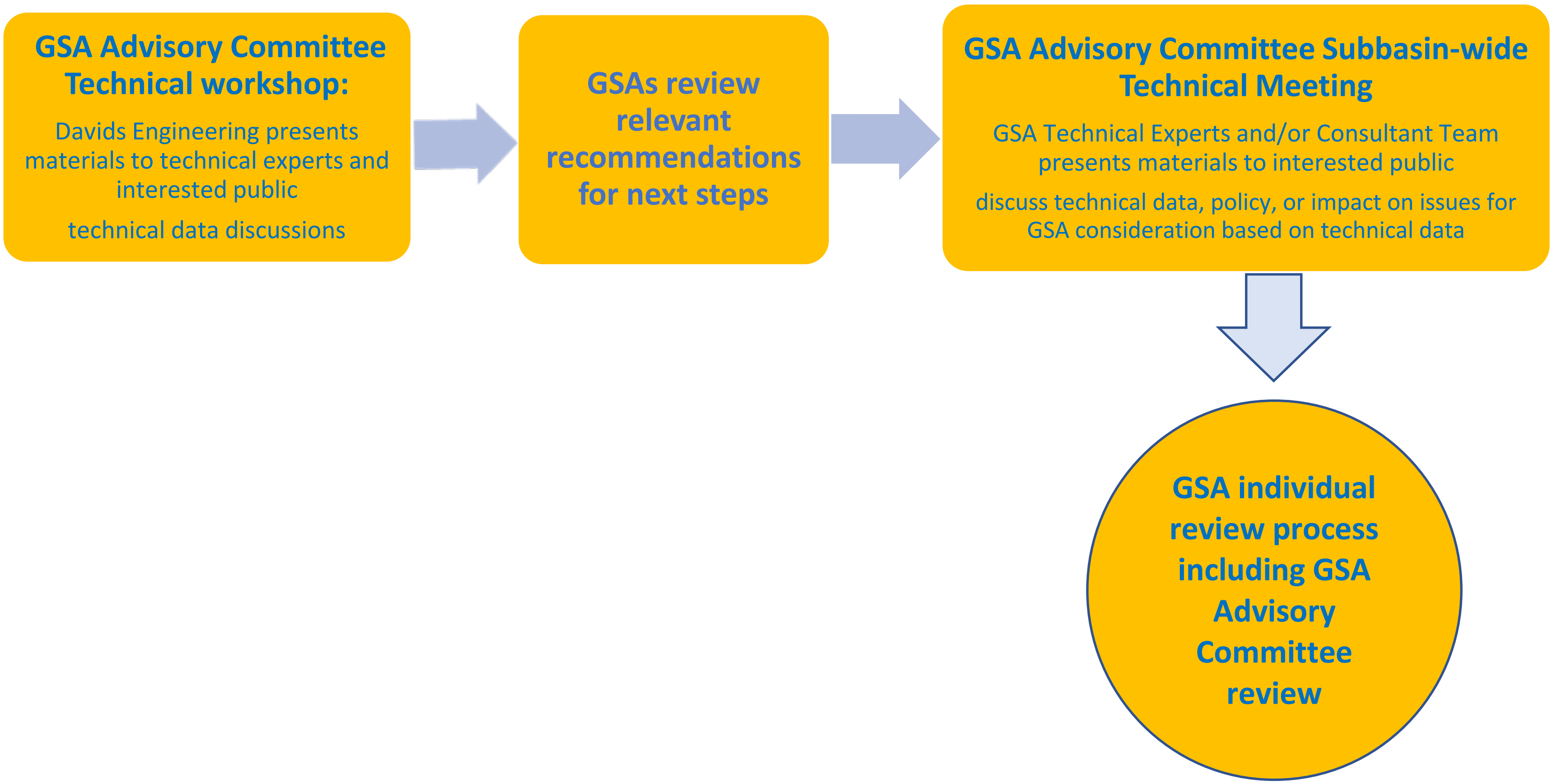

Figure 2-7. Plan Development Sequence (public meetings in yellow).

The written comments and responses can be found in **Appendix 2.C.e**.

2.1.5.4 Informing the Public about GSP Development Progress

2.1.5.4.1 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 CWD and is included in **Appendix 2.C**. 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 this link: https://www.maderacountywater.com/join-list/.

2.1.5.4.2 Distribution of Flyers

Typically, before a public meeting in the Chowchilla Subbasin, a flyer was created with key information provided. The flyer was emailed out to the Interested Party list as well as to the GSAs and the Madera County Farm Bureau for electronic distribution. The flyer was also handed out at GSA meetings and other public meetings. (**Figure 2-8**).

2.1.5.4.3 Press Outreach

Press releases were issued at key junctures and decision-making points for the Chowchilla Subbasin.

2.1.5.4.4 A Centralized Chowchilla Subbasin Website

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

The Chowchilla 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
- A link to the website of the Triangle T Water District GSA
- Information about the County GSAs, adjacent Madera GSAs, Chowchilla Subbasin technical meetings and the Advisory Committee
- GSP background documents
- Fact sheets and Subbasin maps

2.1.5.4.5 Engagement Matrix

The Engagement Matrix, in **Appendix 2.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 Chowchilla 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.

2.1.5.4.6 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** summarizes the public comments received, organized by type of water user, and outlines how this input influenced decision-making in GSP development.

2.1.5.4.7 Public Outreach During GSP Revision Process

During the GSP revision processes in 2022-2023, the GSAs conducted further public outreach through public GSP Advisory Committee meetings, public GSA governing body meetings, and through public notices regarding the GSP revision processes.

Figure 2-8. GSA Public Event.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model (23 CCR § 354.14)

A preliminary hydrogeologic conceptual model (HCM) was developed for the Chowchilla Subbasin (DWR Subbasin No. 5-22.05) 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 GSP report. 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.

2.2.1.1 Regional Geologic and Structural Setting

The Chowchilla Subbasin is generally comprised of relatively flat topography that slopes gently downward to the west. Topographic elevations vary from about 340 feet above mean sea level (MSL) in the east to about 120 feet above MSL in the west over a distance of about 25 miles (**Figure 2-9**). The major geomorphic features of the Subbasin are the alluvial fan and floodplain associated with sediment deposition from the Chowchilla River (Mitten et al., 1970). A map of hydrologic soil groups in Chowchilla Subbasin is provided in **Figure 2-10**, and a map of soil saturated hydraulic conductivity (K_{sat}) is provided in **Figure 2-11.** These maps indicate that soils with higher permeability and infiltration rates are present along and between the Chowchilla River, Ash Slough, and Berenda Slough channels in the central portion of the Subbasin. 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 2-12 and 2-13**. The surficial geology of the Chowchilla 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 between the Chowchilla River and Berenda Slough in the middle portion of the Subbasin.

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 chowchilla 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 Chowchilla 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 middle and western portions of Chowchilla Subbasin (**Figure 2-14**) 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 top of the Corcoran Clay generally ranges from about 50 to 275 feet where present within Chowchilla Subbasin (Provost & Pritchard, 2014). The Corcoran 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 Chowchilla Subbasin (**Figure 2-15**). As explained further in the section on major aquifers/aquitards, the depth to Corcoran Clay in the central to eastern portions of the Subbasin becomes shallow enough such that the regional aquifer occurs entirely below the Corcoran Clay.

2.2.1.2 Lateral and Vertical Subbasin Boundaries

The Chowchilla Subbasin is bordered by the Madera Subbasin to the east and south, Merced Subbasin to the north, and Delta-Mendota Subbasin to the west (**Figure 2-16**). All Subbasin boundaries are political/agency boundaries across which groundwater flow can and does occur. A basin boundary modification request was approved by DWR in 2016, and the revised boundary is incorporated in this study.

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 umhos/cm. Overall, the base of freshwater was mapped as ranging approximately from elevation -600 to -1,200 feet msl within Chowchilla Subbasin. In general, the shallowest depths to base of fresh water were along the southern boundary of the Subbasin, and the greatest depths were areas located just south of the City of Chowchilla and beneath the Chowchilla River in the central portion of the Subbasin (**Figure 2-17).** 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 than 1,000 milligrams/liter (mg/L) and 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 2-18**) and elevation of basement rock (**Figure 2-19**) show increasing depths (and decreasing elevations) to basement rock from northeast to southwest across the Subbasin. The depths to bedrock range from about 500 feet to greater than 3,500 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 2-17** except in the far eastern portions of the Subbasin. 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 Chowchilla Subbasin.

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 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 (Mitten, et al.,1970; Page, 1986). The locations of these two existing geologic cross-sections are provided in **Figure 2-20**, and the individual cross-sections are provided in **Figures 2-21 and 2-22**. A summary of the two regional geologic cross-sections is provided below.

Mitten's (1970) cross-section A-A' (**Figure 2-21**) runs west to east across the northern portion of the Chowchilla Subbasin, and extends down to an elevation of -1,400 feet msl. The top of the E-Clay (Corcoran Clay) is present at a depth of approximately 200 feet below ground surface (bgs) on the western edge of the section (with a thickness of about 50 feet) and thins and tapers out near Ash Slough at a depth of about 80 feet bgs. A small deposit of Quaternary floodplain deposits (Qb) is present at the surface on the western edge of the section, and thin layers of younger Quaternary alluvium (Qya) are present at the surface across the rest of the section. Older Quaternary alluvium (Qoa) underlies the surface deposits, and overlies Tertiary and Quaternary continental deposits (QTc). Undifferentiated Pre-Tertiary and Tertiary marine and continental sedimentary rocks (TpTu) underlie QTc in the eastern portion of the section. Pre-Tertiary basement complex (pTb) is present at the surface along the eastern edge of the section.

Page (1986) cross-section B-B' (**Figure 2-22**) runs north to south through the western portion of the Chowchilla Subbasin, and extends to a depth of about 9,000 feet bgs. Within the Chowchilla Subbasin, the Corcoran Clay is present throughout, at an approximate elevation of -100 feet msl. Thin deposits of Quaternary floodplain 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 (i.e., bedrock) underlies these units at elevations ranging from about -2,500 to -3,500 feet msl.

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 2-20**. The new geologic cross-sections include some that do not cross Chowchilla Subbasin, but are included here because they occur within the Model Domain for the Madera-Chowchilla Groundwater-Surface Water Simulation (MCSim) Model developed for Chowchilla 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 A-A', B-B', and C-C' (**Figures 2-23, 2-24, and 2-25**) extend from southwest to northeast across Chowchilla Subbasin towards (perpendicular to) the Sierra Nevada Mountains, with A-A' being furthest north and C-C' 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 illustrate the interbedded and variable nature of fine- and coarse-grained sediments both laterally and vertically. There are significant coarse-grained layers to depths of at least 800 feet. However, fine-grained sediments comprise a larger percentage of the subsurface than do coarse-grained sediments overall. 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 A-A', B-B', and C-C' also illustrate the Corcoran Clay extends beneath the western and central portions of the Subbasin, and other clay layers are prominent throughout the Subbasin. New geologic cross-sections D-D', E-E', and F-F' (**Figures 2-26, 2-27, and 2-28**) are included here but not described further as they do not cross Chowchilla Subbasin.

New geologic cross-sections G-G' through K-K' (**Figures 2-29, 2-30, 2-31, 2-32, 2-33**) were constructed parallel to the Sierra Nevada Mountain front starting from the southwestern end of Chowchilla Subbasin and progressing towards the northeast (i.e., cross-section G-G' is 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. 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 the Groundwater Model

Documentation (**Appendix 6.D**) used to develop inputs 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 Mitten et al. (1970) 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 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 significant coarse-grained intervals are present to the full depths of most borings shown on the cross sections, although overall the percentage of fine-grained sediments exceeds that of coarse-grained sediments. These cross sections further demonstrate that Kv values are likely to be orders of magnitude less than Kh values.

Groundwater System Conceptualization

The Chowchilla Subbasin is underlain by the Corcoran Clay over approximately the western and central two-thirds of the Subbasin area. The depth to the top of the Corcoran Clay varies from 50 to 100 feet at its northeastern extent to in excess of 250 feet in the southwestern portion of the Subbasin (**Figure 2-14**). In the western portion of the Subbasin, the aquifer system is subdivided into an upper unconfined aquifer above the Corcoran Clay and a lower confined aquifer below the Corcoran Clay (**Figure 2-34**). In the central and eastern portions of the Subbasin where the Corcoran Clay is shallow or does not exist, the aquifer system is generally considered to be semi-confined with discontinuous clay layers interspersed with more permeable coarse-grained units (**Figure 2-34**).

As illustrated in the geologic cross-sections described above and provided in **Appendix 2.D,** the upper 800 feet of sediments are comprised of multiple layers of coarse-grained sediments. 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 distribution of percentages of coarse-grained sediments at various 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 2-35 and 2-36** 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 overall percentages of coarse-grained sediments are less than 50 percent of total sediment thicknesses.

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 Chowchilla Subbasin (DWR, 2004) cited a specific yield value of 0.086 for use in calculating total groundwater in storage. Given that sediments generally become finer grained with depth, it is possible that the lower Sy value from DWR (2004) 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 Chowchilla 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 2-37**), Lower Aquifer (**Figure 2-38**), and for composite wells screened in both aquifers (**Figure 2-39**).

There are six transmissivity values displayed on the map for the Upper Aquifer, all of which are located in the western portion of the Subbasin (**Figure 2-37**). Transmissivity values were quite variable ranging from less than 25,000 to 100,000 gpd/ft. The transmissivity map for the Lower Aquifer (**Figure 2-38**) includes data for 15 wells with 5 wells in the eastern portion of the basin, 6 wells in the central Subbasin and 4 wells in the western Subbasin area. Wells in the eastern Subbasin area show significant variability in estimated transmissivity values from less than 25,000 to 100,000 gpd/ft. The central Subbasin wells have transmissivity values from less than 25,000 to 75,000 gpd/ft, and the western region has wells with estimated transmissivity values ranging from less than 25,000 to 50,000 gpd/ft. Although data for the Upper Aquifer is limited, there were no wells with estimated transmissivity values greater than 100,000 gpd/ft in the Lower Aquifer while 3 of 6 available wells with estimated transmissivity values exceeded 100,000 gpd/ft in the Upper Aquifer. The map of transmissivity values for composite/unknown wells shows three wells in the western portion of the Subbasin (**Figure 2-39**). The transmissivity values range from 50,000 to 100,000 gpd/ft.

2.2.1.5 Recharge and Discharge Areas

Groundwater recharge can occur throughout the Chowchilla Subbasin from infiltration of precipitation and applied water, streamflow percolation, and other sources.[39] 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 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 2-10**). The map of hydrologic soil groups shows the main areas with hydrologic group A soils located along Chowchilla River, Ash Slough, and Berenda Slough. A relatively large area of hydrologic group A and B soils is located in the central portion of the Subbasin from north of Chowchilla River to south of Berenda Slough, and from the City of Chowchilla on the east to Eastside Bypass on the west. Mapping of saturated soil vertical hydraulic conductivity (K) shows a similar distribution of areas with higher infiltration potential as the soil hydrologic group map (**Figure 2-11**). The large area of hydrologic group A and B soils described above has soil saturated vertical K from 1.1 to greater than 5 feet/day, whereas most other areas have soil saturated vertical K of less than 1 foot/day.

The Soil Agricultural Groundwater Banking Index (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 soil surface conditions. The

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

unmodified (by tilling) SAGBI index map (**Figure 2-40**) shows the main areas of high deep percolation potential mirror the relatively large area of higher infiltration potential on the soil hydrologic group map between Highway 99 and Eastside Bypass from north of Chowchilla River to south of Berenda Slough. The modified SAGBI map (**Figure 2-41**) shows similar results as the unmodified SAGBI map with an additional area in the western portion of Chowchilla Subbasin west of Eastside Bypass with moderate to high deep percolation potential.

Another mechanism of groundwater recharge is subsurface inflow from adjacent subbasins, including Merced, Madera, 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 and between rivers/sloughs in the central portion of the Subbasin, and secondary areas with greater recharge potential occur in the western portions of the Subbasin to the west of Eastside Bypass. **Figure 2-42** shows areas of higher recharge potential if defined by mapped soils with relatively high vertical hydraulic conductivities (greater than 2 feet/day). It is worth noting that areas of high infiltration/deep percolation potential shown in **Figures 2-40 to 2-42** occur in the region underlain by the Corcoran Clay, which may constrain the ability to recharge the maximum volumes of water that may be available for recharge basins and on-farm recharge during wet years.

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 2-4 and 2-5**. Maps of the average depths of domestic, agricultural, and public supply wells by section are provided in **Figures 2-43, 2-44, and 2-45**. 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, and public supply wells are concentrated in the central to eastern portions of the Subbasin. Domestic well depths are variable across the Subbasin, with the most common well depths in the 300 to 400-foot range. Similarly, agricultural well depths are variable across the Subbasin, with the most common well depths in the 500 to 750-foot range. Public supply wells are most commonly in the 500 to 750-foot depth range.

A secondary mechanism of groundwater discharge may be subsurface outflow to portions of some adjacent Subbasins. 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 Chowchilla Subbasin include Chowchilla River, Ash Slough, Berenda Slough, Eastside Bypass, and San Joaquin River (along a portion of the western Subbasin boundary). The major reservoirs within the watersheds upstream of Chowchilla Subbasin include Eastman Lake along the Chowchilla River and Millerton Lake along the San Joaquin River (via the Madera Canal). These surface water features are shown on several maps describing the HCM (e.g., **Figures 2-9, 2-12, and 2-20**), 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 Chowchilla 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 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**.

2.2.2.1.1 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 Chowchilla 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 Chowchilla 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 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 the unconfined/semi-confined aquifer zone 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 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 Chowchilla Subbasin. The groundwater contour maps referenced in the discussion below for 1958 through 1984 are provided in **Appendix 2.E**.

The Spring 1958 DWR groundwater contours generally run northwest to southeast with elevations decreasing from northeast to southwest. A significant groundwater depression was developing in the northwest portion of the groundwater basin, initially centered just north of the Chowchilla River in Merced County in the 1950's. Groundwater elevations range from highs exceeding 220 feet msl northeast of the City of Chowchilla to lows of 70 feet msl in the groundwater depression in the northwest portion of Chowchilla Subbasin (as originally defined). Within the City of Chowchilla, groundwater elevations ranged from 200 to 210 feet msl.

The Spring 1962 DWR groundwater elevations showed declines of approximately 20 to 30 feet in the late 1950s/early 1960s, with highs exceeding 190 feet msl northeast of the City of Chowchilla to lows of 50 feet msl in the groundwater depression in the northwest portion of the Subbasin. Within the City of Chowchilla, groundwater elevations were approximately 180 feet msl. The Spring 1969 groundwater elevations showed continued declines in the northeastern portion of the Subbasin, with an overall range from 150 feet msl within the City of Chowchilla to lows of 50 feet msl in the northwestern portion of the Subbasin.

Spring 1976 DWR groundwater elevations indicated declines of approximately 10 feet in the western portion and approximately 10 to 30 feet in the eastern portion of the basin during the 1970s. The depression in the northwest expanded in size throughout the decade, while a separate depression formed in the northeast near the City of Chowchilla along the Chowchilla River. Within the City of Chowchilla, groundwater elevations ranged from 110 to 130 feet msl.

The Spring 1984 DWR groundwater elevations generally showed increases of approximately 10 to 20 feet in the early to mid-1980s. Two groundwater depressions were still present in the northwest and northeast, but a mound had formed in the center of the basin between the two pumping depressions. Within the City of Chowchilla, groundwater elevations ranged from 130 to 140 feet msl.

Contours of groundwater elevations in Winter and Spring 1988 (**Figure 2-46**) show similar patterns as historical groundwater elevations with groundwater flow generally from northeast to southwest. Areas of locally lower groundwater levels are apparent in **Figure 2-46** north of the City of Chowchilla and Chowchilla River (in the adjacent Merced Subbasin), southeast of City of Chowchilla (along the boundary with Madera Subbasin), and in the northwestern portion of the Subbasin. Locally slightly higher groundwater elevations are apparent in 1988 along Chowchilla River, Ash Slough, and Berenda Slough in the central to eastern portions of the Subbasin. In Winter/Spring 1988 groundwater elevations near the City of Chowchilla are between about 150 and 160 feet msl.

In Winter/Spring 2014, unconfined groundwater elevations in the Subbasin are generally lower than in 1988 with several groundwater depressions apparent in **Figure 2-47**. Although the general prevailing groundwater flow direction remains northeast to southwest, 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 to the south of the City of Chowchilla along the Subbasin boundary with the Madera Subbasin, and in the northwestern and southwestern portions of the Subbasin. A small area of slightly higher groundwater elevations occurs within the City of Chowchilla (180 ft msl). Although more limited water level data are available in Winter/Spring 2016, a contour map of groundwater elevation in 2016 is presented in **Figure 2-48** for comparison and illustrates similar patterns in groundwater flow and relative elevations. Groundwater elevation contours in the western part of the Subbasin 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 Groundwater Conditions

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 documented in Chowchilla Subbasin at several sites through review and comparison of local groundwater level data from regulated facility sites obtained from Geotracker and regional groundwater level data from CASGEM and other sources. 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 extraction wells are typically 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. A primary area of perched groundwater is expected to be present in the central to eastern portion of Chowchilla Subbasin above the Corcoran Clay, and it has been specifically documented in the City of Chowchilla area. There are three documented sites with groundwater level data in the City of Chowchilla area. These sites show perched groundwater levels ranging from 36 to 58 feet below ground surface (corresponding to groundwater elevations of 179 to 203 feet msl) over the time period from May 1995 to February 2018. Review of regional groundwater level data from CASGEM and other wells for this same time frame showed groundwater elevations ranging from less than -30 to about 70 feet msl. The perching layer in this area is likely the Corcoran Clay, which is estimated to be present at depths of approximately 70 to 80 feet beneath the City of Chowchilla.

Lower Aquifer

Contouring groundwater elevations in the Lower Aquifer is challenging because of combined limitations in 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.

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 2-49** with only one water level datapoint available in the central to western portion of Chowchilla 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 Chowchilla Subbasin. The Winter/Spring 2014 groundwater elevation contour map for the Lower Aquifer is presented as **Figure 2-50** and indicates Lower Aquifer groundwater elevations of between -30 and -40 feet msl in the area of the Chowchilla Subbasin within the extent of the Corcoran Clay. The contour map for Lower Aquifer in Winter/Spring 2016 (**Figure 2-51**) shows relatively lower groundwater elevations with some areas from -40 and -60 feet msl in the Lower Aquifer in the City of Chowchilla and in the southwestern portion of the Subbasin east of the Eastside Bypass. However, there is also an area of higher groundwater elevations than in 2014 in the middle portion of the Subbasin along Highway 152.

Due to the limited spatial coverage of wells with Lower Aquifer water levels, evaluating groundwater flow gradients and directions within the Lower Aquifer in Chowchilla Subbasin is challenging.

2.2.2.1.2 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 2-52 to 2-54** to illustrate temporal trends in groundwater levels across the Subbasin. Overall, long-term declines were prevalent throughout the Subbasin.

Select hydrographs of water levels in the unconfined groundwater (outside the Corcoran Clay or above the Corcoran Clay) are displayed in **Figure 2-52**. All of the hydrographs displayed on **Figure 2-52** with extended water level histories exhibit long-term water level declines. Two wells (TTR-1 and TTR-35) in the western portion of the Subbasin with short-term water level histories show steep declines between 2013 and 2016 but subsequent recovery of groundwater levels in 2017. The wells in **Figure 2-52** with longer-term records in the eastern to central part of the Subbasin (9S/16E-15Q1, 9S/17E-19L1, 10S/16E-17C1, 10S/15E-35A2) show groundwater level declines of between 4 and 6 feet per year over the period from the mid-1980s through about 2015.

Select hydrographs of water levels in the Lower Aquifer (within the extent of the Corcoran Clay) are displayed in **Figure 2-53**. As discussed above, the availability of groundwater level data known to be specific to the Lower Aquifer is limited. Only two of the wells (9S/15E-23J2 and 9S/16E-16N1) shown in **Figure 2-53** have a period of record sufficiently long to interpret trends in water levels. Over the period of time from the mid-1980s through 2015 there was an annual groundwater level decline of about 5 to 6 feet per year.

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 2-54**. The hydrographs on **Figure 2-54** show groundwater level trends generally consistent with those seen in the Upper and Lower Aquifers with declines of 4 to 6 feet/year over the time period between the mid-1980s and 2015. However, two wells (10S/13E-22R1 and 10S/14E-26C2) located in the western portion of the Subbasin show lower rates of decline between 1 and 3 feet/year. Prior to the mid-1980s, trends of more stable water levels, although slightly declining, are apparent in most wells. Over the period from the mid-1980s to 2015, rates of groundwater level decline greatly increased.

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

2.2.2.2 Groundwater Storage

2.2.2.2.1 Total Groundwater Storage

The total groundwater storage volume within the Chowchilla Subbasin above the basement and base of freshwater is estimated to be between about 6.5 million AF and 13 million AF based on an analysis using contouring of 2014 groundwater levels and an assumed average specific yield range of 5 to 10 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 suggest 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 Chowchilla Subbasin above the base of freshwater to be about 13.9 million

AF using 1995 groundwater levels and a specific yield value of 8.6 percent. However, DWR's Bulletin 118 estimate was for a larger area of about 159,000 acres compared to the current Chowchilla Subbasin area of a little under 146,000 acres.

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

Chowchilla Subbasin Area (acres)	Specific Yield (percent)	Total Groundwater Storage (AF)	Notes on Specific Yield Basis
145,574	5%	6,453,000	
	7%	9,034,000	
	8.6%	11,099,000	DWR Bulletin 118
	10%	12,906,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	15,487,000	
	13%	16,777,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)

2.2.2.2.2 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 2-55** shows the calculated change in unconfined groundwater levels for 1988 to 2014 and **Figure 2-56** presents the calculated change over the period 1988 to 2016. Unconfined groundwater levels declined substantially across much of the Chowchilla Subbasin between 1988 and both 2014 and 2016. Groundwater level declines of 50 to 150 feet occurred throughout most of the Subbasin in 2014, except for an area around the City of Chowchilla and to the west/northwest of the City of Chowchilla and in the far western portion of the Subbasin along the San Joaquin River. The greatest areas of groundwater level decline occurred in the far eastern portion of the Subbasin and in the south-central portion of the Subbasin adjacent to the Madera Subbasin boundary. The patterns of groundwater level declines between 1988 and 2016 were similar to 1988 to 2014, with slightly greater overall declines in the 1988 to 2016 period. The areas indicated in **Figures 2-55 and 2-56** 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 range between -700,000 to -1.3 million AF between 1988 and 2014 and between -800,000 and -1.5million AF between 1988 and 2016, assuming a range of specific yield values from 7 to 13 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 total basin groundwater storage calculation presented above. These storage decreases translate to annual decreases of about -27,000 to -50,000 acre-feet per year (AFY) for 1988 to 2014 and -31,000 to -57,500 AFY for 1988 to 2016. **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	7%	-701,000	-27,000	
	8.6%	-861,000	-33,000	DWR Bulletin 118
	10%	-1,002,000	-38,500	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	-1,202,000	-46,000	
	13%	-1,302,000	-50,000	2014 Regional GMP value (P&P, Wood Rodgers, KDSA)
Change 1988 to 2016	7%	-805,000	-31,000	
	8.6%	-989,000	-38,000	DWR Bulletin 118
	10%	-1,150,000	-44,000	2002 AB3030 Madera County GMP value (Todd Engineers)
	12%	-1,380,000	-53,000	
	13%	-1,495,000	-57,500	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 mg/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 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 in the Chowchilla Subbasin (**Figures 2-57 to 2-59**) indicate variable salinity across the Subbasin with more elevated TDS concentrations in the western portion of the Subbasin. However, wells having high (greater than 1,000 mg/L) TDS concentrations are also intermingled with wells with relatively low (less than 500 mg/L) TDS concentrations. 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. Given the number of wells with groundwater quality data but without well construction details, it is difficult to make interpretations of relationships between water quality and screen depths across the Subbasin from these data.

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 Chowchilla Subbasin. TDS concentrations ranged from less than 250 mg/L in the east to greater than 1,000 mg/L in the northwestern portion 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 considerably larger area of high TDS groundwater (**Appendix 2.E**).

2.2.2.3.2 Nitrate

Maps of maximum historical nitrate concentrations in groundwater are presented for all wells and also individually for Upper Aquifer wells and Lower Aquifer wells in **Figures 2-60 to 2-62**. Due to the limited number of datapoints with known well construction information, many results cannot be attributed to a specific aquifer zone. These maps highlight patterns in historical 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 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 central parts of the Subbasin. Several notable areas with a high density of wells with nitrate concentrations above the MCL of 10 mg/L (as N) are located in the more central parts of the Subbasin to the west and southwest of the City of Chowchilla and between Ash Slough and Highway 152. Most of the higher concentrations are from wells with unknown construction information.

Regional mapping of nitrate concentrations in groundwater were also performed as part of the CV-SALTS project (LSCE and LWA, 2016). Maps of nitrate concentrations in the upper zone (of the Upper Aquifer) showed a relatively large area exceeding the MCL of 10 mg/L (as N) in the central part of the Subbasin, while nitrate in the lower zone (of the Upper Aquifer) was indicated to exceed 10 mg/L in a smaller area in southwest portion of the Subbasin (**Appendix 2.E**).

2.2.2.3.3 Arsenic

Maps of maximum historical arsenic concentrations in groundwater are presented in **Figures 2-63 to 2-65**. Although there are a few wells with higher arsenic concentrations above 7.5 micrograms per liter (µg/L), most of the wells with data have concentrations below 5 µg/L with a considerable number having concentrations of less than 2.5 µg/L. The available groundwater quality data do not indicate any wells with arsenic concentrations above the MCL of 10 µg/L. The map of arsenic concentrations in the Lower Aquifer (**Figure 2-65**) suggest that concentrations of arsenic may be somewhat higher in the Lower Aquifer, although still generally below the MCL.

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 of groundwater constituents that should be considered when evaluating potential groundwater quality impacts from implementation of PMAs to achieve sustainability.

2.2.2.4 Land Subsidence

Recent land subsidence has been a major concern in the western portion of the Chowchilla Subbasin.

2.2.2.4.1 Subsidence Mapping Data

A map of subsidence that occurred between 1926 and 1970 shows one to two feet of subsidence in the western portion of Chowchilla Subbasin (**Figure 2-66**). Subsidence mapping using a combination of InSAR remote sensing data and data from surveys conducted by the USBR for the San Joaquin River Restoration Project for the 2007 to 2021 time period is shown in **Figure 2-67**. A maximum subsidence of almost seven feet occurred in the northwest part of the Chowchilla Subbasin between the Eastside Bypass and the western basin boundary during this period, which reflects a recent period of subsidence re-activation in the Subbasin. Maps of the most recent remote sensing subsidence data available from DWR for the period 2015 through 2021 are presented in **Figures 2-68a and 2-68b**. These maps show one to two feet of subsidence in a large portion of the western Subbasin between the two-year period 2015 to 2017. Since 2017 subsidence has continued in the western part of the Subbasin, although the greatest areas of subsidence since 2017 are focused in areas farther east and south than prior to 2017. The reduction in subsidence rates seen in TTWD since 2017 is attributed, in part, to successful implementation of the Subsidence Control Measures Agreement (**Appendix 3.F**). Additional information about the Agreement is provided in Section 3.3.3. Overall, the available historical subsidence data for the Subbasin indicate up to approximately nine feet of subsidence in some areas of western Chowchilla Subbasin since 1920. The subsidence has generally been concentrated in areas of the Subbasin within the extent of the Corcoran Clay. Specific subsidence monitoring locations are shown in **Figure 2-69**, which shows a relatively continuous monitoring record of subsidence at eight locations in the Subbasin between 2011 and 2021. Review of the subsidence monitoring location records indicate about seven feet of subsidence in the western portion of the Subbasin and about two to three feet of subsidence near the intersection of Highway 152 and Highway 99 in the eastern portion of Chowchilla Subbasin.

Other mapping of recent subsidence is included in **Appendix 2.D**. In northwest Chowchilla Subbasin, subsidence from 2008 to 2010 was 1.5 to two feet. Mapping by USBR between July 2012 and December 2016 showed total subsidence ranging up to three feet in western portion of Chowchilla Subbasin during this period of dry conditions. Various ongoing subsidence monitoring programs are being funded and/or conducted by DWR, USGS, USBR, and National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA-JPL).

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. This concept is also the foundation on which approaches to mitigating subsidence in the western management area of the Subbasin by reducing pumping in the Lower Aquifer are based.

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 2007 through present, but very limited data exist prior to 2007 in the Subbasin and the data for the period since 2007 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 San Joaquin River Restoration Program. Furthermore, long-term groundwater level data for comparing with subsidence monitoring are also limited in availability and often have not occurred at 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 well with historical water level monitoring. **Figure 2-70a** 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 a range of relationships between groundwater levels and subsidence are apparent in the graphs on **Figure 2-70a**, which vary by location and well depth. Some of the graphs on **Figure 2-70a** 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 DWR’s TRE ALTAMIRA 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 DWR InSAR subsidence data are limited. Raster data from the DWR 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 2-70b** 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 remains 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) note that, “Residual compaction may continue long after water levels have stabilized in the aquifers." It was noted in Antelope Valley that 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 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 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 through 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 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 Chowchilla Subbasin indicated that rates of subsidence during the 2012 to 2015 drought ranged from 0.4 to 0.65 feet/year over the Western Management Area with the higher rates generally occurring along the Chowchilla Bypass. The central portion of Chowchilla Subbasin had subsidence rates of 0.3 to 0.4 feet/year from 2012 to 2015. In the years from 2017 to 2021, subsidence rates were approximately 0.2 to 0.4 feet/year in the Western Management Area, while subsidence rates in the central Chowchilla Subbasin and along the border with Madera Subbasin did not appear to decrease significantly from rates prior to 2017.

Based on review and comparison of available groundwater level and subsidence data in Chowchilla Subbasin, establishing definitive relationships between groundwater levels and subsidence is challenging with the limitations of currently available data. However, making use of the best available data results in a range of from 17 to 35 feet in groundwater level decline (with an average of 23 feet) per each foot of subsidence during active subsidence time periods. In addition, the rate of residual subsidence in the immediate 3 to 6 years after groundwater levels stabilized or rose was from 44 to 58% of the active subsidence rate in the Western Management Area.

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 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 was noted that while the modeling results reported in this study are specific an area near Hanford, their modeling approach could be generalized to evaluate subsidence at other locations in San Joaquin Valley.

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 Chowchilla 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. Review of recent subsidence data for the Western Management Area of Chowchilla Subbasin suggest a residual subsidence rate of approximately 50% of the active subsidence rate during the 2012 to 2015 drought period.

2.2.2.5 Groundwater – Surface Water Interaction

The primary surface water features in Chowchilla Subbasin are the Chowchilla River, Ash Slough, Berenda Slough, and San Joaquin River (**Figure 2-10**). Each of these streams is considered to be a natural source of recharge to the Subbasin. A review of historical regional aquifer groundwater levels compared to stream thalweg (deepest portion of stream channel) elevations conducted for this study indicate that surface water – groundwater interactions are not a significant issue (i.e., regional groundwater levels are relatively far below creek thalweg elevations) along Chowchilla River, Ash Slough, and Berenda Slough in Chowchilla Subbasin. However, comparison of historical groundwater levels to the stream thalweg (i.e., deepest portion of stream channel) indicate that the San Joaquin River along the western Subbasin boundary was connected with groundwater from 1958 (and likely before) through 2008. Groundwater levels were generally below (and apparently disconnected from) the San Joaquin River from 2009 through 2016 based on this analysis, which involved use of 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 2-47 and 2-48**).

Maps of depths to shallow groundwater for 2014 and 2016 are displayed on **Figures 2-71** and **2-72**. These maps incorporate very shallow monitoring wells (i.e., less than 50 feet deep), including San Joaquin River Restoration Project (SJRRP) wells (many of which have well screens in the upper 30 feet). 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 in western Chowchilla Subbasin along/adjacent to the San Joaquin River are underlain by the "C" clay and other shallow clay layers that are above the more regional Corcoran Clay. Shallow groundwater in these areas can be considered perched/mounded aquifers in that shallow clay layers help to maintain shallow groundwater levels but there is no unsaturated zone beneath them as in a truly perched aquifer condition described below in the section on groundwater dependent ecosystems. It is likely that seepage from the San Joaquin River is the source of water that, combined with the presence of shallow clay layers, serves to maintain shallow groundwater levels at these locations. The depth to the Corcoran Clay becomes relatively shallow in the Eastern Management Area, where it serves as the base of a shallow perched aquifer. While groundwater levels in this perched aquifer may be approximately 50 to 90 feet below ground surface, the underlying regional water table is typically at depths exceeding 200 feet.

Review of **Figures 2-71 and 2-72** indicates that the San Joaquin River was disconnected from the shallow perched/mounded aquifer during these time periods. 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 depletion in the San Joaquin River along the western boundary of Chowchilla Subbasin and groundwater pumping along this portion of the San Joaquin River within the Chowchilla Subbasin (i.e., within approximately 0.75 miles of the San Joaquin River) is shown in **Figure 2-73**. The relationship between groundwater pumping from the Upper Aquifer throughout the entire Western Management Area and stream seepage is shown in **Figure 2-74**. These figures indicate no distinct and consistent relationships between the amount of groundwater pumping and stream seepage. Similarly, the relationship between streamflow coming in at the upstream boundary of this river reach and stream depletion is provided in **Figure 2-75**. In this case, a very distinct and strong relationship is demonstrated where increasing streamflow correlates with increasing stream depletion. This relationship streamflow and stream depletion is expected because this segment of the San Joaquin River is known to be a losing reach. These relationships among various factors are discussed further in Sections 3.2.5 and 3.3.5.

Regardless of whether or not the San Joaquin River is considered to have interconnected surface water, 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.

Based on review of available data, characterization of hydrogeologic conditions related to the potential for interconnected surface water (and potential impacts on GDEs) 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. It is anticipated that some additional data to better characterize shallow stratigraphy, groundwater levels, interconnected surface water, and GDEs will be available and incorporated into the 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 Subbasin (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[40] 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 Chowchilla 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.

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 Chowchilla 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.

One GDE unit, the San Joaquin River Riparian GDE Unit, was identified in the Chowchilla Subbasin (**Appendix 2.B**). The GDE unit was 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

[40] 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).

dominant plant species, and assess habitat characteristics to determine the potential for presence of special-status species.

Groundwater beneath the San Joaquin River Riparian 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. Below 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 at least possible that changes to the regional aquifer could affect the shallower perched/mounded aquifer that maintains the GDE, although any such connection would be limited by presence of multiple clay layers between the shallow perched/mounded aquifer and the deeper regional aquifer where pumping occurs. The riverine aquatic habitat of the San Joaquin River is not contained within the GDE unit because available hydrologic data indicates no groundwater contribution to the surface flow in this reach of the river (i.e., this reach of the San Joaquin River does not gain but rather is generally disconnected and loses water to the groundwater system). The net-losing condition of the San Joaquin River in this area likely began in 2009 or earlier (Section 2.2.2.5; TNC 2014).

2.2.2.6.1 San Joaquin River Riparian GDE Unit

The San Joaquin River Riparian GDE Unit is located along the San Joaquin River on the western margin of the Chowchilla Subbasin (**Figure 2-76**) and is composed of a mix of riparian forest, shrub, and herbaceous habitat types totaling approximately 70 acres. The May 2019 reconnaissance assessment of representative portions of the San Joaquin River Riparian GDE Unit identified areas of mature riparian forest with a stratified canopy and moderately open understory, overhanging vegetation along the riverbank, and downed wood (**Figure 2-77**). Vegetation at the representative sites provided over 90% native cover in the shrub and tree layer and 15–25% native cover in the herbaceous ground cover, with the balance occupied by non-native species.

Figure 2-77. Stratified canopy along the banks of the San Joaquin River in the San Joaquin River Riparian GDE.

The GDE unit is located in the current and former floodplain of the San Joaquin River, which has been subject to major land use and water use modifications over the last century, primarily resulting from agricultural development and the near-complete curtailment of flow in the San Joaquin River subsequent to completion of Friant Dam in 1944 (McBain & Trush 2002). Despite these changes, the San Joaquin River Riparian GDE Unit provides habitat or ecosystem support for several special-status species and natural communities, including aquatic species that use the adjacent San Joaquin River for all or part of their life cycle including:

- bald eagle (*Haliaeetus leucocephalus),*
- Swainson's hawk (*Antrozous pallidas),*
- pallid bat (*Antrozous pallidas),*
- western red bat *(Lasiurus blossevillii),*
- western pond turtle (*Emys marmorata),*
- Sanford's arrowhead (*Sagittaria sanfordii),*
- California satintail (*Imperata brevifolia),*
- brittlescale (*Atriplex depressa),*
- heartscale (*Atriplex cordulata* var. *Cordulata),*
- palmate-bracted bird's-beak (*Chloropyron palmatum),*

- spiny-sepaled button-celery (*Eryngium spinosepalum),*
- California alkali grass (*Puccinellia simplex),*
- Valley Sacaton Grassland, and
- Sycamore Alluvial Woodland.

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** for the status of each species listed above). This unit does not contain or overlap any known protected lands or critical habitat for federally listed species (USFWS 2019, NMFS 2019) 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).

Designated fish and wildlife beneficial uses of other surface water bodies in the Chowchilla Subbasin, including the Fresno River and Chowchilla River, are limited to warm freshwater habitat (WARM) and wildlife habitat (WILD). The Basin Plan also lists coldwater spawning habitat (SPWN) for salmon and trout as a potential beneficial use for this portion of the San Joaquin River.

The San Joaquin River Riparian 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 in the unit; (2) the vulnerability of these species and their habitat to changes in groundwater levels; and (3) contributions of the unit to the ecological function of adjacent riverine habitat that supports special-status salmonids and other species.

2.2.2.7 Data Gaps in Hydrogeologic Conceptualization and Groundwater Conditions

Although considerable evaluation and synthesis of data on hydrogeology and groundwater conditions in the Subbasin have occurred historically and as part of the development of the GSP, improved information in several notable areas would enhance the understanding of the hydrogeology and groundwater conditions in the Subbasin. Keys areas where improved characterization of the hydrogeologic conceptualization and groundwater conditions would benefit the sustainable management of groundwater in the Subbasin are listed below.

2.2.2.7.1 Wells

This GSP presents the best available data to characterize existing wells in the Subbasin based on DWR WCR data, well permits, and other available sources. The Subbasin completed a Domestic Well Inventory project in 2022, which sought to improve the mapping of existing domestic wells and evaluate their potential to be impacted by future groundwater level conditions. The Domestic Well Inventory project also identified three locations where additional dedicated monitoring wells are to be installed in 2022 for monitoring conditions in areas of higher densities of domestic wells. Although currently available data on WCRs and well permits provide useful information on where wells have historically been constructed and some of their construction characteristics (e.g., total depth, perforated interval, seal depth), no data indicating currently active domestic and agricultural wells is currently available across the Subbasin. Refining the available well information to identify the active wells in the Subbasin and their characteristics would improve the ability to sustainably manage groundwater in the Subbasin, including determining what impacts on beneficial uses and users may occur in the Subbasin and improving the assessment of what conditions represent an undesirable result. There may be opportunities to coordinate these data refinement activities with well permitting activities and data recordkeeping occurring in the Subbasin.

2.2.2.7.2 Water Levels

A key data gap related to water levels in the Subbasin is the availability of well construction information for wells currently monitored and wells with historical water level monitoring records. This is important for understanding groundwater levels conditions and trends at different depths within the groundwater system across the Subbasin. The lack of known construction information for some wells, in combination with the destruction of some wells with long-term water level monitoring history and challenges accessing water level observations in wells present difficulties in assessing current and historical groundwater conditions and tracking future conditions. The GSAs recognized these challenges, and since 2019 the GSAs have installed 25 dedicated monitoring wells at nine unique sites in the Subbasin that targeted filling water level monitoring data gaps, as part of a Proposition 1 Sustainable Groundwater Management Planning grant from DWR. Ten additional dedicated monitoring wells are planned for installation in the Subbasin as part of completion of Proposition 1 and Proposition 68 grant projects. Additional dedicated monitoring facilities are also planned as part of the construction of recharge projects in the Subbasin. These dedicated groundwater monitoring facilities, and the continuous groundwater level monitoring that is occurring at these sites, will greatly improve the characterization of groundwater conditions in the Subbasin; however, it will take some time before the monitoring record at these sites is sufficiently long to integrate into the understanding of the Subbasin hydrogeologic conceptualization and trends in groundwater conditions. The need and opportunity for supplementing or replacing historical water level monitoring facilities that may not provide optimal monitoring information with dedicated monitoring facilities should continue to be evaluated on an ongoing basis.

2.2.2.7.3 Subsidence

There are many subsidence benchmarks in the Subbasin that are monitored twice a year by the USBR as part of the SJRRP. The continued monitoring of these sites, and the extension of the monitoring record at each site, will be greatly beneficial to tracking and understanding subsidence trends and patterns in the Subbasin. To improve understanding of the relationship between groundwater levels and subsidence, coupling groundwater level monitoring in the vicinity of these benchmark sites would provide value information. The locations of these benchmark sites should be considered as part of the groundwater monitoring planning in the Subbasin, including when considering locations for potential additional dedicated groundwater monitoring facilities. Continuation of monitoring at the SJRRP benchmarks will also be important for evaluating any elasticity to the historical subsidence, or any recovery of historical subsidence that may occur.

In addition to the existing SJRRP benchmark subsidence monitoring that occurs within the Subbasin, there is likely also benefit to installing some continuous GPS monitoring or other station for continuous monitoring of vertical displacement or compaction at a finer temporal resolution. The benefit of such monitoring would likely be greatest in the western management area where the greatest historical subsidence has occurred and near key water conveyance features. Coupling any new continuous subsidence monitoring stations with dedicated groundwater monitoring facilities would provide the greatest benefit to relating groundwater conditions to land subsidence.

One of the key aspects of subsidence in the Subbasin that is not well understood or quantified relates to residual subsidence and differentiating residual subsidence caused by historical conditions from new subsidence. Robust subsidence monitoring coupled with well-defined groundwater level monitoring will be important for tracking the different mechanisms related to subsidence.

Since initial GSP development, the GSAs have created a subsidence workplan to help develop a more robust subsidence monitoring program and fill data gaps (**Appendix 3.H**). Key considerations and topics that will be addressed through implementation of the workplan include, but are not limited to, the following:

- Summarizing existing subsidence-related monitoring data, including airborne electromagnetic (AEM) survey data and information collected as part of the Subsidence Control Measures Agreement.
- Completing additional field work to install land subsidence monitoring facilities at a key location in the Subbasin to identify how compaction at different depth zones (i.e., Upper and Lower Aquifer) contributes to the total land subsidence occurring in the Subbasin.
- Completing technical analyses to synthesize the available information on dynamics between groundwater levels and land subsidence and to refine subsurface hydrogeologic characterization related to subsidence.
- Updating groundwater modeling processes (in conjunction with the five-year GSP update) to better evaluate historical and projected land subsidence in the Subbasin.
- Providing technical support for development of a strategy for managing groundwater pumping and recharge in the WMA.
- Providing recommendations on future subsidence and groundwater monitoring needs.
- Providing recommendations on future analytical activities.
- Conducting additional stakeholder outreach and interbasin coordination.

2.2.2.7.4 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 data suggest that historically there likely has been some very limited 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 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 prominent clay layers beneath the San Joaquin River, including the A Clay and C Clay units of the Tulare Formation, along with other shallow clays, likely play a major role in how stream seepage interacts with the groundwater system and the extent to which these clay layers caused perched groundwater conditions occurring 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. The work plan is provided in **Appendix 3.I**. Key considerations and topics addressed in the workplan include, but are not limited to, 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 pumping 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 western areas of the Subbasin

2.2.3 Water Budget Information (23 CCR § 354.18)

The Chowchilla Subbasin is managed by four GSAs (CWD GSA, Madera Co GSA, Merced Co GSA, TTWD GSA) whose jurisdictional areas have been organized into five Subbasin subregions for GSP planning efforts (**Figure 2-78)**. These subregions include: CWD GSA, Madera Co GSA – East, Madera Co GSA – West, Sierra Vista Mutual Water Company (SVMWC), and TTWD GSA.

This section presents the historical and current water budgets for the entire Chowchilla Subbasin refined with information and knowledge gained during the assembly of individual water budgets for each of the five subregions within the Subbasin.

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 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 Chowchilla 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) following the GSP implementation period (2020-2039) using projected future land use and historical 1965-2015 hydrologic data.

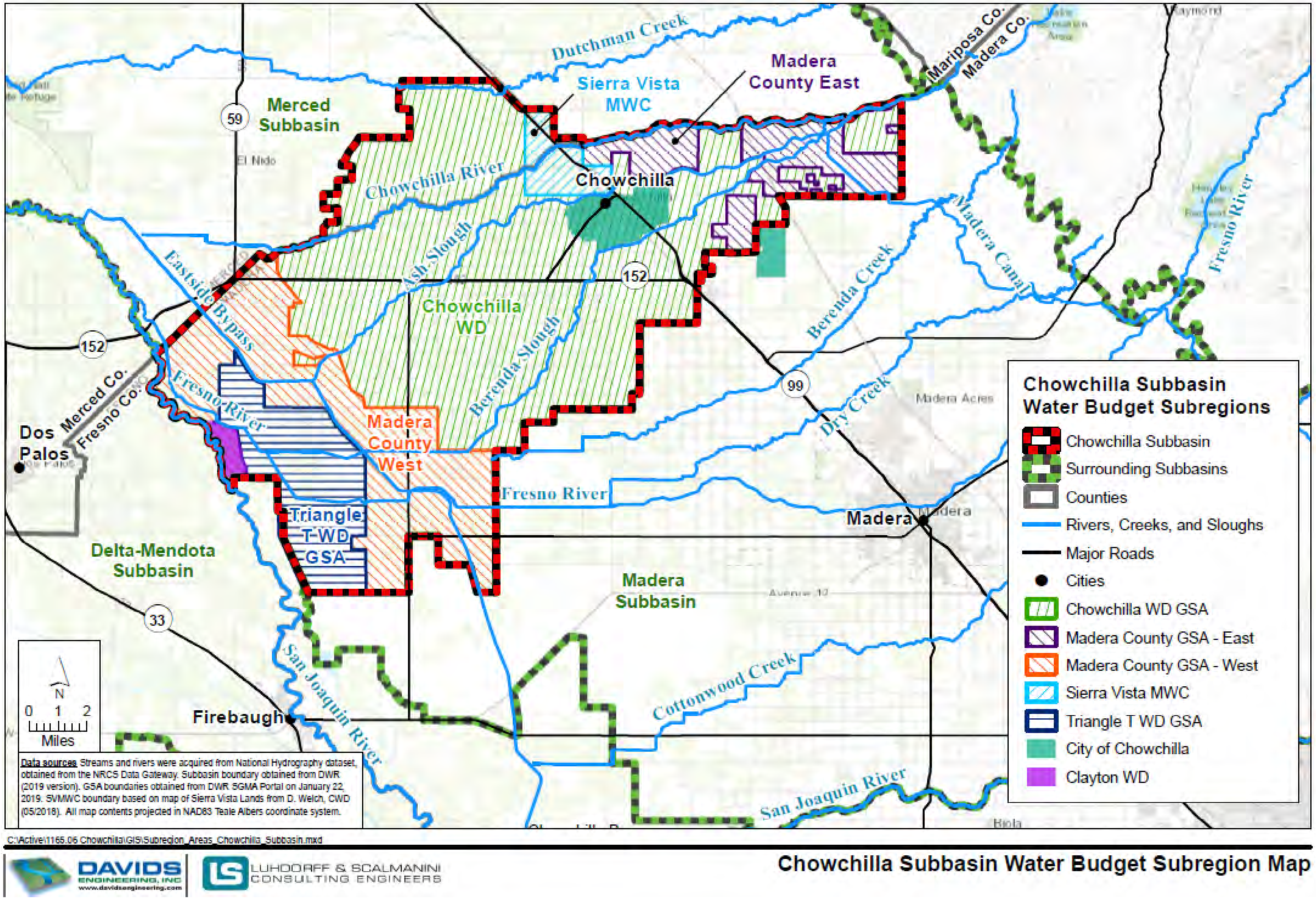

Figure 2-78. Chowchilla Subbasin Water Budget Subregions.[1]

[1] *In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.*

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[41] 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 or subregion, this method also facilitates assessment of the total volume of surface water entering and leaving a defined GSA or subregion boundary.

The conceptual model for the Chowchilla Subbasin and subregion 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 subregions utilizing the data sources and procedures outlined in Section 2.2.3.3 below.

2.2.3.1.1 Study Area

The water budget study area is defined as the Chowchilla Subbasin Plan Area, 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 five subregions: CWD GSA, Madera Co GSA – East, Madera Co GSA – West, SVMWC, and TTWD GSA. The relationships between the Chowchilla Subbasin GSAs and subregions is outlined in **Table 2-9**. Each subregion represents either one entire GSA (CWD GSA, TTWD GSA), a portion of one GSA (Madera Co GSA – East, Madera Co GSA – West), or combined areas across more than one GSA (SVMWC).

For each subregion, the SWS water budget was developed based on subregion-specific information describing land use, available surface water supplies, and other flow paths to facilitate estimation of groundwater extraction.

[41] 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.

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

<table>
<tr><th>GSA</th><th>Subregion</th><th>Subregion Abbreviation</th><th>Subregion Area, Acres</th></tr>
<tr><td>Chowchilla Water District GSA</td><td>Chowchilla Water District GSA</td><td>CWD GSA</td><td>85,200</td></tr>
<tr><td rowspan="3">Madera County GSA[1]</td><td>Madera County GSA – East</td><td>Madera Co GSA – East</td><td>11,400</td></tr>
<tr><td>Madera County GSA – West</td><td>Madera Co GSA – West</td><td>31,200</td></tr>
<tr><td rowspan="2">Sierra Vista Mutual Water Company</td><td rowspan="2">SVMWC</td><td rowspan="2">3,800</td></tr>
<tr><td>Merced County GSA</td></tr>
<tr><td>Triangle T WD GSA[1]</td><td>Triangle T Water District GSA</td><td>TTWD GSA</td><td>14,700</td></tr>
<tr><td colspan="3">Total</td><td>146,300</td></tr>
</table>

[1] In February 2023, TTWD annexed approximately 3,062 acres formerly located in the Madera County GSA within portions of the Chowchilla, Madera, and Delta-Mendota Subbasins. GSA boundary modifications will be reflected in the five-year GSP update.

2.2.3.1.2 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 2-79**.

For accounting for water in the SWS, interrelated water budgets were prepared individually for each subregion and for the entire Subbasin. For accounting for 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 MCSim model water budget accounting centers and components is provided in **Figure 2-80**. 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.

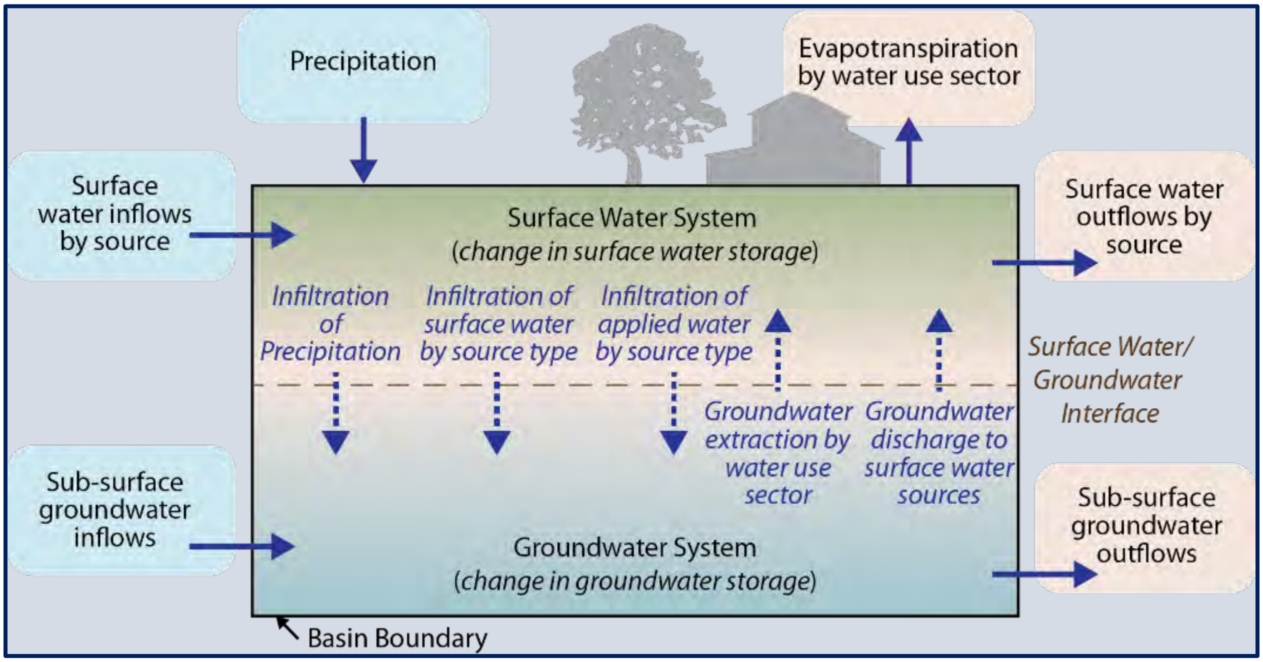

Figure 2-79. Water Budget Accounting Structure (Source: DWR, 2016).

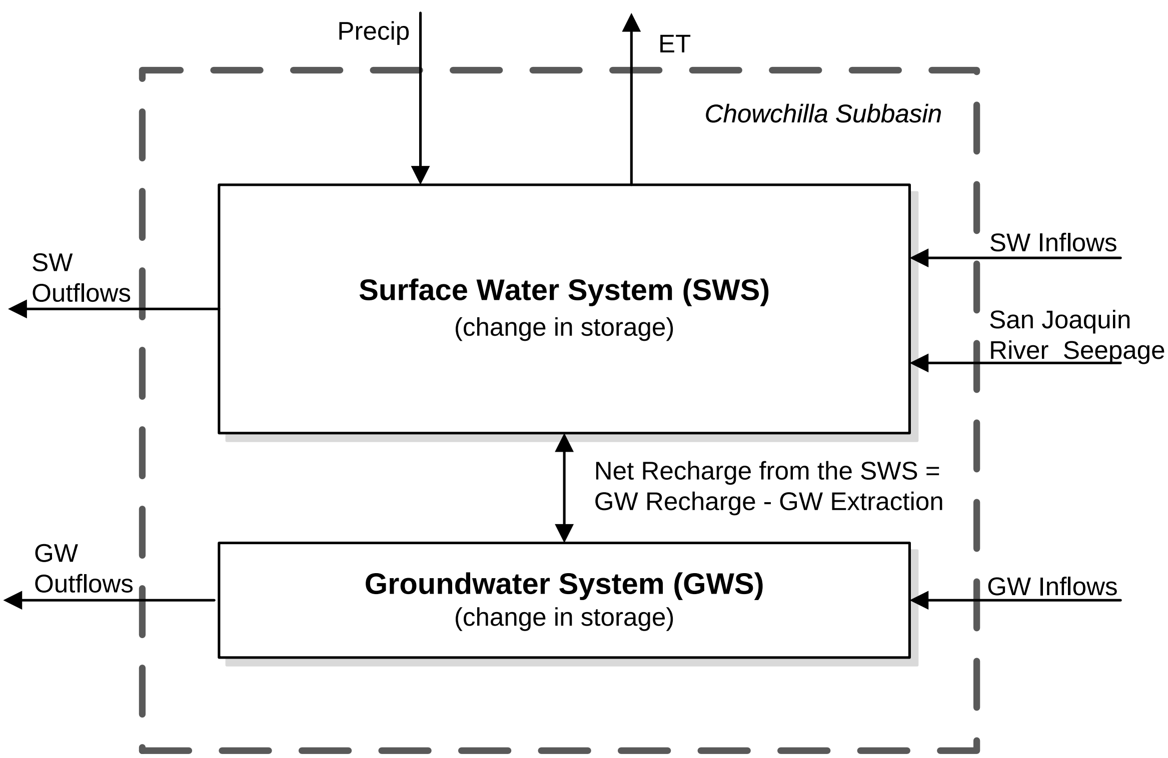

Figure 2-80. Chowchilla Subbasin Boundary Water Budget Diagram.

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

Accounting Center	Water Budget Component (flow direction)	23 CCR Section[42]
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 SWS 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[3] (-)	§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

[42] 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 Figure 2-80 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).

$$\text{Inflows} - \text{Outflows} = \text{Change in Storage (monthly time step)} \qquad [2\text{-}1]$$

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 regarding inflows to and outflows from each subregion 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 subregion in **Appendix 2.F.a.** through **Appendix 2.F.e.**

Quantification of GWS inflows and outflows is described below and in **Appendix 6.D.**, Groundwater Model Documentation. The GWS water budget was completed for the entire Subbasin on a monthly time step. Some subregions 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 subregions.

2.2.3.1.3 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 Chowchilla 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.

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 Chowchilla Subbasin SWS are described in **Tables 2-11** through **Table 2-13**. These water budget components were independently considered for each subregion to account for unique inflows and outflows to each subregion 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[43] (considered negligible in the Chowchilla 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 Chowchilla 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 SWS Storage	Storage	Change in SWS storage of applied water within the root zone.

[43] "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.[44]
	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.

2.2.3.1.4 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.

[44] 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[45] (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)).[46] 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 2-81**, 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

2.2.3.2.1 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 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.

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[45] 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.

[46] 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.

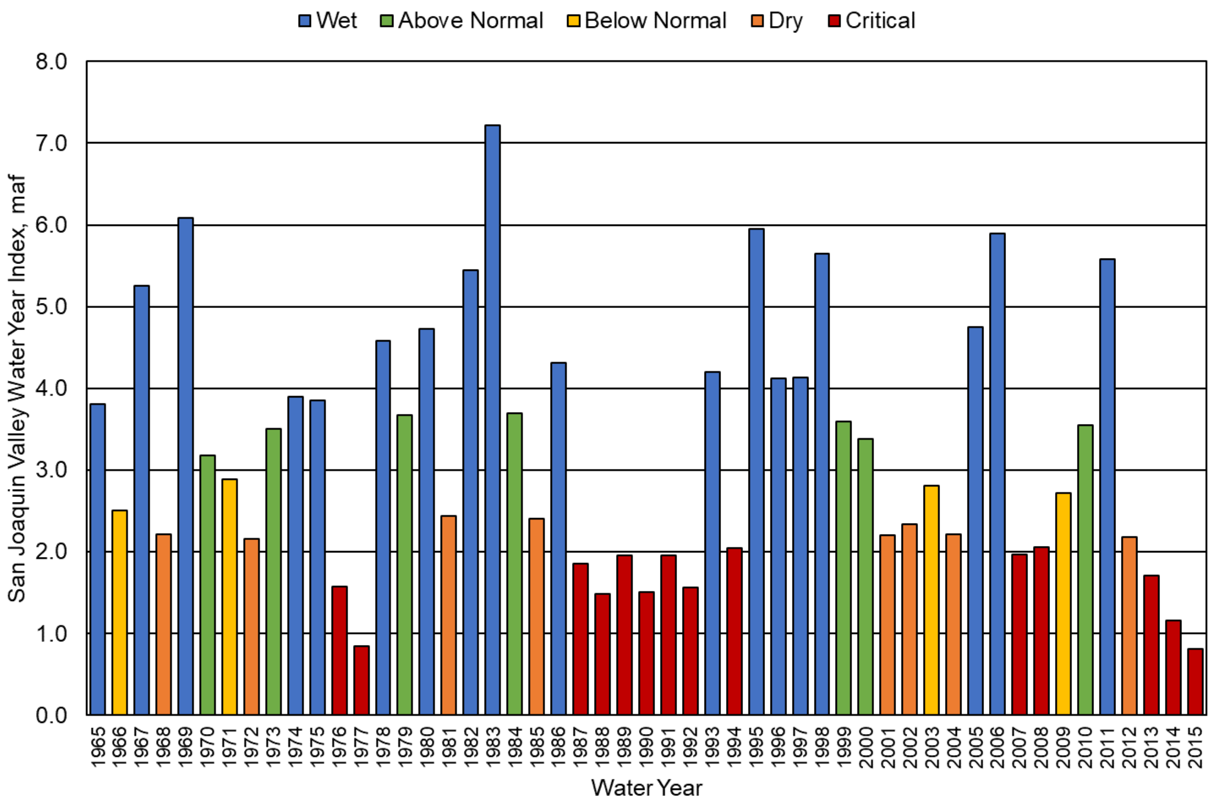

Figure 2-81. San Joaquin Valley Water Year Index, 1965-2015.

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 Chowchilla 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.

2.2.3.2.2 Historical Period

For the Chowchilla 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 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 from a nearby weather station in Madera, including annual precipitation, mean annual precipitation, and cumulative departure[47] from mean annual precipitation, are provided in **Figure 2-82**. As shown, alternating wet and dry periods between the late 1920s and late 1950s were followed by a 20-year average period between the late 1950s and the late 1970s. This 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 along Madera Canal and unimpaired flows[48] along the Chowchilla River are shown in **Figures 2-83** and **2-84**. 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[49]. 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.

2.2.3.2.3 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. The objective of completing a current water budget is to understand the impact of current land use on the water budget. This requires applying average historical climatic demands and water supplies to the current water budget. This was accomplished by assuming the 2015 land use occurred in each year during the 1989 through 2014 historical base period.

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[47] 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.

[48] 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).

[49] 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.

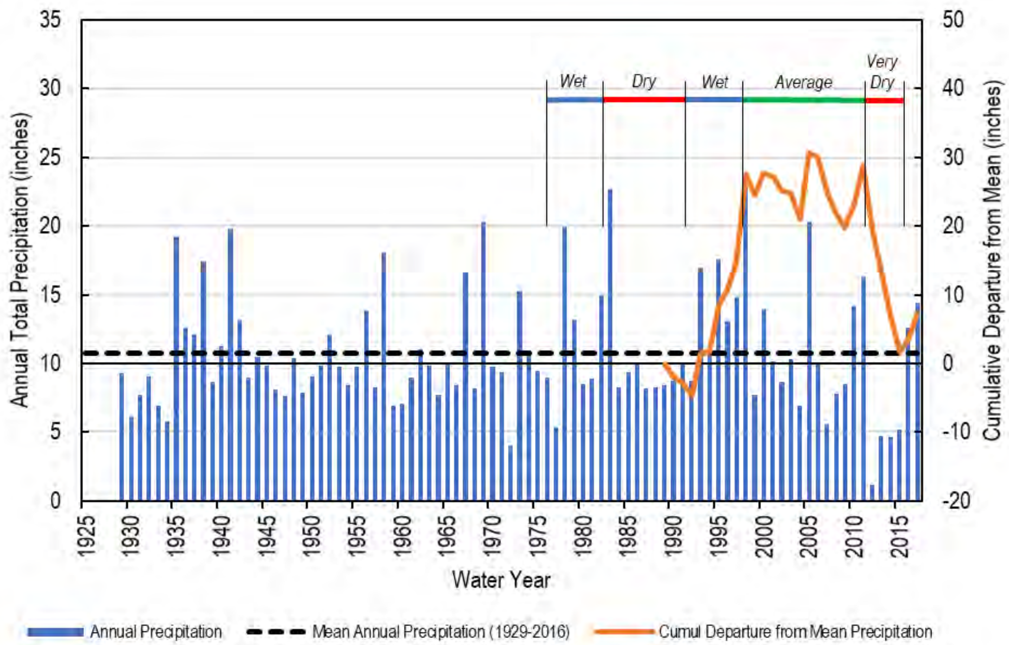

Figure 2-82. Annual Precipitation and Cumulative Departure from Mean Precipitation in Madera, CA.[50]

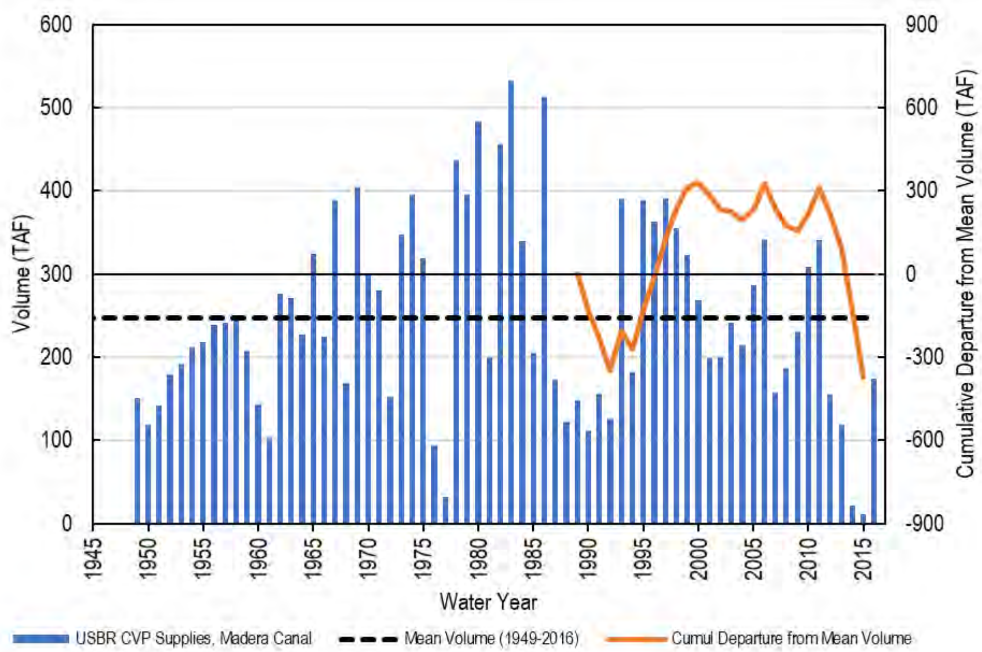

Figure 2-83. Annual CVP Supplies and Cumulative Departure from Mean CVP Supplies along Madera Canal.[51]

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

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

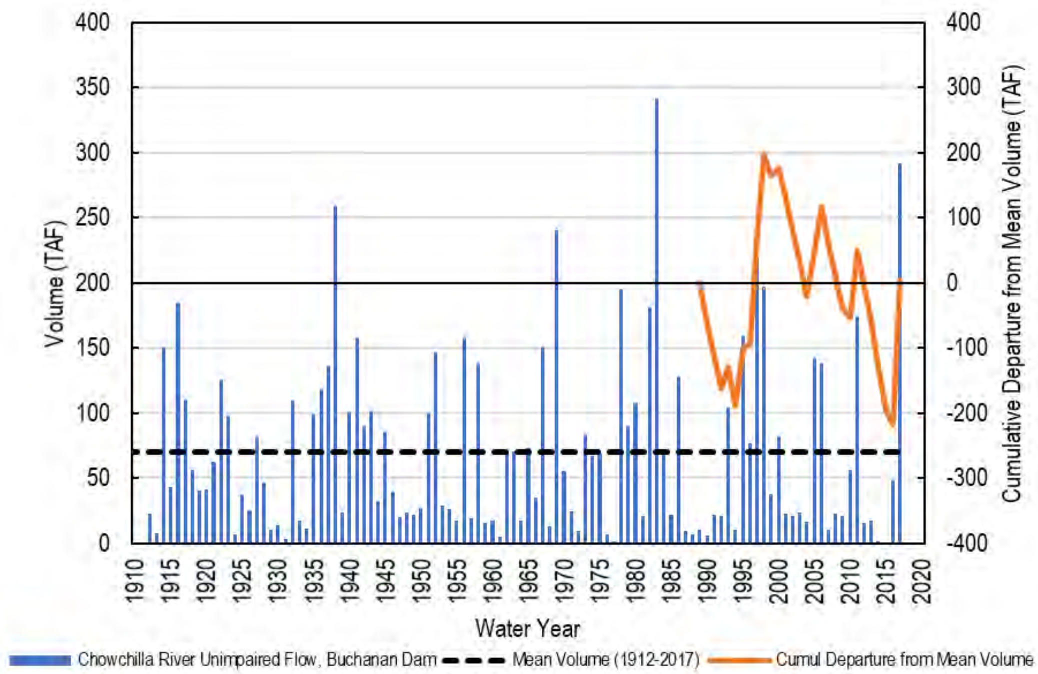

Figure 2-84. Annual Natural Flow and Cumulative Departure from Mean Natural Flow along Chowchilla River at Buchanan Dam.[52]

2.2.3.2.4 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[53]
3. 2017 land use adjusted for urban area projected growth from 2017-2070 (areas were held constant from 2071-2090)[54]

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[52] Chowchilla River natural flows compiled from: U.S. Army Corps of Engineers (USACE) computed natural flows at Buchanan Lake (1912-1970); U.S. Geological Survey (USGS) Station 11259000 (CHOWCHILLA R BL BUCHANAN DAM NR RAYMOND CA) (1971-1975); USACE computed inflows to Eastman Lake (1976-2017).

[53] 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.

[54] 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.”

The first eleven years of the projected period were simulated with hydrologic and water supply data from 2000-2010. 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[55]
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)

2.2.3.2.5 Water Budget Time Step

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.

2.2.3.2.6 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 Chowchilla 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 Chowchilla 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

[55] Climate change factors are from the DWR CalSim II simulated volume projections from State Water Project (SWP) and CVP operations under the 2030 mean climate change scenario.

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.

2.2.3.3.1 Land Surface System

In the Chowchilla 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 four water budget accounting centers representing Agricultural Land (AG), Urban Land (UR) (urban, industrial, and semi-agricultural land), Native Vegetation Land (NV), and Managed Recharge Land (MR) water use sectors. In the Chowchilla Subbasin, land is not exclusively demarcated for managed recharge, so the MR water use sector represents a small portion of agricultural land receiving flood deliveries for managed recharge during non-irrigation season months.

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 Chowchilla Subbasin subregion, 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.

Meteorological Data

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

The California Irrigation Management Information System (CIMIS) and National Oceanic and Atmospheric Administration National Centers for Environmental Information (NOAA NCEI) weather stations provide all weather data required for developing time series of many of the Land Surface System water budget components. CIMIS and NOAA NCEI data were obtained and quality controlled following the procedure described in **Appendix 2.F.f.** to develop daily reference crop evapotranspiration (ET_{ref}) and precipitation records for the Chowchilla Subbasin during the water budget analysis periods described in the previous section. **Table 2-15** lists the stations and periods of record used for each station.

Precipitation

Precipitation inflows to each Land Surface System water use sector were calculated as the daily precipitation depth derived from weather station data applied over the total area of that water use sector within the Subbasin. 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.

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	Closure Term	Calculated as the difference of total inflows and total outflows from the Water Use Sector water balance	Closure Term
Surface Water Deliveries	Inflow	AG	CWD GSA	Surface Water Data	Measured by CWD	CWD STORM delivery database, CWD monthly water supply reports
Water Rights Deliveries[1]	Inflow	AG	CWD GSA, Madera Co GSA – East, Madera Co GSA – West, SVMWC, TTWD GSA	Surface Water Data	Reported riparian/appropriative/prescriptive water rights deliveries during flood releases and/or natural flood flows; estimated from streamflow and crop ET when records not available	CWD delivery records, eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Flood Deliveries	Inflow	MR	CWD GSA	Surface Water Data	Measured by water supplier during flood releases outside the irrigation season	CWD STORM delivery database
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 Chowchilla 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 SWS 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

[1] Includes riparian, appropriative, and prescriptive water rights deliveries during flood releases and/or natural flood flows along Subbasin waterways.

Table 2-15. Chowchilla 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.

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 is widely used throughout California and was selected for this application. Daily ET_o values were provided as inputs to the root zone model for simulating crop consumptive use requirements.

Root Zone Model

To support water budget development for each Land Surface System water use sector, the IDC 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 in the root zone. A daily root zone water budget is a generally accepted and widely used method to estimate effective rainfall (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). 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 equal monthly flows by component in the SWS water budgets, and then integrated with the Chowchilla Subbasin C2VSim application. 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 Chowchilla 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.g.**

Land Use Data

Accurate land use areas are required for determining crop consumptive use (ET) and for developing an accurate root zone model. Thus, the objective of the land use analysis was to develop Madera and Merced County-wide annual spatial crop acreage datasets from which annual crop areas in the Chowchilla Subbasin and each subregion were derived. The procedure used for land use data development is described in **Appendix 2.A.**

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 2-2** 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 2-3** and **Table 2-2**). Across the Subbasin, agriculture has historically been dominated by orchard crops, mixed pasture, alfalfa, and corn. In particular, orchard acreage, which includes primarily almonds and pistachios, has more than tripled 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 Chowchilla Subbasin, as the majority of water used by dairies is applied to crops (approximately 90%).

Detailed land use summaries are provided for each subregion 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 reference ET-crop coefficient method (ASCE, 2016). Crop coefficients for major crops, native vegetation, and urban areas 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 the Chowchilla Subbasin, annual historical 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 Chowchilla Subbasin water budgets.

Urban Water Use

Urban water use was computed in the IDC application through the urban land use module (see **Appendix 2.F.g.**). 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 for City of Chowchilla, 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.

Surface Water Data

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

Surface water deliveries are reported by CWD in its monthly water summary records for 1981-2018 and in its STORM deliveries database for 2000-2018. The STORM delivery database is the water ordering and delivery management software used by Chowchilla Water District which is used to track all delivery events to turnouts within the district conveyance system.

Water rights deliveries – including riparian, appropriative, and prescriptive water rights deliveries – are comprised of water that is diverted directly to riparian parcels from adjacent waterways. Deliveries along the Chowchilla River system are reported by monthly or annual district or user records and by the State Water Resources Control Board's Electronic Water Rights Information Management System (eWRIMS). Deliveries along Fresno River to water rights holders in TTWD and Madera County are also reported by eWRIMS. In the water budget, reported water rights diversions are subtracted from the total flows along their respective waterways.

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 were estimated based on the quality control procedures described following the component data source descriptions.

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. 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).

2.2.3.3.2 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[56], 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 Chowchilla Subbasin in **Table 2-16** along with a brief description of the estimation technique and information sources

[56] The San Joaquin River does not cross the lateral boundaries of the Chowchilla 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.

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 Chowchilla Subbasin. A surface hydrology map summarizing the Chowchilla Subbasin inflows, outflows, and available data sources is provided in **Figure 2-85**. Surface water diverted under surface water rights is included in the associated agencies' GSA water budgets found in **Appendix 2.F.**

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

Chowchilla Bypass

The Chowchilla Bypass is located in the western part of the Chowchilla Subbasin, serving as a flood control channel operated via gates along the San Joaquin River during times when San Joaquin River flows would exceed the 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 records were estimated based on the quality control procedures described following the component data source descriptions.

Subbasin inflows were estimated by adjusting the CDEC and WDL records for estimated seepage and evaporation from the measurement point to the Chowchilla Subbasin boundary inflow point. Downstream of where the Fresno River enters the Chowchilla Bypass, the waterway is known as the Eastside Bypass.

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	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
			Chowchilla River	Reported Buchanan Dam flood releases	USACE records
			Dutchman Creek	Estimated as equal to Received Legrand water reported by CWD	CWD monthly water supply reports
			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
			Madera Canal	Reported Madera Canal flood releases	USBR records for Madera Canal Miles 33.6 and 35.6
Spillage	Inflow	Surface Water Data	Berenda Slough, Ash Slough, Chowchilla River	Reported by CWD monthly records; estimated as average monthly values of available records.	CWD SCADA records
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	Soils Data	All	Estimated from wetted area and estimated seepage coefficient by soil type	NRCS soil survey, GIS waterway attributes analysis
Flood Diversions	Outflow	Surface Water Data	Chowchilla River, Ash Slough, Berenda Slough	Calculated from CWD delivery records during Buchanan Dam and Madera Canal flood releases	CWD STORM delivery database, CWD monthly water supply reports, USACE records, USBR records
Water Rights Deliveries[1]	Outflow	Surface Water Data	All	Reported riparian/appropriative/prescriptive water rights deliveries during flood releases and/or natural flood flows; estimated from streamflow and crop ET when records not available	CWD delivery records, eWRIMS, Fresno State/Madera/Madera II CIMIS Stations, land use data
Surface Outflows	Outflow	Closure Term	All	Calculated as the difference of total inflows and total outflows from the Water Use Sector water balance	Closure Term

[1] Includes riparian, appropriative, and prescriptive water rights deliveries during flood releases and/or natural flood flows along Subbasin waterways.

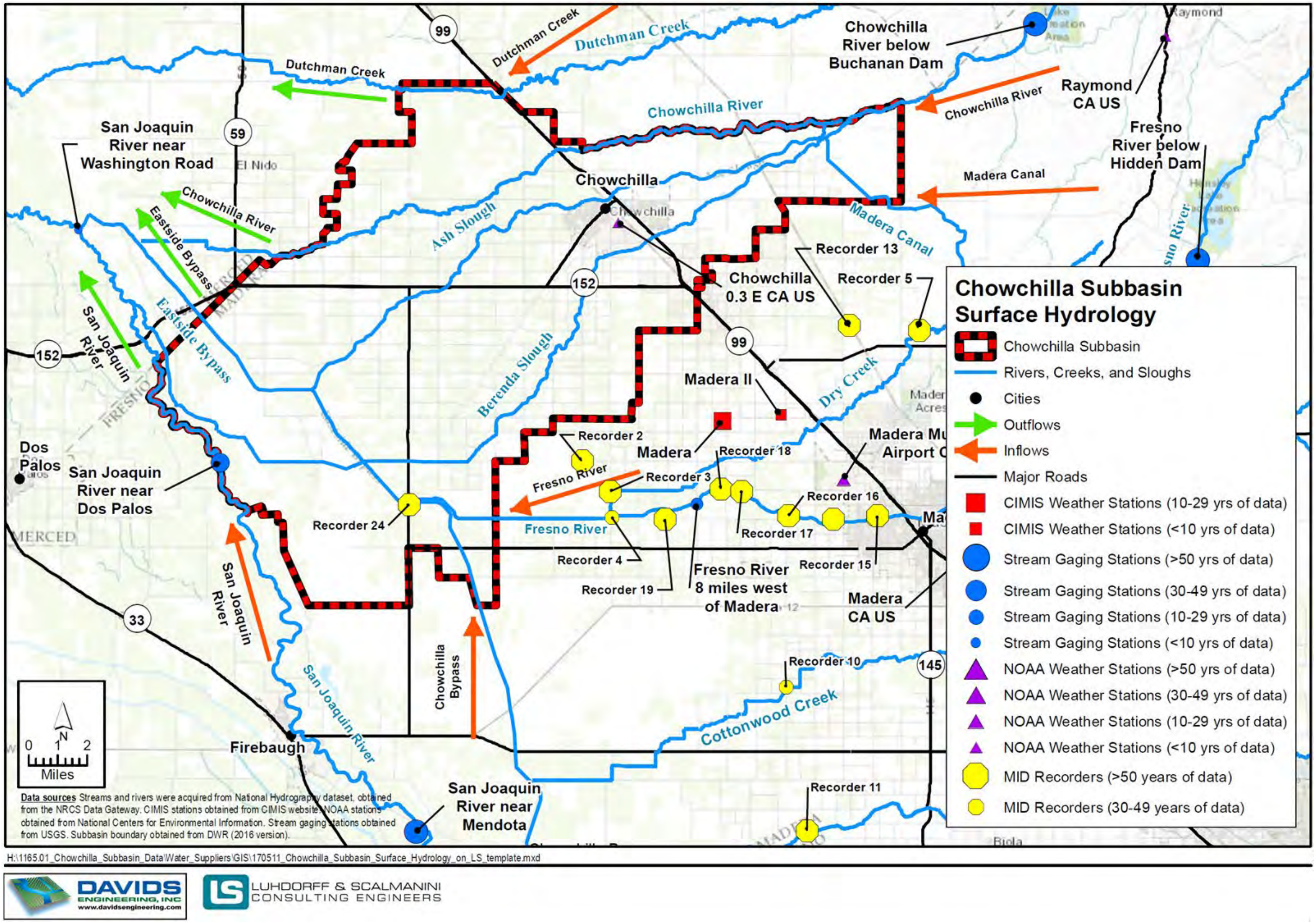


Figure 2-85. Chowchilla Subbasin Inflows and Outflows.

Chowchilla River

Inflow data for Chowchilla River were assembled from daily USACE records of irrigation and flood releases from Eastman Lake at Buchanan Dam upstream of the northeastern Subbasin boundary. Daily records of irrigation releases and flood releases in cubic feet per second (cfs) were available for 1981-2017.

During non-flood releases, the Chowchilla River is considered part of the CWD conveyance system, while at other times the Chowchilla River is considered a natural waterway. During non-flood releases, flows along Chowchilla River reach C-2 also contribute seepage that is allocated to SVMWC, per an agreement between SVMWC and CWD. Irrigation releases and water rights deliveries are accounted as inflows to the CWD GSA Canal System and/or SVMWC Rivers and Streams accounting center, and flood releases are accounted as inflows to the Subbasin Rivers and Streams System.

Subbasin inflows along Chowchilla River to the Rivers and Streams System were estimated by adjusting the associated daily data for estimated seepage and evaporation along the portion of the river downstream of Buchanan Dam and upstream of the Subbasin boundary.

Fresno River

Inflow data for the Fresno River were assembled from records provided by MID from its extensive network of recorders, which measure key inflows and outflows from the MID conveyance system and waterways within the Madera Subbasin. Fresno River inflows to Chowchilla Subbasin were derived from “Recorder 4: Fresno River Rd. 16” records available 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 flows are accounted as part of the Fresno River inflow.

Surface inflows were estimated from these records with adjustment for estimated seepage and evaporation from the portion of the river downstream of the Recorder 4 measurement site and upstream of the Chowchilla Subbasin boundary.

Madera Canal

The Madera Canal enters the Chowchilla Subbasin along its eastern boundary and runs northwesterly through Madera Co GSA, terminating near the inflows to Ash Slough, Berenda Slough, and the lower Chowchilla River. Located along the canal are two delivery points to CWD at miles 33.6 and 35.6.

Surface inflows to Chowchilla Subbasin were assembled from USBR CVP recorded irrigation deliveries and flood deliveries at Madera Canal Miles 33.6 and 35.6. Daily records of irrigation deliveries and flood deliveries in cubic feet per second (cfs) were provided by CWD for 1978-2018.

During irrigation releases, Madera Canal inflows are considered part of the CWD conveyance system. During flood releases, water discharged from Madera Canal Miles 33.6 and 35.6 are considered to enter natural waterways in the Subbasin. Thus, irrigation releases are accounted as inflows to the CWD GSA Canal System accounting center, and flood releases are accounted as inflows to the Subbasin Rivers and Streams System.

Madera Canal inflows to the Subbasin Rivers and Streams system were estimated from flood release records by adding an adjustment for estimated seepage and evaporation that occurred in the portion of the Madera Canal between the Mile 33.6 and Mile 35.6 measurement points and the Chowchilla Subbasin boundary.

Water Rights Deliveries

Water rights deliveries from the Rivers and Streams System include riparian, appropriative, and prescriptive water rights deliveries to riparian parcels during flood releases and/or natural flood flows along Subbasin waterways. Water rights deliveries data sources are described above in the Land Surface System components descriptions.

Flood Diversions

While irrigation releases from Buchanan Dam and Madera Canal serve as the major source of water delivered by CWD for irrigation, a portion of flood releases is also diverted from waterways within CWD for irrigation. These flood diversions were calculated as the volume of water required to supply reported CWD deliveries during available flood releases from Buchanan Dam and Madera Canal.

Surface water deliveries are reported by CWD in its monthly water summary records for 1981-2018 and in its STORM deliveries database for 2000-2018, as described in the Land Surface System components descriptions above. Daily records of flood releases are available for Buchanan Dam during 1981-2017 and for Madera Canal during 1978-2018.

Spillage from CWD

Excess flows in the CWD conveyance system are released at spill sites into Berenda Slough, Ash Slough, and Chowchilla River. Monthly spillage volumes were assembled from CWD SCADA data available between 1995-2017. Missing records were estimated based on the quality control procedures described following the component data source descriptions.

San Joaquin River

The San Joaquin River flows along the western Subbasin boundary but does not cross the lateral boundaries of the Chowchilla Subbasin. Thus, flow along the San Joaquin River was not explicitly included in surface water inflows to the Subbasin water budget. Only 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 Subbasin estimates of overdraft and net recharge from SWS.

To develop these seepage estimates, measured inflow data were assembled for 1980-2013 from WDL records of USGS site 11256000 (“San Joaquin River near Dos Palos”), located near the town of Dos Palos in Merced County. Seepage was calculated based on these available inflows and the waterway attributes of San Joaquin River reaches along the Subbasin boundary, following the process described below. These seepage estimates were found to be consistent with San Joaquin River Restoration Study values.[57] For the section of the San Joaquin River bordering the Chowchilla 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.

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

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified previously 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 subregion.

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[58] (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.g.**

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.

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 each subregion. Total Subbasin seepage was calculated as the sum of seepage in all subregions.

2.2.3.3.3 Canal System

In the Chowchilla Subbasin, the Canal System includes all canals in the CWD conveyance system as well as natural waterways used to convey irrigation releases or water rights deliveries. Other than the TTWD GSA, which uses pipelines to convey water to different areas, all other subregions do not contain subregion-wide irrigation water distribution systems.

Detailed Canal System water budget components are summarized in **Table 2-17** for CWD GSA. This table also includes brief descriptions of the estimation techniques and information sources for each component. Details for each component are briefly summarized below.

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

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

Detailed Component	Category	Data Type	Calculation/Estimation Technique	Information Sources
Irrigation Releases from Buchanan Dam	Inflow	Surface Water Data	Reported Buchanan Dam irrigation releases	USACE records
Irrigation Releases from Madera Canal	Inflow	Surface Water Data	Reported Madera Canal irrigation releases	USBR records for Madera Canal Miles 33.6 and 35.6
Flood Diversions to CWD	Inflow	Surface Water Data	Calculated from CWD delivery records during combined Buchanan Dam and Madera Canal flood releases	CWD STORM delivery database, CWD monthly water supply reports, USACE records, USBR 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	Reported by CWD monthly records; estimated as average monthly values of available records.	CWD SCADA records
Surface Water Deliveries	Outflow	Surface Water Data	Measured by CWD	CWD STORM delivery database, CWD monthly water supply reports
Water Rights Deliveries during Irrigation Releases	Outflow	Surface Water Data	Reported riparian/appropriative/prescriptive water rights deliveries to growers in TTWD, SVMWC and Madera Co GSA – East and Madera Co GSA – West during irrigation releases	CWD delivery records

Surface Water Data

Surface water data includes diversions of irrigation releases 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 below.

Irrigation Releases to CWD

Diversions to the CWD distribution system include irrigation releases from Buchanan Dam along the Chowchilla River and irrigation releases from Madera Canal at Mile 33.6 and Mile 35.6. Irrigation releases from both sources converge and are distributed downstream along Chowchilla River, Berenda Slough, and part of Ash Slough. These waterways serve as an integral part of the CWD conveyance system as they are used to distribute water to CWD canals. For water budget accounting, diversions to CWD include all irrigation releases from Buchanan Dam and Madera Canal at the measurement points described for each waterway in the Rivers and Streams System component descriptions above. Daily records of irrigation releases were available for Buchanan Dam during 1981-2017 and for Madera Canal Mile 33.6 and 35.6 during 1978-2018.

Flood Diversions to CWD

Flood diversions to CWD are described in the Rivers and Streams System component descriptions above

Spillage

Spillage from the CWD conveyance system is described in the Rivers and Streams System component descriptions above.

Surface Water Deliveries

Surface water deliveries from the CWD conveyance system are described in the Land Surface System component descriptions above.

Water Rights Deliveries during Irrigation Releases

Water rights deliveries include all riparian, appropriative, and prescriptive water rights deliveries to riparian parcels. These deliveries occur during both the irrigation releases and flood releases and/or natural flood flows along Subbasin waterways. When appropriative and prescriptive water rights deliveries coincide with irrigation releases, they are accounted for within the CWD Canal System water budget. Data sources for all Water rights deliveries are described above in the Land Surface System components descriptions.

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 CWD Canal System.

Evaporation

Evaporation was calculated from quality controlled daily ET_o records obtained from the weather stations identified in **Table 2-15** multiplied by the free water surface evaporation coefficient of 1.05 from UCCE (1989) and ASCE (2016) and the total surface area of CWD canals and waterways used in conveying irrigation releases.

Soils Data

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

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. During non-flood releases along the Chowchilla River, some seepage along reach C-2 is allocated to SVMWC. Per an agreement between SVMWC and CWD, 70% of non-flood seepage along reach C-2 is allocated to SVMWC, and 30% is allocated to CWD.

2.2.3.3.4 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 applied to meteorological data, soils data, and other data prepared for IDC root zone water budget development are described in **Appendix 2.F.f** and **2.F.g.**

2.2.3.3.5 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 subregion water budgets. **Table 2-18** 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 Historical Water Budget Analysis

The conceptual water budget model for the Chowchilla Subbasin and the subregions identified in **Table 2-9** 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 Chowchilla 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 subregion are presented and discussed in **Appendices 2.F.a.** through **2.F.e.** along with summaries of subregion land use data relevant to water budget development.

2.2.3.4.1 Surface Water Inflows

Surface water inflows include surface water flowing into the basin across the basin 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.

Local Supplies

Local supply inflows to the Chowchilla Subbasin include surface water inflows along Chowchilla Bypass; pre-1914, riparian, and prescriptive water rights on the Chowchilla River; and water received from Legrand Dam.

Local Imported Supplies

Chowchilla Subbasin does not receive local imported supplies.

CVP Supplies

Agencies with CVP contracts can receive CVP supplies in the Chowchilla Subbasin. These CVP supplies include Buchanan Dam irrigation and flood releases received via Chowchilla River and Millerton Reservoir irrigation and flood releases received via Madera Canal. Millerton Reservoir releases are diverted to Chowchilla Water District from Madera Canal Mile 33.6 and Mile 35.6. Irrigation releases from both sources are accounted as inflows to the CWD GSA water budget Canal System, while flood releases are accounted as inflows to the Subbasin Rivers and Stream System.

Table 2-18. 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)
	Water Rights Deliveries	Measurement	10%	Estimated measurement accuracy.
	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	Surface Water Outflows	Measurement	15%	Estimated streamflow measurement accuracy with adjustment for infiltration and evaporation.
	Evaporation	Calculation	20%	Estimated accuracy of calculation based on CIMIS reference ET and free water surface evaporation coefficient.
	ET of Applied Water	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, estimated crop coefficients from SEBAL energy balance, and annual land use.
	ET of Precipitation	Calculation	10%	Estimated accuracy of daily IDC root zone water budget component based on CIMIS reference ET, precipitation, estimated crop coefficients from SEBAL energy balance, and annual land use.
	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.
	Infiltration of Surface Water	Calculation	15%	Estimated accuracy of daily seepage calculation using NRCS soils characteristics and measured streamflow data compared to field measurements.
	Change in SWS Storage	Calculation	50%	Professional Judgment.
Net Recharge from SWS		Calculation	20%	Estimated water budget accuracy; typical value calculated for Subbasin-level net recharge from SWS.

Recycling and Reuse

Recycling and reuse are not a significant source of supply within Chowchilla 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 2-86** and **Table 2-19**. 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 under 70 taf during average critical years to over 900 taf during average wet years.

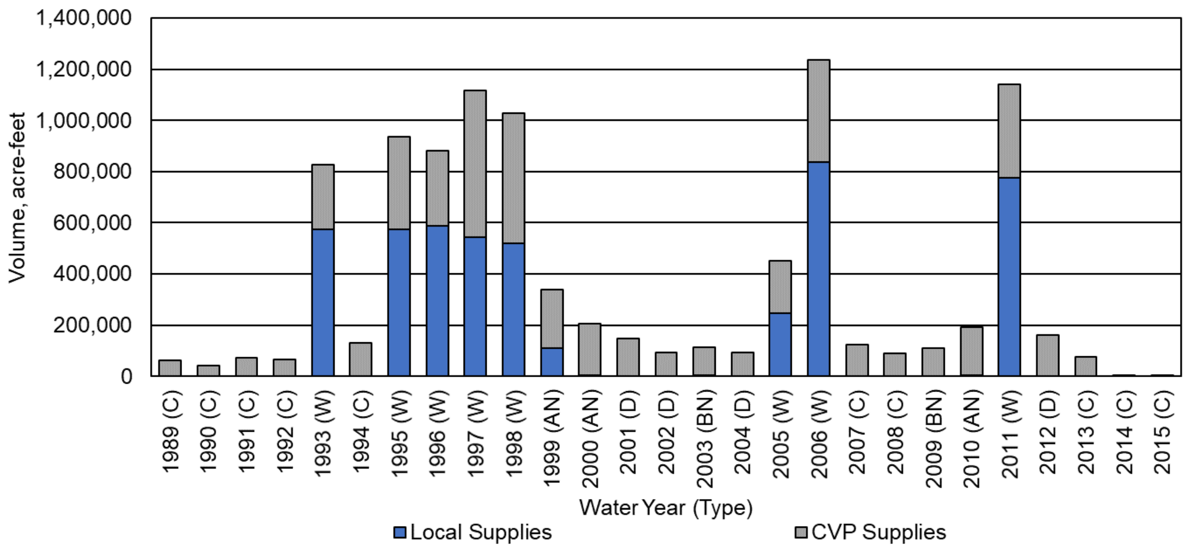


Figure 2-86. Chowchilla Subbasin Surface Water Inflows by Water Source Type.

Table 2-19. Chowchilla Subbasin Surface Water Inflows by Water Source Type (AF) (23 CCR §354.18(b)(1)).

Water year (Type)	Local Supplies			CVP Supplies						Surface Water Inflows Total
	Chowchilla Bypass	Received LeGrand	Water Rights Deliveries*	Irrigation Releases from Buchanan Dam	Flood Releases from Buchanan Dam	Irrigation Releases from Madera Canal	Flood Releases from Madera Canal	Fresno River	Deliveries to CWD Growers from MID	
1989 (C)	0	0	0	7,890	0	54,730	0	0	0	62,620
1990 (C)	0	0	0	3,480	0	38,790	0	0	0	42,270
1991 (C)	0	0	1,240	17,040	0	55,060	0	0	0	73,350
1992 (C)	0	0	790	16,970	0	46,470	0	0	0	64,220
1993 (W)	571,210	0	2,830	18,210	0	166,480	0	66,920	0	825,650
1994 (C)	0	0	1,660	62,630	0	65,320	0	170	0	129,780
1995 (W)	572,200	0	3,460	47,580	24,860	84,660	81,530	120,760	0	935,040
1996 (W)	587,640	0	1,560	53,420	29,450	135,210	3,410	71,330	0	882,010
1997 (W)	541,010	0	930	37,660	186,330	136,550	26,850	188,130	0	1,117,450
1998 (W)	517,240	0	1,840	83,240	108,760	42,800	82,930	192,100	0	1,028,910
1999 (AN)	108,790	910	1,490	48,320	0	131,550	17,620	30,300	0	338,980
2000 (AN)	4,240	1,020	310	57,980	6,840	113,230	0	22,010	0	205,630
2001 (D)	0	880	890	81,760	0	64,750	0	330	0	148,610
2002 (D)	0	1,120	760	22,160	0	69,850	0	0	0	93,880
2003 (BN)	0	320	2,140	10,730	0	99,040	0	0	0	112,230
2004 (D)	0	690	860	19,620	0	70,290	0	0	0	91,460
2005 (W)	244,630	70	1,930	46,330	0	112,740	16,870	27,130	0	449,700
2006 (W)	831,930	540	3,480	54,850	76,550	98,770	44,750	126,760	0	1,237,640
2007 (C)	0	190	760	80,450	0	39,110	0	4,640	0	125,160
2008 (C)	0	0	570	24,090	0	64,860	0	0	0	89,530
2009 (BN)	0	0	840	15,070	0	94,850	0	0	0	110,760
2010 (AN)	0	530	1,990	17,620	0	159,480	0	13,940	0	193,560
2011 (W)	771,100	390	3,190	26,050	64,340	156,740	10,860	106,810	150	1,139,640
2012 (D)	0	0	810	97,830	0	55,340	0	8,140	140	162,260
2013 (C)	0	0	80	36,620	0	36,290	0	1,700	80	74,770
2014 (C)	0	0	0	0	0	440	0	0	0	440
2015 (C)	0	0	0	0	0	530	0	0	0	530
Average (1989-2014)	182,690	260	1,320	37,980	19,120	84,360	10,950	37,740	10	374,440
Average (1989-2014) W	579,620	130	2,400	45,920	61,290	116,740	33,400	112,490	20	952,000
Average (1989-2014) AN	37,680	820	1,260	41,310	2,280	134,750	5,870	22,080	0	246,050
Average (1989-2014) BN	0	160	1,490	12,900	0	96,940	0	0	0	111,490
Average (1989-2014) D	0	670	830	55,340	0	65,060	0	2,120	30	124,050
Average (1989-2014) C	0	20	510	24,920	0	40,160	0	650	10	66,270

*Includes water diverted under pre-1914, riparian, and prescriptive water rights along Chowchilla River.

2.2.3.4.2 Surface Water Outflows

Surface water outflows are summarized in **Figure 2-87** and **Table 2-20**. These include natural flows along waterways, runoff of precipitation, and flood releases or spillage of CVP deliveries. As surface outflows serve as the water budget closure term, the monthly proportion of outflows of each water source type is estimated as equal to the proportion of inflows of each water source type by waterway. Overall, total surface outflows are significantly higher in wet years, averaging over 700 taf during wet years.

2.2.3.4.3 Groundwater System Inflows

Estimates of groundwater system inflows are provided in **Figure 2-88** and **Table 2-21**. These inflows include calculated inflows from the SWS and subsurface groundwater inflows from adjacent subbasins[59]. 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.

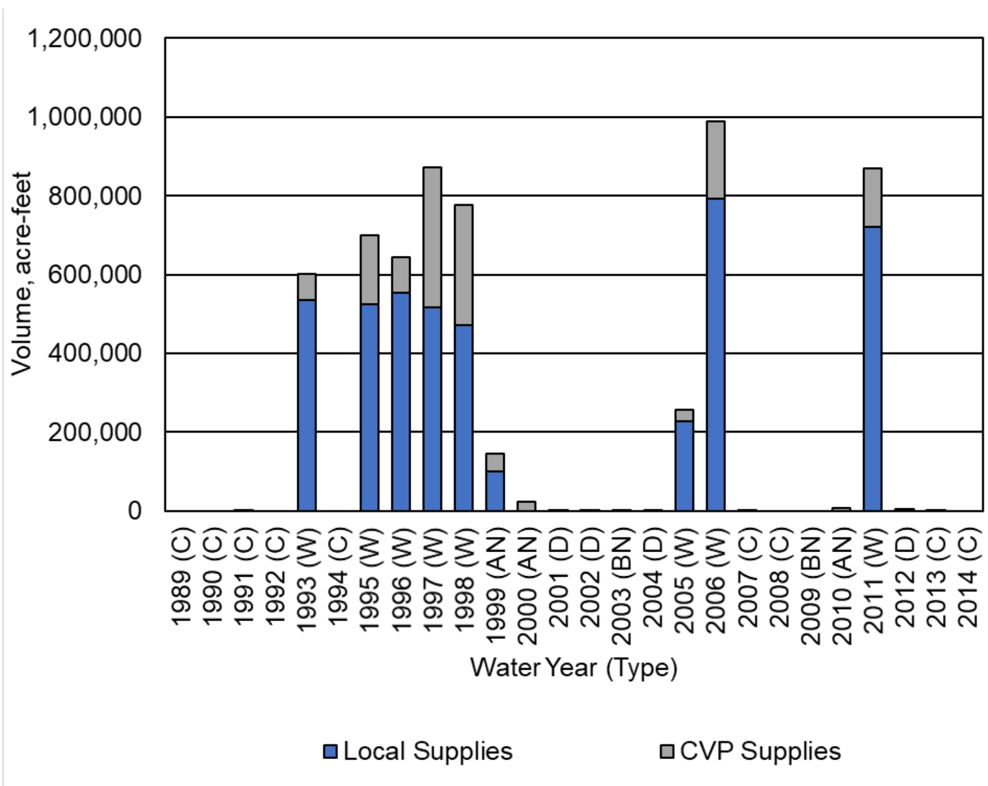


Figure 2-87. Chowchilla Subbasin Surface Outflows by Water Source Type.

[59] Subsurface groundwater inflows to Chowchilla Subbasin include simulated inflows from the Delta-Mendota, Madera, and Merced subbasins.

Table 2-20. Chowchilla Subbasin Surface Outflows by Water Source Type (AF) (23 CCR §354.18(b)(1)).

Water Year	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	240	0	240
1992 (C)	0	0	0
1993 (W)	535,240	66,690	601,930
1994 (C)	0	0	0
1995 (W)	524,170	176,640	700,810
1996 (W)	554,090	89,210	643,300
1997 (W)	516,760	356,340	873,100
1998 (W)	471,770	306,340	778,110
1999 (AN)	99,710	45,300	145,010
2000 (AN)	440	24,460	24,900
2001 (D)	300	560	860
2002 (D)	860	140	1,000
2003 (BN)	50	170	220
2004 (D)	0	320	320
2005 (W)	228,820	27,640	256,460
2006 (W)	792,690	195,090	987,780
2007 (C)	90	1,930	2,020
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	430	7,470	7,900
2011 (W)	721,820	148,630	870,450
2012 (D)	170	4,330	4,500
2013 (C)	130	220	350
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	171,070	55,830	226,890
Average (1989-2014) W	543,170	170,820	713,990
Average (1989-2014) AN	33,530	25,740	59,270
Average (1989-2014) BN	30	90	110
Average (1989-2014) D	330	1,340	1,670
Average (1989-2014) C	50	240	290

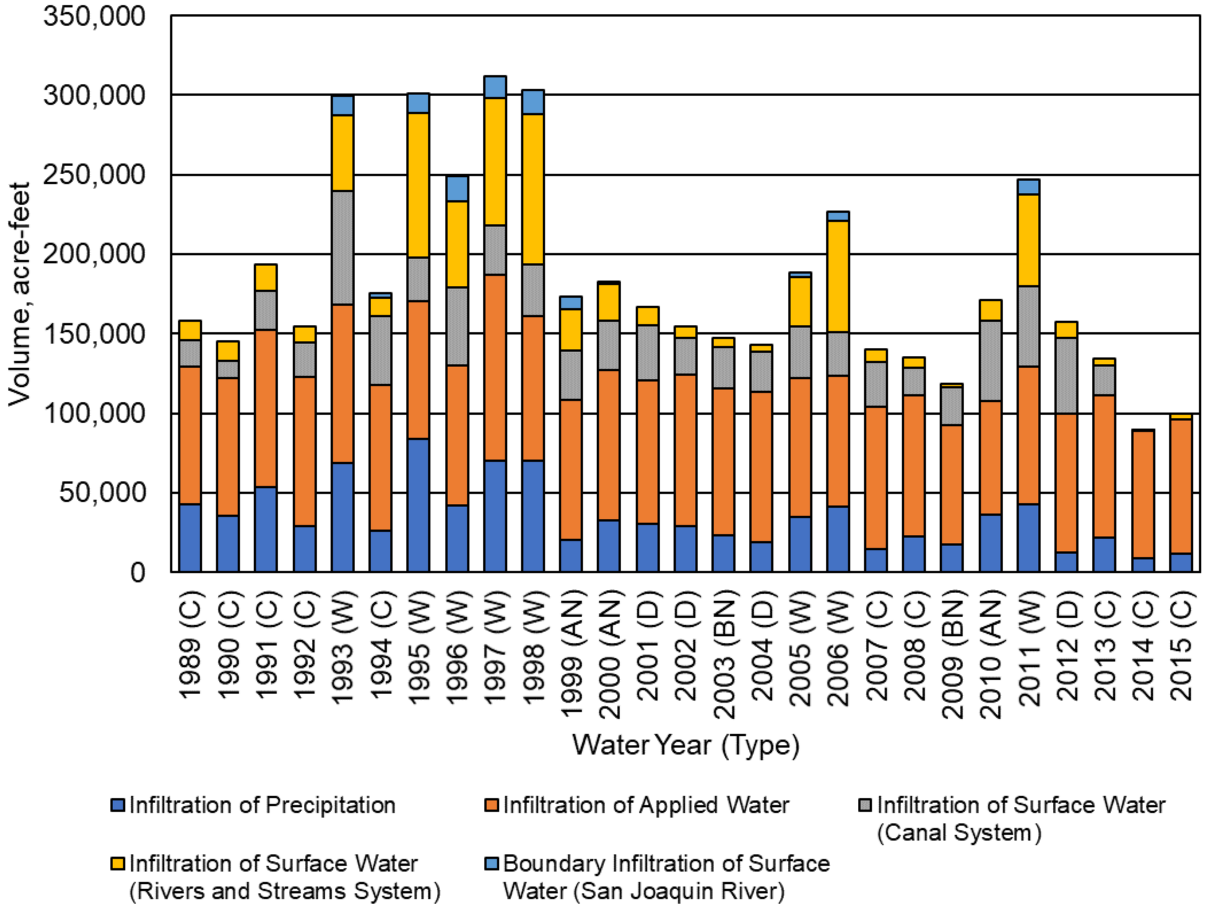


Figure 2-88. Chowchilla Subbasin Groundwater System Inflows.

Table 2-21. Chowchilla Subbasin Groundwater System Inflows (AF) (23 CCR §354.18(b)(2)).

Water Year (Type)	Net Subsurface Groundwater Inflow*	Infiltration of Precip	Infiltration of Applied Water	Infiltration of Surface Water (Canal System)	Infiltration of Surface Water (Rivers and Streams System)[1]
1989 (C)	*	42,470	87,050	16,410	11,930
1990 (C)	*	35,580	86,210	11,330	12,030
1991 (C)	*	53,200	99,140	25,590	16,740
1992 (C)	*	29,150	93,670	22,290	10,390
1993 (W)	*	68,910	99,510	74,020	59,820
1994 (C)	*	26,450	91,210	44,720	14,610
1995 (W)	*	83,880	86,780	30,630	103,330
1996 (W)	*	42,280	87,980	49,960	70,030
1997 (W)	*	70,440	116,280	32,210	94,033
1998 (W)	*	70,160	91,040	33,990	109,978
1999 (AN)	*	20,630	87,680	32,670	33,613
2000 (AN)	*	32,960	94,410	31,180	24,203

Water Year (Type)	Net Subsurface Groundwater Inflow*	Infiltration of Precip	Infiltration of Applied Water	Infiltration of Surface Water (Canal System)	Infiltration of Surface Water (Rivers and Streams System)[1]
2001 (D)	*	30,220	90,370	35,540	11,210
2002 (D)	*	28,890	95,360	24,450	6,950
2003 (BN)	*	23,120	92,400	28,280	5,820
2004 (D)	*	18,640	94,860	26,480	3,950
2005 (W)	*	34,490	87,680	34,660	33,930
2006 (W)	*	41,170	82,150	31,420	75,850
2007 (C)	*	14,710	89,190	28,890	7,900
2008 (C)	*	22,610	88,330	18,680	6,150
2009 (BN)	*	17,160	75,160	24,790	2,620
2010 (AN)	*	36,210	71,730	52,700	13,000
2011 (W)	*	42,450	86,770	54,170	66,610
2012 (D)	*	12,590	87,410	47,810	10,060
2013 (C)	*	22,000	89,080	18,840	4,330
2014 (C)	*	9,070	79,630	30	390
2015 (C)	*	11,500	84,610	10	3,770
Average (1989-2014)	47,280	35,750	89,660	31,990	31,130
Average (1989-2014) W	*	56,720	92,270	42,630	76,700
Average (1989-2014) AN	*	29,930	84,610	38,850	23,610
Average (1989-2014) BN	*	20,140	83,780	26,540	4,220
Average (1989-2014) D	*	22,590	92,000	33,570	8,040
Average (1989-2014) C[2]	*	28,360	89,280	20,750	9,390

*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] Includes combined infiltration of surface water from the Subbasin Rivers and Streams System and boundary infiltration of surface water from the San Joaquin River.
[2]Average infiltration of precipitation higher in critical years due to relatively higher amounts of precipitation in 1989-1992.

2.2.3.4.4 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in **Figure 2-89** and **Table 2-22**. For agricultural and urban (urban, semi-agricultural and industrial) lands, groundwater extraction represents pumping, while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be minimal[60] 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.

[60] Groundwater extraction of native vegetation estimated by ET_{aw} from the Chowchilla IDC application is less than 5 AF/yr.

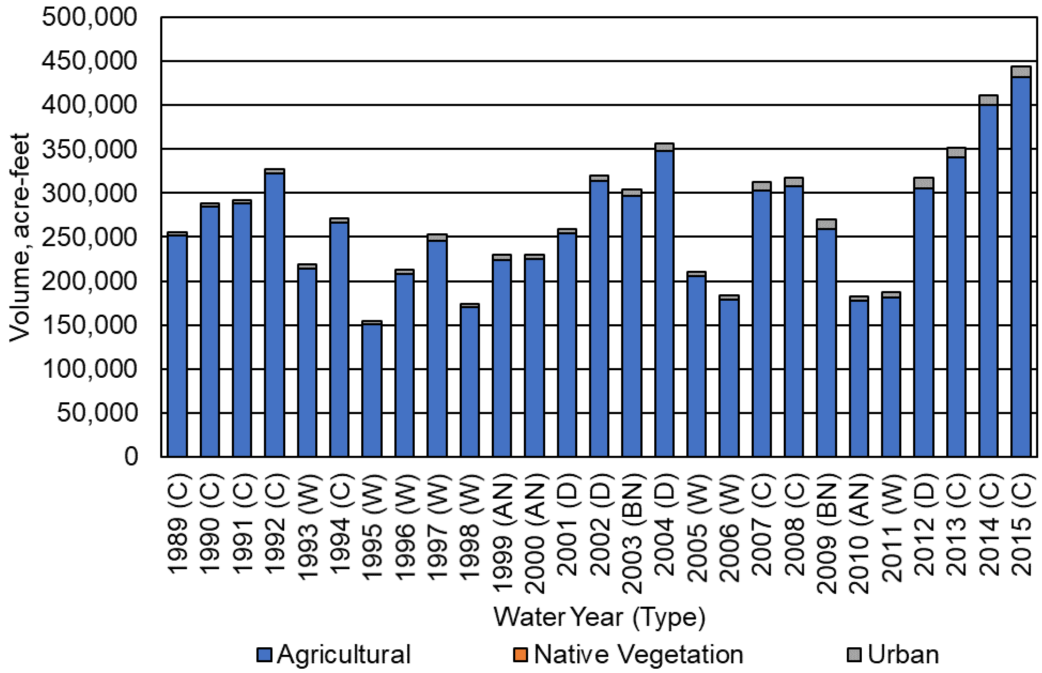


Figure 2-89. Chowchilla Subbasin Groundwater Extraction by Water Use Sector.

Table 2-22. Chowchilla Subbasin Groundwater Extraction by Water Use Sector (AF) (23 CCR §354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Total
1989 (C)	251,340	0	3,440	254,780
1990 (C)	283,970	0	3,760	287,730
1991 (C)	288,060	0	3,810	291,870
1992 (C)	321,910	0	4,930	326,840
1993 (W)	214,460	0	3,930	218,390
1994 (C)	266,480	0	4,880	271,360
1995 (W)	151,330	0	2,640	153,970
1996 (W)	208,230	0	4,030	212,260
1997 (W)	245,760	0	6,650	252,410
1998 (W)	170,840	0	3,470	174,310
1999 (AN)	224,000	0	5,620	229,620
2000 (AN)	224,830	0	4,950	229,780
2001 (D)	254,620	0	4,820	259,440
2002 (D)	313,640	0	6,580	320,220
2003 (BN)	296,800	0	6,670	303,470
2004 (D)	347,970	0	8,830	356,800
2005 (W)	205,020	0	5,790	210,810
2006 (W)	178,220	0	5,820	184,040
2007 (C)	303,090	-10	9,640	312,720
2008 (C)	307,660	0	9,920	317,580
2009 (BN)	259,520	0	10,010	269,530
2010 (AN)	177,000	0	5,920	182,920
2011 (W)	181,040	0	6,570	187,610
2012 (D)	305,780	0	11,110	316,890
2013 (C)	340,050	0	11,150	351,200

Water Year	Agricultural	Native Vegetation	Urban	Total
2014 (C)	399,610	0	10,960	410,570
2015 (C)	432,110	0	12,080	444,190
Average (1989-2014)	258,510	0	6,380	264,890
Average (1989-2014) W	194,360	0	4,860	199,230
Average (1989-2014) AN	208,610	0	5,500	214,100
Average (1989-2014) BN	278,160	0	8,340	286,490
Average (1989-2014) D	305,500	0	7,840	313,340
Average (1989-2014) C	306,910	0	6,940	313,850

2.2.3.4.5 Groundwater Discharge to Surface Water Sources

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

2.2.3.4.6 Evapotranspiration by Water Use Sector

Total evapotranspiration (ET) by water use sector is reported in **Figure 2-90** and **Table 2-23**. Total ET varies between years but has gradually increased over time due to changes in crops, with the lowest observed in 1989, at approximately 300 taf, and the greatest in 2015, at over 400 taf. Agricultural ET tends to increase in drier years, while native vegetation ET decreases.

In addition to total ET from land surfaces, estimates of evaporation from rivers and streams are reported in **Figure 2-91** and **Table 2-24**. Evaporation is highest in wet years when surface water inflows are typically higher, averaging approximately 2.5 taf overall.

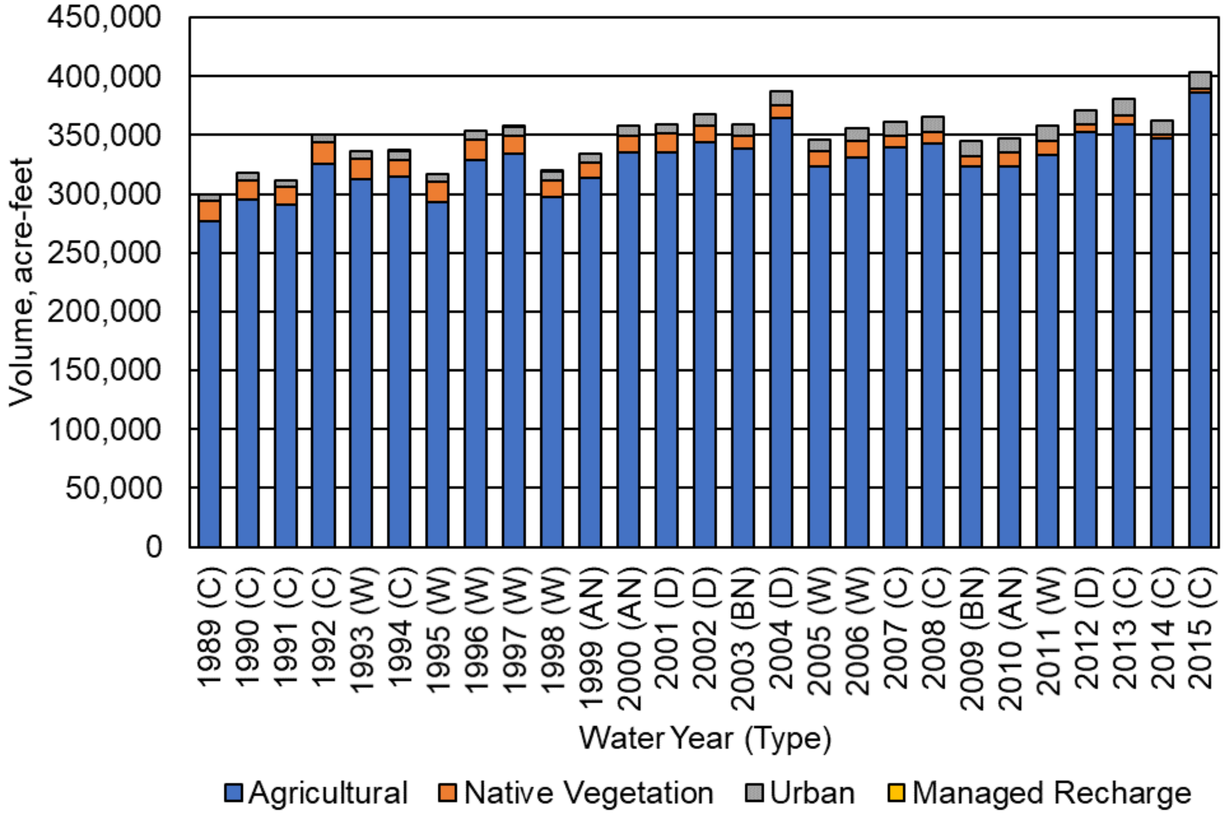


Figure 2-90. Chowchilla Subbasin Total Evapotranspiration by Water Use Sector.

Table 2-23. Chowchilla Subbasin Total Evapotranspiration by Water Use Sector (AF) (23 CCR §354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
1989 (C)	277,050	16,730	5,960	0	299,740
1990 (C)	295,140	16,670	6,360	0	318,170
1991 (C)	290,960	14,820	5,780	0	311,560
1992 (C)	325,520	18,030	7,230	0	350,780
1993 (W)	312,470	17,220	7,080	0	336,770
1994 (C)	314,570	14,280	7,190	10	336,050
1995 (W)	293,420	16,550	6,750	0	316,720
1996 (W)	328,400	17,490	7,450	0	353,340
1997 (W)	333,910	15,470	8,070	20	357,470
1998 (W)	297,250	14,180	7,230	30	318,690
1999 (AN)	313,390	12,940	7,480	0	333,810
2000 (AN)	335,290	14,130	8,160	0	357,580
2001 (D)	335,770	15,330	8,260	0	359,360
2002 (D)	343,980	14,250	9,370	0	367,600
2003 (BN)	338,240	11,140	9,630	0	359,010
2004 (D)	364,120	11,820	11,320	0	387,260
2005 (W)	323,270	12,920	10,430	0	346,620
2006 (W)	331,270	13,790	11,180	0	356,240
2007 (C)	339,570	10,030	11,680	0	361,280
2008 (C)	342,680	10,050	13,240	0	365,970

Water Year	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
2009 (BN)	323,520	8,170	13,500	0	345,190
2010 (AN)	323,730	11,330	12,590	0	347,650
2011 (W)	333,570	11,790	13,220	0	358,580
2012 (D)	353,050	6,230	12,310	0	371,590
2013 (C)	359,330	7,040	14,320	0	380,690
2014 (C)	347,440	3,400	11,990	0	362,830
2015 (C)	386,190	3,610	13,350	0	403,150
Average (1989-2014)	326,040	12,920	9,530	0	348,480
Average (1989-2014) W	319,200	14,930	8,930	10	343,050
Average (1989-2014) AN	324,140	12,800	9,410	0	346,350
Average (1989-2014) BN	330,880	9,660	11,570	0	352,100
Average (1989-2014) D	349,230	11,910	10,320	0	371,450
Average (1989-2014) C	321,360	12,340	9,310	0	343,010

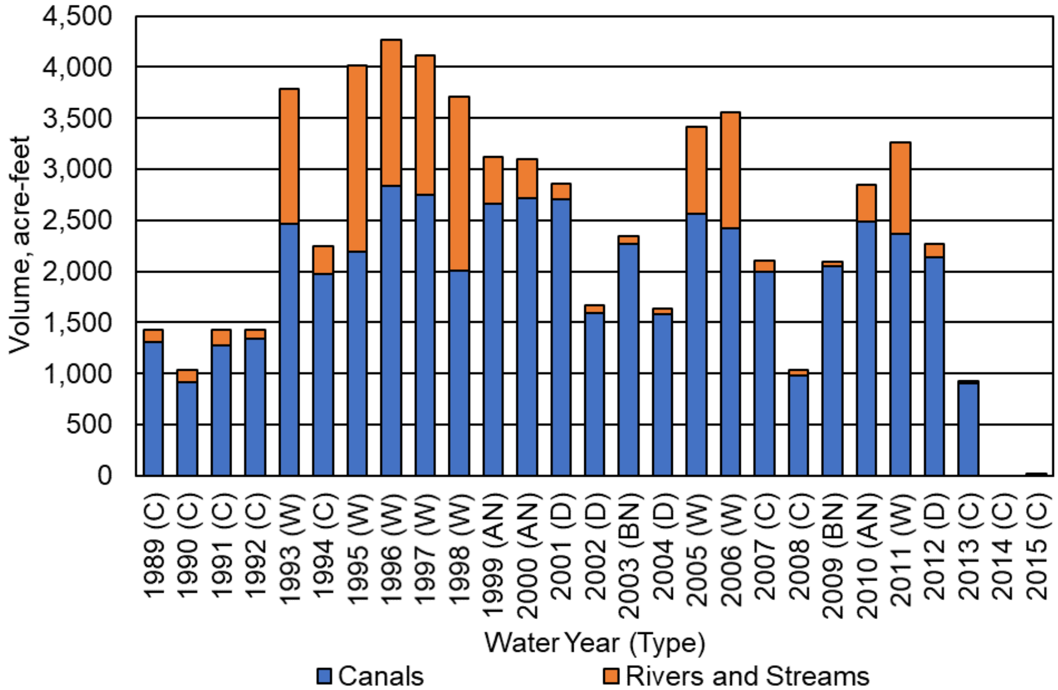


Figure 2-91. Chowchilla Subbasin Evaporation from the Surface Water System.

Table 2-24. Chowchilla Subbasin Evaporation from the Surface Water System (AF) (23 CCR §354.18(b)(3)).

Water Year	Canals	Rivers and Streams	Total
1989 (C)	1,310	120	1,430
1990 (C)	910	130	1,040
1991 (C)	1,270	160	1,430
1992 (C)	1,340	90	1,430
1993 (W)	2,460	1,330	3,790
1994 (C)	1,970	270	2,240
1995 (W)	2,190	1,820	4,010
1996 (W)	2,840	1,430	4,270
1997 (W)	2,750	1,360	4,110
1998 (W)	2,010	1,700	3,710
1999 (AN)	2,660	460	3,120
2000 (AN)	2,720	380	3,100
2001 (D)	2,710	150	2,860
2002 (D)	1,590	80	1,670
2003 (BN)	2,270	80	2,350
2004 (D)	1,580	50	1,630
2005 (W)	2,560	860	3,420
2006 (W)	2,420	1,140	3,560
2007 (C)	2,000	100	2,100
2008 (C)	980	50	1,030
2009 (BN)	2,050	40	2,090
2010 (AN)	2,490	360	2,850
2011 (W)	2,370	890	3,260
2012 (D)	2,140	130	2,270
2013 (C)	900	30	930
2014 (C)	0	0	0
2015 (C)	0	20	20
Average (1989-2014)	1,940	510	2,450
Average (1989-2014) W	2,450	1,320	3,770
Average (1989-2014) AN	2,620	400	3,020
Average (1989-2014) BN	2,160	60	2,220
Average (1989-2014) D	2,010	100	2,110
Average (1989-2014) C	1,190	110	1,290

2.2.3.4.7 Change in Storage

Estimates of average annual change in storage within the GWS are summarized for each water budget scenario in **Table 2-27**.

2.2.3.4.8 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage under historical conditions in the Chowchilla Subbasin SWS are summarized in **Figure 2-92**. 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 hydrology on the surface water system water budget and opportunities for projects to increase groundwater recharge and the sustainable yield.

Detailed historical water budget components in each subregion are summarized in detail in **Appendices 2.F.a.** through **2.F.e.**

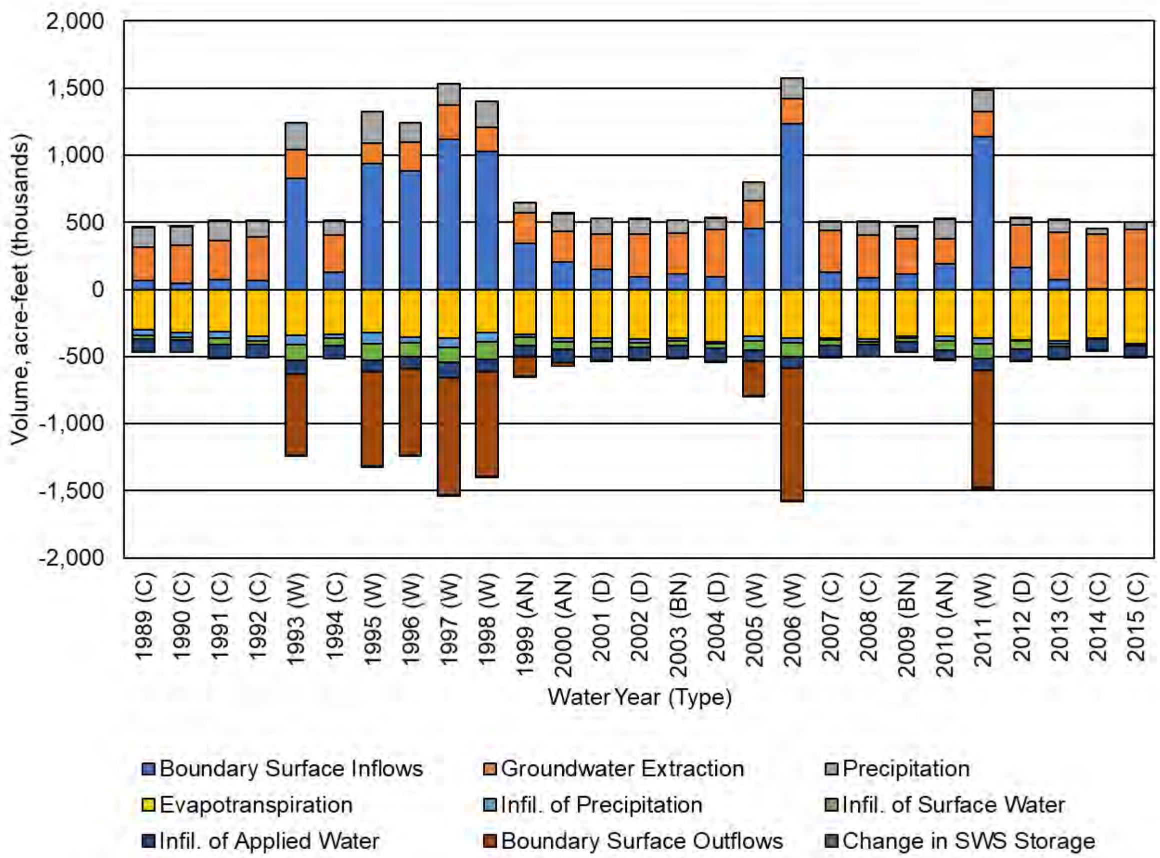


Figure 2-92. Chowchilla Subbasin Surface Water System Historical Water Budget.

2.2.3.4.9 Current Water Budget Summary

Annual inflows, outflows, and change in SWS storage under current land use conditions in the Chowchilla Subbasin SWS are summarized in **Figure 2-93**. 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 **Appendices 2.F.a.** through **2.F.e.**

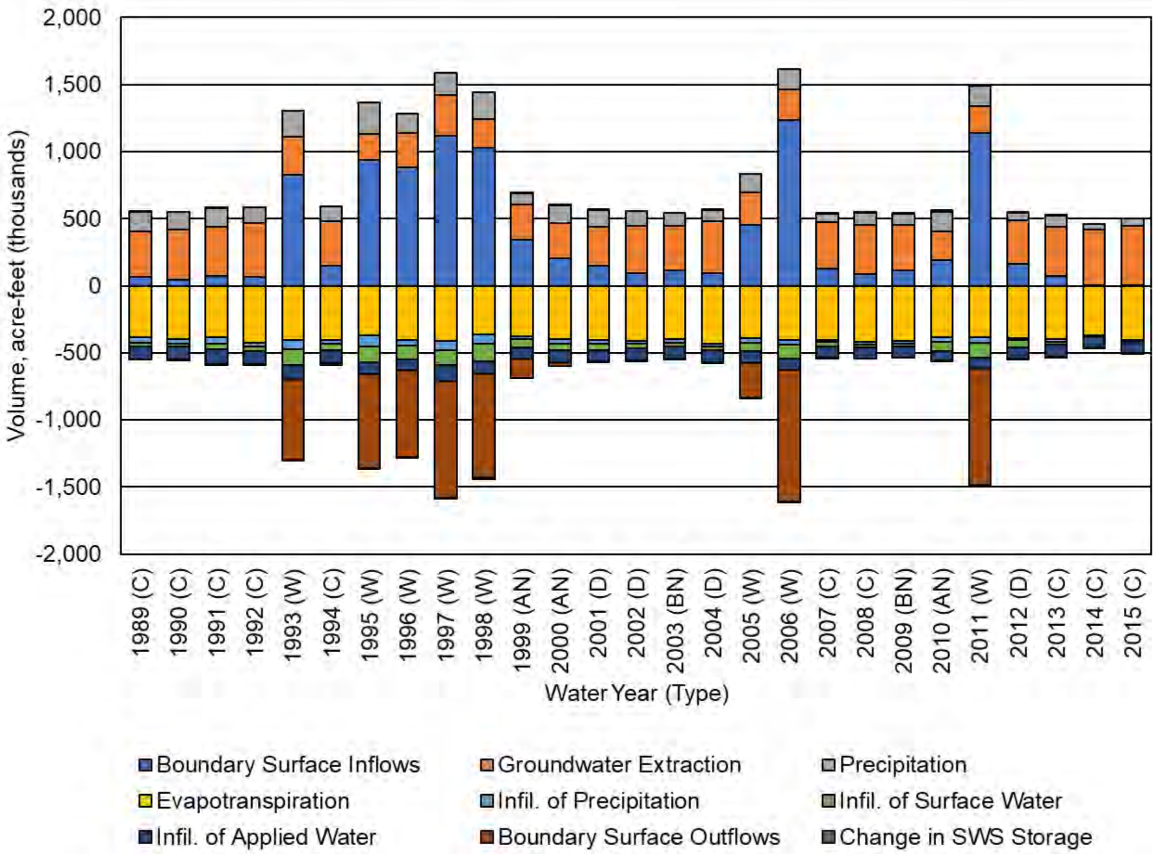


Figure 2-93. Chowchilla Subbasin Surface Water System Current Water Budget.

2.2.3.4.10 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 implementation period (2020-2039), during which PMAs are implemented to bring the basin 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 2-25** and **2-26** below.

Table 2-25. 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 2-26. 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 – Chowchilla River (Buchanan 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 Eastman 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 Eastman 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 – 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
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

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)
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
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.

2.2.3.4.11 Comparison of Water Budget Scenarios

Table 2-27 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. This table also provides an estimate of Subbasin sustainable yield from the projected with projects water budget.

Table 2-27. Comparative Summary of all Water Budget Scenarios, Annual Average Volumes by Flow Path (AF).

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	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090	
354.18(b)(1)	N/A (SWS flow path)	Surface Water Inflows	374,400	374,400	329,200	309,600	Decrease due to SJRRP (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		Local Supplies	*182,900*	*182,900*	*143,600*	*123,100*	Decrease in Chowchilla Bypass flows with SJRRP (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		CVP Supplies	*191,500*	*191,500*	*185,600*	*186,500*	Decrease in CVP deliveries with SJRRP (Projected)
354.18(b)(1)	N/A (SWS flow path)	Surface Water Outflows	226,900	226,900	206,100	129,200	Decrease due to decreased surface water inflows described above (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		Local Supplies	*171,100*	*171,100*	*187,000*	*117,200*	
		CVP Supplies	*55,800*	*55,800*	*19,100*	*12,000*	
Implied	N/A (SWS flow path)	Precipitation	124,200	124,300	144,100	144,100	Increase due to higher proportion of W water years anticipated in projected period (35% of years, versus 31% in historical period)
354.18(b)(2)	Inflow	Infiltration of Surface Water	63,100	62,100	67,200	120,500	Increase due to infiltration of GSP projects (With Projects)
354.18(b)(2)	Inflow	Infiltration of Applied Water	89,700	89,300	83,000	82,300	Decrease due to urban growth (Projected), demand management (with Projects)
354.18(b)(2)	Inflow	Infiltration of Precipitation	35,700	33,700	34,500	38,400	N/A

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	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090	
354.18(b)(3)	N/A (SWS flow path)	Evapotranspiration	350,900	398,000	394,300	369,500	Increase due to cropping (Current; Projected, No Action); Decrease due to demand management (Projected, With Projects)
354.18(b)(3)	Outflow	GW Pumping	264,900	307,600	297,800	248,500	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	47,300	N/A[1]	71,400	9,700	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	-29,100	N/A[1]	-41,700	2,400	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	-29,100	N/A[1]	-41,700	2,400	Changes due to reasons above.

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

2.2.3.4.12 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 Chowchilla 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 2-28**) and current land use water budget (**Table 2-29**).

2.2.3.4.13 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 2-28. Historical Water Budget: Average Overdraft by Water Year Type, 1989-2014 (AF) (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[1] (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	92,270	56,720	119,330	199,230	*
AN	3	*	84,610	29,930	62,460	214,100	*
BN	2	*	83,780	20,140	30,760	286,490	*
D	4	*	92,000	22,580	41,610	313,340	*
C	9	*	89,280	28,360	30,140	313,850	*
Annual Average (1989-2014)	26	47,280[2]	89,660	35,750	63,120	264,890	-29,080

* 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] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

[2]Significant uncertainty in net groundwater inflow arises from the use of different methods/tools and boundary assumptions in groundwater system analysis. As a result, net subsurface inflow has been revised since initial presentation based on additional groundwater modeling resulting in a lower overdraft than was originally presented.

Table 2-29. Current Land Use Water Budget: Average Overdraft by Water Year Type, 1989-2014 (AF) (23 CCR §354.18(b)(5)).

Year Type	Number of Years	Subsurface Groundwater Inflow (a)	Infiltration of Applied Water (b)	Infiltration of Precipitation (c)	Infiltration of Surface Water[1] (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	92,140	53,830	118,190	239,510	*
AN	3	*	82,150	28,240	62,000	245,370	*
BN	2	*	84,180	18,710	30,140	336,830	*
D	4	*	86,190	20,940	41,120	340,770	*
C	9	*	91,730	26,550	28,700	367,580	*
Annual Average (1989-2014)	26	N/A[2]	89,320	33,670	62,100	307,580	N/A[2]

* 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] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.
[2] Net subsurface inflow not estimated for current water budget due to uncertainties in adjacent basin groundwater conditions.

Average net recharge from the SWS is presented below for 1989-2014 based on the historical water budget (**Table 2-30**) and current land use water budget (**Table 2-31**). Historically, average annual net recharge from the SWS in the Chowchilla Subbasin was approximately -76 taf between 1989 and 2014. Under current land use conditions, average net recharge from the SWS in the Chowchilla Subbasin has decreased to approximately -122 taf.

Table 2-30. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (AF).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	92,270	56,720	119,330	199,230	69,090
AN	3	84,610	29,930	62,460	214,100	-37,100
BN	2	83,780	20,140	30,760	286,490	-151,810
D	4	92,000	22,580	41,610	313,340	-157,150
C	9	89,280	28,360	30,140	313,850	-166,070
Annual Average (1989-2014)	26	89,660	35,750	63,120	264,890	-76,360

[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

Table 2-31. Current Land Use Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (AF).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	92,140	53,830	118,190	239,510	24,650
AN	3	82,150	28,240	62,000	245,370	-72,980
BN	2	84,180	18,710	30,140	336,830	-203,800
D	4	86,190	20,940	41,120	340,770	-192,520
C	9	91,730	26,550	28,700	367,580	-220,600
Annual Average (1989-2014)	26	89,320	33,670	62,100	307,580	-122,490

[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

2.2.3.4.14 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 2-32** for historical, current, projected without projects (no action), and projected with projects conditions.

Table 2-32. Comparative Summary of Annual Supply, Demand, and Change in Storage by Water Year Type (AFY) (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	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090
W	Supply	Surface Water Inflows	952,000	952,000	702,000	638,900
	Supply	Precipitation	173,400	173,400	201,900	201,900
	Demand	Evapotranspiration	346,800	393,200	392,300	366,300
	Change in Storage	Change in Groundwater Storage	106,900	N/A[1]	92,300	289,900
AN	Supply	Surface Water Inflows	246,100	246,100	243,900	260,800
	Supply	Precipitation	119,600	119,600	145,500	145,500
	Demand	Evapotranspiration	349,400	387,900	398,700	372,300
	Change in Storage	Change in Groundwater Storage	-4,200	N/A[1]	-8,900	-54,200
BN	Supply	Surface Water Inflows	111,500	111,500	119,800	118,600
	Supply	Precipitation	91,600	91,600	115,500	115,500
	Demand	Evapotranspiration	354,300	407,100	400,100	375,200
	Change in Storage	Change in Groundwater Storage	-93,800	N/A[1]	-106,900	-138,900

Water Year Type	Water Budget Element	Water Budget Flow Paths	Water Budget Period			
			Historical	Current	Projected, No Action	Projected, With Projects
			1989-2014	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090
D	Supply	Surface Water Inflows	124,100	124,100	124,900	127,800
	Supply	Precipitation	91,800	91,800	105,700	105,700
	Demand	Evapotranspiration	373,600	408,900	407,200	380,100
	Change in Storage	Change in Groundwater Storage	-109,500	N/A[1]	-121,900	-182,400
C	Supply	Surface Water Inflows	66,300	66,300	69,000	69,200
	Supply	Precipitation	99,200	99,200	99,200	99,200
	Demand	Evapotranspiration	350,200	399,300	385,600	364,500
	Change in Storage	Change in Groundwater Storage	-121,100	N/A[1]	-165,800	-192,900

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

2.2.3.4.15 Subbasin Sustainable Yield Estimate.

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 Section 10721(w)).

Sustainable yield is dependent upon conditions in existence at the time, and therefore changes during the 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 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 Section 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 2-33**) 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 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 was assumed to be zero over this 50-year period. By this method, sustainable yield is estimated to be 245,700 AFY. Accounting for all uncertainties in GWS inflows and outflows, the sustainable yield is estimated to range between 184,300 AF and 307,100 AFY.

Table 2-33. 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	245,700	25%	184,300	307,100

[1] Confidence interval source: Professional judgment based on historical calculations.

2.2.3.4.16 Surface Water Available for Groundwater Recharge

Implementation of the GSP will require the Chowchilla 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.

There are five potential sources of water available for groundwater recharge projects: Buchanan flood releases, Madera Canal flood releases, Eastside Bypass flows, additional CVP diversions, and water purchased from outside the Subbasin.

Buchanan flood releases include designated flood releases from Buchanan Dam along the Chowchilla River and exclude irrigation releases to CWD. During the historical base period (1989-2014), Buchanan flood releases occurred during six of eight years classified as wet and one year classified as above normal by DWR's San Joaquin River Water Year Index. The average annual inflow volume during the historical base period was 61 taf during wet years and 2 taf during above normal years. Across the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets (historical hydrologic and water supply data, as described in Section 2.2.3.2), Buchanan flood releases are expected during 11 out of 18 wet years (averaging 46 taf per wet year) and during 2 out of 7 above normal years (averaging 2 taf per above normal year).

Madera Canal flood releases are comprised of flood releases to the Chowchilla Subbasin along Madera Canal (including Section 215 water[61], 16(b) water[62], or other sources of CVP yield determined by Reclamation to be available to its contractors). During the historical base period, Madera Canal flood releases occurred in 8 of 26 years. Seven of these years were classified as wet years (33 taf per year on average), while the remaining year was classified as above normal (6 taf per year). Madera Canal flood releases are projected to occur in an estimated 21 years out of 51 years of the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets.

Eastside Bypass flows include all water entering the Subbasin along Fresno River and Chowchilla Bypass downstream of Madera Subbasin. During the historical base period, combined flood inflows from the

[61] 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.

[62] San Joaquin River Restoration Settlement, Paragraph 16(b): Recovered Water Account.

Chowchilla Bypass and Fresno River[63] are available in eight wet years and three above normal years, averaging approximately 680 taf and 54 taf across all wet and above normal years, respectively. Eastside Bypass flows are projected to occur during wet and above normal years, which include 25 out of 51 total 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 major contributor to Eastside Bypass flow, the duration of flow 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 to supply 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 and potential areas to be covered by potential Management Areas were discussed among GSA representatives and the GSP consultant team and in public meetings. The Chowchilla Subbasin GSAs decided to designate two Management Areas: A Western Management Area (WMA) comprised of Triangle T Water District GSA and Madera County GSA – West, and an Eastern Management Area (EMA) comprised of Chowchilla Water District, Madera County GSA – East, and Sierra Vista Mutual Water Company (Merced County GSA and portion of Madera County GSA – East) (**Figure 2-94**).

The primary reason for creation of these two Management Areas was differences in historical and recent subsidence impacts. The amount of subsidence occurring in the Western Management Area has resulted in significant impacts to infrastructure. While some amount of subsidence has also occurred in the Eastern Management Area, the magnitude of subsidence in the Eastern Management Area has not yet (as of 2019) resulted in significant impacts to infrastructure. It should also be noted that the Western Management Area includes a GDE Unit, whereas no GDE Units were identified in the Eastern Management Area. Delineation of two Management Areas allows for subsidence (and other SMC, as necessary) to be set differently to more reliably manage the Subbasin to reach sustainability.

The hydrogeologic conceptual model, groundwater conditions, and water balance information for the areas encompassing both Management Areas are included in Sections 2.2.1, 2.2.2. and 2.2.3, respectively, in this GSP. A distinguishing hydrogeologic feature is that the Western Management Area is comprised of two distinct and viable aquifers in terms of an Upper Aquifer and the Lower Aquifer (above and below the regionally continuous Corcoran Clay), whereas the Upper Aquifer in the East Management Area is largely unsaturated or only contains a thin perched aquifer and/or the Corcoran Clay layer is not present. The sustainable management criteria (SMC) and projects/management actions for each management area are described in Sections 3 and 4, respectively. The primary differences in SMC among the two Management Areas relate to subsidence and are described in more detail in Section 3.

[63] The total historical available Fresno River flood inflows exclude appropriative water rights diversions and riparian diversions along Fresno River in Chowchilla Subbasin, which are considered unavailable to groundwater recharge projects.

CHAPTER 2 PLAN AREA AND BASIN SETTING

2.3 Selected Figures

The following figures can be found after this page: Figures 2-4 to 2-6, Figures 2-9 to 2-76 and 2-94.

3 SUSTAINABLE MANAGEMENT CRITERIA

This chapter of the GSP provides a discussion of the sustainability goals, measurable objectives (MOs), interim milestones (IMs), minimum thresholds (MTs), undesirable results, and the monitoring network for each sustainability indicator. Undesirable results occur when significant and unreasonable effects for any sustainability indicators defined by the Sustainability Groundwater Management Act (SGMA) are caused by groundwater conditions occurring in the Subbasin.

This is the fundamental chapter that defines sustainability in the Subbasin, and it addresses significant regulatory requirements. The MOs, MTs, and undesirable results presented in this chapter define the future sustainable conditions in the Subbasin and commit the GSAs to actions that will achieve the Subbasin sustainability goal and avoid undesirable results.

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®]. The 50-year planning and implementation horizon in the 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 and depending on hydrologic conditions. DWR recognizes in the SGMA Best Management Practices (BMP) guidance documents that it may be acceptable for groundwater levels to temporarily exceed MTs during the GSP implementation period (prior to 2040) provided that the GSAs are managing groundwater and implementing PMAs as outlined in the GSP. 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 Sustainable Management Criteria (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. The SMC presented in this chapter are based on current available data and applications of the best available science.

As noted in this GSP, data gaps and uncertainty exist in the characterization of the hydrogeologic conceptual model and groundwater conditions. The uncertainty was considered when developing the SMC and because of these uncertainties, the SMC presented herein are considered initial criteria. The GSAs will periodically evaluate this GSP, assess changing conditions in the Subbasin that may warrant modifications of the GSP or management objectives, and may adjust components accordingly. The GSAs will focus their evaluation on determining whether the actions under the GSP are meeting the GSP’s 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
    - The methodology for setting IMs
- 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, meetings with GSA technical experts, and meetings with DWRs technical experts. The general process for establishing SMC included:

- GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC
- Conducting 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 Subbasin
- Reviewing public input on preliminary SMC methodologies with GSA staff/technical experts
- Providing a Draft GSP for public review and comment
- 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 experts.
- In 2022, SMC for chronic groundwater level decline, subsidence, and interconnected surface water were updated or added to address deficiencies identified by DWR in their January 2022 Subbasin Consultation Letter (supplemented and clarified during five meetings with DWR).
- During the GSP revision processes in 2022-2023, the GSAs conducted public outreach to discuss GSP deficiencies identified by DWR and how they were addressed through public GSP Advisory Committee meetings, through multiple public GSA governing body meetings, and through public notices regarding the GSP revision processes.

To ensure the Subbasin meets its sustainable goal by 2040, the GSAs have proposed several projects and management actions (PMAs), described in Chapter 4, to address undesirable results and to achieve and maintain sustainable groundwater conditions at the end of the GSP implementation period. The projects and management actions expected to be implemented will include several 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 goals 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 Subbasin without and with GSP implementation.

3.1 Sustainability Goal (23 CCR § 354.24)

3.1.1 Goal Description

The sustainability goal for the Chowchilla 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, established MOs, and MTs will ensure that 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 GSP.

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 (Western Management Area)	Yes	Yes	Yes	No
Land Subsidence (Eastern Management Area)	No	No	Possibly	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] Surface water and groundwater are disconnected under existing conditions for most of Subbasin. 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. A data gaps workplan for interconnected surface water (Appendix 3.I) will provide additional data to evaluate this sustainability 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 20-year GSP Implementation Period from 2020 through 2040. All projects and the management actions are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and interconnected surface water by augmenting groundwater supplies through recharge or reducing groundwater use. Together the 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.

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 new 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 result in groundwater inflows equaling outflows over the Sustainability Period (2040 to 2090), as described in Section 2.

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 IMs are detailed below. A description of the MOs and how they were established are provided, along with recognition of the anticipated fluctuations in basin conditions around the established MOs. In addition, this section describes how the GSP helps to meet each measurable objective, how each measurable objective is intended to achieve the sustainability goal for the Subbasin for long-term beneficial uses, how MOs are integrated for the two different Management Areas, and how the IMs 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 Plan to achieve the sustainability goal for the basin.

Per the GSP regulations:

1. MOs shall be established, including IMs in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
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.
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.
4. A representative measurable objective 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. Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of IMs for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years.

The MOs developed for each applicable sustainability indicator in this 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 IMs, 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 IMs for chronic lowering of groundwater levels were updated through an extensive and collaborative coordination process between all GSAs in the Subbasin. As described below, the MO for groundwater levels is defined as the Fall 2011 groundwater elevation at each RMS well[64] and the IMs represent a trajectory from current groundwater levels to achieve the MOs by 2040. While groundwater levels are anticipated to temporarily fall below 2015 levels (i.e., below the MTs) during the GSP Implementation Period, as shown in the IMs, the implementation of projects and management actions is expected to return groundwater levels to the MOs by 2040. DWR recognizes in the SGMA SMC BMP guidance documents that it may be acceptable for groundwater levels to temporarily exceed MTs during the GSP implementation period (prior to 2040) provided that the GSAs are managing groundwater and implementing projects and management actions as outlined in the GSP. In the meantime, the GSAs are implementing a Domestic Well Mitigation Program to assist domestic well owners and shallow wells that supply drinking water users that may be adversely impacted by groundwater levels while the GSAs work to implement PMAs.

The SMC for chronic lowering of groundwater levels have been designated with these considerations in mind, and with the clear commitment of the GSAs to fund and implement a Domestic Well Mitigation Program beginning in 2023 and continuing until groundwater sustainability is achieved. The GSAs' commitment to implementing the Domestic Well Mitigation Program is discussed below, followed by a discussion of the planned MOs and IMs for chronic lowering of groundwater levels.

3.2.1.1 Domestic Well Mitigation Program

The 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 wells and shallow wells that supply drinking water users.

In their ongoing efforts to uphold these commitments, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program (Program). The Program has been developed to assist domestic well owners and shallow well owners that supply drinking water users who may have been adversely impacted by declining groundwater levels since GSP implementation began (i.e., since 2020). The Program will help to mitigate well impacts that interfere with groundwater production or quality and will be coordinated with the Madera County SB 552 Drought Plan that is under development.

The GSAs have proceeded with planning and implementing the Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved, upholding their clear commitment memorialized in a Memorandum of Understanding (MOU) (**Appendix 3.D)**. The Program has been developed with review and consideration of the content and recommendations set forth by Self-Help Enterprises, the Leadership Counsel for Justice and Accountability, and the Community Water Center in their publication

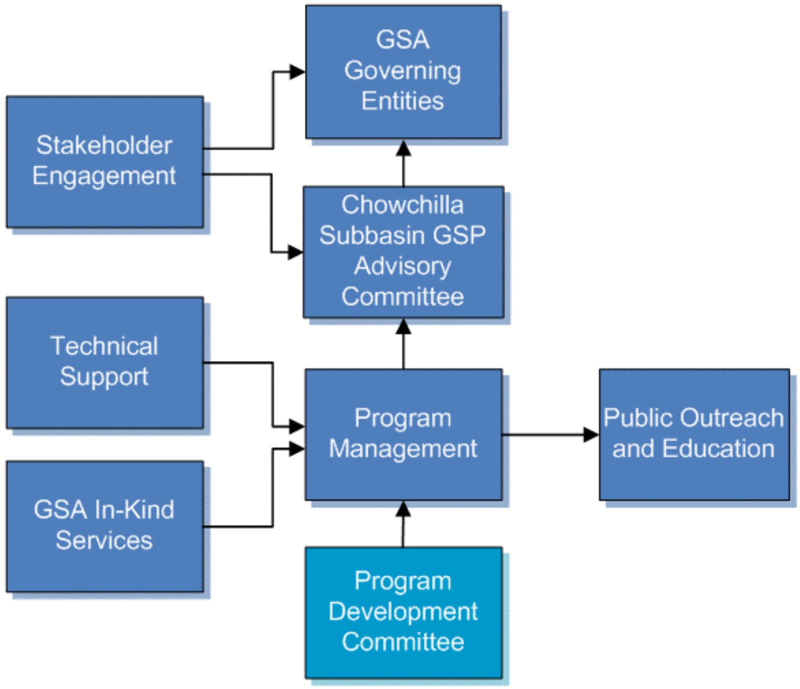
[64] MO is set equal to the Fall 2011 measurement, if observed data is available at the RMS. Otherwise, the MO is set equal to the simulated Fall 2011 groundwater elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated data.

titled, “Framework for a Drinking Water Well Impact Mitigation Program” (SHE et al., 2020). An organizational structure and a workflow designed to guide operation of the Program are provided in **Figures 3-1** and **3-2**.

The GSAs are proceeding with Program implementation and, as of May 2023, stakeholders in the Subbasin are engaging with the GSAs to discuss mitigation opportunities. It is expected that the Program will be implemented during the GSP Implementation Period and that Program implementation would continue as needed until groundwater sustainability is achieved. By 2040 and during the sustainability period, groundwater levels are expected to stabilize at or above Fall 2015 historical levels, avoiding continued undesirable results for groundwater uses and users. Thus, the Program is not anticipated to be needed beyond the Implementation Period. Nevertheless, as stated in the MOU, the Program is intended to remain in place until groundwater sustainability is achieved.

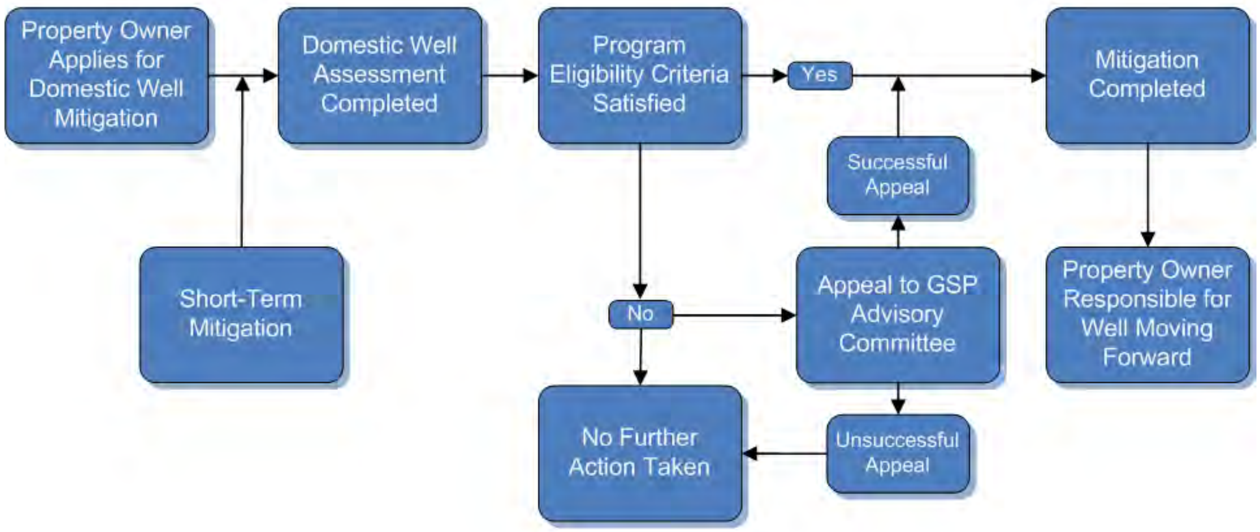
As currently planned, well owners seeking mitigation are required to submit an application to the Program, after which agency staff would review and approve eligible well mitigation claims. Approved well owners would then sign an agreement with the Chowchilla Subbasin GSAs for one-time well mitigation services. The GSAs would then facilitate well mitigation services once for each eligible well through a pre-screened preferred contractor identified by the GSAs. The Program application and agreement – both developed following the July 2022 GSP revisions – are provided in **Appendix 3.D**.

Assistance efforts are expected to benefit drinking water users, including disadvantaged communities and underrepresented communities, who are experiencing adverse impacts as a result of overdraft conditions. 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. Economic analyses conducted to compare costs of implementing the Program versus immediately requiring full implementation of demand reduction in 2020 are provided in **Appendix 3.C**. 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 and shallow well owners that supply drinking water users – that would be more significant than the costs of implementing the Program.



Notes:
1. That shown herein is subject to revision by the Parties.
2. Public Outreach and Engagement is a necessary component as outlined by Self-Help Enterprises, Leadership Counsel for Justice and Accountability, and the Community Water Center in their publication titled, "Framework for a Drinking Water Well Impact Mitigation Program."
3. The Chowchilla Subbasin GSP Advisory Committee is as defined and established under Section 3 of the Memorandum of Understanding with Respect to the Coordination, Cooperation and Cost Sharing in the Implementation of Chowchilla Subbasin Groundwater Sustainability Plan entered into by the Parties on December 17, 2019.

Figure 3-1. Chowchilla Subbasin Domestic Well Mitigation Program Organizational Structure.



Notes:
1. Steps shown herein are intended to demonstrate critical decision points and is not intended to be indicative of all steps that may be required.
2. That shown herein is subject to revision by the Parties.
3. The GSAs have reviewed and considered the content and recommendation set-for by Self-Help Enterprises, Leadership Counsel for Justice and Accountability, and the Community Water Center in their publication titled, "Framework for a Drinking Water Well Impact Mitigation Program."

Figure 3-2. Chowchilla Subbasin Domestic Well Mitigation Program Implementation Flowchart.

3.2.1.2 Measurable Objectives

MOs for groundwater levels were established in accordance with the Subbasin sustainability goal through review and evaluation of measured historical groundwater elevation data, to the extent available, and simulated historical groundwater levels derived from the Madera-Chowchilla Groundwater-Surface Water Simulation Model (MCSim) (**Appendix 6.D**). MOs for groundwater levels were set at Fall 2011 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 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 2011 groundwater elevation data, when available. In cases where observed Fall 2011 groundwater elevation data were not available, simulated Fall 2011 groundwater elevation values were used to determine the MO, with consideration for offsets between historically observed and simulated groundwater elevations at each RMS.

MOs for groundwater levels for each RMS well are summarized in **Table 3-2**, and locations of groundwater level RMS wells are shown in **Figure 3-3**[65]. The groundwater level MOs are set specific to each principal aquifer, designated as the Upper Aquifer (above the Corcoran Clay where present, and equivalent depth to the east where Corcoran Clay is not present) and the Lower Aquifer. Groundwater elevation hydrographs showing MOs for each groundwater level RMS are provided in **Appendix 3.A.**

[65] Figure titles that are bolded can be found at the end of each chapter.

Table 3-2. Summary of Groundwater Level Measurable Objectives for Representative Monitoring Sites.

Well I.D.	Ground Surface Elevation (ft, msl)	Well Depth (ft bgs)	Screen Interval Top-Bottom Depth (ft bgs)	Model Layer(s)	Aquifer Designation	MO Depth to Water (ft bgs)[1]	MO GW Elev (ft, msl)[1]	GSA	CASGEM Well?
CWD RMS-1	171	275	160-275	4	Lower	144	27	CWD	CASGEM
CWD RMS-2	193	780	230-775	4	Lower	193	0	CWD	No
CWD RMS-3	206	Unknown	Unknown	4	Lower	177	29	CWD	No
CWD RMS-4	225	800	320-800	4	Lower	201	24	CWD	CASGEM
CWD RMS-5	207	Unknown	Unknown	4	Lower	148	59	CWD	Voluntary
CWD RMS-6	275	820	257-726	4	Lower	263	12	CWD	CASGEM
CWD RMS-7	169	330	135-288	3,4	Lower	120	49	CWD	CASGEM
CWD RMS-8	219	Unknown	Unknown	4	Lower	183	36	CWD	Voluntary
CWD RMS-9	164	97	82-97	3	Upper	86	78	CWD	CASGEM
CWD RMS-10	182	Unknown	Unknown	4	Lower	153	29	CWD	Voluntary
CWD RMS-11	199	529	187-529	4	Lower	109	90	CWD	CASGEM
CWD RMS-12	176	Unknown	Unknown	3	Upper	102	74	CWD	Voluntary
CWD RMS-13	167	Unknown	Unknown	4	Lower	120	47	CWD	Voluntary
CWD RMS-14	152	455	185-365	4	Lower	115	37	CWD	CASGEM
CWD RMS-15	213	955	290-935	4	Lower	182	31	CWD	CASGEM
CWD RMS-16	212	Unknown	Unknown	4	Lower	168	44	CWD	Voluntary
CWD RMS-17	203	624	278-588	4	Lower	156	47	CWD	CASGEM
MCE RMS-1	276	Unknown	Unknown	4	Lower	255	21	Madera County East	Voluntary
MCE RMS-2	272	466	218-464	4	Lower	274	-2	Madera County East	CASGEM
MCW RMS-1	120	186	Unknown	3	Upper	31	89	Madera County West	Voluntary
MCW RMS-2	123	Unknown	Unknown	2	Upper	21	102	Madera County West	No
MCW RMS-3	122	Unknown	Unknown	2,3	Upper	22	100	Madera County West	Voluntary

Well I.D.	Ground Surface Elevation (ft, msl)	Well Depth (ft bgs)	Screen Interval Top-Bottom Depth (ft bgs)	Model Layer(s)	Aquifer Designation	MO Depth to Water (ft bgs)[1]	MO GW Elev (ft, msl)[1]	GSA	CASGEM Well?
MCW RMS-4	138	Unknown	Unknown	4	Lower	109	29	Madera County West	Voluntary
MCW RMS-5	146	Unknown	Unknown	4	Lower	129	17	Madera County West	Voluntary
MCW RMS-6	139	Unknown	Unknown	4	Lower	100	39	Madera County West	Voluntary
MCW RMS-7	138	800	290-400	4	Lower	77	61	Madera County West	CASGEM
MCW RMS-8	142	480	160-475	3,4	Composite	99	43	Madera County West	CASGEM
MCW RMS-9	155	700	265-696	5	Lower	144	11	Madera County West	CASGEM
MCW RMS-10	123	26	25-Oct	1	Upper	11	112	Madera County West	No
MCW RMS-11	127	30	Unknown	1	Upper	7	120	Madera County West	No
MCW RMS-12	127	29	Unknown	1	Upper	11	116	Madera County West	No
MER RMS-1	225	Unknown	Unknown	4	Lower	199	26	SVMWC	No
TRT RMS-1	134	196	158-192	3	Upper	60	74	TTWD	No
TRT RMS-2	135	500	300-500	4	Lower	48	87	TTWD	CASGEM
TRT RMS-3	137	799	168-790	5	Lower	125	12	TTWD	No
TRT RMS-4	141	840	190-260	3,4	Composite	116	25	TTWD	CASGEM

[1] 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 representative monitoring sites within their GSA area. However, SJRRP well data is collected by USBR.

3.2.1.3 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 2040, at years 2025, 2030, and 2035. IMs were established through review and evaluation of measured groundwater elevation data, to the extent available, and simulated historical groundwater elevations, as well as consideration of the SMCs (e.g., MOs and MTs) defined for the Sustainability Period (starting in 2040). IMs were developed specifically for each individual RMS based on a range of historically measured or simulated conditions at the RMS through the process described in **Appendix 3.J**. The range of conditions evaluated includes variability in groundwater levels between wet (at the high end of the range) and dry (at the low end of the range) periods. The final IMs for each five-year interval were based on a percentage between the high and low values. Final IMs for groundwater levels for each RMS are summarized in **Table 3-3**, and locations of groundwater level RMS are shown in **Figure 3-3**.

During the Implementation Period, some level of continued temporary decline in groundwater levels is expected in the Subbasin. Additionally, some RMS are currently below their MT. IMs are set to allow for some temporary decline below the MT during the GSP Implementation Period while projects and management actions are implemented, before increasing above the MT and toward the MO by 2040. The GSAs will prioritize implementation of projects and management actions, to the extent feasible, in those areas of the Subbasin where IMs are anticipated to be lowest in 2030 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.

Table 3-3. Summary of Groundwater Level Interim Milestones for Representative Monitoring Sites.

Well I.D.	Aquifer Designation	2025 IM DTW (ft bgs)	2030 IM DTW (ft bgs)	2035 IM DTW (ft bgs)	2025 IM GW Elev (ft, msl) GW Elev (ft, msl)	2030 IM GW Elev (ft, msl)	2035 IM GW Elev (ft, msl)	GSA
CWD RMS-1	Lower	269	257	193	-98	-86	-22	CWD
CWD RMS-2	Lower	300	295	239	-107	-102	-46	CWD
CWD RMS-3	Lower	345	338	253	-139	-132	-47	CWD
CWD RMS-4	Lower	350	360	295	-125	-135	-70	CWD
CWD RMS-5	Lower	289	279	206	-82	-72	1	CWD
CWD RMS-6	Lower	380	374	321	-105	-99	-46	CWD
CWD RMS-7	Lower	241	239	179	-72	-70	-10	CWD
CWD RMS-8	Lower	346	339	253	-127	-120	-34	CWD
CWD RMS-9	Upper	91	92	89	73	72	75	CWD
CWD RMS-10	Lower	333	325	230	-151	-143	-48	CWD
CWD RMS-11	Lower	123	123	118	76	76	81	CWD
CWD RMS-12	Upper	141	144	122	35	32	54	CWD
CWD RMS-13	Lower	244	249	180	-77	-82	-13	CWD
CWD RMS-14	Lower	331	341	239	-179	-189	-87	CWD
CWD RMS-15	Lower	370	377	290	-157	-164	-77	CWD
CWD RMS-16	Lower	360	345	246	-148	-133	-34	CWD
CWD RMS-17	Lower	369	352	250	-166	-149	-47	CWD
MCE RMS-1	Lower	360	345	292	-84	-69	-16	Madera County East
MCE RMS-2	Lower	363	368	331	-91	-96	-59	Madera County East
MCW RMS-1	Upper	101	100	68	19	20	52	Madera County West
MCW RMS-2	Upper	47	45	32	76	78	91	Madera County West
MCW RMS-3	Upper	55	59	40	67	63	82	Madera County West
MCW RMS-4	Lower	228	217	156	-90	-79	-18	Madera County West
MCW RMS-5	Lower	256	251	184	-110	-105	-38	Madera County West
MCW RMS-6	Lower	223	214	150	-84	-75	-11	Madera County West
MCW RMS-7	Lower	150	168	139	-12	-30	-1	Madera County West

Well I.D.	Aquifer Designation	2025 IM DTW (ft bgs)	2030 IM DTW (ft bgs)	2035 IM DTW (ft bgs)	2025 IM GW Elev (ft, msl) GW Elev (ft, msl)	2030 IM GW Elev (ft, msl)	2035 IM GW Elev (ft, msl)	GSA
MCW RMS-8	Composite	178	183	139	-36	-41	3	Madera County West
MCW RMS-9	Lower	277	267	198	-122	-112	-43	Madera County West
MCW RMS-10	Upper	29	27	18	94	96	105	Madera County West
MCW RMS-11	Upper	39	36	20	88	91	107	Madera County West
MCW RMS-12	Upper	49	47	27	78	80	100	Madera County West
MER RMS-1	Lower	354	342	262	-129	-117	-37	SVMWC
TRT RMS-1	Upper	120	119	87	14	15	47	TTWD
TRT RMS-2	Lower	138	152	111	-3	-17	24	TTWD
TRT RMS-3	Lower	200	203	162	-63	-66	-25	TTWD
TRT RMS-4	Composite	155	153	132	-14	-12	9	TTWD

3.2.1.4 Achieving and Maintaining Sustainability

The combination of IMs and MOs reflect how the GSAs intend to achieve and maintain sustainability in the Subbasin.

IMs have been established as quantitative metrics to facilitate the Subbasin achieving its MOs for groundwater levels by 2040. As reflected in the IMs – and as recognized by DWR in the SGMA SMC BMP guidance documents – the GSAs expect some level of temporary groundwater level decline prior to reaching the MOs while projects and management actions are developed and implemented. Groundwater levels are anticipated to reach future lows generally between 2025-2030, before rebounding to higher levels after PMAs are implemented.

MOs are quantitative targets representing sustainable groundwater conditions above the MT, allowing for a range of active management activities to achieve the Subbasin sustainability goal. The GSAs anticipate – and DWR recognizes in the SGMA SMC BMP guidance documents – that groundwater levels will fluctuate in “a reasonable margin of operational flexibility” between the MOs and MTs depending on future drought conditions, climate change, conjunctive use operations, or other groundwater management activities.

Groundwater levels at Upper Aquifer wells representative of the shallow zone along the San Joaquin River are considered representative of the single GDE Unit in the Subbasin, located along the San Joaquin River in the WMA. The IMs and MOs for Upper Aquifer wells are anticipated to maintain groundwater levels that are suitable for continued support of GDEs during the Implementation Period and Sustainability Period.

SMC for groundwater levels have been set intentionally to be protective of domestic wells and shallow wells that supply drinking water users. Review of RMS groundwater hydrographs suggests that temporary declines in groundwater levels during the GSP Implementation Period may impact a relatively small percentage of existing domestic wells and shallow wells that supply drinking water users. A detailed domestic well inventory and analysis that the GSAs completed in 2022 (**see Appendix 2.G**) reinforces the need for a Domestic Well Mitigation Program during the GSP Implementation Period prior to achieving Subbasin sustainability. As described in Section 3.2.1.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved.

3.2.1.5 Impact of Selected Measurable Objectives on Adjacent Basins

The MOs established for the Subbasin 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 average groundwater levels expected to be maintained during the Sustainability Period. Ultimately, the potential for impacts on adjacent subbasins will be primarily a function of average groundwater levels in the Subbasin during the Sustainability Period, average groundwater levels in adjacent subbasins during the Sustainability Period, and natural groundwater flow conditions that would be expected to occur at subbasin boundaries (e.g., pre-development groundwater flow conditions).

As indicated in the individual RMS hydrographs in **Appendix 3.A**, the MOs are higher than historical lows and in many cases much higher than historical low groundwater elevations. MCSim results indicate that the average groundwater levels will result in greatly reduced net subsurface inflow to the Subbasin from surrounding subbasins during the Sustainability Period compared to historical net subsurface inflow. Therefore, the MOs established in this GSP are expected to benefit adjacent subbasins (compared to historical conditions) and not hinder the ability of adjacent subbasins to be sustainable. Discussions between Subbasin representatives and adjacent subbasin representatives have occurred in meetings described in **Appendices 2.C and 6.C**.

3.2.2 Reduction in Groundwater Storage

MOs and IMs 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) allowing groundwater levels to be used as a proxy for the groundwater storage sustainability indicator in this GSP. Therefore, the measurable objective for reduction in groundwater storage is based on the MOs for chronic lowering of groundwater levels. The measurable objective 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 IMs for reduction in groundwater storage are based on the IMs for chronic lowering of groundwater levels.

3.2.2.3 Achieving and Maintaining Sustainability

The combination of IMs and MOs reflect how the basin 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.

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 Chowchilla Subbasin from surrounding basins compared to historical net subsurface inflow. This will serve to allow more groundwater to remain in storage in adjacent basins. Therefore, the projects and management actions implemented for this GSP will not hinder the ability of adjacent basins to be sustainable with regards to groundwater storage.

3.2.3 Land Subsidence

Information on historical subsidence in the Subbasin is presented in the HCM (Chapter 2). The Western Management Area (WMA) has experienced significant historical subsidence and associated damage to infrastructure since 2005. SMC for land subsidence have been developed for the WMA to limit impacts to infrastructure resulting from land subsidence during the GSP Implementation Period and, ultimately, to avoid subsidence after 2040.

Historical land subsidence has not resulted in significant and unreasonable impacts to infrastructure in the Eastern Management Area (EMA). However, land subsidence SMC have been developed for the EMA to avoid significant and unreasonable impacts from occurring in this part of the Subbasin in the future.

MOs and IMs for land subsidence in the Subbasin are described below.

3.2.3.1 Measurable Objective

A MO for subsidence of 0.00 feet/year of was established for both the WMA and EMA with the goal of long-term avoidance of land subsidence in the Subbasin. Achievement of this MO will take into consideration the level of uncertainty associated with survey measurements. For example, the San Joaquin River Restoration Program (SJRRP) has reported that elevation survey measurements made using the current technology available to the United States Bureau of Reclamation (USBR) have a vertical accuracy of +/-2.5 centimeters (USBR, 2011). With two measurements necessary to calculate a rate of change over time, the total uncertainty in the subsidence rate calculated from USBR survey data is 5 centimeters, or approximately 0.16 feet. Therefore, a rate of subsidence of +/-0.16 feet/year is considered to be within the uncertainty of the current survey measurement methods used by USBR and would be considered to be within the range of uncertainty of the MO of 0.00 feet/year.

The MO for land subsidence is set recognizing that land subsidence within the Subbasin is tied to actions in neighboring subbasins, and the ability to meet this measurable objective is dependent on the successful implementation of projects and management actions in neighboring subbasins. It should also be noted that while groundwater level MTs and MOs are not specifically tied to subsidence SMC, they are consistent with the subsidence SMC and will serve to limit the potential for future subsidence..

3.2.3.2 Interim Milestones

IMs for land subsidence were established at five-year intervals over the Implementation Period from 2020 to 2040, at years 2025, 2030, and 2035. IMs were set recognizing the subsidence that may continue to occur during the Implementation Period due to historical low groundwater elevations and to provide adequate time for GSAs to implement projects and management actions. A network of 10 elevation survey benchmarks monitored by the USBR on a semi-annual basis since 2011 as part of the SJRRP have been selected as the land subsidence RMS in the Subbasin. Locations of subsidence RMS are shown in **Figure 3-4**. Subsidence RMS are grouped according to the land subsidence Management Area where they are located: Western Management Area (WMA) or Eastern Management Area (EMA). The maximum rate of historic annual subsidence observed at each RMS between 2016-2020 is presented in **Table 3-4.**

Table 3-4. Summary of Observed Maximum Rate of Recent Land Subsidence for Representative Monitoring Sites.

RMS ID	Management Area	Maximum Annual Rate of Subsidence (feet)	Time Period	Data Source
123	Western Management Area (WMA)	-0.6	Dec 2017 to Dec 2018	SJRRP
1055R	Western Management Area (WMA)	-0.6	Dec 2019 to Dec 2020	SJRRP
1054R	Western Management Area (WMA)	-0.54	Dec 2017 to Dec 2018	SJRRP
1053R	Western Management Area (WMA)	-0.53	Dec 2017 to Dec 2018	SJRRP
2362	Western Management Area (WMA)	-0.32	Dec 2016 to Dec 2017	SJRRP
2062	Western Management Area (WMA)	-0.23	Dec 2016 to Dec 2017	SJRRP
2378	Eastern Management Area (EMA)	-0.5	Dec 2017 to Dec 2018	SJRRP
135	Eastern Management Area (EMA)	-0.37	Dec 2017 to Dec 2018	SJRRP
124	Eastern Management Area (EMA)	-0.31	Dec 2017 to Dec 2018; Dec 2019 to Dec 2020	SJRRP
2076	Eastern Management Area (EMA)	-0.31	Dec 2017 to Dec 2018	SJRRP

Within each Management Area, the first land subsidence IM for 2025 was set at an annual rate of subsidence equal to the maximum rate observed between 2016 and 2020. This was done in recognition of the likelihood for some amount of subsidence to continue over the implementation period and the time necessary for GSAs to implement projects and management actions to reduce the rate of subsidence. The IMs for 2030 and 2035 are set at gradually reduced subsidence rates as the Subbasin progresses towards sustainability by 2040 and a target MO subsidence rate of 0.00 feet/year.

There are six RMS in the WMA where subsidence has historically been a concern, as identified in **Section 2.2.2.4**. The IMs for RMS in the WMA are defined as:

- 2025: -0.60 feet/year
- 2030: -0.40 feet/year
- 2035: -0.20 feet/year

There are four RMS in the EMA where subsidence has not historically been a concern. The IMs for RMS in the EMA are defined as:

- 2025: -0.50 feet/year
- 2030: -0.33 feet/year
- 2035: -0.17 feet/year

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).

The IMs 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 IMs is dependent on the successful implementation of projects and management actions in neighboring subbasins.

The GSAs will continue to prioritize implementation of projects and management actions, 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.

3.2.3.3 Achieving and Maintaining Sustainability

The combination of IMs and MOs reflect how the Subbasin will achieve and maintain sustainability. The land subsidence IMs and MOs are set at values reflecting gradual reductions in the rate of subsidence over the Implementation Period with the intent of limiting future subsidence and achieving a long-term rate of zero subsidence by 2040. The IMs and MOs 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 IMs and MOs depends on the successful implementation of projects and management actions and making adequate progress towards achieving sustainability in neighboring subbasins.

3.2.3.4 Impact of Selected Measurable Objectives on Adjacent Basins

The MO for land subsidence is set at 0.00 feet/year to prevent significant and unreasonable impacts to infrastructure, and is therefore not likely to impact adjacent subbasins or their ability to achieve sustainability.

3.2.4 Degraded Water Quality

Varied levels of particular constituents within the groundwater exist and affect water quality considerations throughout the Subbasin (see Section 2). In some cases, the level of certain constituents have raised water quality concerns for the use of groundwater for drinking or for irrigated agriculture.

Effects on GDEs due to degraded water quality can include visually detectable declines in the health of terrestrial vegetation. However, available data do not provide evidence of any such effects in the Subbasin and no such effects are expected in the future (**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 basin. As noted in Section 2 (HCM), elevated concentrations of nitrate are present in some wells in the Subbasin, and trends in these wells may be increasing with time. Continued increases in these concentrations may occur due to historical 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 Subbasin's interested parties meet water quality objectives. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Subbasin; therefore, groundwater quality degradation is considered significant and unreasonable based on adverse impacts to this beneficial use. This GSP intends 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 projects or management actions. 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. As discussed in Section 2 of this 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 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 Subbasin including in areas of greater domestic and public water supply well density (see **Section 2**). For all groundwater quality RMS, the measurable objective concentrations for arsenic, nitrate, and TDS are set at levels representative of recent concentrations observed in the well with the intent to ensure that activities related to GSP projects or management actions do not significantly adversely impact groundwater quality conditions. Recent concentrations observed from 2015 to early 2019, as well as anticipated continued trends that this period may reflect, were used as the basis for setting the measurable objective concentrations. The measurable objective concentrations for wells with existing or historical water quality results are the average of the recent concentrations 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. Measurable objective concentrations for groundwater quality for each sustainability indicator well are summarized in **Table 3-5**, and locations of groundwater quality sustainability indicator wells are shown in **Figure 3-5**. Tables and graphs of historical results for key water quality constituents in the representative groundwater quality indicator wells are presented in **Appendix 3.B**.

Table 3-5. Summary of Groundwater Quality Measurable Objectives for Representative Monitoring Sites.

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation	MO Arsenic Concentration (µg/L)	MO Nitrate Concentration (mg/L)	MO TDS Concentration (mg/L)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Wells Monitored by GSAs: Existing										
CWD RMS-1	Domestic	275	160-275	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-2	Irrigation	780	230-775	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-4	Irrigation	800	320-800	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-5	Unknown	Unknown	Unknown	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-6	Irrigation	820	257-726	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-7	Irrigation	330	135-288	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-9	Monitoring	97	82-97	Upper	8†	8†	400†	CWD	CWD	Annual
CWD RMS-10	Unknown	Unknown	Unknown	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-11	Irrigation	529	187-529	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-12	Unknown	Unknown	Unknown	Upper	8†	8†	400†	CWD	CWD	Annual
CWD RMS-13	Unknown	Unknown	Unknown	Lower	8†	8†	400†	CWD	CWD	Annual
CWD RMS-15	Irrigation	955	290-935	Lower	8†	8†	400†	CWD	CWD	Annual
MCE RMS-1	Unknown	Unknown	Unknown	Lower	8†	8†	400†	Madera County East	Madera County	Annual
MCW RMS-1	Irrigation	186	Unknown	Upper	8†	8†	400†	Madera County West	Madera County	Annual
MCW RMS-4	Unknown	Unknown	Unknown	Lower	8†	8†	400†	Madera County West	Madera County	Annual
MCW RMS-7	Irrigation	800	290-400	Lower	8†	8†	400†	Madera County West	Madera County	Annual
MCW RMS-9	Irrigation	700	265-696	Lower	8†	8†	400†	Madera County West	Madera County	Annual
TRT RMS-1	Unknown	196	158-192	Upper	8†	8†	400†	TTWD	TTWD	Annual
TRT RMS-3	Unknown	799	168-790	Lower	8†	8†	400†	TTWD	TTWD	Annual
TRT RMS-4	Irrigation	840	190-260	Composite	8†	8†	400†	TTWD	TTWD	Annual
Clayton Ag Well #2	Irrigation	135	Unknown	Upper	8†	8†	400†	Madera County West	Madera County	Annual
Wells Monitored by GSAs: Future Monitoring Wells										
Site 1 MW – Shallow	Monitoring	150*	50-150*	Upper	8†	8†	400†	MID*	ILRP/Madera County	Annual
Site 1 MW – Middle	Monitoring	400*	200-400*	Lower	8†	8†	400†	MID*	Madera County	Annual
Site 1 MW – Deep	Monitoring	700*	500-700*	Lower	8†	8†	400†	MID*	Madera County	Annual
Site 2 MW – Shallow	Monitoring	100*	50-100*	Upper	8†	8†	400†	Madera County West*	ILRP/Madera County	Annual
Site 2 MW – Middle	Monitoring	350*	150-350*	Lower	8†	8†	400†	Madera County West*	Madera County	Annual
Site 2 MW – Deep	Monitoring	700*	500-700*	Lower	8†	8†	400†	Madera County West*	Madera County	Annual
Site 3 MW – Shallow	Monitoring	100*	50-100*	Upper	8†	8†	400†	Madera County East*	ILRP/Madera County	Annual
Site 3 MW – Middle	Monitoring	350*	150-350*	Lower	8†	8†	400†	Madera County East*	Madera County	Annual
Site 3 MW – Deep	Monitoring	700*	500-700*	Lower	8†	8†	400†	Madera County East*	Madera County	Annual

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation	MO Arsenic Concentration (µg/L)	MO Nitrate Concentration (mg/L)	MO TDS Concentration (mg/L)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Site 5 MW – Shallow	Monitoring	150*	50-150*	Upper	8[†]	8[†]	400[†]	MID/Madera County West*	ILRP/Madera County	Annual
Site 5 MW – Middle	Monitoring	400*	200-400*	Lower	8[†]	8[†]	400[†]	MID/Madera County West*	Madera County	Annual
Site 5 MW – Deep	Monitoring	700*	500-700*	Lower	8[†]	8[†]	400[†]	MID/Madera County West*	Madera County	Annual
Site 6 MW – Shallow	Monitoring	200*	100-200*	Upper	8[†]	8[†]	400[†]	Madera County West*	ILRP/Madera County	Annual
Site 6 MW – Middle	Monitoring	400*	200-400*	Lower	8[†]	8[†]	400[†]	Madera County West*	Madera County	Annual
Site 6 MW – Deep	Monitoring	700*	500-700*	Lower	8[†]	8[†]	400[†]	Madera County West*	Madera County	Annual
Site 7 MW – Shallow	Monitoring	250*	100-250*	Upper	8[†]	8[†]	400[†]	Madera County East*	ILRP/Madera County	Annual
Site 7 MW – Middle	Monitoring	400*	200-400*	Lower	8[†]	8[†]	400[†]	Madera County East*	Madera County	Annual
Site 7 MW – Deep	Monitoring	700*	500-700*	Lower	8[†]	8[†]	400[†]	Madera County East*	Madera County	Annual
Site 9 MW – Shallow	Monitoring	150*	50-150*	Upper	8[†]	8[†]	400[†]	MID*	ILRP/Madera County	Annual
Site 9 MW – Middle	Monitoring	400*	200-400*	Lower	8[†]	8[†]	400[†]	MID*	Madera County	Annual
Site 9 MW – Deep	Monitoring	700*	500-700*	Lower	8[†]	8[†]	400[†]	MID*	Madera County	Annual
Wells Monitored By Non-GSA Entities										
2000511-001	Public Supply	Unknown	Unknown	Unknown	2	6	350	CWD	DDW	Variable, according to DDW reqs.
2000597-001	Public Supply	Unknown	300-?	Lower	1	5	200	CWD	DDW	
2000681-002	Public Supply	Unknown	Unknown	Unknown	1	2	200	CWD	DDW	
2010001-008	Public Supply	Unknown	242-297	Lower	2	2	200	CWD	DDW	
2010001-010	Public Supply	Unknown	358-474	Lower	2	6	450	CWD	DDW	
2010001-011	Public Supply	Unknown	310-393	Lower	1	1	200	CWD	DDW	
2400216-001	Public Supply	Unknown	400-460	Lower	5	2	200	Madera County East	DDW	
ESJ11	Domestic	340	Unknown	Unknown	N/A[‡]	8	550	CWD	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.
[†] 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.

3.2.4.2 *Interim Milestones*

The IMs for the groundwater quality sustainability indicator are the same as the MOs and include ensuring that during the Implementation Period, GSP PMAs 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 IMs are maintaining existing groundwater quality concentrations for arsenic, nitrate, and TDS at each sustainability indicator well over the Implementation Period as summarized in **Table 3-6**. Consistent with the MOs, groundwater quality IMs 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.

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.

3.2.4.3 *Achieving and Maintaining Sustainability*

The combination of IMs and MOs reflect how the basin 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 Subbasin. 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.

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 Subbasin, including municipal and drinking water supply, and as a result 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, regional unconfined groundwater levels have generally been below the stream channel bottoms in the Chowchilla Subbasin for at least the last several years, and for many decades in most of the Subbasin. Thus, the connection between regional groundwater and streams was broken prior to 2015 along most streams, and the surface water depletion sustainability criterion is not applicable for most of the Subbasin. 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 western Chowchilla Subbasin boundary. These shallow groundwater levels indicate the San Joaquin River may be technically connected to groundwater during some portion of a given time period. 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. The GSAs have developed a workplan to refine and improve the hydrogeologic understanding related to interconnected surface water (ISW) (**Appendix 3.I**). In the meantime, while more information is gathered, interim SMC have been developed to monitor and manage ISW along the San Joaquin River.

Table 3-6. Summary of Groundwater Quality Interim Milestones for Representative Monitoring Sites.

Well ID	Aquifer Designation	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)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Wells Monitored by GSAs: Existing																
CWD RMS-1	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-2	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-4	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-5	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-6	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-7	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-9	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-10	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-11	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-12	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-13	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
CWD RMS-15	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	CWD	CWD	Annual
MCE RMS-1	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East	Madera County	Annual
MCW RMS-1	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West	Madera County	Annual
MCW RMS-4	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West	Madera County	Annual
MCW RMS-7	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West	Madera County	Annual
MCW RMS-9	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West	Madera County	Annual
TRT RMS-1	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	TTWD	TTWD	Annual
TRT RMS-3	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	TTWD	TTWD	Annual
TRT RMS-4	Composite	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	TTWD	TTWD	Annual
Clayton Ag Well #2	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West	Madera County	Annual
Wells Monitored by GSAs: Future Monitoring Wells																
Site 1 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	ILRP/Madera County	Annual
Site 1 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	Madera County	Annual
Site 1 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	Madera County	Annual

Well ID	Aquifer Designation	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)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Site 2 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	ILRP/Madera County	Annual
Site 2 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	Madera County	Annual
Site 2 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	Madera County	Annual
Site 3 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	ILRP/Madera County	Annual
Site 3 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	Madera County	Annual
Site 3 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	Madera County	Annual
Site 5 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID/Madera County West*	ILRP/Madera County	Annual
Site 5 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID/Madera County West*	Madera County	Annual
Site 5 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID/Madera County West*	Madera County	Annual
Site 6 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	ILRP/Madera County	Annual
Site 6 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	Madera County	Annual
Site 6 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County West*	Madera County	Annual
Site 7 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	ILRP/Madera County	Annual
Site 7 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	Madera County	Annual
Site 7 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	Madera County East*	Madera County	Annual
Site 9 MW – Shallow	Upper	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	ILRP/Madera County	Annual
Site 9 MW – Middle	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	Madera County	Annual

Well ID	Aquifer Designation	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)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Site 9 MW – Deep	Lower	8†	8†	8†	8†	8†	8†	8†	8†	400†	400†	400†	400†	MID*	Madera County	Annual
Wells Monitored By Non-GSA Entities																
2000511-001	Unknown	2	2	2	2	6	6	6	6	350	350	350	350	CWD	DDW	Variable, according to DDW reqs.
2000597-001	Lower	1	1	1	1	5	5	5	5	200	200	200	200	CWD	DDW	
2000681-002	Unknown	1	1	1	1	2	2	2	2	200	200	200	200	CWD	DDW	
2010001-008	Lower	2	2	2	2	2	2	2	2	200	200	200	200	CWD	DDW	
2010001-010	Lower	2	2	2	2	6	6	6	6	450	450	450	450	CWD	DDW	
2010001-011	Lower	1	1	1	1	1	1	1	1	200	200	200	200	CWD	DDW	
2400216-001	Lower	5	5	5	5	2	2	2	2	200	200	200	200	Madera County East	DDW	
ESJ11	Unknown	N/A‡	N/A‡	N/A‡	N/A‡	8	8	8	8	550	550	550	550	CWD	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.
† 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.

Available data and analyses (see Section 2.2.2.5) indicate the source of shallow groundwater that occurs along the San Joaquin River is infiltrating streamflow (i.e., shallow groundwater is surface water dependent) and that regional groundwater likely does not support streamflow along this reach of the San Joaquin River adjacent to the western boundary of Chowchilla Subbasin. Nonetheless, it is assumed that these conditions constitute interconnected surface water as defined under the GSP regulations for the purposes of establishing interim SMC prior to more fully characterizing shallow hydrogeologic conditions along the San Joaquin River and 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, six RMS wells screened in the Upper Aquifer in close proximity to the San Joaquin River were evaluated by comparing simulated groundwater elevations to adjacent stream thalweg elevations (**Figure 3-6** and **Table 3-7)**. 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 amount of time over a given time period for which the groundwater elevations at an RMS well are at/above the stream thalweg elevation are defined as the percent of time ISW exists at that given location. As indicated in **Table 3-7**, the percent of time connected among the six RMS wells was 3% at MCW RMS-1 and MCW RMS-3, 11 to 26% at MCW RMS-2, MCW RMS-11 and MCW-12, and 78% at MCW RMS-10 over the historical time period from 1989 to 2015.

San Joaquin River restoration flows were initiated in October 2009 and continued through November 2011, prior to being interrupted by drought conditions from December 2011 through January 2016. In the Chowchilla Subbasin, the San Joaquin River flows adjacent to the San Joaquin River Riparian GDE Unit and is in a net-losing condition, with infiltrating surface water flows likely contributing directly to the shallow groundwater system that supports the vegetation in the unit. While it appears the source of shallow groundwater is infiltrating surface water and therefore shallow groundwater can only occur when surface flows are present (i.e., groundwater does not support surface water flows, but rather surface water flows support shallow groundwater), there is at least some potential for surface water flows and the shallow groundwater system supporting GDEs to be affected by regional pumping during certain periods of time when shallow groundwater is present. If regional pumping depletes shallow groundwater, beneficial uses and users of surface water and groundwater could be negatively affected. These include riparian vegetation along the San Joaquin River and the wildlife habitat and ecosystem functions it provides, as well as riverine habitat in the San Joaquin River that supports migration and potentially spawning of special-status fishes including salmon and steelhead. Special-status species and their habitat in the San Joaquin River are included in the analyses of potential effects on the San Joaquin River Riparian GDE Unit 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 will also serve to provide support for the shallow groundwater system and GDEs that did not exist before.

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 condition 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 (i.e., depletion) is most closely related to the amount of streamflow entering the San Joaquin River reach of concern from upstream, which is related to releases from Friant Dam. Therefore, the amount of surface water depletion would not be a good choice as the metric for ISW SMC. Similarly, review of available data indicates that shallow groundwater elevations are also closely tied to the amount of streamflow; therefore, using groundwater levels as a proxy for ISW SMC would also not be a good choice. The best option for the metric is percent of time connected as discussed further in Section 3.2.5.1.

Table 3-7. Comparison of Interconnected Surface Water Representative Monitoring Sites Groundwater Elevations to Stream Thalweg Elevations – Percent of Time Connected.

	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
MCW RMS-1 (streambed elevation = 100.93 feet; Model Layer 3)			
1989-2015	325	11	3%
2016-2019	48	0	0%
2020-2039	240	0	0%
2040-2090	612	34	6%
MCW RMS-2 (streambed elevation = 103.63 feet; Model Layer 2)			
1989-2015	325	67	21%
2016-2019	48	0	0%
2020-2039	240	11	5%
2040-2090	612	117	19%
MCW RMS-3 (streambed elevation = 109.08 feet; Model Layers 2 & 3)			
1989-2015	650	18	3%
2016-2019	96	0	0%
2020-2039	480	0	0%
2040-2090	1224	124	10%
MCW RMS-10 (streambed elevation = 106.72 feet; Model Layer 1)			
1989-2015	325	254	78%
2016-2019	48	45	94%
2020-2039	240	183	76%
2040-2090	612	455	74%
MCW RMS-11 (streambed elevation = 115.01 feet; Model Layers 1 & 2)			
1989-2015	650	172	26%
2016-2019	96	19	20%
2020-2039	480	51	11%
2040-2090	1224	349	29%

	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
MCW RMS-12 (streambed elevation = 116.05 feet; Model Layers 1 & 2)			
1989-2015	650	72	11%
2016-2019	96	0	0%
2020-2039	480	21	4%
2040-2090	1224	284	23%

3.2.5.1 Measurable Objective

The measurable objective 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 3-8** for the six RMS wells screened in the Upper Aquifer near the San Joaquin River (**Figure 3-6**). 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 3-8**) 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.

Table 3-8. 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
MCW RMS-1	120	186	Unknown	3	Upper	3%	Madera County West
MCW RMS-2	123	Unknown	Unknown	2	Upper	21%	Madera County West
MCW RMS-3	122	Unknown	Unknown	2,3	Upper	3%	Madera County West
MCW RMS-10	123	26	Unknown	1	Upper	78%	Madera County West
MCW RMS-11	127	30	Unknown	1	Upper	26%	Madera County West
MCW RMS-12	127	29	Unknown	1	Upper	11%	Madera County West

[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.

3.2.5.2 Interim Milestones

IMs for ISW along the San Joaquin River are the same as the MOs described in Section 3.2.5.1. 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.

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 western boundary of Chowchilla 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 depletion, 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 Chowchilla 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 Chowchilla 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 Chowchilla Subbasins GSAs and/or due to other factors such as the SJRRP, it is possible that the adjacent Delta-Mendota Subbasin may be affected by higher groundwater levels in the shallow zone.

3.2.6 Seawater Intrusion

The seawater intrusion sustainability criteria is not applicable to this Subbasin, because it is located more than 70 miles inland from and hydraulically disconnected from the ocean.

3.2.7 Management Area Measurable Objectives

Chowchilla Subbasin was divided into two Management Areas – the Western Management Area and the Eastern Management Area. The primary differences between these two Management Areas in terms of SMC are related to land subsidence and GDEs.

Undesirable results for subsidence during the time period from 2005 to 2015 have occurred in the Western Management Area related to infrastructure but not in the Eastern Management Area. The MTs for subsidence for the two Management Areas are different, as described in the next section. However, the subsidence MOs are based on the same methodology in both the Western Management Area and the Eastern Management Area. There will be ongoing review of subsidence surveys and adaptive management in both Management Areas to adjust subsidence MOs, if necessary.

A single GDE unit occurs in the Western Management Area along the San Joaquin River, and there are no GDE units in the Eastern Management Area. Because GDEs are present in only one of the two Management Areas, there are no concerns about the basin operating under different MOs for GDEs in the two Management Areas.

Thus, there will be no inconsistencies caused by setting of MOs for the two different Management Areas. Differences in management area measurable thresholds for land subsidence and GDEs are discussed below in the section on MTs.

3.3 Minimum Thresholds (23 CCR § 354.28)

The 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. Significant and unreasonable effects occur when MTs are exceeded for one or more sustainability indicators. This section describes the following for each sustainability indicator relevant to Chowchilla Subbasin: 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, the measurement method, and integration of MTs for the two different Management Areas.

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 through an extensive and collaborative coordination process between all GSAs in the Subbasin. As described below, the MT for groundwater levels is defined as the Fall 2015 groundwater elevation at each RMS well.[66] This MT maintains groundwater levels generally at or above levels experienced prior to SGMA. In this way, impacts to domestic well users, public supply wells, and other beneficial users of groundwater in 2040 and beyond 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 temporarily fall below 2015 levels during the GSP implementation period (2020-2040), the implementation of projects and management actions is expected to cause groundwater levels to return to historical levels by 2040.DWR recognizes in the SGMA SMC BMP guidance documents that it may be acceptable for groundwater levels to temporarily exceed MTs during the GSP implementation period (prior to 2040) provided that the GSAs are managing groundwater and implementing PMAs as outlined in the GSP. In the meantime, the GSAs are implementing a Domestic Well Mitigation Program to provide assistance to domestic wells and shallow wells that supply drinking water users who may be adversely impacted prior to 2040, while the GSAs work to implement PMAs. As described in Section 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved.

[66] 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 elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.

The groundwater level MTs and other groundwater level SMC have been designated with these considerations in mind, and with consideration for protection against significant and unreasonable impacts to groundwater storage volumes, land subsidence, and some groundwater quality concerns. However, ultimately the sustainability indicator with the most constraining MT will govern the determination of whether an undesirable result has occurred.

GDEs were also considered in setting of MTs for chronic lowering of groundwater levels. The single GDE unit identified in the Subbasin is dominated by terrestrial vegetation, which is susceptible to adverse impacts (i.e., undesirable results) if shallow groundwater levels in the underlying perched/mounded aquifer 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, and the water budget discussed in previous chapters.

MTs are listed in **Table 3-9** for the groundwater level RMS wells shown in **Figure 3-3**. Groundwater level hydrographs showing MTs for each groundwater level RMS are provided in **Appendix 3.A.**

The RMS described in **Table 3-9** and **Figure 3-3** are in locations that reflect a wide cross section of Subbasin groundwater conditions. These locations are representative of the overall Subbasin conditions because they are spatially distributed throughout the Subbasin both vertically (within the Upper and Lower Aquifers in the Corcoran Clay area) and laterally throughout the Subbasin. 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 (including some areas where Corcoran Clay is present) in the central to eastern portions of the Subbasin. The GSAs have determined that management to avoid the groundwater elevation MTs and achieve the groundwater elevation MOs at each of the RMS wells by 2040 (along with implementation of a Domestic Well Mitigation Program) will help avoid undesirable results of chronic lowering of groundwater levels by reducing the likelihood that access to adequate water resources for beneficial uses and users within the Subbasin will be compromised.

Table 3-9. Summary of Groundwater Level Minimum Thresholds for Representative Monitoring Sites.

Well I.D.	Ground Surface Elevation (ft, msl)	Well Depth (ft bgs)	Screen Interval Top-Bottom Depth (ft bgs)	Model Layer(s)	Aquifer Designation	Depth to Reduced Deposits (ft bgs)	MT Depth to Water (ft bgs)[1]	MT GW Elev (ft, msl)[1]	GSA	CASGEM Well?
CWD RMS-1	171	275	160-275	4	Lower	NA	212	-41	CWD	CASGEM
CWD RMS-2	193	780	230-775	4	Lower	575	264	-71	CWD	No
CWD RMS-3	206	Unknown	Unknown	4	Lower	450	273	-67	CWD	No
CWD RMS-4	225	800	320-800	4	Lower	450	260	-35	CWD	CASGEM
CWD RMS-5	207	Unknown	Unknown	4	Lower	NA	232	-25	CWD	Voluntary
CWD RMS-6	275	820	257-726	4	Lower	450	309	-34	CWD	CASGEM
CWD RMS-7	169	330	135-288	3,4	Lower	NA	185	-16	CWD	CASGEM
CWD RMS-8	219	Unknown	Unknown	4	Lower	NA	292	-73	CWD	Voluntary
CWD RMS-9	164	97	82-97	3	Upper	NA	93	71	CWD	CASGEM
CWD RMS-10	182	Unknown	Unknown	4	Lower	NA	271	-89	CWD	Voluntary
CWD RMS-11	199	529	187-529	4	Lower	NA	114	85	CWD	CASGEM
CWD RMS-12	176	Unknown	Unknown	3	Upper	NA	138	38	CWD	Voluntary
CWD RMS-13	167	Unknown	Unknown	4	Lower	NA	225	-58	CWD	Voluntary
CWD RMS-14	152	455	185-365	4	Lower	NA	220	-68	CWD	CASGEM
CWD RMS-15	213	955	290-935	4	Lower	600	269	-56	CWD	CASGEM
CWD RMS-16	212	Unknown	Unknown	4	Lower	600	280	-68	CWD	Voluntary
CWD RMS-17	203	624	278-588	4	Lower	600	254	-51	CWD	CASGEM
MCE RMS-1	276	Unknown	Unknown	4	Lower	450	300	-24	Madera County East	Voluntary
MCE RMS-2	272	466	218-464	4	Lower	450	305	-33	Madera County East	CASGEM

Well I.D.	Ground Surface Elevation (ft, msl)	Well Depth (ft bgs)	Screen Interval Top-Bottom Depth (ft bgs)	Model Layer(s)	Aquifer Designation	Depth to Reduced Deposits (ft bgs)	MT Depth to Water (ft bgs)[1]	MT GW Elev (ft, msl)[1]	GSA	CASGEM Well?
MCW RMS-1	120	186	Unknown	3	Upper	NA	59	61	Madera County West	Voluntary
MCW RMS-2	123	Unknown	Unknown	2	Upper	NA	37	86	Madera County West	No
MCW RMS-3	122	Unknown	Unknown	2,3	Upper	NA	55	67	Madera County West	Voluntary
MCW RMS-4	138	Unknown	Unknown	4	Lower	NA	176	-38	Madera County West	Voluntary
MCW RMS-5	146	Unknown	Unknown	4	Lower	NA	214	-68	Madera County West	Voluntary
MCW RMS-6	139	Unknown	Unknown	4	Lower	NA	173	-34	Madera County West	Voluntary
MCW RMS-7	138	800	290-400	4	Lower	NA	110	28	Madera County West	CASGEM
MCW RMS-8	142	480	160-475	3,4	Composite	NA	171	-29	Madera County West	CASGEM
MCW RMS-9	155	700	265-696	5	Lower	NA	224	-69	Madera County West	CASGEM
MCW RMS-10	123	26	Unknown	1	Upper	NA	21	102	Madera County West	No
MCW RMS-11	127	30	Unknown	1	Upper	NA	25	102	Madera County West	No
MCW RMS-12	127	29	Unknown	1	Upper	NA	34	93	Madera County West	No
MER RMS-1	225	Unknown	Unknown	4	Lower	400	290	-65	SVMWC	No
TRT RMS-1	134	196	158-192	3	Upper	NA	102	32	TTWD	No
TRT RMS-2	135	500	300-500	4	Lower	NA	97	38	TTWD	CASGEM
TRT RMS-3	137	799	168-790	5	Lower	NA	189	-52	TTWD	No
TRT RMS-4	141	840	190-260	3,4	Composite	NA	141	0	TTWD	CASGEM

[1] The actual MT 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 representative monitoring sites within their GSA area.

3.3.1.1 Methodology

The methodology to develop groundwater elevation MTs was based on many considerations, including: 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; review of the DWR January 2022 consultation letter subsequent meetings with DWR in 2022; as well as review of DWR's March 2023 inadequate determination letter, subsequent discussions with DWR and the SWRCB, and further pending discussions (as of May 2023).

There were several steps involved with identification of RMS wells and determination of groundwater elevation MTs as follows:

1) 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 groundwater levels, availability of recent groundwater level data, good spatial distribution) and select appropriate RMS;
2) For each selected RMS, set the groundwater level MT equal to the Fall 2015 measurement, if this observed data point is available at a given RMS;
3) If no Fall 2015 groundwater elevation measurement is available, utilize simulated groundwater elevations from MCSim to determine the expected Fall 2015 groundwater elevation, with adjustments up or down to account for offset between historical observed and simulated groundwater elevations, if necessary.

Example hydrographs showing the steps in determining MTs based on Fall 2015 groundwater elevations are provided in **Figures 3-7 and 3-8**. The hydrographs for MCE RMS-2 (**Figure 3-7a**) and CWD RMS-1 (**Figure 3-7b**) demonstrate the process for determining MT values based on observed Fall 2015 data. In these cases, simulated groundwater model results are not needed and MTs are set directly based on observed groundwater elevation data. The hydrographs for CWD RMS-3 (**Figure 3-8a**) and MCW RMS-2 (**Figure 3-8b**) demonstrate the process for determining MT values based on simulated Fall 2015 groundwater elevations from the MCSim groundwater model. The hydrographs for CWD RMS-3 and MCW RMS-2 demonstrate how the groundwater model was used to help determine MTs when Fall 2015 observed data are not available (**Figure 3-8**). Consideration of any groundwater elevation offset between observed and simulated groundwater levels (demonstrated in **Figure 3-8b** for MCW RMS-2) was applied in cases where simulated groundwater elevations are consistently above or below observed groundwater elevations, or situations where observed groundwater elevations occasionally spike below seasonal low simulated groundwater elevations. Overall, the purpose of adjusting for differences between observed and simulated groundwater elevations is to obtain the most representative value for the Fall 2015 groundwater elevation at each RMS when measurements are not available.

As described in Section 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved. Economic analyses conducted for this GSP (**Appendix 3.C**) demonstrate that the impacts to the County and its residents would be much greater if projects and management actions were implemented immediately to try to avoid further declines in groundwater levels during the Implementation Period. Therefore, it was determined that the phased implementation schedule of PMAs adopted in this GSP (Chapter 4 and Chapter 5) combined with a Domestic Well Mitigation Program reduces the overall risk of adverse impacts to the County and its residents.

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. Comparison of existing recent groundwater levels to MTs (as well as MOs) should use historical low groundwater elevations (in most cases, most likely to be recent Fall measurements) for existing levels as the basis of comparison.

3.3.1.2 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 described below. However, ultimately the sustainability indicator with the most constraining MT in any part of the Subbasin will govern the determination of whether an undesirable result has occurred.

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 Sustainability Period. Pumping at or less than the sustainable yield will maintain or raise average groundwater elevations in the Subbasin. The groundwater elevation MTs are set at Fall 2015 groundwater elevations, consistent with avoiding undesirable results associated with 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.

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. A zero MT for subsidence has been set for the Subbasin to avoid potential future subsidence impacts as well. The groundwater elevation MT set equal to Fall 2015 groundwater elevations is consistent with the subsidence MT established for the Subbasin.

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 (e.g., elevated arsenic) to flow upward into existing wells. Groundwater elevation MTs are set equal to Fall 2015 groundwater elevations and are generally well above depths to reduced deposits from which poorer quality water (with respect to naturally occurring constituents) may be derived (Table 3-9), thereby reducing opportunities for poor quality groundwater to flow into wells.

    b. Changes in groundwater elevation as a result of PMAs 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 on the groundwater elevations themselves. Therefore, the MTs for groundwater elevations do not directly lead to significant and unreasonable degradation of groundwater quality in wells. Although there are no current documented large-scale contaminant plumes of concern in the regional groundwater aquifers, 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 will be 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 to the water table. Such projects 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 projects, it may be the case that GSP projects 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 projects; however, the overall groundwater monitoring program developed for this GSP plus any additional site-specific monitoring (e.g., soil and/or groundwater sampling) determined to be needed will be utilized to evaluate need for adaptive management related to GSP recharge projects.

4. Depletion of interconnected surface waters (ISW). The assessment of surface water flows and groundwater levels indicate that there are likely time periods with ISW along the San Joaquin River (but not in the remainder of the Subbasin). 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 MTs for ISW specify the percent of time with connected between surface water and shallow groundwater be maintained. Therefore, the MT for ISW is consistent with the groundwater elevation MTs being equal to Fall 2015 groundwater elevations.

3.3.1.3 Impact of Selected Minimum Thresholds to Adjacent Basins

The potential for impacts on adjacent subbasins will primarily be a function of average groundwater levels in the Plan area during the sustainability period, average groundwater levels 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 Subbasin are reflected in the MOs. Therefore, the impact to adjacent subbasins is described in more detail under the section on MOs..

3.3.1.4 Minimum Thresholds Impact on Beneficial Uses and Users

By definition, MTs define the quantitative values that represent the groundwater conditions at RMS that, when exceeded individually or in combination with MTs at other monitoring sites, may cause undesirable results in the Subbasin. Exceedance of the established groundwater elevation MTs are likely to have several undesirable results for beneficial uses and users of groundwater, land use, and property in the Subbasin. 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 and shallow well owners can generally expect to see declining groundwater levels during the initial 10 to 15 years of the Implementation Period, followed by stabilization of groundwater levels during the latter portion of the Implementation Period and some potential recovery in groundwater levels after 2040. However, significant adverse impacts to domestic wells from declining groundwater levels will be addressed through a Domestic Well Mitigation Program being implemented by the GSAs. As described in Section 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved. The economic analyses conducted to compare costs of implementing a Domestic Well Mitigation Program versus immediately requiring full implementation of demand reduction in 2020 is provided in **Appendix 3.C**.

Potential ecological impacts are possible in the San Joaquin River Riparian GDE Unit along the western margin of the Subbasin, but the severity of the effects is likely to be minor, if any. The GDE unit is composed of vegetation which may access shallow groundwater within approximately 30 feet of the surface.

Simulated historical and future groundwater elevation lows show depths to water exceeding 30 feet. This is an indication that that the GDE Unit is able to survive short-term declines in groundwater levels, possibly due in part to the presence of a capillary fringe above the water table. In general, simulated future lows during severe droughts are on the order of five to seven feet below historical simulated low groundwater levels. However, it should be noted that the historical model period does not capture all the climate variability and droughts covered in the future model period (e.g., 1970's short-term but extreme drought). The MT depths of 21–34 feet below ground surface for RMS wells MCW RMS-10, MCW RMS-11, and MCW RMS-12 are protective of the GDE Unit. As noted previously both simulated historical and future levels do exceed 30 feet for short durations. Historical model results for these wells reflect shallow groundwater conditions under which the vegetation currently composing the GDE Unit has persisted since at least 1989 with no apparent adverse effects, suggesting that similar conditions in the future (and possibly deeper groundwater levels) would continue to support the GDEs. If a future drought and projected reductions to MT levels were to occur, potential effects on GDEs could include short term adverse impacts such as water stress and possibly longer-term impacts such as reduced growth and recruitment, and potential branch dieback or tree mortality resulting in some loss of vegetation structure, ecological function, and habitat for special status species. Given the relatively low projected frequency and short duration of the shallow groundwater level declines to depths greater than 40 feet, uncertainty in the relationship between shallow zone groundwater and groundwater pumping from deeper zones, and apparent resiliency of the GDE Unit to historical drought periods, adverse impacts due to groundwater pumping are unlikely. Overall, sustainable groundwater management in the Chowchilla Subbasin is expected to maintain the health and resiliency of the vegetation communities composing the San Joaquin River Riparian GDE despite some potential future temporary impacts that may occur if the minimum groundwater level thresholds are reached.

3.3.1.5 Comparison between Minimum Thresholds and Relevant State, Federal or Local Standards

There are no Federal, State, or local standards that exist for chronic lowering of groundwater levels.

3.3.1.6 Minimum Thresholds Measurement Method

Groundwater level MTs will be directly monitored through groundwater elevation measurements collected at existing RMS wells and any potential new RMS wells that may be added during the GSP Implementation Period. 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 9 wells in the Upper Aquifer and 25 wells in the Lower Aquifer (plus 2 additional composite wells). Madera County has already installed 11 new nested monitoring wells (with three separate wells at each site) in the Subbasin since 2019, which are being incorporated in the monitoring network.

3.3.2 Reduction in Groundwater Storage

The cause of basin 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, periodic evaluations of changes in groundwater storage will be conducted after 2040. These analyses 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 may not provide coverage of the entire basin such as would be important for a total basin-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 basin groundwater storage calculation. Rather, the main purpose is to determine the representative relative change in storage for the basin 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 periodic 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 3-9** and **Figure 3-3** are in locations that reflect a wide cross section of Subbasin groundwater conditions. These locations are representative of the overall Subbasin conditions because they are spatially distributed throughout the Subbasin 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 east of where Corcoran Clay is present), results in relatively large areas of unsaturated Upper Aquifer in the central to eastern portions of the Subbasin. 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 Subbasin will be compromised.

The reduction in groundwater storage MT is closely related to the chronic lowering of groundwater level MT and set independently of other sustainability indicators. However, ultimately the sustainability indicator with the most constraining MT will govern the determination of whether an undesirable result has occurred.

1. 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.
2. Subsidence. Because future average groundwater levels will be stable under the reduction in groundwater storage MT, they will not induce any additional active subsidence.
3. 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.
4. Depletion of ISW. The assessment of surface water flows and groundwater levels indicate that there are not ISW bodies in most of the Subbasin. Since MTs are being set independently for each sustainability indicator, ISW MTs and undesirable results will not be affected by the reduction in groundwater storage MT. The potential for reduction in groundwater storage to impact 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 basins. A MT for reduction in groundwater storage tied to evaluation of changes in groundwater storage over long-term periods 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 of maintaining stable average groundwater elevations during the Sustainability Period will require some amount of reduction in groundwater pumping in the Subbasin. Reduced pumping may impact beneficial uses and users of groundwater in the Subbasin. 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, primarily from the Lower Aquifer, 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.

Undesirable results for land subsidence are significant and unreasonable adverse impacts from land subsidence on critical surface infrastructure that impair the operation and function of the infrastructure. Critical infrastructure identified in the Subbasin include water conveyance infrastructure, well infrastructure, transportation-related infrastructure, and other water and wastewater-related infrastructure in the Chowchilla Subbasin. An analysis of infrastructure sensitivity to land subsidence in the Chowchilla Subbasin is provided in **Appendix 3.E** and summarized in Section 3.3.3.7, below.

MTs for land subsidence in both the WMA and EMA of the Subbasin were established at a rate of 0 feet/year with recognition and consideration of infrastructure sensitivity.

MTs for land subsidence were also established with consideration for ongoing actions by landowners in the WMA to mitigate subsidence in and adjacent to Triangle T Water District, in areas of the Subbasin where subsidence rates have historically been greatest. Landowners managing more than 14,000 acres in the WMA of the Subbasin have entered into an agreement with agencies in the Delta-Mendota Subbasin to reduce pumping from the Lower Aquifer with the goal of mitigating subsidence in the WMA and preventing adverse impacts to surrounding critical infrastructure. Details and provisions of the Subsidence Control Measures Agreement are summarized in Section 3.3.3.7, below, and are included in **Appendix 3.F**. Subsidence-based MTs established for RMS in the WMA and EMA are intended to mitigate future adverse impacts from subsidence on critical surface infrastructure.

3.3.3.1 *Methodology*

The MT for land subsidence was selected to prevent undesirable results. As discussed in Section 2.2.2.4 of this GSP, some amount of subsidence is currently occurring due to recent historical groundwater conditions and will likely occur for some time into the future during the GSP Implementation Period. Given the expectation of some future subsidence that is already occurring due to past groundwater conditions, IMs were set to manage subsidence during the GSP Implementation Period. IMs for subsidence are described in **Section 3.2.3.2** of this GSP.

The land subsidence MT is set at a rate of 0 feet/year for both the WMA and the EMA. However, compliance with this MT will take into consideration the level of uncertainty associated with survey measurements. For example, SJRRP has reported that elevation survey measurements made using the current technology available to USBR have a vertical accuracy of +/-2.5 centimeters (USBR, 2011). With two measurements necessary to calculate a rate of change over time, the total uncertainty in the subsidence rate calculated from USBR survey data is 5 centimeters, or approximately 0.16 feet. 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 current survey measurement methods used by USBR and would be considered to be within the range of uncertainty of the MT of 0 feet/year and therefore would not be considered an MT exceedance.

3.3.3.2 Relationship to Other Sustainability Indicators

Although there are potential relationships between land subsidence and other sustainability indicators, setting an MT of 0 feet/year for land subsidence does not conflict with other sustainability indicators and associated MTs. Ultimately, the sustainability indicator with the most constraining MT will govern the determination of whether an undesirable result has occurred.

1. It should also be noted that while land subsidence MTs and MOs are not specifically tied to groundwater levels, implementation of PMAs intended to halt declines, stabilize, and possibly raise groundwater levels will limit the potential for future subsidence along with serving to prevent chronic lowering of groundwater levels.

3.3.3.3 Impact of Selected Minimum Thresholds to Adjacent Basins

Based on review of adjacent GSPs along the western and northern borders of the Subbasin (San Joaquin River Exchange Contractors or SJREC, Merced Subbasin, and Madera Subbasin), land subsidence MTs in the WMA are generally consistent with those being set in adjacent areas of the Delta-Mendota, Merced, and Madera Subbasins. Furthermore, the MTs for land subsidence in the WMA were established to be consistent with the Subsidence Control Measures Agreement between landowners in and around the Triangle T Water District and agencies in the Delta-Mendota Subbasin. The provisions of this agreement are specifically designed to mitigate subsidence and avoid undesirable results to critical infrastructure in the Delta-Mendota and Chowchilla Subbasins (see Section 3.3.3.7, below). Chowchilla Subbasin representatives plan to continue working closely with SJREC to monitor subsidence during the Implementation Period.

3.3.3.4 Minimum Thresholds Impact on Beneficial Uses and Users

The land subsidence MT will necessarily require shifting some groundwater pumping from the Lower Aquifer to the Upper Aquifer combined with some net overall reduction in groundwater pumping. Shifting of pumping from the Lower Aquifer to Upper Aquifer and reduced overall groundwater pumping may impact beneficial uses and users of groundwater in the Subbasin. 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. Those expected to be most impacted by pumping reductions are agricultural land uses and users, as those users are the primary users of groundwater from the Lower Aquifer in the Chowchilla Subbasin. 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. In addition, requirements to pump less from the Lower Aquifer and more from the Upper Aquifer may impact groundwater levels for GDEs (ecological land use and users) during droughts (depending on the balance between GSP recharge projects in the Upper Aquifer vs. additional pumping from the Upper Aquifer).

It should be noted that landowners within and adjacent to Triangle T Water District have already entered into an agreement to mitigate subsidence in a portion of the WMA of Chowchilla Subbasin. The agreement, in effect since 2017, contains provisions that limit pumping from the Lower Aquifer to reduce subsidence in areas of the Chowchilla Subbasin where subsidence rates have historically been greatest, and also provide irrigators in the Chowchilla Subbasin access to surface water for irrigation in-lieu of groundwater. These actions are designed and have already begun to mitigate impacts of land subsidence on beneficial uses and users in the Chowchilla Subbasin. Additional information is provided in Section 3.3.3.7, below.

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

The elevation at each land subsidence RMS (SJRRP elevation survey benchmarks) will be monitored twice a year to determine annual change in elevation (December to December) at each RMS for comparing with MTs. The USBR plans to continue their current monitoring of these sites twice a year and these data will be used for assessment of conditions in relation to subsidence SMC.

3.3.3.7 Other Considerations for Setting Minimum Thresholds

3.3.3.7.1 Infrastructure Sensitivity Assessment

The GSAs completed an infrastructure assessment to evaluate the characteristics of critical infrastructure in the Chowchilla Subbasin, including its proximity, orientation, and relative vulnerability to adverse effects of land subsidence. The assessment is documented in **Appendix 3.E.** and the results from this assessment were considered during development of SMC in the Subbasin with the goal of protecting this critical infrastructure from experiencing significant adverse impacts.

3.3.3.7.2 Subsidence Control Measures Agreement

The MTs for land subsidence in the Subbasin, specifically the WMA, were established to be consistent with the Subsidence Control Measures Agreement (initial Agreement) between certain landowners in the WMA of the Subbasin, the Central California Irrigation District (CCID), and San Luis Canal Company. Landowners that have entered into the initial Agreement collectively manage more than 14,000 acres in the WMA. A copy of the initial Agreement is provided in **Appendix 3.F.** The initial Agreement was executed in 2017 and was in effect from 2017-2021. The parties worked under a one-year extension in 2022 and are in the process of negotiating another extension in 2023.

The provisions of the initial Agreement were designed to mitigate subsidence and avoid undesirable results to beneficial uses and users and critical infrastructure in the Chowchilla Subbasin and the adjacent Delta-Mendota Subbasin. The expressed purpose of the initial Agreement is to:

1. Reduce the use of groundwater 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 initial Agreement, including the Expert Panel established under the Agreement.

2. Facilitate the distribution and use of surface water in areas of the Chowchilla Subbasin that are managed by participating landowners in order to reduce groundwater extraction (particularly from the Lower Aquifer), reduce subsidence, recharge the Upper Aquifer, and mitigate effects to critical infrastructure, including Sack Dam and the Poso Canal. Both systems are gravity-flow systems that are vulnerable to capacity reductions due to land subsidence and may require significant operational changes if subsidence continues unabated (e.g., pumping, relocation or reconstruction of diversion infrastructure).

Under the initial 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 also requires evaluation of the Lower Aquifer safe Yield by an Expert Panel to determine the allowable amount of pumping from the Lower Aquifer that can occur without causing continuation of subsidence. While this Safe Yield evaluation was being conducted, the initial Agreement set specific limits for Lower Aquifer pumping as follows: 0.9 acre-feet per acre (AF/ac) in 2017, 0.75 AF/ac in 2018, 0.65 AF/ac in 2019, 0.6 AF/ac in 2020, and 0.5 AF/ac in 2021. Following completion of the Lower Aquifer Safe Yield Study by the Expert Panel, the annual limits and future allowable groundwater pumping amounts from the Lower Aquifer were modified in accordance with Expert Panel findings. The most recent Draft 2022 Expert Panel Report prepared in April 2023 is provided in **Appendix 3.F**.

Since the initial Agreement was signed in 2017, parties to the Agreement have successfully constructed facilities to supply and distribute surface water to users in the Chowchilla Subbasin. Despite the dry start to the GSP implementation period and through the actions and infrastructure improvements performed in accordance with the initial Agreement, more than 25,000 AF of surface water has been delivered to participating landowners in the Chowchilla Subbasin since 2018. This surface water has provided direct benefits to participating landowners for irrigation and groundwater recharge in an area that has historically relied solely on groundwater pumping, resulting in reduced pumping and helping to mitigate subsidence.

Landowners in the Chowchilla Subbasin that are party to the Agreement have also consistently fulfilled their obligation to report, under penalty of perjury, the amounts of groundwater pumped, the source of that groundwater (Upper Aquifer or Lower Aquifer), the amount recharged, the amounts of surface water used for irrigation, and other information about their irrigated acreage and crops. **Table 3-10** provides a summary of groundwater pumping, surface water use, and irrigated acreage from the Draft 2022 Expert Panel Report (**Appendix 3.F**). Beginning in 2017, participating landowners in the Chowchilla Subbasin have reduced pumping from the Lower Aquifer, including shifting considerable pumping from the Lower Aquifer to the Upper Aquifer. Each year since signing the initial Agreement, the participating landowners have collectively reported pumping between 0.13 and 0.50 AF/ac from the Lower Aquifer, less than the specified limits for Lower Aquifer pumping in the initial Agreement. Use of surface water during years it has been available has also provided between 0.66 and 1.76 AF/ac of benefit to those irrigated lands, providing direct recharge to the Upper Aquifer and offsetting demand for groundwater.

Efforts under the initial Agreement have already been successful for mitigating subsidence in the TTWD area of the WMA. Annual vertical displacement rates in the Subbasin, as reported from InSAR data, indicate a relative decrease in the rate of subsidence within Triangle T Water District since approximately 2017, as compared with rates of subsidence in surrounding areas (see Section 2.2.2.4).

Table 3-10. Reported Groundwater Use, Surface Water Use, and Total Water Use by Chowchilla Subbasin Landowners that are Signatories to the Subsidence Control Measures Agreement.[1]

Description	2017	2018	2019	2020	2021	2022
Total Groundwater Use (AF)	17,089	27,764	23,988	30,478	34,744	34,851
Lower Aquifer Pumping (AF)	*1,777*	*6,978*	*1,770*	*5,355*	*5,262*	*6,036*
Upper Aquifer Pumping (AF)	*15,312*	*20,786*	*22,218*	*25,123*	*29,482*	*28,815*
Total Surface Water Use (AF)	22,653	10,244	24,798	9,329	0	1,444
Surface Water Purchases (AF)	*0*	*8,279*	*10,746*	*9,329*	*0*	*1,444*
Surface Water Diversions, Fresno River (AF)	*15,666*	*620*	*11,007*	*0*	*0*	*0*
Surface Water Diversions, Eastside Bypass (AF)	*6,987*	*1,345*	*3,045*	*0*	*0*	*0*
Total Water Use (AF)	39,742	38,008	48,786	39,807	34,744	36,295
Total Irrigated Area (ac)	13,911	13,911	14,111	14,111	14,111	14,111
Total Groundwater Use (AF/ac)	1.23	2.00	1.70	2.16	2.46	2.47
Lower Aquifer Pumping (AF/ac)	*0.13*	*0.50*	*0.13*	*0.38*	*0.37*	*0.43*
Upper Aquifer Pumping (AF/ac)	*1.10*	*1.49*	*1.57*	*1.78*	*2.09*	*2.04*
Total Surface Water Use (AF/ac)	1.63	0.74	1.76	0.66	0.00	0.10
Surface Water Purchases (AF/ac)	*0.00*	*0.60*	*0.76*	*0.66*	*0.00*	*0.10*
Surface Water Diversions, Fresno River (AF/ac)	*1.13*	*0.04*	*0.78*	*0.00*	*0.00*	*0.00*
Surface Water Diversions, Eastside Bypass (AF/ac)	*0.50*	*0.10*	*0.22*	*0.00*	*0.00*	*0.00*
Total Water Use (AF/ac)	2.86	2.73	3.46	2.82	2.46	2.57

[1] Source: Appendix 3.F. Draft 2022 Expert Panel Report ("2022 Monitoring Data for the Sack Dam-Red Top Area"), Table S3-Subsidence Abatement Agreement Summary.

Landowners in the Chowchilla Subbasin that are party to the initial Agreement are committed to fulfilling the obligations under the Agreement. Fulfillment of these obligations is expected to also support sustainable groundwater management in the Chowchilla Subbasin in accordance with the SMC established in this GSP. Actions under the Agreement are expected to help maintain groundwater levels in the Lower Aquifer at or above recent historical levels, thereby avoiding undesirable results related to land subsidence. Compliance with the Agreement will help avoid undesirable results to infrastructure – including Sack Dam, Poso Canal, and other waterways in the WMA – as well as other beneficial uses of land and groundwater in the surrounding region. The initial Agreement has already provided significant and measurable benefits to the Chowchilla Subbasin. The outcomes and effectiveness of the Agreement will continue to be evaluated, and will be reported in subsequent periodic GSP updates and Annual Reports as more is known.

3.3.3.7.3 Other Subsidence Control Measures in the Western Management Area

Outside of areas managed under the Agreement, the GSAs in the Chowchilla Subbasin plan to couple their GSP projects and implementation efforts with provisions that complement and are consistent with the Agreement.

For example, Madera County GSA and TTWD GSA are developing large, coordinated groundwater recharge projects in the WMA that will enhance groundwater storage in the Upper Aquifer. The GSAs will be executing agreements with participating landowners as part of these projects. In these agreements the GSAs plan to include 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 parts of the WMA outside of the TTWD GSA. Together, the combined benefit area of these projects and the lands managed under the Subsidence Control Measures Agreement represent the majority of land within the WMA (**Figure 3-9**).

While development of these groundwater recharge projects is ongoing, the GSAs will continue to monitor the progress and subsidence mitigation benefits of the initial Agreement. These findings will be used to inform development of Lower Aquifer groundwater pumping restrictions or other efforts to mitigate subsidence in the Madera County GSA area. 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. Based on the results of the "Projected, With Projects" water budget scenario simulated in the Madera-Chowchilla Groundwater-Surface Water Simulation (MCSim)[67], it is expected that shifts in pumping practices, paired with implementation of the planned PMAs, will help to achieve sustainable groundwater conditions in the Chowchilla Subbasin. Updates and outcomes of other subsidence mitigation measures will be reported in future GSP updates and Annual Reports. Together, landowners and GSAs are making consistent efforts to achieve and maintain groundwater sustainability in the WMA.

[67] See Appendix 6.D, Section 3.5.3.2. In the MCSim projected model, approximately 90 percent of groundwater pumping was simulated from the Upper Aquifer and approximately 10 was simulated from the Lower Aquifer.

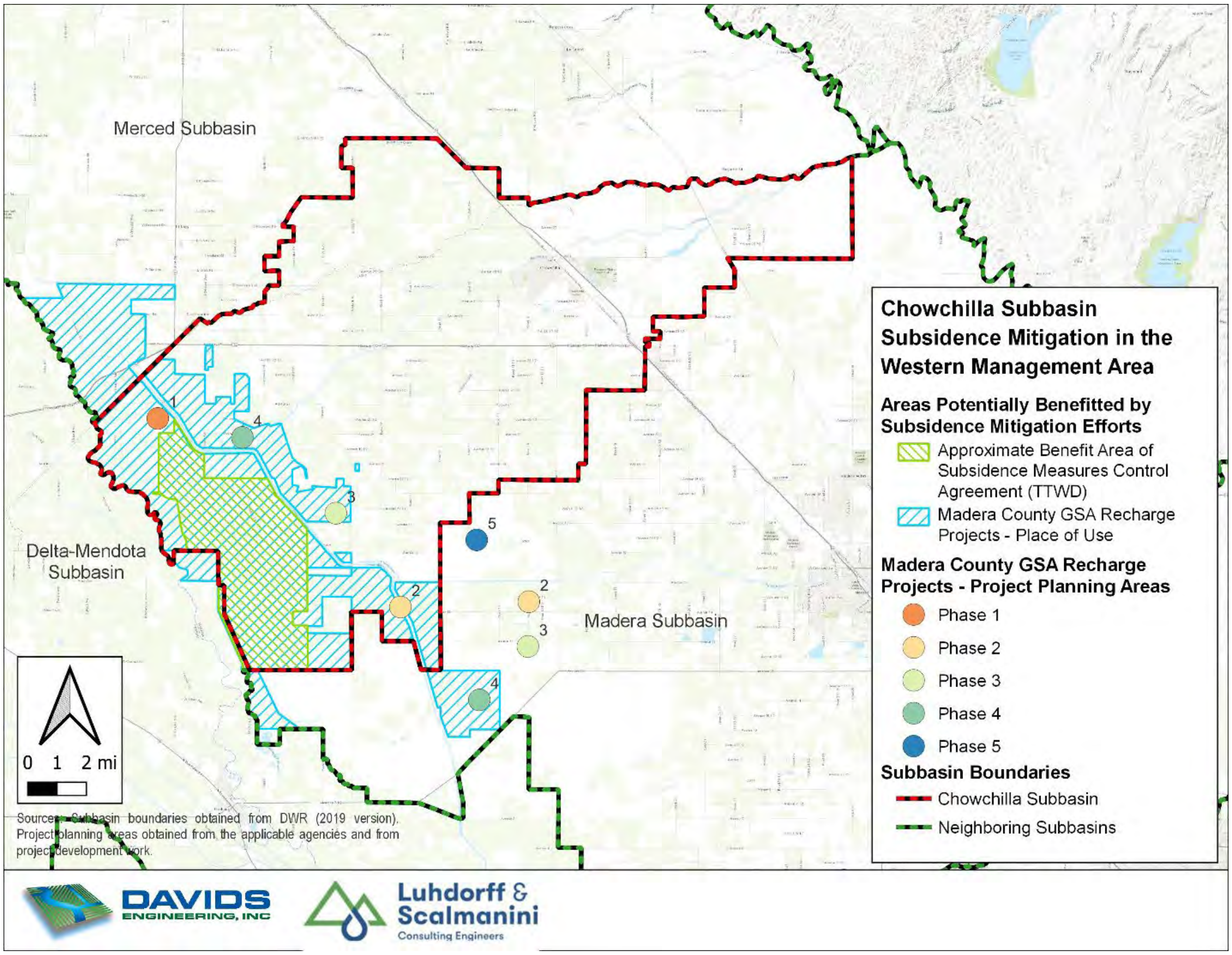


Figure 3-9. Subsidence Mitigation Efforts in the Western Management Area.

3.3.4 Degraded Water Quality

The cause of basin 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 MCLs for drinking water for identified key constituents (10 mg/L for nitrate as nitrogen; 500 mg/L for TDS; 10 ug/L for arsenic). There are no known significant large-scale groundwater quality contamination plumes in regional groundwater aquifers within the Subbasin. Municipal and domestic supply (MUN) is a designated beneficial use for groundwater in the Subbasin; therefore, groundwater quality degradation 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, 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 Section 2 of the GSP 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.

The MTs for degraded water quality apply to RMS selected from among existing and proposed future wells located throughout the Subbasin and screened in both the Upper and Lower Aquifers. The RMS for groundwater quality include a combination of irrigation, public supply, domestic, and monitoring wells to be sampled and analyzed by the Subbasin 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 3-11** and shown on **Figure 3-5**.

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. In accordance with the Basin Plan, groundwater in the Subbasin 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 current concentration plus 20 percent. 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 water quality monitoring commences. The applicable MTs for groundwater quality in the GSP apply to degraded groundwater quality as a direct result of impacts from projects/MAs under the GSP that cause an exceedance to occur. Future exceedances of the MT may occur due to activities or conditions unrelated to implementation of the GSP, in which case they would not constitute an MT exceedance that contributes to an undesirable result.

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. Ultimately, the sustainability indicator with the most constraining MT will govern the determination of whether an undesirable result has occurred.

3.3.4.3 Impact of Selected Minimum Thresholds to Adjacent Basins

The MTs for groundwater quality established for the Subbasin are intended to protect all beneficial uses within the Subbasin, including municipal and domestic water supply uses, from groundwater quality degradation caused by projects or management actions included in the GSP, 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 3-11** and **Figure 3-5**. 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).

Table 3-11. Summary of Groundwater Quality Minimum Thresholds for Representative Monitoring Sites.

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation	MT Arsenic Concentration (µg/L)	MT Nitrate Concentration (mg/L)	MT TDS Concentration (mg/L)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Wells Monitored by GSAs: Existing										
CWD RMS-1	Domestic	275	160-275	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-2	Irrigation	780	230-775	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-4	Irrigation	800	320-800	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-5	Unknown	Unknown	Unknown	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-6	Irrigation	820	257-726	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-7	Irrigation	330	135-288	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-9	Monitoring	97	82-97	Upper	10†	10†	500†	CWD	CWD	Annual
CWD RMS-10	Unknown	Unknown	Unknown	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-11	Irrigation	529	187-529	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-12	Unknown	Unknown	Unknown	Upper	10†	10†	500†	CWD	CWD	Annual
CWD RMS-13	Unknown	Unknown	Unknown	Lower	10†	10†	500†	CWD	CWD	Annual
CWD RMS-15	Irrigation	955	290-935	Lower	10†	10†	500†	CWD	CWD	Annual
MCE RMS-1	Unknown	Unknown	Unknown	Lower	10†	10†	500†	Madera County East	Madera County	Annual
MCW RMS-1	Irrigation	186	Unknown	Upper	10†	10†	500†	Madera County West	Madera County	Annual
MCW RMS-4	Unknown	Unknown	Unknown	Lower	10†	10†	500†	Madera County West	Madera County	Annual
MCW RMS-7	Irrigation	800	290-400	Lower	10†	10†	500†	Madera County West	Madera County	Annual
MCW RMS-9	Irrigation	700	265-696	Lower	10†	10†	500†	Madera County West	Madera County	Annual
TRT RMS-1	Unknown	196	158-192	Upper	10†	10†	500†	TTWD	TTWD	Annual
TRT RMS-3	Unknown	799	168-790	Lower	10†	10†	500†	TTWD	TTWD	Annual
TRT RMS-4	Irrigation	840	190-260	Composite	10†	10†	500†	TTWD	TTWD	Annual
Clayton Ag Well #2	Irrigation	135	Unknown	Upper	10†	10†	500†	Madera County West	Madera County	Annual
Wells Monitored by GSAs: Future Monitoring Wells										
Site 1 MW – Shallow	Monitoring	150*	50-150*	Upper	10†	10†	500†	MID*	ILRP/Madera County	Annual
Site 1 MW – Middle	Monitoring	400*	200-400*	Lower	10†	10†	500†	MID*	Madera County	Annual
Site 1 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	MID*	Madera County	Annual
Site 2 MW – Shallow	Monitoring	100*	50-100*	Upper	10†	10†	500†	Madera County West*	ILRP/Madera County	Annual
Site 2 MW – Middle	Monitoring	350*	150-350*	Lower	10†	10†	500†	Madera County West*	Madera County	Annual
Site 2 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	Madera County West*	Madera County	Annual
Site 3 MW – Shallow	Monitoring	100*	50-100*	Upper	10†	10†	500†	Madera County East*	ILRP/Madera County	Annual
Site 3 MW – Middle	Monitoring	350*	150-350*	Lower	10†	10†	500†	Madera County East*	Madera County	Annual

Well ID	Well Type	Well Depth	Screen Top-Bottom	Aquifer Designation	MT Arsenic Concentration (µg/L)	MT Nitrate Concentration (mg/L)	MT TDS Concentration (mg/L)	GSA Location	Entities to Conduct Monitoring	Measurement Frequency
Site 3 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	Madera County East*	Madera County	Annual
Site 5 MW – Shallow	Monitoring	150*	50-150*	Upper	10†	10†	500†	MID/Madera County West*	ILRP/Madera County	Annual
Site 5 MW – Middle	Monitoring	400*	200-400*	Lower	10†	10†	500†	MID/Madera County West*	Madera County	Annual
Site 5 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	MID/Madera County West*	Madera County	Annual
Site 6 MW – Shallow	Monitoring	200*	100-200*	Upper	10†	10†	500†	Madera County West*	ILRP/Madera County	Annual
Site 6 MW – Middle	Monitoring	400*	200-400*	Lower	10†	10†	500†	Madera County West*	Madera County	Annual
Site 6 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	Madera County West*	Madera County	Annual
Site 7 MW – Shallow	Monitoring	250*	100-250*	Upper	10†	10†	500†	Madera County East*	ILRP/Madera County	Annual
Site 7 MW – Middle	Monitoring	400*	200-400*	Lower	10†	10†	500†	Madera County East*	Madera County	Annual
Site 7 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	Madera County East*	Madera County	Annual
Site 9 MW – Shallow	Monitoring	150*	50-150*	Upper	10†	10†	500†	MID*	ILRP/Madera County	Annual
Site 9 MW – Middle	Monitoring	400*	200-400*	Lower	10†	10†	500†	MID*	Madera County	Annual
Site 9 MW – Deep	Monitoring	700*	500-700*	Lower	10†	10†	500†	MID*	Madera County	Annual
Wells Monitored By Non-GSA Entities										
2000511-001	Public Supply	Unknown	Unknown	Unknown	10	10	500	CWD	DDW	Variable, according to DDW reqs.
2000597-001	Public Supply	Unknown	300-?	Lower	10	10	500	CWD	DDW	
2000681-002	Public Supply	Unknown	Unknown	Unknown	10	10	500	CWD	DDW	
2010001-008	Public Supply	Unknown	242-297	Lower	10	10	500	CWD	DDW	
2010001-010	Public Supply	Unknown	358-474	Lower	10	10	500	CWD	DDW	
2010001-011	Public Supply	Unknown	310-393	Lower	10	10	500	CWD	DDW	
2400216-001	Public Supply	Unknown	400-460	Lower	10	10	500	Madera County East	DDW	
ESJ11	Domestic	340	Unknown	Unknown	N/A‡	10	650	CWD	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.
† 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.

3.3.5 Depletion of Surface Water

As described in the HCM in Section 2, regional groundwater levels have been below the stream channel bottoms in Chowchilla Subbasin for at least the last several years, and for many decades in most of the Subbasin. 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, 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 western boundary of Chowchilla 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 and other tributary inflows upstream of Chowchilla Subbasin, 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 are the same as the interim measurable objectives: 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.

3.3.5.1 Methodology

As described in the HCM in Section 2 and in the discussion the measurable objectives in Section 3.2.5, interim SMC are being established for ISW 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 ISW 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 measurable objectives: 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 **Figure 3-6** and **Table 3-12** are the same as those shown for measurable objectives and shown in **Table 3-8**.

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 ISW 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 six 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 given 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 ISW (and having potential impacts on surface water flows or GDEs). Ultimately, the sustainability indicator with the most constraining MT will govern the determination of whether an undesirable result has occurred.

3.3.5.3 *Impact of Selected Minimum Thresholds to Adjacent Basins*

Maintaining a similar percent of time connected for ISW along the San Joaquin River under sustainable groundwater conditions for Chowchilla 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 Chowchilla Subbasins GSAs and/or due to other factors such as the SJRRP, it is possible that the adjacent 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*

ISW 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, and ecological land use and users. Overall, agricultural land use and users will be impacted in terms of increased costs to design and construct recharge projects (to provide additional water to the Upper Aquifer) and in terms of reduced crop yields from required reductions in consumptive use for irrigation. Additional water is needed for the Upper Aquifer to support migration of Lower Aquifer pumping to the Upper Aquifer as part of the actions needed to address subsidence in the Western Management Area. While it does not appear likely based on analyses conducted to date, it is possible that meeting MTs for ISW may constrain how the Upper Aquifer is operated to help address the subsidence MTs. Ecological beneficial users are expected to benefit from implementation of MTs for ISW.

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*

ISW will be monitored on an annual basis by measuring groundwater levels at identified representative ISW RMS wells presented in **Table 3-12** and **Figure 3-6**. 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 3-12. 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
MCW RMS-1	120	186	Unknown	3	Upper	3%	Madera County West
MCW RMS-2	123	Unknown	Unknown	2	Upper	21%	Madera County West
MCW RMS-3	122	Unknown	Unknown	2,3	Upper	3%	Madera County West
MCW RMS-10	123	26	Unknown	1	Upper	78%	Madera County West
MCW RMS-11	127	30	Unknown	1	Upper	26%	Madera County West
MCW RMS-12	127	29	Unknown	1	Upper	11%	Madera County West

[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 criteria is not applicable to this Subbasin.

3.3.7 Management Area Minimum Thresholds

As described above, Chowchilla Subbasin was divided into two Management Areas – the Western Management Area and the Eastern Management Area. The primary differences between these two Management Areas in terms of SMC are related to land subsidence and GDEs.

Significant impacts to infrastructure related to subsidence occurred during the time period from 2005 to 2015 in the Western Management Area, but similar infrastructure impacts have not occurred in the Eastern Management Area. The measurable objective methodology for subsidence for the two Management Areas is the same, as described in a previous section. The subsidence MTs are based on the different methodologies for the two Management Areas due to differences in historical impacts related to subsidence in the two areas. Subsidence MTs and how undesirable results are defined for subsidence in the Western Management Area are generally more strict than those established for the Eastern Management Area due to differences in historical impacts to infrastructure from subsidence in the two areas. There will be ongoing review of subsidence surveys and adaptive management in both Management Areas to adjust subsidence MTs, if necessary.

A single GDE unit occurs in the Western Management Area along the San Joaquin River, and there are no GDE units in the Eastern Management Area. Because GDEs are present in only one of the two Management Areas, there are no concerns about the basin operating under different MTs for GDEs in the two Management Areas.

Thus, there will be no undesirable results caused by setting of different MTs for certain sustainability criteria in the two different Management Areas.

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 3-13**, and detailed discussion of each sustainability indicator is provided in subsequent sections of this Chapter.

Table 3-13. Summary of MTs, MOs 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 elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.	Set equal to the Fall 2011 measurement, if that observed data point is available at the RMS. Otherwise, set equal to the expected Fall 2011 groundwater elevation determined from MCSim results, with adjustment, if necessary, to account for the offset between historical observed and simulated groundwater elevation.	Greater than 25% of the same RMS wells below minimum threshold for two consecutive fall measurements.
Reduction of Groundwater Storage	Same as minimum thresholds for chronic lowering of groundwater levels.	Same as measurable objectives for chronic lowering of groundwater levels.	Greater than 25% of the same RMS wells 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	Subsidence rate across 75 percent 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 RMS wells above the minimum threshold for the same constituent due to GSP projects and/or management actions, 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 equal to historical conditions for a similar climatic/hydrologic period.	A percent of time surface water is connected to shallow groundwater equal to historical conditions for a similar climatic/hydrologic period.	Greater than 30 percent of RMS wells below MT 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®]. The 50-year time period in the Chowchilla 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 Subbasin that continue to exceed average annual inflows, thus continuing the long-term trend of lowering groundwater levels. 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 relying on Subbasin groundwater resources, 2) Cause groundwater level conditions at private domestic wells that cannot be mitigated, and 3) Interfere with other sustainability indicators. Specific significant and unreasonable effects on groundwater uses and users in the Subbasin could include: adverse impacts to groundwater users that impair their access to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes; adverse impacts to groundwater users that cause significant financial burden; and adverse impacts to other beneficial uses and users in the Subbasin associated with other sustainability indicators (e.g., disconnection of interconnected surface water, impacts to GDEs).

The SMC and planned GSP implementation activities have been developed with the goal of avoiding these significant and unreasonable effects of lowering groundwater levels on groundwater supply uses and users in the Subbasin. The GSAs anticipate that groundwater levels below Fall 2015 levels after 2040 may cause significant financial burden to all beneficial uses and users relying on Subbasin groundwater resources, may cause domestic wells to go dry, and may interfere with other sustainability indicators. Thus, the MTs have been established at Fall 2015 levels, consistent with avoiding these undesirable results during the sustainability period (after 2040).

For the Chowchilla Subbasin, the chronic lowering of groundwater levels undesirable result is defined as a relationship between frequency of groundwater elevation MT exceedances at a given RMS, and the number of RMS locations experience the exceedances at the same time. Using the Fall measurements (assumed to be collected in late October), a groundwater elevation undesirable result is defined to occur when greater than 25% of the same RMS each exceed the groundwater level MTs for two consecutive Fall readings. Given a total of 36 RMS sites, a total of 10 or more the RMS would need to exceed MTs as defined above to constitute an undesirable result for chronic lowering of groundwater levels. 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 will change accordingly.

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 uses and users. Reducing the percentage of allowed MTs exceedances ensures strict adherence to MTs but reduces flexibility due to uncertainty related to hydrogeologic conditions. The 25% criterion was selected to balance the interest of beneficial use with the practical aspect of groundwater management uncertainty.

Conditions other than excessive regional basin wide pumping (plus other outflows) greater than average annual inflows that may lead to an undesirable result include extensive and unanticipated drought. MTs were established based on historical groundwater levels and reasonable estimates of future groundwater levels (including a future drought of equal duration to the longest historical drought since 1965). Extensive unanticipated droughts (beyond that accounted for already, or earlier in the Implementation Period or Sustainability Period than assumed herein) may lead to excessively low groundwater levels and undesirable results.

As described in Section 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program. The Program has been developed to provide assistance to domestic wells and shallow wells that supply drinking water adversely impacted by declining groundwater levels since GSP implementation began (i.e., since 2020) that interfere with groundwater production or quality and will be coordinated with the Madera County SB 552 Drought Plan.

The GSAs in the Chowchilla Subbasin expressed and formalized their clear commitment to fund and implement the Program beginning no later than January 1, 2023, as memorialized in an MOU executed in July 2022 (**Appendix 3.D**). Planned assistance efforts will benefit domestic well owners and owners of shallow wells that supply drinking water, including disadvantaged communities and underrepresented communities, experiencing adverse impacts as a result of overdraft conditions. The GSAs are proceeding with Program implementation and, as of May 2023, stakeholders in the Subbasin are engaging with the GSAs to discuss mitigation opportunities. It is expected that the Program will be implemented during the GSP implementation period, and that Program implementation would continue as needed until groundwater sustainability is achieved. By 2040 and during the sustainability period, groundwater levels are expected to stabilize at or above Fall 2015 historical levels, avoiding continued undesirable results for groundwater uses and users.

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 Subbasin 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 Subbasin 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 uses and 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 3.2.1, the GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved.

Conditions that may lead to an undesirable result for the reduction in groundwater storage sustainability indicator include an extensive and 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 equivalent to historical droughts (since the mid-1960s). Extensive, unanticipated droughts (beyond that accounted for already, 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 groundwater elevation 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 basin with average inflows equal to average outflows, and the undesirable result will not have a negative effect on the beneficial uses and users 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, basin groundwater users can expect significant fluctuations in groundwater levels above the MT.

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 Subbasin that exceed average annual inflows and result in groundwater levels that decline to a level that, combined with clay layers having certain properties conducive to compaction, result in significant land subsidence in areas that have already experienced significant impacts to infrastructure (i.e., the WMA) and areas where significant impacts to infrastructure are possible (i.e., the EMA). 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, through individual stakeholder input to various GSA representatives, and in meetings with all technical representatives from all GSAs in the Subbasin. Significant and unreasonable land subsidence results in significant impacts to infrastructure. An assessment of critical infrastructure in the Subbasin was conducted and is provided in **Appendix 3.G**.

An undesirable result is defined as occurring when the rate of subsidence across 75 percent or more RMS in one or both Management Areas exceeds the MT for two consecutive years. Conditions that may lead to an undesirable result 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. This is of particular concern in the Lower Aquifer and in areas where the Corcoran Clay exists, because of the confined nature of the groundwater conditions in these area coupled with the presence of sediments that are more susceptible to compaction when the piezometric head in the aquifer is reduced. 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 may cause excessive localized drawdowns that lead to undesirable results in specific areas. These effects could also be caused by pumping in neighboring subbasins.

  Extensive, unanticipated drought. Extensive, unanticipated droughts may lead to excessively low groundwater elevations and 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 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 Subbasin; 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 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. There are no known significant and large-scale groundwater quality contamination plumes in the regional aquifers within the Subbasin; therefore, exacerbating plume migration or impacting the ability to contain localized contamination plumes is not a significant concern for GSP PMAs.

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. An exceedance of a MT at a given representative monitoring site is defined based on the average concentration 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 the MT for a given key constituent related to a GSP project or management action.

A notable condition that may lead to an undesirable result for degraded groundwater quality sustainability indicator is the following:

- 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 surface water depletion sustainability criterion is not applicable to most of this Subbasin. However, the occurrence of shallow groundwater levels during certain time periods along the San Joaquin River at the western boundary of the Chowchilla Subbasin, combined with extensive data gaps related to hydrogeologic conditions affecting characterization of ISW in this area, require that interim SMC be established pending further data collection and studies. The SMC for ISW 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 is defined as greater than 30 percent of RMS wells exceeding their MTs for two consecutive five-year rolling averages (e.g., 2 of the current 6 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.

As discussed in Section 3.2.5, the San Joaquin River is adjacent to, but not a part of, the San Joaquin River Riparian GDE Unit and is in a net-losing condition, with surface flow likely contributing directly to the shallow groundwater system that supports the vegetation in the unit. The shallow groundwater system adjacent to the San Joaquin River (regardless of whether or not it is considered connected to surface water), which supports the GDE unit, does have at least the potential (albeit quite muted) to be affected by regional groundwater pumping. Therefore, hydrologic and biologic GDE monitoring are incorporated as discussed elsewhere in this GSP.

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 Plan 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
- Describe level of monitoring and analysis for each management area (if necessary)

The GSP groundwater level monitoring network was initially developed using existing wells in the Subbasin and will be supplemented (and/or some initial wells replaced) by new nested monitoring wells installed since 2019. 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 simulated water levels preferred;
- Good spatial distribution preferred;
- Representation of both Upper (where present in western portion of Subbasin) and Lower Aquifers preferred.

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 and because many wells have unknown well construction. Matching of simulated 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, land subsidence, degraded water quality, and ISW). The Subbasin is isolated from the Pacific Ocean and is not threatened by seawater intrusion; therefore, this GSP does not provide monitoring for the seawater intrusion sustainability indicator.

As described above, for the purposes of the GSP monitoring program, a subset of existing wells was identified that best meet certain criteria. Not all the criteria were satisfied for each well, but this effort resulted in 36 wells to represent the Subbasin, with 9 wells in the Upper Aquifer and 25 wells in the Lower Aquifer, and 2 composite wells – referred to as the representative monitoring sites. Due to incomplete well construction information for some these wells, the portion of the aquifer being monitored could not be determined with certainty for all wells, but was initially classified based on match to model results where construction data is unknown.

These wells are distributed throughout the Subbasin 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 Subbasin for the Lower Aquifer. The spatial coverage for the Upper Aquifer is currently limited to the southwestern portion of the Subbasin due to availability of existing wells and the general lack of Upper Aquifer saturation in the eastern portion of the Subbasin (installation of nested monitoring wells since 2019 helps 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 (included DWR grant funded nested monitoring wells installed since 2019). The monitoring network will be periodically reviewed and improvements made where possible.

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 monitoring network for groundwater levels, comprised of wells monitored for CASGEM, by GSAs, and by USBR, is provided in **Appendix 3.A**.

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 basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

A map of the Subbasin showing the overall groundwater level monitoring network is provided in **Appendix 3.A**, along with a table listing each well. **Figures 3-10** and **3-11** 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 shown in **Figure 3-12**). **Tables 3-14** and **3-15** 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 3-16**.

Table 3-14. Summary of Upper Aquifer Groundwater Level Monitoring Network Wells.

Well I.D.	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number Measurements	Selection Rationale
CWD RMS-9	37.0882	-120.3471	Spring/Fall	2015	2022	7	14	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-12	37.0613	-120.3746	Spring/Fall	1961	2022	61	91	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCW RMS-1	37.043	-120.5288	Spring/Fall	1963	2022	59	84	CASGEM voluntary well; known well construction; long history of WL data; spatial/vertical distribution
MCW RMS-2	37.0202	-120.5349	Spring/Fall	1964	2022	58	79	Long history of WL data; spatial/vertical distribution
MCW RMS-3	37.018	-120.5179	Spring/Fall	1960	2022	62	69	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCW RMS-10	37.028	-120.5444	Daily	2010	2021	11	3,341	SJRRP well; known well construction; spatial/vertical distribution
MCW RMS-11	36.9816	-120.4918	Monthly	2012	2021	9	278	SJRRP well; known well depth; spatial/vertical distribution
MCW RMS-12	36.9817	-120.4859	Monthly	2012	2021	9	269	SJRRP well; known well depth; spatial/vertical distribution
TRT RMS-1	37.011	-120.4603	Summer	2011	2021	10	15	Known well construction; spatial/vertical distribution

Table 3-15. Summary of Lower Aquifer Groundwater Level Monitoring Network Wells.

Well I.D.	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number Measurements	Selection Rationale
CWD RMS-1	37.1166	-120.4193	Spring/Fall	1949	2022	73	108	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-2	37.171	-120.3746	Spring/Fall	1980	2022	42	45	Known well construction; spatial/vertical distribution
CWD RMS-3	37.1446	-120.3474	Spring[1]	1980	2022	42	45	Long history of WL data; spatial/vertical distribution
CWD RMS-4	37.1271	-120.2927	Spring/Fall	2015	2022	7	10	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-5	37.1049	-120.3296	Spring[2]	1968	2022	54	76	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
CWD RMS-6	37.1265	-120.1498	Spring/Fall	2015	2022	7	14	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-7	37.0618	-120.4232	Spring/Fall	2015	2022	7	11	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-8	37.0913	-120.2924	Spring[1]	1957	2022	65	96	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
CWD RMS-10	37.0902	-120.3741	Spring[1]	1961	2022	61	92	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
CWD RMS-11	37.0568	-120.3307	Spring/Fall	1946	2022	76	129	CASGEM well; known well construction; long history of WL data; spatial/vertical distribution
CWD RMS-13	37.0168	-120.3593	Spring[1]	1934	2022	88	127	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
CWD RMS-14	37.0238	-120.3107	Spring/Fall	2015	2022	7	12	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-15	37.0732	-120.2342	Spring/Fall	2015	2022	7	13	CASGEM well; known well construction; spatial/vertical distribution
CWD RMS-16	37.0516	-120.2571	Spring	1961	2022	61	99	CASGEM voluntary well; spatial/vertical distribution
CWD RMS-17	37.0182	-120.2433	Spring/Fall	2015	2022	7	14	CASGEM well; known well construction; spatial/vertical distribution
MCE RMS-1	37.156	-120.2063	Spring[3]	1987	2022	35	37	CASGEM voluntary well; long history of WL data; spatial/vertical distribution

Well I.D.	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number Measurements	Selection Rationale
MCE RMS-2	37.1418	-120.2338	Spring/Fall	1980	2022	42	61	CASGEM well; known well construction; long history of WL data; spatial/vertical distribution
MCW RMS-4	37.0663	-120.4779	Spring1	1980	2022	42	55	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCW RMS-5	37.0391	-120.4443	Spring1	1980	2022	42	52	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCW RMS-6	37.0393	-120.4649	Spring1	1980	2022	42	37	CASGEM voluntary well; long history of WL data; spatial/vertical distribution
MCW RMS-7	37.018	-120.4515	Spring/Fall	2015	2022	7	11	CASGEM well; known well construction; spatial/vertical distribution
MCW RMS-9	36.9675	-120.3748	Spring/Fall	2015	2022	7	9	CASGEM well; known well construction; spatial/vertical distribution
MER RMS-1	37.1638	-120.3021	Spring1	1964	2020	56	75	Long history of WL data; spatial/vertical distribution
TRT RMS-2	36.9998	-120.4577	Spring/Fall	2010	2021	11	22	CASGEM well; known well construction; spatial/vertical distribution
TRT RMS-3	36.9899	-120.4326	Summer	2010	2021	11	13	Known well construction; spatial/vertical distribution

[1] Fall measurements stopped in 2009
[2] Fall measurements stopped in 1999
[3] Fall measurements stopped in 2007

Table 3-16. Summary of Composite Aquifer Groundwater Level Monitoring Network Wells.

Well I.D.	Latitude	Longitude	Frequency	First Year Data	Last Year Data	Years Measured	Number Measurements	Selection Rationale
MCW RMS-8	37.0047	-120.3929	Spring/Fall	2015	2022	7	13	CASGEM well; known well construction; spatial/vertical distribution
TRT RMS-4	36.96	-120.4283	Spring/Fall	2013	2021	8	31	CASGEM well; known well construction; spatial/vertical distribution

In order to assist GSAs with the preparation of their GSP's, DWR released a series of best management practices guidance documents. The best management practices document for monitoring networks provides guidance on determining an appropriate number of monitoring wells for a given district. The method developed by Hopkins (1984) was applied to the Subbasin. This methodology states that, for districts pumping more than 10,000 AFY over 100 square miles, they should have four monitoring wells for every 100 square miles. The Subbasin occupies an area of approximately 228 square miles, yielding 9 monitoring wells for this minimum density requirement. This number was taken to be the minimum number of monitoring wells for the Subbasin and several additional wells were added based on informational needs resulting from management actions and historical trends in groundwater levels. This GSP includes 36 existing RMS with a potential for future addition (and/or substitution for some existing RMS wells) of up to 25 monitoring wells from the nested well installation program. The selection rationale for all water level monitoring wells is summarized in **Tables 3-14** through **3-16.**

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 Aquifer 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 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 3-10** and **3-11** illustrate the locations of the wells selected for monitoring of groundwater levels for the Upper and Lower Aquifers, respectively. **Tables 3-14** and **3-15** list the well identification, location, monitoring frequency, well construction data, and measurement years, and number of measurements for the Upper Aquifer 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 3-14** and **3-15**).

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 3-13**, is comprised of all benchmark survey points monitored by the United States Bureau of Reclamation (USBR) as part of the SJRRP and local continuous GPS stations monitored by UNAVCO as part of the Plate Boundary Observatory (PBO) Project. Additional monitoring stations located outside of the Subbasin are included in the network to provide regional context. 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.

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 Subbasin include the following as they relate to the implementation of GSP PMAs:

- Evaluate groundwater quality conditions in the various areas of the basin, 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, a network of representative monitoring sites selected from among existing and proposed future wells located throughout the Subbasin 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 Subbasin 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 3-11** and shown on **Figure 3-5**. Information on well construction and historical groundwater quality monitoring for each of the indicator wells is included in **Appendix 3.B**.

The network of groundwater quality representative monitoring sites includes 21 existing wells that are also part of the water level monitoring indicator well network and will also be sampled for groundwater quality by the Subbasin GSAs. Additionally, eight nested monitoring well sites have been constructed in the Subbasin and each of the three individual monitoring wells at each site will be sampled for groundwater quality by the Subbasin 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 seven selected public supply wells will also be incorporated into the representative groundwater quality monitoring in the Subbasin. 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 one domestic well 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 one current domestic well 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, growers in the Subbasin also must sample and report groundwater quality for 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 in terms of 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.

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 ISW 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 ISW.

The objectives of the groundwater level and streamflow monitoring programs related to ISW 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 western boundary of Chowchilla Subbasin; and
- Generate data to better estimate groundwater basin conditions related to ISW; update analyses as additional data become available.

For the purpose of monitoring ISW 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 ISW include a combination of irrigation and monitoring wells to be monitored by the Subbasin GSAs. The selected RMS for ISW are listed in **Table 3-12** and shown on **Figure 3-6**. Information on well construction and historical groundwater levels for each of the indicator wells is included in **Appendix 3.B**.

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 Subbasin, 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 generally capture seasonal highs and lows (target months for groundwater level measurements are March and late October).
- 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.

3.5.2.1.1 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 entered into the basin'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.

3.5.2.2 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.

3.5.2.3 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.

3.5.2.4 Groundwater Quality Monitoring Program

Annual monitoring of groundwater quality will include sampling and laboratory analysis of key parameters of interest as indicated on **Table 3-17** to be conducted by GSAs as presented in **Tables 3-5, 3-6,** and **3-11**. Additional groundwater quality results reported by monitoring entities to DDW (in accordance with DDW testing requirements) for indicator public supply wells 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, measurement of select water quality parameters will take place in the field. These field parameters should be measured at an annual frequency and include electrical conductivity at 25 °C (EC) in µS/cm, pH, temperature (in °C), redox, and dissolved oxygen (DO) in mg/L. The annual testing is summarized in **Table 3-17**.

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.

Table 3-17. Summary of Groundwater Quality Monitoring Constituents and Measurement Frequency for Representative Monitoring Sites.

Well ID	Well Type	Monitoring Entity	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 GSAs: Existing																		
CWD RMS-1	Domestic	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-2	Irrigation	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-4	Irrigation	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-5	Unknown	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-6	Irrigation	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-7	Irrigation	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-9	Monitoring	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-10	Unknown	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-11	Irrigation	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-12	Unknown	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-13	Unknown	CWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
CWD RMS-15	Irrigation	CWD	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	Unknown	Madera County	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	Irrigation	Madera County	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	Unknown	Madera County	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-7	Irrigation	Madera County	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-9	Irrigation	Madera County	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
TRT RMS-1	Unknown	TTWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
TRT RMS-3	Unknown	TTWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
TRT RMS-4	Irrigation	TTWD	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year	Five-Year
Clayton Ag Well #2	Irrigation	Madera County	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 GSAs: Future Monitoring Wells																		
Site 1 MW – Shallow	Monitoring	ILRP/Madera County	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 1 MW – Middle	Monitoring	Madera County	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	Well Type	Monitoring Entity	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
Site 1 MW – Deep	Monitoring	Madera County	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 2 MW – Shallow	Monitoring	ILRP/Madera County	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 2 MW – Middle	Monitoring	Madera County	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 2 MW – Deep	Monitoring	Madera County	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	Monitoring	ILRP/Madera County	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	Monitoring	Madera County	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	Monitoring	Madera County	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	Monitoring	ILRP/Madera County	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	Monitoring	Madera County	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	Monitoring	Madera County	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	Monitoring	ILRP/Madera County	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	Monitoring	Madera County	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	Monitoring	Madera County	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 7 MW – Shallow	Monitoring	ILRP/Madera County	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 7 MW – Middle	Monitoring	Madera County	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 7 MW – Deep	Monitoring	Madera County	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 9 MW – Shallow	Monitoring	ILRP/Madera County	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 9 MW – Middle	Monitoring	Madera County	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 9 MW – Deep	Monitoring	Madera County	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 Non-GSA Entities																		
2000511-001	Public Supply	DDW	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.															
2000597-001	Public Supply	DDW																
2000681-002	Public Supply	DDW																
2010001-008	Public Supply	DDW																
2010001-010	Public Supply	DDW																
2010001-011	Public Supply	DDW																
2400216-001	Public Supply	DDW																
ESJ11	Domestic	ILRP	Annual	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

- 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 dissolved 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.

3.5.2.5 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.

3.5.2.6 GDE Monitoring Program

The GDE monitoring program will include monitoring of groundwater levels and biologic monitoring. Groundwater level monitoring being conducted for the overall GSP includes three shallow SJRRP monitoring wells adjacent to the GDE unit along the San Joaquin River in western Chowchilla Subbasin. Biological monitoring was conducted in May 2019 and will be conducted every five years to document ecological condition of the San Joaquin River Riparian GDE Unit. Biological data will be analyzed in conjunction with hydrological data to assess potential ecological effects related to changes in groundwater levels and the relative degree of influence on GDE conditions exerted by streamflows and groundwater levels associated with the 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 representative monitoring sites reflect general conditions in the area

Groundwater level data are collected from a large network of CASGEM and USBR wells (**Appendix 3.G**). Representative monitoring sites (RMS) are defined in the SGMA regulations as a subset of monitoring sites that are representative of conditions in the Subbasin. 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 subsidence. 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 in and around the Subbasin. Significant impacts to infrastructure (e.g., bypass, canals, wells) have occurred and been documented within the Western Management Area of Chowchilla Subbasin since 2005. The occurrence of subsidence in this area has been linked to groundwater pumping and declining groundwater levels in the Lower Aquifer from 2005 through 2015-16. The drought from 2012 to 2015 resulted in historical low groundwater elevations in many Lower Aquifer wells in the 2014 to 2016 time frame, which correlate to elevated rates of subsidence during this time period. As described in Section 2, residual subsidence occurs after groundwater levels stabilize and recover due to compaction lag times in Lower Aquifer clay layers. The analysis provided in Section 2 indicated that while the occurrence of residual subsidence complicates the relationship between groundwater levels and subsidence, it is clear that occurrence of active (new) subsidence is a function of groundwater levels declining below historical low groundwater levels. Thus, representative Lower Aquifer monitoring wells are included in the RMS sites with MTs tied to recent groundwater levels to minimize future subsidence.

Ongoing monitoring of changes in water levels will be used in combination with subsidence surveys to develop the relationship/correlation between groundwater levels, the amount/rate of subsidence, and the occurrence of residual subsidence.

3.5.4 Assessment and Improvement of Monitoring Network (23 CCR § 354.38)

Per Section 354.38 of the GSP regulations, 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

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. This evaluation will involve a review of the described MTs and MOs and their comparison to observed trends in the networks. Furthermore, a more comprehensive review of the monitoring networks will be conducted every five years. 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.

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.

3.5.4.2.1 Groundwater Elevation

Groundwater elevation data has been extensively collected within the Subbasin 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 Subbasin, and the Lower Aquifer in the south central and extreme eastern and western portions of the Subbasin are lacking in monitoring wells. These gaps are evident in the designed monitoring network as 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 will be filled with installation of the new nested monitoring wells – 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, 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 San Joaquin River GDE Unit may be impacted by occurrence of temporary short-term declines in shallow groundwater levels below historical lows. 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.

3.5.4.3 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.

3.5.4.3.1 Subsidence

Significant subsidence that has impacted infrastructure has occurred since 2005, particularly in the WMA of Subbasin. Subsidence benchmark surveys for the SJRRP have indicated the occurrence of some subsidence in the EMA of Chowchilla Subbasin as well. A temporal data gap exists, as the SJRRP network is currently monitored bi-annually (in July and December). Increasing the frequency of monitoring would fill this temporal data gap. Additionally, the network will be reevaluated on a yearly basis for any other emerging data gaps.

3.5.4.3.2 Groundwater Quality

Considerable historical groundwater quality data exist for the Subbasin although the spatial distribution and association of well construction information with groundwater quality observations present limitations. Some of the wells in the groundwater quality sustainability indicator monitoring network have not historically been monitored for groundwater quality. The addition of these wells and the monitoring wells recently and currently being constructed 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. As GSP PMAs are implemented and the planned locations for these activities are better known, the groundwater quality monitoring network will be reviewed and modified if needed to provide sufficient groundwater quality monitoring to meet the stated objectives.

3.5.4.3.3 Interconnected Surface Water

Significant data gaps exist for adequately characterizing ISW along the San Joaquin River along the western boundary of Chowchilla 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.

3.5.4.4 Description of Steps to Fill Data Gaps

Data gaps have been presented in the groundwater level, groundwater storage, land subsidence, groundwater quality, and ISW monitoring networks. The following steps will be taken to address these data gaps:

- The GSAs have created two workplans to fill data gaps and guide development of a more robust monitoring program for subsidence and ISW (**Appendices 3.H and 3.I**).
- Madera County recently added eight new nested monitoring well sites with three well completions at each site (total of 24 new monitoring wells) within the Subbasin, along with one new shallow single-completion monitoring well. 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 **3-2**). Groundwater level and quality data are being collected from these monitoring wells to evaluate baseline conditions, and they will be considered for addition to the RMS monitoring network for the 2025 GSP Update.
- As part of a Proposition 68 DWR Sustainable Groundwater Management grant award to Madera County for a domestic well inventory project, nine additional new monitoring wells at three different sites were installed in 2022 and will provide additional information on hydrogeologic conditions and trends in areas of domestic wells within the Chowchilla Subbasin.
- 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 will be coordinated with well owners to prevent pumping and access issues.
- Review of potential additional steps to address data gaps related to subsidence and ISW is currently in progress.

In addition to these steps, the monitoring networks will be evaluated on a yearly and five-year basis. 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 of this report.

CHAPTER 3 SUSTAINABLE MANAGEMENT CRITERIA

3.6 Selected Figures

The following figures can be found after this page: Figures 3-3to 3-8, and 3-10 to 3-12.

4 SUBBASIN PROJECTS AND MANAGEMENT ACTIONS

To achieve the Subbasin sustainability goal by 2040 and avoid undesirable results through 2090 as required by SMGA 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 are expected to be implemented by each GSA in the Subbasin to meet sustainability objectives. Projects generally refer to structural features whereas management actions are typically non-structural programs or policies designed to incentivize reductions in groundwater pumping.

Subbasin PMAs are described in accordance with §354.42 and §354.44 of the SGMA regulations. The estimated groundwater recharge benefit and capital, operating, and maintenance costs of developing and operating each PMA is shown. PMA cost information is limited for many PMAs because a detailed feasibility assessment has not been completed. Other PMAs have cost estimates that were developed several years ago and may not reflect current conditions. To the extent possible, PMA costs are adjusted and reported on a consistent basis. For example, a consistent water purchase price is applied across all PMAs 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 (either the Implicit Price Deflator or the Engineering News Report Construction Cost Index) and reported in current (2019) dollars. GSAs will further develop PMAs during the GSP implementation period and refine estimated costs.

GSAs will identify sources of funding to cover PMA 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 PMA 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 implementing PMAs that provide additional surface water supply 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 adaptive management of PMAs through an approach informed by continued monitoring of groundwater conditions using the monitoring networks. As PMAs are implemented and monitored, the PMA timelines and volume of demand management necessary will be reviewed. 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 annual reports and/or the five-year periodic evaluation and GSP updates. Three main types of projects are included in the Chowchilla Subbasin GSP for implementation: recharge, conveyance, and storage (**Table 4-1**). Recharge projects are designed to support sustainability by increasing recharge. 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). Storage projects store additional water supplies for increased recharge or for direct use for irrigation, thereby reducing groundwater pumping. Some projects have a specific water source, but many of the recharge projects can draw from the same general sources. A section at the end of this chapter describes and quantifies available water from the potential sources. A demand management action is described for the Madera County GSA, though the other GSAs within the Subbasin can also use it as needed to attain sustainability. The demand management action provides groundwater users a flexible way to meet any future pumping restrictions. The GSAs are also coordinating and considering other activities that support adaptive management of the Subbasin, including efforts consistent with Madera County's multi-benefit agricultural land repurposing plan, project planning, project permitting, and implementation projects. Updates will be provided in subsequent annual reports and/or the five-year periodic evaluation and GSP updates.

The 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 well owners and owners of wells that supply drinking water users. In their ongoing efforts to uphold these commitments, the GSAs plan, to the extent feasible, to prioritize project implementation efforts in the vicinity of public supply wells, especially Flood-MAR, on-farm recharge projects, multi-benefit projects, and voluntary land repurposing efforts that can be flexibly targeted to specific areas of need. These priority areas **(Figure 4-1)** were developed with the intent of directly benefitting groundwater conditions in the immediate vicinity of public supply wells in order to mitigate any negative effects that may be experienced during GSP implementation. A larger priority area was given to areas of the Subbasin with a higher density of public supply wells to further mitigate the negative effects that may occur in those areas and maximize benefits to the greatest number of groundwater users. By replenishing groundwater supplies in these priority areas, the PMAs are also expected to benefit the groundwater supplies available to the domestic well users in the Subbasin, many of whom are also located within these same priority areas (see **Figures 2-4 and 2-5**).

The cost, timing, and gross groundwater benefit (yield) of the PMAs included in the GSP vary by GSA. **Table 4-2** lists all of the PMAs, by GSA or subregion, and the estimated implementation timeline, capital cost, operating cost, and gross benefit of the PMAs. Recharge basins, a common project, may also provide environmental benefits that are not quantified in the table. **Table 4-3** further summarizes the total gross benefits and costs of all PMAs developed for each GSA or subregion.

The gross yield across all PMAs at full implementation (2040) equals approximately 129,300 acre-feet per year (AFY). This includes the Madera County demand management program implemented by the Madera County GSA that will reduce net groundwater pumping by about 28,000 AFY.

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 water year 2022 GSP Annual Report.

Table 4-1. Projects and Management Actions and Water Sources considered in the Chowchilla Subbasin.

GSA	PMA type	PMA Mechanism	Water Source			
			Chowchilla River Flood Release	Millerton Flood Release and Section 215 water	Eastside Bypass flows	Purchase
Recharge						
All	Recharge Basins	Increase Recharge	X	X	X	X
All	Flood-MAR	Increase Recharge	X	X	X	X
Conveyance						
TTWD	Poso Canal Pipeline	Increase Recharge or Reduce GW Pumping				X
TTWD	Columbia Canal Company Pipeline	Increase Recharge or Reduce GW Pumping				X
CWD	Merced Intertie	Increase Recharge or Reduce GW Pumping				X
Storage						
CWD	Eastman Lake Increase	Increase Recharge or Reduce GW Pumping	X			
Management Actions						
MC	Demand Management	Reduce demand at lower cost by trading groundwater credits				
MC, in Coordination with All	Voluntary Land Repurposing Program[1]	Reduce demand through voluntary land repurposing.				

[1] The Voluntary Land Repurposing Program is being developed and implemented consistent with the Demand Management management action proposed in the January 2020 GSP.

Table 4-2. Chowchilla Subbasin Projects and Management Actions.[1]

GSA[2]	PMA	First Year of Implementation	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	Recharge Basin	2018	1,359	3.1	0.01
CWD	Flood-MAR	2020	5,836	N/A	0.2
CWD	Additional Recharge Basins (1,000 acres)	2021	10,803	38.6	0.5
CWD	Merced-Chowchilla Intertie	2035	7,350	6.7	1.5
CWD	Eastman Lake (Buchannan Dam) Enlargement	2040	8,753	49.2	0.2
Madera County (East)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	3,015	1.0	1.1

GSA[2]	PMA	First Year of Implementation	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
Madera County (West)	Water Purchase/Import for Direct or In-Lieu Recharge	2020	27,953	118.0	0.7
Madera County (All)	Demand Management	2020	27,550	N/A	19.6[4]
SVMWC[3]	SVMWC Recharge Basin	2020	4,344	7.5	0.2
TTWD	Poso Canal Pipeline / Settlement Agreement	2020	7,647	5.2	4.6
TTWD	Eastside Bypass Flood Water / Redtop Joint Banking	2021	24,657	24.5	0.7
Total			129,267	254	29.4

[1] Costs and benefits updated to remove CWD's Madera Canal Capacity Increase project from consideration. Other updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.
[2] PMAs summarized by each GSA, GSA subregion, or local agency responsible for implementation.
[3] SVMWC includes portions of both Madera County GSA and Merced County GSA.
[4] Costs of demand management include reduced economic activities in Madera County, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

Table 4-3. Summary of Chowchilla Subbasin Projects and Management Actions by GSA.[1]

GSA[2]	Gross Average Annual Benefit at Full Implementation (AF)	Estimated Capital Cost ($, millions)	Estimated Average Annual Operating Cost ($/year, millions)
CWD	34,101	97.6	2.41
Madera County	58,518	119.0[3]	21.4[4]
SVMWC[3]	4,344	7.5	0.2
TTWD	32,304	29.7	5.3
Total	129,267	254	29.4

[1] Costs and benefits updated to remove CWD's Madera Canal Capacity Increase project from consideration. Other updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.
[2] PMAs summarized by each GSA or local agency responsible for implementation.
[2] SVMWC includes portions of both Madera County GSA and Merced County GSA.
[3] Costs of demand management include reduced economic activities in Madera County, this includes approximately $19.1 million per year in direct economic impacts alone (excluding multiplier effects).

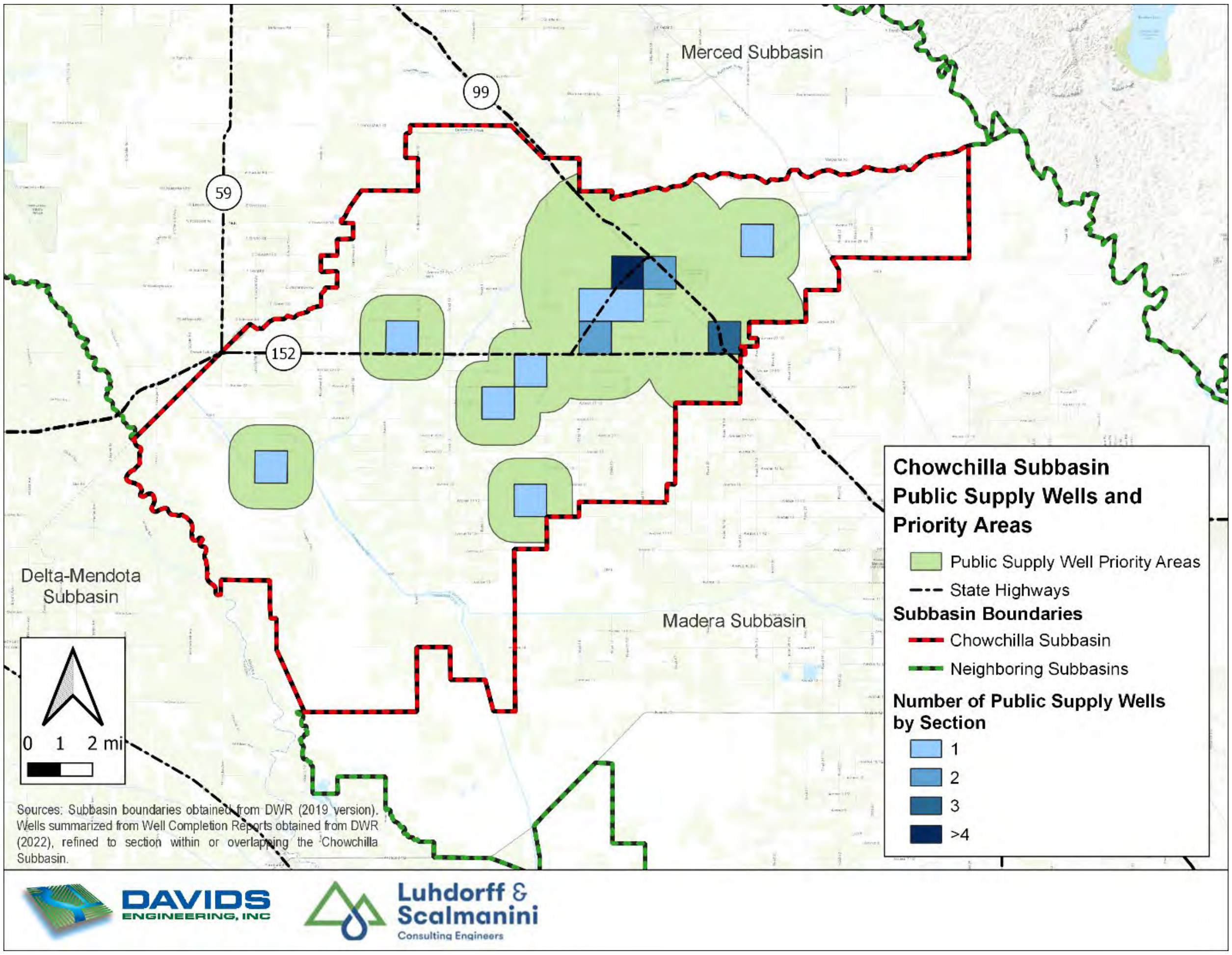


Figure 4-1. Public Supply Wells and Priority Areas in the Chowchilla Subbasin.

4.1 Chowchilla Water District GSA Projects

The Chowchilla Water District GSA (CWD) has identified several projects to include in its implementation of the GSP. These include new or expanded recharge capacity, storage, and additional capacity to move water available from other areas. CWD has also specified other management actions that may be implemented to meet sustainability objectives as warranted by hydrologic conditions and the performance of other projects. The project descriptions are based on information developed during the initial GSP development process and, where applicable, previous studies.

At the time of initial GSP development, planning for the projects was at varying stages of development, so complete information on construction requirements, operations, costs, permitting requirements, and other details were not available. Section 4.6 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2022). A description of how all the PMAs operate as part of the overall GSP is provided in Chapter 5: Plan Implementation.

4.1.1 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 CWD. For example, some of the water that percolates from the recharge basin may move laterally to nearby streams and flow out of the basin before it can reach the deeper aquifer. CWD will develop recharge basins to maximize recharge efficiency to ensure maximum net recharge benefits stay within the Subbasin.

4.1.1.1 Project Overview

CWD will construct groundwater recharge basins totaling about 1,000 acres, distributed throughout its service area. Locations and sizes of basins will be selected based on land uses, access to delivery facilities, and soils having appropriate percolation rates. Sites will be selected to maximize recharge efficiency and benefits to the Subbasin groundwater system.

4.1.1.2 Implementation

Implementation will start immediately with additional development staged over a ten-year period, beginning in 2020. CWD will conduct a study in 2020 to identify sites that are good locations for construction of groundwater recharge ponds. Permitting and environmental documentation will be initiated, and financing for construction will be identified and secured. CWD completed a 40-acre recharge basin in 2018 and began using it in early 2019. Construction of additional basins will start in 2021 and continue potentially through 2040, with the target of about 1,000 acres of basins to be completed in total. CWD will monitor recharge pond performance and select sites that provide the greatest recharge benefit (**Table 4-4)**.

Table 4-4. CWD Recharge Basins Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2030
Financing	2020	2040
Construction	2021	2030
Operation	2021	Indefinite

4.1.1.2.1 Construction activities and requirements

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 CWD.

4.1.1.2.2 Water source

Water for recharge is expected to be available from one or more of the following sources:

- CWD has a contract for CVP Class 1 and Class 2 water, and it can receive CVP surplus flows when they are available.
- Flood releases from Buchanan Dam, and potentially additional yield from an increase in storage capacity.
- Other water supplies that may be available in future, potentially via exchange through the larger Friant system and delivered by Madera Canal.

The analysis of benefits provided by the CWD recharge basins assumes that the source of water will be flood flows available from Buchanan Dam. 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.

4.1.1.2.3 Conditions or constraints on implementation

This is a planned project of the GSP and its implementation does not depend on the performance of other projects or activities. CWD will monitor conditions in the GSA to determine the location and scale of additional recharge ponds that are developed over the implementation period.

4.1.1.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting roles for the project: Madera County, Merced County, Regional Water Quality Control Board, Reclamation (if using CVP contract supply or Section 215 water). CWD will obtain grading permits from Madera County and Merced County for construction of the groundwater basins. The District will apply for permits required from the State Water Board for diversion of water into the recharge basins to the extent that diversion is not already permitted under existing water rights and contracts. 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.

4.1.1.3 Project Operations and Monitoring

CWD will be responsible for project operations and monitoring. It will begin implementing the project in 2020 and continue to develop additional recharge basins up to the estimated buildout capacity of 1,000 acres by 2040. CWD will assess the performance of recharge basins in its feasibility assessments prior to development and continue to monitor and maintain basins after implementation.

The project will be operated based on the availability of flood flows or other sources of water supply. CWD expects that water will be available for recharge in approximately one out of three years. It will be delivered using existing CWD canals and laterals. During years in which water is available, at the maximum buildout of the project, CWD expects to deliver enough water to fill all 1,000 acres for 90 days. Delivery would typically occur during the winter and spring but could occur any time that surplus water is available.

CWD will monitor deliveries and performance of recharge basins. Extraction of recharged groundwater will be done by water users in CWD. If CWD determines that allocation of groundwater recharge is necessary, groundwater extraction will be monitored and enforced by CWD with meters installed on individual deep wells.

4.1.1.4 Project Benefits

Recharge basins provide groundwater benefits by diverting flows that would have otherwise left the Subbasin into ponds that allow water to percolate into the aquifer. CWD expects that the efficiency of recharge basins it develops will vary depending on the location of the basin and timing of deliveries. Recharge might be lower during wet periods if the soil is already saturated or if groundwater moves laterally into nearby streams, ultimately leaving the Subbasin. The estimated project benefits developed for the GSP are based on average conditions and assume that CWD will be able to develop basins in areas with the greatest potential recharge efficiency.

Based on a hydrologic and operations analysis covering the historical period, 1989-2014, and the resulting frequency and amount of recharge, the average annual net recharge benefit for an 80-acre basin would be 924 AF. For the full 1,000 acres at buildout, the net yield would average 10,800 AFY. The reliability of source water is based on historical hydrology being a good projection of future hydrology. **Table 4-5** summarizes the estimated annual net recharge benefit (new water that stays within the basin), expected probability of water year type, and the weighted-average annual recharge for the 80-acre recharge basin. **Appendix 4.A.** summarizes the estimated monthly benefit and corresponding weighted-average annual benefit of the project.

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 4-5. CWD 80-acre Recharge Basin Estimated Average Recharge Volume by Year Type, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	2,772	35%	978
AN	2,772	14%	380
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			1,359

The gross benefit of additional recharge basins, up to the project buildout of 1,000 acres, is estimated to scale in proportion to the 80-acre basin. **Table 4-6** summarizes the estimated annual net recharge benefit (new water that stays within the basin), expected probability of water year type, and the weighted-average annual recharge for project buildout of 1000 acres of recharge basin in CWD. **Appendix 4.A.** summarizes the estimated monthly benefit and weighted-average annual benefit of the total CWD basin recharge project.

Table 4-6. CWD 1000-acres of Recharge Basins Estimated Average Recharge Volume by Year Type, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	28,325	35%	9,997
AN	5,869	14%	806
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			10,803

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 ISW by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, the recharge basins are also expected to benefit the groundwater supplies available to domestic well users and public supply wells, especially those located within CWD near the recharge basins (**Figure 4-1** and **Figure 2-4**).

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.

4.1.1.5 Project Costs

CWD developed project costs for a typical 80-acre recharge basin. Costs for each basin will vary based on site characteristics and market conditions affecting land, construction, and material costs at that time. For example, CWD developed a recharge basin in 2018 for significantly less than the costs shown in **Table 4-7** because it was able to acquire land below current market prices. Capital costs include site survey, soil sampling, land purchase costs, earthwork, pumps, fencing, and power connection. Additional development costs including project administration, legal, permitting, and environmental review. Actual project costs may be lower than estimated costs if some of these activities are not required. Estimated project costs do not include groundwater extraction costs (which would be borne by private pumpers in CWD). All costs are reported in current 2019 dollars.

Table 4-7. Estimated Project Costs for an 80-Acre Recharge Basin.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Land purchase and construction, 80-acre basin	$3,060,000	Start of construction	
O&M Costs			
Annual Power and other O&M	$10,000	All	$30,000 in 1 out of 3 years when water is available

Total capital and operating costs of 1,000 acres of recharge basins at project buildout will depend on site-specific characteristics of additional recharge basins that will be developed by CWD. If costs are approximately proportional to the 80-acre basin, the total capital cost of 1,000 acres of new recharge basins would be approximately $38.6 million in current dollars. Capital costs would be spread over the implementation period as additional recharge basins are developed. Operating costs for the project at buildout would be proportional to the 80-acre basin, depending on the efficiency of each individual recharge basin and water supply costs. Total capital costs, including land purchase, planning, permitting, and construction, are summarized in **Table 4-7**, in 2019 dollars.

4.1.2 Flood-MAR (Winter Recharge)

Flood Managed Aquifer Recharge (Flood-MAR) diverts surplus flows that would have otherwise left the basin onto farms and fields of willing participants (growers) to percolate into the aquifer and provide recharge benefits for the Subbasin. Flood-MAR requires that the GSA has capacity to capture and divert water to growers and requires willing growers to participate in the program. The Flood-MAR project assumes that growers would operate existing irrigation systems on their fields when CWD is able to provide water.

Preliminary feedback from stakeholders indicates that Flood-MAR may increase risks of crop damage. It imposes additional management costs on the GSA and additional operating costs on the grower to divert water, manage fields, and operate irrigation systems. CWD will evaluate incentive structures to encourage growers to participate in the program.

4.1.2.1 Project Overview

Flood-MAR is a groundwater recharge approach in which flood water available during winter and spring months is spread on agricultural or other suitable land for percolation to groundwater. The project is distinct from recharge basins that will be developed by CWD because existing land uses would be maintained, no basins would be constructed, and existing delivery facilities would be used. However, both projects rely on the same sources of supply: flood flows that are typically available in the winter and early spring that would have otherwise left the Subbasin.

A preliminary assessment using the Soil Agricultural Groundwater Banking Index (SAGBI) and current district cropping patterns was developed to evaluate the potential scale of the Flood-MAR project at full buildout. Assuming that Flood-MAR will be targeted to fields that provide the greatest recharge benefit (based on the SAGBI) and have crops that are suitable for Flood-MAR activities (including grapes and tree crops), CWD anticipates that about 13,000 acres will participate in its Flood-MAR program. CWD will develop economic analysis to identify incentive structures and further develop the Flood-MAR program starting in 2020.

4.1.2.2 Implementation

Because no new facilities are needed, the project can be implemented relatively quickly after CWD completes planning and permitting and prepares agreements with participating landowners. The rate of implementation will depend on the rate of adoption by CWD growers. CWD will develop economic studies to identify incentive structures to encourage participation in the Flood-MAR program. It is assumed that the project will be implemented starting in 2020 and will scale up as additional growers participate in the program (**Table 4-8**).

Table 4-8. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2020
Financing	2020	Indefinite
Construction	NA	NA
Operation	2020	Indefinite

4.1.2.2.1 Construction activities and requirements

Flood-MAR requires CWD 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.

4.1.2.2.2 Water source

Water for recharge is expected to be available from one or more of the following sources:

- Flood releases from Buchanan Dam
- CVP surplus flows, when they are available, delivered by Madera Canal

The analysis of benefits below assumes that the source of water will be flood flows available from Buchanan Dam and Madera Canal. 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.

The CWD Flood-MAR project will compete for water with recharge basins developed by CWD, and potentially, other GSAs. However, a preliminary assessment indicates that in very high runoff years the combined projects could capture and recharge more water in total than is included in the GSP implementation plan. The CWD project to expand Buchanan Dam (see Section 4.1.4) would also reduce available flood flows by the additional amount it would capture and store. The GSP analysis of potential yield (benefit) to the entire Subbasin includes a preliminary assessment of the joint effect of all proposed GSA PMAs.

4.1.2.2.3 Conditions or constraints on implementation

Winter and spring flooding can impose costs and inconvenience on participating landowners and therefore they must receive an incentive to participate. The incentive could be financial, or if CWD decides to monitor individual groundwater pumping it could come in the form of additional groundwater pumping credits that would accrue to participating landowners in proportion to the net recharge (percolation) benefits generated by their activity. The general incentive structure would need to provide a greater benefit to the landowner (in financial compensation or the value of recharge credits) than the total cost (including risk) to the grower. CWD will evaluate options as it further develops the Flood-MAR program.

Deliveries of flood flows will need to be coordinated with maintenance activities on canals and other delivery facilities, both within CWD and, if applicable, Madera Canal operators. The diversions are expected to occur during periods when flow exceeds beneficial or environmental uses. Nevertheless, CWD will need to evaluate whether the diversion of winter flood water affects existing uses of the water.

4.1.2.2.4 Permitting process and agencies with potential permitting and regulatory control

CWD has legal authority to deliver water to its customers. It would negotiate agreements with participating landowners for spreading the water and potentially develop additional incentive structures and agreements. If CWD determines that allocation of groundwater recharge is necessary, potentially to allocate groundwater recharge credits for participating in the Flood-MAR program, groundwater extraction will be monitored and enforced by CWD with meters installed on individual wells.

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. Reclamation will be consulted if using CVP contract supply or Section 215 water.

4.1.2.3 Project Operations and Monitoring

During flood releases from Buchanan Dam and Madera Canal, CWD will make water available for flooding cropland under the Flood-MAR program. It is anticipated that the water will be delivered to about 21,400 acres of participating lands that have high percolation rates.

Extraction of a portion (for example, 80% to 90%, which will be determined by CWD) of the recharged groundwater will be done by water users in CWD using their private wells. If allocation of the project's groundwater recharge is determined to be necessary, groundwater extraction will be monitored and enforced by CWD with meters installed on individual wells.

4.1.2.4 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 ISW by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, the on-farm groundwater recharge is also expected to benefit the groundwater supplies available to domestic well users and public supply wells, especially when those efforts can be focused within the identified public supply well priority areas **(Figure 4-1)**.

Groundwater recharge benefits are estimated using available flood flow over the historical hydrologic period 1989-2014. Based on the analysis, flood releases are expected to occur in approximately 1 out of 3 years. Flood-MAR sites will be identified such that nearly all will percolate to the groundwater. The expected average annual quantity of groundwater recharge is 5,836 AF (**Table 4-9**).

The reliability of the CWD Flood-MAR project is similar to the groundwater recharge basin project. Namely, 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.

Table 4-9. CWD Flood-MAR Estimated Average Annual Recharge Volume by Year Type, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	15,777	35%	5,522
AN	2,287	14%	314
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			5,836

4.1.2.5 Project Costs

Capital costs of the CWD Flood-MAR project are expected to be minimal because the project uses existing CWD 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.

The Flood-MAR project will create additional operating costs to CWD and growers that participate in the program. Operating costs are uncertain at this time and will be evaluated by CWD as part of its initial project development and evaluation of potential incentive structures. In general, operating costs for the Flood-MAR project include the cost of the water, CWD operating and maintenance costs, grower irrigation system cost, labor to irrigate, and labor to manage fields for recharge during times of the year when soils are typically saturated. O&M costs are not well known at this time. A cost of $50 per acre-foot (including district and grower O&M costs) is used to illustrate the potential costs of the Flood-MAR project (**Table 4-10**). Flood-MAR costs vary significantly depending on site specific characteristics. $50 per acre-foot is used as a conservative estimate of O&M (labor, energy, operations, maintenance, field work) based on a review of recent studies[68]. This assumes no (or minimal) field work or other management besides running irrigation systems.

Table 4-10. CWD Flood-MAR Estimated Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
All	N/A	N/A	None anticipated
O&M Costs			
Estimated average annual district and grower O&M cost	$177,000	All	$177,000 reflects average annual cost. O&M costs are higher in years when water is available

4.1.3 Merced-Chowchilla Intertie

The CWD Merced-Chowchilla Intertie project would provide benefits to the Subbasin by allowing CWD to purchase excess water supply from Merced during years in which excess supplies are available. The project would consist of building a pipeline connection and negotiating short- and long-term transfer arrangements between CWD and water management entities in Merced. A preliminary reconnaissance-level feasibility assessment of the project was developed under earlier San Joaquin River Restoration Program planning efforts (**Appendix 4.B**). CWD will perform additional studies of the project to refine costs and explore partnership opportunities during the GSP implementation period.

4.1.3.1 Project Overview

Water conveyance facilities consisting of a canal, pipeline and appurtenant facilities would be constructed to convey water from Merced Irrigation District (Merced ID) to CWD. CWD would then use that water within its service area in-lieu of groundwater pumping, or for recharge (basins or Flood-MAR), depending on conditions at the time water is available. The most likely option is that water would be acquired from Merced ID by short-term or long-term contract and delivered to CWD for direct irrigation use, thereby reducing groundwater demand within CWD's service area.

4.1.3.2 Implementation

CWD has already conducted preliminary investigations of the Merced-Chowchilla Intertie as part of its own planning efforts[69] and under the San Joaquin River Restoration Program. CWD will begin planning, permitting, and other agreements by 2025. CWD anticipates that construction would begin in 2033, with operation starting in 2035 (**Table 4-11**).

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[68] McMullin Groundwater Recharge Area Farmer Survey Report. Sustainable Conservation. 2015.

Groundwater Recharge through Winter Flooding of Agricultural Land in the San Joaquin Valley. RMC. October 2015.

Analyzing Cost-Effectiveness for Kings Basin Flood Flow Recovery. Report for Sustainable Conservation. March 2016.

Kocis and Dahlke. 2017. Availability of high-magnitude streamflow for groundwater banking in the Central Valley, California. Environ. Res. Lett. 12 084009.

[69] Water Transfer Feasibility Study: Merced Irrigation District to Chowchilla Water District. Prepared by Tolladay, Fremming and Parson for the U.S. Bureau of Reclamation. Summer 2000.

Table 4-11. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2025	2033
Financing	2030	2063
Construction	2033	2035
Operation	2035	Indefinite

4.1.3.2.1 Construction activities and requirements

A reconnaissance-level feasibility investigation was developed for an early conceptual approach to the project in 2000. The initial study assumed that the intertie would be developed to facilitate up to 15,000 AFY in transfers from Merced ID to CWD. Construction activities would generally include new facilities and enlargement of existing facilities. Several alternatives were identified in the initial feasibility study. CWD will evaluate and refine those alternatives to reflect current conditions, and to identify the most cost-effective construction alternative. Specific construction activities, scheduling, and more detailed cost estimates will be developed by CWD as part of final design of the project between now and 2030 (start of construction).

4.1.3.2.2 Water source

CWD will acquire water from Merced ID, which holds water rights on the Merced River. The quantity, timing, and cost of that water will be assessed under future evaluation of the project by CWD. CWD has assumed for the initial assessment for the GSP that transfers of 15,000 AFY will occur in AN and W year types. The reliability of the source water is Merced ID water rights on the Merced River. The reliability of the source water to CWD depends on those rights and Merced ID willingness to transfer water under different year types.

4.1.3.2.3 Conditions or constraints on implementation

The availability and timing of available water will depend on Merced ID’s willingness to make water available and the terms of the agreement between CWD and Merced ID. The terms of the agreement are not known at this time. CWD will engage Merced ID to discuss terms for short- and long-term transfers under project studies conducted between now and 2030.

4.1.3.2.4 Permitting process and agencies with potential permitting and regulatory control

In addition to CWD and Merced ID, the following agencies are likely to have permitting and regulatory control over the project: California Department of Water Resources, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and the Central Valley Regional Water Quality Control Board. CWD and Merced ID would work with all the responsible agencies to complete the permitting and approval processes.

4.1.3.3 Project Operations and Monitoring

During AN and W year types, CWD will purchase 15,000 AF of water from Merced ID. CWD may use this water in different ways for the benefit of CWD, including Flood-MAR and placing it in recharge ponds. Alternatively, CWD will use those supplies for direct delivery to growers which would be used in-lieu of groundwater pumping. CWD will monitor deliveries and charge growers using its existing system. If water is instead diverted for CWD recharge benefits (ponds or Flood-MAR), CWD will monitor those deliveries.

If project water is used for groundwater recharge and it is determined that monitoring of groundwater recharge is necessary, groundwater extraction will be monitored and enforced by CWD with meters installed on individual deep wells.

4.1.3.4 Project Benefits

Surface water supplies from this project will contribute to groundwater sustainability in the Subbasin by reducing demand for groundwater pumping. The in-lieu recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and ISW by increasing surface water use and reducing groundwater pumping.

CWD intends to purchase an annual average of 15,000 AF from Merced ID in AN and W years. This amount is based on a conservative estimate of CWD's initial target specified in the initial feasibility study (15,000 AFY). It does not depend on a hydrologic analysis of water available from the Merced River. The actual pattern of purchases will be defined in the terms of agreement with Merced ID. Assuming purchases of 15,000 AFY in all AN and W years, and the water is used in-lieu of pumping in CWD, the average annual benefit of the project equals 7,350 AFY (**Table 4-12**).

Table 4-12. CWD Merced-Chowchilla Intertie Estimated Average Annual Benefit Volume by Year Type, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	15,000	35%	5,250
AN	15,000	14%	2,100
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			7,350

4.1.3.5 Project Costs

Construction costs are based on a reconnaissance-level feasibility study prepared in 2000[70] (**Appendix 4.B**). The analysis considered different alternatives for construction of new facilities and expansion of existing facilities. Study alternative 6 is used for the GSP. The construction cost for alternative 6 in the feasibility study was indexed to current dollars, totaling $6.7 million. It should be noted that the study completed in 2000 assumes lower land acquisition costs and does not include environmental permitting or Right-of-Way costs. CWD will develop a current estimate of project costs during the GSP implementation period.

Operating costs of the project include the costs to operate the system and move water from Merced ID to CWD, in addition to ongoing administration, maintenance and legal costs. O&M costs additionally include water purchase costs. Merced ID faces similar water management constraint to CWD, including potential curtailments to surface water diversions and groundwater management specified in its GSP. This will affect the availability of water and purchase costs under an agreement with Merced ID. The average

[70] Water Transfer Feasibility Study: Merced Irrigation District to Chowchilla Water District. Prepared by Tolladay, Fremming and Parson for the U.S. Bureau of Reclamation. Summer 2000.

annual water purchase and project O&M cost equals $1.5 million. Actual O&M and water purchase costs will be assessed by CWD as the project is developed. These costs reflect weighted-average annual costs; costs are higher in years when water is purchased and delivered (**Table 4-13**).

Table 4-13. CWD Merced-Chowchilla Intertie Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project development	$6,700,000	Start of project	Does not include Right-of-Way costs, and does not include all permitting and legal costs
O&M Costs			
Water purchase cost	$1,500,000	All	Average annual cost; costs are higher in years when water is available.

4.1.4 Buchanan Dam Capacity Increase

As part of the San Joaquin River Restoration Program, Reclamation, working with CWD, investigated the feasibility of expanding Eastman Lake[71]. The purpose of the project is to enlarge the capacity of Eastman Lake by approximately 50 thousand AF (from 150 to 200 TAF). The additional capacity would allow for additional deliveries to CWD, and CWD would deliver water to growers to reduce groundwater pumping within the CWD service area. However, the additional deliveries would partially offset the availability of flood flows which are used for groundwater recharge benefits under other CWD projects (recharge basins and Flood-MAR). CWD will assess these tradeoffs under future project planning efforts.

4.1.4.1 Project Overview

The U.S. Army Corps of Engineers (USACE) owns and operates Buchanan Dam and Eastman Lake on the Chowchilla River as part of the Central Valley Project, with a gross capacity of 150 thousand AF (TAF). It is operated with a 45 TAF flood management reservation. CWD has a long-term contract with Reclamation for 24 TAF of CVP supplies per year from Eastman Lake. In wet years storage in Eastman Lake is carried over to subsequent drier years. In wet years, inflows that would encroach into the flood reservation space are evacuated as flood flows.

Under this project, CWD would enlarge the current 150 TAF capacity of Eastman Lake by 50 TAF to 200 TAF. The reconnaissance-level feasibility assessment conducted in 2014 estimated that the existing dam and spillway crest would be raised in place by 24 feet, and a 700-foot saddle dam would be constructed to the east of the spillway. The increase in capacity would allow USACE to maintain the flood reserve and store additional runoff for delivery to CWD.

4.1.4.2 Implementation

CWD expects that studies and permitting would begin by 2025 and continue for 10-12 years. Construction is planned over a three-year period, beginning in 2037 and completed in 2040. By 2040 the expanded dam would be ready to capture and deliver additional yield to CWD (**Table 4-14**). The availability of that yield

[71] Eastman Lake Enlargement. Working Administrative Draft. Water Management Goal – investment Strategy. San Joaquin River Restoration Program. January 2014. U.S. Bureau of Reclamation.

to CWD depends on the quantity and timing of future hydrologic conditions, and the ability to store and deliver additional runoff.

Table 4-14. Implementation Timeline.

Phase	Start	End
Design, Permitting and environmental documentation	2025	2037
Financing	2037	2067
Construction	2037	2040
Operation	2040	Indefinite

4.1.4.2.1 Construction activities and requirements

The preliminary feasibility assessment developed by Reclamation in 2014 identified the general types of construction activities that would be necessary in a pre-appraisal level cost estimate. The existing dam and spillway crest would be raised in place by 24 feet, and a 700-foot saddle dam would be constructed to the east of the spillway. Environmental documentation and mitigation would likely be required. Details on construction activities, schedule, and project costs will be developed as part of final project design.

4.1.4.2.2 Water source

Runoff in the Chowchilla River watershed that exceeds Buchanan Dam's existing storage space is currently released as flood flow during times that it cannot be diverted and used by CWD. Some of this released water would be stored behind the expanded dam and CWD would be able to deliver the stored water to its growers. Average annual inflows over the 1990 – 2017 hydrologic period averaged 70,195 AF (**Table 4-15**). CWD diverted an average of 40,765 AF over the same period, and 21,901 was released for flood management. The potential benefit of the project is to capture additional flood releases, which typically occur in W and AN year types. The reliability of the source water depends on annual hydrology.

Table 4-15. Buchanan Dam Inflow, CWD Diversion, and Flood Release 1990-2017.

Year	Water Year Type	Inflow, AF	CWD Diversion, AF	Flood Release, AF
1990	C	5,079	3,448	0
1991	C	21,562	18,356	0
1992	C	19,404	17,751	0
1993	W	104,457	22,095	0
1994	C	6,387	57,640	0
1995	W	158,046	63,371	11,485
1996	W	78,895	55,345	40,105
1997	W	233,681	42,999	186,296
1998	W	194,825	78,291	111,794
1999	AN	35,817	44,283	0
2000	AN	81,991	60,333	7,600
2001	D	23,183	74,028	0
2002	D	20,998	22,910	0
2003	BN	23,454	12,532	0
2004	D	18,029	19,526	0
2005	W	144,626	57,831	0

Year	Water Year Type	Inflow, AF	CWD Diversion, AF	Flood Release, AF
2006	W	134,024	69,358	65,757
2007	C	9,601	72,455	0
2008	C	24,703	24,711	0
2009	BN	21,653	15,906	0
2010	AN	56,277	19,610	0
2011	W	173,820	51,861	45,078
2012	D	15,219	91,017	0
2013	C	17,415	34,862	0
2014	C	1,420	0	0
2015	C	1,113	0	0
2016	D	47,522	44,060	0
2017	W	292,248	66,843	145,099
Average		*70,195*	*40,765*	*21,901*

4.1.4.2.3 Conditions or constraints on implementation

This is a planned project of the GSP and its implementation does not depend on the performance of other projects or activities. However, there are possible environmental issues that could impede the project, such as inundating miles of stream, that CWD will continue to monitor. Implementation would begin by 2025.

4.1.4.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies would have permitting or other regulatory authority over the construction and operation of the Buchannan Dam capacity increase project: USACE, U.S. Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and the California Water Resources Control Board.

USACE would be the owner of the project and would obtain approvals from Congress to construct the project. CWD would coordinate with partner agencies to develop environmental documents and in other planning efforts.

4.1.4.3 Project Operations and Monitoring

Operations would be integrated into the current operations of Buchannan Dam. In general, more runoff would be held during heavy rain events (or sequence of events). The stored water would be released later in the same irrigation year or held over to subsequent years for release to CWD. CWD would divert and deliver the water using its current facilities. The released water would be used for irrigation delivery or delivery to direct recharge facilities. Water held over from previous years would be subject to spillage if current year storage begins to encroach into the flood reserve space.

CWD will keep track of how much additional water supply it estimates has been delivered as a result of the project. The project would not require any additional groundwater monitoring beyond what is already planned to implement the GSP or needed to track performance of other PMAs. If applicable, CWD will estimate any additional groundwater recharge from percolation of the water supply. Credit for that recharge will be accounted for in the same way as percolation from other surface water delivery, as specified in Chapter 2 of the GSP.

4.1.4.4 Project Benefits

Water provided by the capacity increase would help meet total water demands in the Subbasin. Surplus flood water conserved by the project would be released to CWD for delivery to water users in CWD to meet on-farm irrigation demands, thereby reducing groundwater pumping. Percolation of the additional water would provide some groundwater recharge. Alternatively, CWD may choose to deliver some of the additional water to recharge basins or for Flood-MAR, depending on conditions.

This project will contribute to groundwater sustainability in the Subbasin by reducing groundwater pumping and replenishing groundwater supplies. The recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and ISW by increasing surface water use and reducing groundwater pumping. By replenishing groundwater supplies in the Subbasin, the recharge basins are also expected to benefit the groundwater supplies available to domestic well users and public supply wells, especially when surface water made available by the project can be delivered and used for recharge near the identified priority areas **(Figure 4-1)**.

Based on a hydrologic and operations analysis covering the historical period, 1990-2017, the project would yield an average of 8,753 AFY. The table below illustrates the average annual supply that CWD expects to be able to receive from the project. **Appendix 4.C**. summarizes the estimated monthly benefit and weighted-average annual benefit of the Buchannan Dam enlargement project.

Table 4-16. Estimated Additional Average Deliveries by Year Type for Buchanan Dam Capacity Increase, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	24,800	35%	8,753
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			8,753

4.1.4.5 Project Costs

Construction costs are based on the pre-appraisal level cost estimate developed by Reclamation in 2014. The construction cost was indexed to current dollars, totaling $49.6 million. The estimated average annual O&M cost equals $220,000, assuming $25 per acre-foot. Actual O&M costs will be assessed by CWD as the project is developed. These costs reflect weighted-average annual costs; O&M costs are higher in years when water is purchased and delivered (**Table 4-17**).

4.1.5 CWD Project Financing

Pursuant to 23 CCR § 354.44 and § 354.6, CWD 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 CWD will cover project costs is presented. CWD 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.

Table 4-17. Buchannan Dam Enlargement Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project planning and development	$49,200,000	Start of project	Pre-appraisal estimate prepared by Reclamation
O&M Costs			
Other O&M cost	$220,000	All	Average annual cost; costs are higher in years when water is available. Does not include water purchase costs.

CWD will pursue available state and federal grants or loans to help construct projects. The remaining construction costs will be financed through issuance of bonds, to be repaid from revenues raised through water rates and/or fees and assessments. Operation and maintenance costs will be paid using revenues raised through water rates and/or fees and assessments. CWD will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve rates, fees, or assessments to provide the required funding. CWD water users have, in the past, approved assessments to fund projects.

4.1.6 CWD Coordination with Other GSAs and Planning Agencies

As part of the Chowchilla Subbasin GSP, the Chowchilla Water District GSA will coordinate with other GSA's in the GSP. Coordination will continue among these and other agencies as needed to implement projects successfully.

4.2 Madera County GSA Projects

Madera County GSA (Madera County) has identified two projects and a demand management action that it will implement as part of the GSP.

Madera County West, which is in the Management Area shared with Triangle T Water District, will develop a winter floodwater recharge project. It will construct basins to recharge floodwater diverted from the Eastside Bypass. Groundwater recharge benefits would be managed for the benefit of Madera County groundwater pumpers.

Madera County East will purchase surplus water (e.g., Section 215 flood flow from the CVP Friant Division) or other water that may become available, such as from Sites Reservoir. The water would be used for recharge or delivered for irrigation in lieu of pumping in eastern areas of Madera County.

Madera County (East and West) proposes to implement a demand management action that would impose groundwater pumping limits, allocate pumping credits to parties based on those limits, and allow groundwater users to buy, sell, or carry over pumping credits. Madera County is currently working with stakeholders to develop program-specific parameters.

The projects and demand management action descriptions are based on information developed during the initial GSP development process and, where applicable, other studies. Water available from these projects 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. Section 4.6 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2021). A description of how these PMAs fit and coordinate with other Subbasin PMAs is provided in Chapter 5: Plan Implementation.

4.2.1 Madera County West: Recharge Basins

Madera County will develop recharge basins. Water will be diverted off the Eastside Bypass into basins where it will percolate into the deep aquifer. The size, location, and performance of Madera County recharge basins depends on site-specific characteristics that are currently being assessed by Madera County. Madera County will develop recharge basins to maximize recharge efficiency to ensure maximum net recharge benefits stay within the Subbasin.

4.2.1.1 Project Overview

Madera County recharge basins encompass three projects that would divert water from the Eastside Bypass and Ash Slough into recharge basins or fields during wet and above normal years when water is available.

1. Eastside Bypass diversions to recharge ponds within Clayton Water District
2. Office of Emergency Services (OES) Joint Redtop Banking Project with Triangle T Water District and with Clayton Water District
3. Expanded Joint Redtop Banking Project with Triangle T Water District

The Eastside Bypass diversion project is a joint project with Clayton Water District. Project costs and benefits are split proportionally between Madera County and Clayton Water District. The joint banking projects would be implemented jointly with Triangle T Water District (TTWD). The gross project benefit for each project reflects the split of benefits between the County and TTWD. The projects would include three or more recharge basins capable of recharging an average of nearly 28,000 AFY, although the recharge activity would likely occur only in W or AN water years. In years of large available flood flow, an average of 79,000 AF could be recharged. In addition, the project would construct 14 new 20-cfs slant pump turnouts to flood recharge basins and fields.

The recharge basins would be located in the Madera County West portion of the Madera County GSA, which is in the same Management Area as TTWD. Recharge in this management area will be managed for water supply benefits and to prevent additional land subsidence to stay above MTs and meet MOs specified in GSP Chapter 3. The County and TTWD will work cooperatively to maximize the opportunities for recharge and benefits for this Management Area of the Subbasin. Coordination will include potential pursuit of joint water rights applications, joint facilities, grant funding, and design and construction efforts.

4.2.1.2 Implementation

Implementation would be staged over a five-year period, beginning in 2020 as shown in the table below. Madera County has conducted a preliminary review of suitable lands using the SAGBI index and by soliciting feedback from growers. It will conduct a detailed study to identify appropriate recharge sites starting in 2020. 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.

Table 4-18. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2022
Financing	2022	2023
Construction	2023	2024
Operation	2025	Indefinite

4.2.1.2.1 Construction activities and requirements

Madera County, working with Davids Engineering, has developed preliminary construction cost estimates for facilities to divert water from the bypass and convey it to fields or basins. A summary of this analysis is provided in **Appendix 4.D.** Cost estimates are being refined to reflect the optimal scale of the project. General construction activities include developing diversions from the bypass, conveyance to recharge basins, and the basins.

The basins will be in operation by 2025. Land purchased for the basins will be selected based on location and suitability for recharge. It is assumed that land purchased for recharge basins would be land that is currently farmed.

4.2.1.2.2 Water source

Flood flow from the Eastside Bypass and Ash Slough would be diverted into recharge basins or fields during wet and above normal years when water is available.

4.2.1.2.3 Conditions or constraints on implementation

The projects rely on the availability of flood flow in the Eastside Bypass and the availability of suitable land to purchase for the basins. Madera County will coordinate with TTWD to ensure that the projects are jointly implemented and operated to achieve their purpose.

4.2.1.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting roles for the project: Madera County, Regional Water Quality Control Board, and State Water Resources Control Board. Recharge basin projects of this scale may require an environmental review process under CEQA. This would require either an Environmental Impact Report, and Negative Declaration, or a Mitigated Negative Declaration.

Madera County will obtain grading permits for construction of the recharge basins and will apply for permits required from the State Water Resources Control Board for diversion of water into the recharge basins or onto fields to the extent that diversion is not already permitted under existing water rights and contracts.

4.2.1.3 Project Operations and Monitoring

During periods of winter flood flow, water will be diverted from the bypass into recharge basins. Based on hydrologic analysis, the initial basins will recharge up to 79,000 AF in wet years, about one out of three years. Delivery would typically occur during the winter and spring but could occur any time that surplus water is available.

Extraction of recharged groundwater will be done by water users within the Madera County. If allocation of groundwater recharge credits is determined to be necessary, groundwater extraction will be monitored and enforced by Madera County with meters installed on individual deep wells. Any allocation of credits will be consistent with the Madera County demand management action (see Section 4.2.3).

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 ISW by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, the recharge basins are also expected to benefit the groundwater supplies available to domestic well users and public supply wells, especially those located within Madera County near the recharge basins **(Figures 2-4 and 2-5)**.

Table 4-19 summarizes the expected diversions to the recharge areas by year type for the three projects that form the Madera West recharge basins project. The expected annual volume of water recharged (averaged over all year types) is 27,953 AF.

Table 4-19. Madera County Recharge Basins Estimated Average Flood Flow Diversions by Year Type for Recharge, in AFY.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	79,200	35%	27,953
AN	0	14%	0
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			27,953

4.2.1.5 Project Costs

Construction costs are based on the estimates developed by Davids Engineering and the TTWD's Office of Emergency Services Grant. Estimated capital and operating costs are shown for each of the three Madera County recharge basin projects, ranging from $110 million to $1 million. The combined capital cost equals $118 million. Madera County will continue to work with its partners to develop refined project costs.

The development of project cost estimates is summarized in an **Appendix 4.D**.

O&M costs include costs to deliver water to fields or basins are assumed to equal $25 per acre-foot. Actual diversion and pumping costs may be significantly higher, Madera County will develop refined project cost estimates as part of its planning efforts during the project implementation period (**Table 4-20**). Project operating costs do not include any water purchase costs for Eastside Bypass flood flows. Madera County will need to obtain permits to divert the water from the bypass. Since other GSAs are looking to divert the same source of water, future water costs may increase (either to obtain permits or negotiate agreements with other GSAs looking to utilize the same supply).

Table 4-20. Madera County West Recharge Basins Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project #1. Eastside Bypass diversions to Madera County recharge ponds	$110,000,000	Start of project	Preliminary capital cost estimate; will be refined
Project #2. OES Joint Banking Project	$7,000,000	Start of project	Preliminary capital cost estimate; will be refined
Project #3. OES Joint Banking Project	$1,000,000	Start of project	Preliminary capital cost estimate; will be refined
O&M Costs			
Project #1. Eastside Bypass diversions to Madera County recharge ponds	$450,000	All	Average annual cost; costs are higher in years when water is available. Assumes no water purchase costs.
Project #2. OES Joint Banking Project	$225,000	All	Average annual cost; costs are higher in years when water is available. Assumes no water purchase costs.
Project #3. OES Joint Banking Project	$32,000	All	Average annual cost; costs are higher in years when water is available. Assumes no water purchase costs.

4.2.2 Madera County East: Water Purchase

Madera County will develop additional recharge basins, encourage Flood-MAR, or deliver water for in-lieu recharge in the Madera County East area. The project would purchase additional water supplies that would be delivered to the Madera County East area. Madera County is currently working with partners to identify sources of supply, costs, and maximize net recharge benefits in the Subbasin. The water purchase project includes two related projects:

1. Import other water supplies from partners into Madera County East and deliver that water for in-lieu recharge
2. Import CVP 215 water into Madera County East using Madera Canal and deliver that water to recharge ponds, dry wells, or as Flood-MAR on cropland

Both projects are similar, and the general concept/approach is described in the following section.

4.2.2.1 Project Overview

The County GSA would directly acquire or facilitate the acquisition of approximately 5,000 AF of new surface water supplies that would be available for diversion from Millerton during an irrigation season. The 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 East parcels that are within ½ mile of an existing major water delivery system (e.g. Madera Canal, CWD delivery system, natural stream course). Water would be conveyed to the various locations under a conveyance agreement entered into with CWD and others, as may be appropriate. Diversion and conveyance facilities would be constructed to serve the lands not currently within the delivery system of a district. The 5,000 AF would be expected to serve the irrigation needs of approximately 3,000 to 5,000 acres of currently irrigated lands – depending on the irrigation needs of the properties.

4.2.2.2 Implementation

The County will contact (either directly or through brokers) 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 East area. 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 ½ mile of a conveyance pathway (e.g. Madera Canal, CWD channel, or natural stream course).

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 4-21. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2022
Financing	2022	2023
Construction	2023	2024
Operation	2025	Indefinite

4.2.2.2.1 Construction activities and requirements

Madera County would need to obtain a permit to divert water for the project. 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 expects to identify parcels that are located near existing CWD facilities and build a turn out to receive delivery at those parcels. This would require a wheeling agreement with CWD.

4.2.2.2.2 Water source

The project will acquire water from Millerton by agreement with an existing CVP contractor. Other water that may be available for acquisition will also be considered. This could include any water that can be conveyed to Madera County via exchange agreements, including water from potential new projects such as Sites Reservoir.

4.2.2.2.3 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 with CWD.

4.2.2.2.4 Permitting process and agencies with potential permitting and regulatory control

The project will require conveyance agreements with CWD (and/or others) 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.

Depending on how the water is used, the following agencies have potential permitting roles for the project: Madera County, Regional Water Quality Control Board. The project may require an environmental review process under CEQA. This would require either an Environmental Impact Report, and Negative Declaration, or a Mitigated Negative Declaration.

4.2.2.3 Project Operations and Monitoring

Up to 5,000 AF would be targeted for acquisition every year, adjusted as appropriate for hydrologic constraints imposed on the availability of water. The water would be delivered during the irrigation season using existing conveyance facilities.

4.2.2.4 Project Benefits

Additional surface water supplies from this project will contribute to groundwater sustainability in the Subbasin by reducing groundwater pumping. The in-lieu recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and ISW by increasing surface water use and reducing groundwater pumping.

Table 4-22 summarizes the results of an integrated hydrologic analysis of water potentially available by year type and month for this project. Although 5,000 AF would be sought every year, a conservative estimate of the overall average delivery is 3,015 AFY, with the largest delivery acquired from Millerton floodwater (Section 215) water in wet years. Deliveries in other year types are purchases from existing or new supplies.

Table 4-22. Estimated Average Deliveries by Year Type for Madera County East Water Purchases, in AFY.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	5,000	35%	1,765
AN	0	14%	0
BN	1,875	8%	147
D	3,750	16%	588
C	1,875	27%	515
Avg. Annual			3,015

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 delivered.

Madera County will manage the projects for the benefit of its GSA. It may decide to allocate water to specific parcels and will decide how to allocate project costs to those specific parcels, and other groundwater pumpers in the Madera County GSA.

4.2.2.5 Project Costs

The project would require purchasing water, constructing facilities, and delivering water to the lands which are not currently served by surface water. The cost components are:

- Cost to acquire water. Water would be purchased from existing water suppliers or from new supplies that may become available, potentially in all year types. The estimated cost of water in Millerton (accounting for likely exchanges and conveyance costs) would be $1,000/acre-foot.
- O&M costs to convey water. Madera County would pay an additional fee per acre-foot of water to convey water, based on conveyance agreements with CWD and/or others. Additional costs are expected to convey water from the existing facilities to the served lands. For purposes of project estimating, this total cost is estimated to be $50/acre-foot.
- Capital costs for Infrastructure. Diversion of water from existing canals or streams could rely on a combination of temporary and permanent infrastructure. This is estimated to be $50,000 per diversion. Assuming 200 acres served per diversion, 10 diversion locations would be required at a total capital cost of $500,000 (2019 dollars).
- Other permitting, environmental review, legal, and consultant costs.

Madera County is currently developing project details and will continue to work with partners to develop and refine project costs. Preliminary capital cost estimates are around $500,000 for each project to build turnouts and other limited infrastructure. The first water purchase project relies on expensive sources of imported water, therefore O&M costs are moderate, but water purchase costs are significant (around $1,000 per acre-foot). The second project assumes that CVP 215 water is available at cost and a wheeling agreement with CWD. (See **Table 4-23**)

Table 4-23. Madera County East Water Purchase Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project #1. Other water purchase for irrigation	$500,000	Start of project	Preliminary capital cost estimate; costs will be refined.
Project #2. CVP 215 water purchase for recharge	$500,000	Start of project	Preliminary capital cost estimate; costs will be refined.
O&M Costs			
Project #1. Other water purchase for irrigation	$1,000,000	All	Average annual cost; costs are higher in years when water is available.
Project #2. CVP 215 water purchase for recharge	$110,000	All	Average annual cost; costs are higher in years when water is available.

4.2.3 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.

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 net groundwater pumping (pumping net of recharge). That is, it must reduce consumptive use or irrecoverable losses into a saline water body.

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.

4.2.3.1 Project 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. Pumping will be monitored and enforced by Madera County 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)

4.2.3.2 Implementation

Madera County is currently evaluating a range of demand management program options. All options impose a limit on groundwater pumping that will start in 2020. Madera County is continuing to work with stakeholders to develop a program that is implementable, consistent with the guiding principles, and achieves sustainability objectives in the basin. 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 historical 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 will impose groundwater pumping limits starting in 2020. The program applies to both the Madera County East and Madera County West portions of the Madera County GSA. 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 reduce average annual groundwater pumping by 27,550 AF (16,250 AF in Madera County West and 11,300 in Madera County East). However, if Madera County project yields are lower than initially estimated, Madera County will proportionally 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 is reduced by 2% (of the total demand reduction amount) per year, for a total cumulative reduction of 10% by 2025. Groundwater pumping is reduced by 6% per year starting in 2026 and continuing through 2040. **Figure 4-2** illustrates the annual reduction in pumping by year between 2020 and 2040. The annual reduction in pumping in Madera County equals 27,550 AF by 2040. The second axis shows the corresponding reduction in ET_{aw} under the demand management program. Crop ET_{aw} is reduced to 71% of the current ET_{aw} in the Madera County area by 2040.

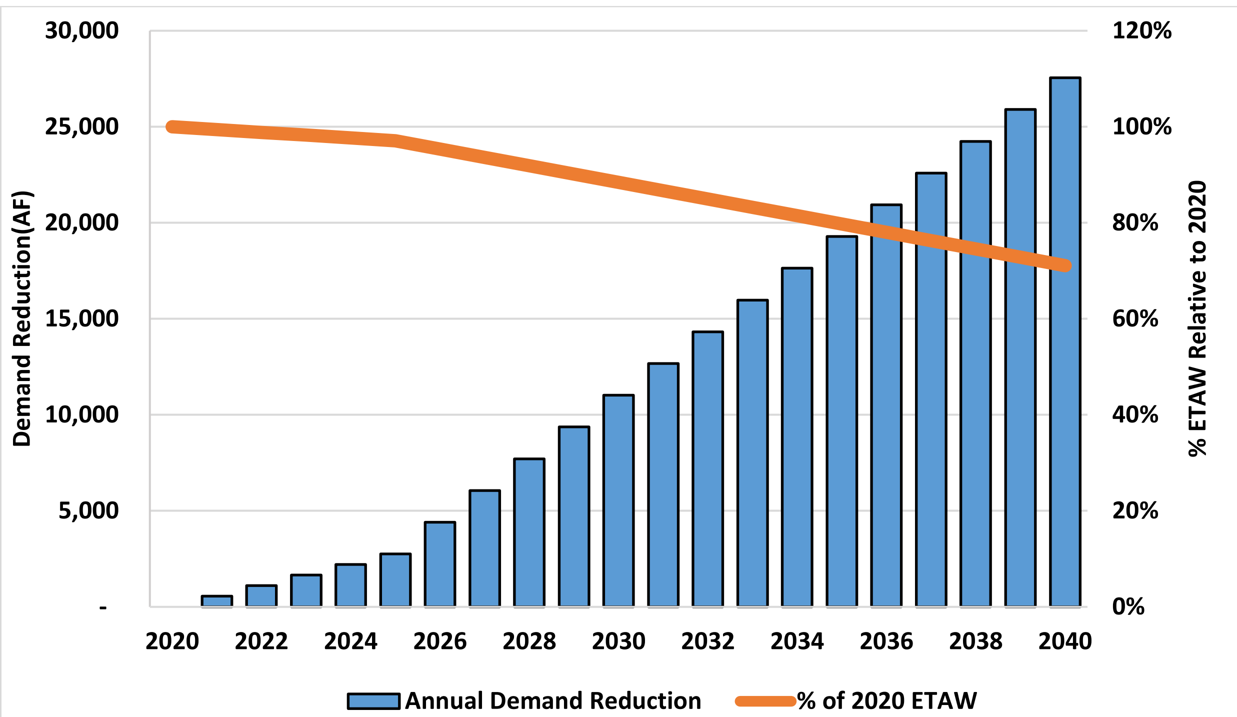

Figure 4-2. Madera County Demand Management Program.

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 4-2). 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. (See **Table 4-24**)

Table 4-24. Madera County Demand Management Program Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	Indefinite
Financing	2020	Indefinite
Construction	N/A	N/A
Operation	2020	Indefinite

4.2.3.2.1 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 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.

4.2.3.2.2 Water source

No new water is provided. The existing groundwater is capped and allocated under the demand management program.

4.2.3.2.3 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 demand management 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.

4.2.3.2.4 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.

4.2.3.3 Project 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}.

4.2.3.4 Project Benefits

The demand management program allows Madera County GSA and groundwater users to achieve the sustainability targets in a 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 ISW by reducing demand for additional groundwater pumping.

4.2.3.5 Project 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 $19 million per year. 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.

4.2.4 Madera County 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 be covered through grants and fees on groundwater pumpers.

To cover project costs, Madera County will pursue available state and federal grants or loans to help construct projects. The remaining 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.

To cover demand management program costs, Madera County will obtain available state and federal grants or loans to help set up and test the program. Any remaining set-up cost will be paid for using revenues raised through fees and assessments. Water trading program operating costs may be paid using a per-unit fee on trades or using revenues raised through fees and assessments. Madera County will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve rates, fees, or assessments to provide the required funding.

4.2.5 Coordination with Other GSAs and Planning Agencies

As part of the Chowchilla Subbasin GSP, the Madera County GSA will coordinate with other GSA's in the GSP. Coordination will continue among these and other agencies as needed to implement projects successfully.

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.

4.3 Sierra Vista Mutual Water Company Projects

Sierra Vista Mutual Water Company (SVMWC) is a private water company located in the Merced County and Madera County GSAs. SVMWC irrigated area covers all of the Merced County GSA and a small area of the Madera County GSA. SVMWC has identified one project for implementation of the Chowchilla Subbasin GSP. The SVMWC project is the construction and operation of a winter floodwater recharge project within or near the SVMWC lands, or the participation in a joint recharge project yielding similar results with CWD. The source of water for the project for recharge is floodwater diverted from the Chowchilla River. The project description is based on information developed during the initial GSP development process and, where applicable, other studies. Section 4.6 summarizes applicable PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2021). A description of how this project fits and coordinates with other Subbasin projects and actions is provided in Chapter 5: Plan Implementation.

4.3.1 Recharge Basins to Capture Floodwater

SVMWC intends to develop and manage recharge basins to capture flood water for groundwater recharge benefits in SVMWC.

4.3.1.1 Project Overview

The project proposes to develop infrastructure and up to 300 acres of recharge ponds within the SVMWC area, or nearby lands, that could be used to recharge Chowchilla River flood flows during the winter months of wet years. SVMWC would keep track of the amount of water recharged and stored underground. In dry years, the recharged water would be pumped and used by landowners to irrigate the approximately 3,500 acres of irrigated farmland within SVMWC. Recharge ponds are assumed to recharge 4.6 inches of water per day when operating at full capacity.

4.3.1.2 Implementation

Implementation will occur over a three-year period, beginning in 2020. SVMWC will identify recharge pond locations and begin environmental and permitting studies in 2020. Once recharge pond locations and designs are finalized, SVMWC will establish project financing through its corporate structure and/or available grant programs. Construction is likely in 2022 with operation beginning in 2023 or when wet year flood flows for recharge are available thereafter (See **Table 4-25**). Operations are expected to continue throughout the planning horizon (through 2090).

Table 4-25. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2020	2021
Financing	2021	2022
Construction	2021	2022
Operation	2023	Indefinite

4.3.1.2.1 Construction activities and requirements

Construction activities vary by recharge basin site. General activities include survey, initial feasibility assessment, permitting, environmental review, land purchase (if needed), 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 the recharge basins developed by SVMWC.

4.3.1.2.2 Water source

Water for recharge is floodwater in the Chowchilla River, diverted using facilities already in place or to be constructed as part of the project. The analysis of benefits below does not account for other potential sources nor for any changes in operations elsewhere that might affect availability of flows in these rivers.

4.3.1.2.3 Conditions or constraints on implementation

This is a planned project of the GSP and its implementation does not depend on the performance of other projects or activities.

4.3.1.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies may have permitting or other regulatory roles in project implementation: State Water Resources Control Board, US Army Corp of Engineers, Regional Water Quality Control Board, California Department of Fish and Wildlife, San Joaquin Valley Air Pollution Control District, and California Stormwater Pollution Prevention Plan.

The proposed project components will be installed on land owned by landowners in SVMWC or on nearby land that SVMWC acquires by purchase or lease. Agreements will be developed between SVMWC and landowners during the Environmental Planning and Permitting phase of the schedule.

4.3.1.3 Project Operations and Monitoring

SVMWC expects that floodwater will be available for diversion and recharge in approximately 1 in 3 years and would be delivered using existing SVMWC diversion and conveyance structures plus the facilities constructed or modified for this project. In years when flood waters are available, SVMWC would divert the water into recharge basins covering up to 300 acres, recharging 4.6 inches per day. The availability of flood flows varies but is estimated to be 100 days per year during the winter and spring months of wet year types. SVMWC will account for the amount of water recharged.

Extraction and beneficial use of recharged groundwater will be done by water users in SVMWC who will pump the recharged water in future years to irrigate crops in SVMWC. SVMWC will account for groundwater pumped with meters installed on individual wells.

4.3.1.4 Project Benefits

The 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 ISW by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, the recharge basins are also expected to benefit the groundwater supplies available to domestic well users.

Based on a hydrologic and operations analysis covering the historical period, 1989-2014, and the resulting frequency and amount of recharge, the average annual net recharge for 300 acres at buildout, the net yield would average 11,490 AFY in wet years (assuming 0.383 AF/day x 100 days x 300 acres), and lesser amounts in above normal years. The project would not operate in below normal and dry year types.

The table below illustrates the anticipated frequency and amount of flood water that could be diverted into the project. The reliability of source water is based on historical hydrology being a good projection of future hydrology.

Table 4-26. SVMWC Recharge Basin Estimated Average Recharge Volumes by Year Type, in AFY.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	11,490	35%	4,022
AN	2,298	14%	322
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			4,344

4.3.1.5 Project Costs

SVMWC will evaluate project costs to develop 300 acres of recharge basins. Costs for each basin will vary based on site characteristics and market conditions affecting land, construction, and material costs at that time. Costs shown here are representative of average recharge basin development costs. All costs are reported in current 2019 dollars.

Table 4-27. SVMWC Recharge Basins Project Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Land purchase and construction, 300 acres of basins	$7,500,000	Start of construction	Assumed $20,000/acre purchase and $5,000/acre development cost; costs will be refined.
O&M Costs			
Annual Power and other O&M	$217,200	All	Assumed $50/AF average annual cost; O&M costs are higher in years when water is available

4.3.2 SVMWC Project Financing

SVMWC intends to finance capital costs through available grants and/or assessments through its corporate structure. SVMWC will conduct the necessary studies and decision processes to approve the assessments to provide the required funding.

4.3.3 Coordination with Other GSAs and Planning Agencies

As part of the Chowchilla Subbasin GSP, SVMWC will coordinate with all other GSA's in the GSP, as well as neighboring GSAs in the surrounding subbasins. Coordination will continue among these and other agencies as needed to implement projects successfully. In particular, since SVMWC is not a separate GSA, but is covered in part by the Madera County GSA and in part by the Merced County GSA, SVMWC will coordinate with the two county GSAs.

4.4 Triangle T Water District GSA Projects

The Triangle T Water District GSA (TTWD) has identified the following projects that it has included in the GSP: (i) the OES Joint Redtop Banking Project is a winter floodwater recharge project that would construct basins to recharge the shallow groundwater for use in lieu of pumping deep groundwater, and (ii) the Poso Canal Pipeline and Columbia Canal Pipeline projects that would enable purchases of surface water (from San Joaquin River Exchange Contractors and others) to be conveyed into the District for irrigation supply in lieu of pumping groundwater. The Poso Canal Pipeline is already complete and the Columbia Canal Pipeline is expected to be complete by 2021. A portion of the OES project is outside of the TTWD service area and is being developed jointly with the Madera County GSA and the clayton Water District.

Project descriptions are based on information developed during the initial GSP development process and, where applicable, other studies. 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. Section 4.6 summarizes PMA implementation efforts and updates from the time of initial GSP development through the latest GSP Annual Report (water year 2021). Description of how these projects fit and coordinate with other Subbasin projects and actions is provided in Chapter 5: Plan Implementation.

4.4.1 OES Project Recharge Basins to Capture Floodwater

TTWD intends to develop and manage recharge basins to capture flood water for groundwater recharge benefits in TTWD.

4.4.1.1 Project Overview

The recharge basins are being developed under an OES Federal Emergency Management Agency (FEMA) grant. The project proposes to develop infrastructure and 310 acres of recharge ponds within the Red Top area that would allow San Joaquin/Fresno River flood flows to be stored in the shallow aquifer. The stored water would be pumped in dry years to reduce pumping from beneath the Corcoran Clay layer, in order to reduce overdraft and mitigate land subsidence. Recharge ponds can accept approximately 500 AF of additional water per day when operating at full capacity from existing and new turnouts and facilities. The project would improve monitoring of both groundwater and surface water use to better manage resources. Three measurement structures are proposed along the Fresno River and Berenda Slough, consisting of one rate section and two flow measurement devices. Recovered water would be used in dry or critical water years.

4.4.1.2 Implementation

Implementation started in 2019. Approximately 1,500 acres will be identified that show good recharge potential, and TTWD will construct 310 acres of recharge ponds within the 1,500 acres. TTWD will begin environmental and permitting studies in 2019. When locations and designs are finalized, financing for construction will be secured and construction will begin in 2020. TTWD will complete construction and begin operation of the recharge facilities in 2021. Operations are expected to continue indefinitely.

Table 4-28. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	2019	2020
Financing	2020	2021
Construction	2020	2021
Operation	2021	Indefinite

4.4.1.2.1 Construction activities and requirements

The broader OES FEMA grant project proposes 13 new shallow water wells, 5.5 miles of surface water distribution pipeline (to distribute surface water conveyed to TTWD through the pipeline projects, described under Section 4.4.2), increasing the capacity of the existing Road 9 turnout, removing and replacing one turnout, adding one turnout from the Fresno River, and adding twelve new turnouts (slant pumps) into the project area, some of which will be in the TTWD area and others will be in the Madera County GSA. The split of project benefits and costs reflects these differences.

The OES recharge basin project includes: constructing 5 new 20-cfs slant pump turnouts to flood recharge basins and fields; and a new 48-inch RCBC (60 to 150 cfs) off Eastside Bypass to Fresno River, along with capacity improvements to Grover Junction to flood recharge basins and fields.

Details on construction activities, schedule, and project costs will be developed as part of final project design.

4.4.1.2.2 Water source

Water for recharge is floodwater in the San Joaquin and/or Fresno River, diverted using facilities already in place or to be constructed as part of the project. The analysis of benefits below does not account for other potential sources nor for any changes in operations elsewhere that might affect availability of flows in these rivers.

4.4.1.2.3 Conditions or constraints on implementation

Implementation of these projects does not depend on the implementation or performance of other projects or activities.

4.4.1.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting or regulatory roles in implementing the project: US Army Corp of Engineers, Regional Water Quality Control Board, California Department of Fish and Wildlife, San Joaquin Valley Air Pollution Control District, and California Stormwater Pollution Prevention Plan.

The proposed project components will be installed on land owned by various landowners in the Red Top Area. Agreements will be developed between the Districts and landowners during the Environmental Planning and Permitting phase of the schedule.

Encroachment permits have been submitted for 6 of the turnouts along the Eastside Bypass to the Flood Protection Board. The remaining will be submitted as the projects proceed. Encroachment permits and license agreements may be needed with the County for placing a pipeline along Road 4 and along the Road 4 Bridge over the Eastside Bypass.

Agreements will be developed between the Districts and landowners during the Environmental Planning and Permitting phase of the schedule.

4.4.1.3 Project Operations and Monitoring

TTWD expects that floodwater will be available for diversion and recharge in wet and above normal years. It would be delivered using existing structures plus the facilities constructed or modified for this project. For the first project, TTWD expects to deliver sufficient water during such years to recharge 310 acres of basins, recharging up to a maximum recharge rate of 500 AF per day. Delivery would typically occur during the winter and spring but could occur any time that surplus water is available.

TTWD expects to divert up to 15,000 AF per month in wet years during January through March. The expected recharge from the OES projects, averaged over all year types, will be about 16,000 AFY.

Recharge will be delivered by TTWD to groundwater recharge basins and for application to fields. Extraction of recharged groundwater will be by water users in TTWD and nearby lands in the Subbasin. If allocation of groundwater recharge is determined to be necessary, groundwater extraction will be monitored and enforced by TTWD with meters installed on individual wells.

4.4.1.4 Project Benefits

The 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 ISW by augmenting groundwater supplies in the Subbasin. By replenishing groundwater supplies in the Subbasin, the recharge basins are also expected to benefit the groundwater supplies available to domestic well users and public supply wells, especially those located near the recharge basins **(Figures 2-4 and 2-5)**.

Based on a hydrologic and operations analysis covering the historical period, 1989-2014, and the resulting frequency and amount of recharge, the combined OES FEMA grant projects yield 24,657 AFY.

The size, location, and performance of a recharge basin depends on site-specific characteristics that will be assessed by TTWD. For example, some of the water that percolates from the recharge basin may move laterally to nearby streams and flow out of the basin before it can reach the deeper aquifer. This lost water would not provide any recharge benefits to TTWD or the Subbasin. TTWD will develop recharge basins to maximize recharge efficiency to ensure maximum net recharge benefits stay within the Subbasin and monitor for losses to calculate the true net benefit.

The table below illustrates the frequency and amount of floodwater the three projects are expected to divert into recharge. The reliability of source water is based on historical hydrology being a good projection of future hydrology. In addition, reliability depends on other users diverting supplies.

Table 4-29. TTWD Recharge Basins Estimated Average Recharge Volume by Year Type, in AF.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	65,000	35%	22,941
AN	12,500	14%	1,716
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual			24,657

4.4.1.5 Project Costs

TTWD will evaluate project costs to develop recharge basins. Costs for each basin will vary based on site characteristics and market conditions affecting land, construction, and material costs at that time. Costs shown here are representative of average recharge basin development costs. All costs are reported in current 2019 dollars.

Table 4-30. TTWD Recharge Basin Estimated Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Capital costs for TTWD projects	$24,500,000	Start of construction	
O&M Costs			
Water purchase costs and other O&M	$700,000	All	Average annual cost; O&M costs are higher in years when water is available

4.4.2 Poso Canal Pipeline and Columbia Canal Company (CCC) Pipeline Projects

TTWD will implement a pipeline project to buy and deliver surface water. It will construct conveyance for delivery of water purchased from San Joaquin River Exchange Contractors and others. The water will be used in-lieu of groundwater pumping in TTWD. The Poso Canal Pipeline is operational and the Columbia Canal Pipeline is expected to be operational in 2021.

4.4.2.1 Project Overview

The projects propose to construct conveyance for delivery of water to be purchased from one or more San Joaquin River Exchange Contractors or other partners to the west and south of the District. A portion of the purchased water would be conveyed through new pipelines from the Poso Canal west of TTWD and from CCC to the south. The water would be delivered to recharge facilities or used for irrigation in lieu of pumping groundwater, in order to reduce overdraft and mitigate land subsidence. Up to 8,000 AFY would be targeted for purchase in total.

4.4.2.2 Implementation

Planning and agreements have been under development, with construction of the Columbia Pipeline expected to begin in 2019 or 2020. The Poso Canal Pipeline is operational and the Columbia Canal Pipeline is expected to be operational and provide deliveries in 2021. **Table 4-31** summarizes the anticipated timeline for construction and operations of the pipelines.

Table 4-31. Implementation Timeline.

Phase	Start	End
Permitting and environmental documentation	Under way	2019
Financing	2019	2020
Construction	2019	2020
Operation	2020	indefinite

4.4.2.2.1 Construction activities and requirements

Details on construction activities, schedule, and project costs will be developed as part of final project design.

4.4.2.2.2 Water source

Water would be purchased from willing sellers and delivered through Exchange Contractor facilities. Exchange Contract deliveries are among the most reliable among CVP deliveries, with 100% deliveries in most years, dropping to 75% in the driest years (about one in 10). The cost to purchase water from Exchange Contractors or other willing partners will increase as GSPs are implemented and multiple parties, including TTWD, compete for water transfer partners.

4.4.2.2.3 Conditions or constraints on implementation

The projects will compete with other users for water within the San Luis-Delta Mendota Water Authority and SWP service areas. This will increase the cost of the project to TTWD over time.

4.4.2.2.4 Permitting process and agencies with potential permitting and regulatory control

The following agencies have potential permitting or regulatory roles in implementing the project: US Army Corp of Engineers, Regional Water Quality Control Board, State Water Resources Control Board, California Department of Fish and Wildlife, San Joaquin Valley Air Pollution Control District, and California Stormwater Pollution Prevention Plan.

4.4.2.3 Project Operations and Monitoring

Water will be acquired by long-term and/or short-term agreements between TTWD and Central California Irrigation District (CCID), CCC, and other willing sellers. Operations and deliveries will be coordinated between the Poso Canal Pipeline and the CCC Pipeline. Water will be delivered for recharge and irrigation in lieu of groundwater pumping. Quantities delivered will be tracked as part of the GSA's monitoring of groundwater use, recharge, and conditions.

4.4.2.4 Project Benefits

The additional surface water supplies from this project will contribute to groundwater sustainability in the Subbasin by reducing groundwater pumping. The in-lieu recharge benefits of this project are expected to benefit groundwater levels, groundwater storage, subsidence, groundwater quality, and ISW by increasing surface water use and reducing groundwater pumping.

The table below shows the planned water purchase and delivery amounts by water year type, for both the Poso Canal Pipeline project and the CCC Pipeline project.

Table 4-32. Estimated Average by Year Type for Poso Canal and CCC Pipeline Projects, in AFY.

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	7,000	35%	2,471
AN	8,000	14%	1,098
BN	8,000	8%	627
D	8,000	16%	1,255
C	8,000	27%	2,196
Avg. Annual			7,647

Based on the projected year type frequency, the average annual amount purchased and conveyed into the District by the two projects is estimated to be 7,647 AF. Increasing water purchase costs may limit the economic feasibility of purchasing water in some years.

4.4.2.5 Project Costs

The value of water supply is high in this region, especially in critical years. According to records of water purchased by San Luis and Delta Mendota Water Authority for its member agencies, the Authority paid an average of $289 per acre-foot during non-critical years and $500 per acre-foot during the 2015 critical year (see analysis provided by Castle and Cooke in CCID's application to the Hazard Mitigation Grant Program DR-4308). Therefore, TTWD expects water purchase costs to increase in the future, which may increase the cost of the project.

TTWD will evaluate project costs as it continues to refine and implement the project. The most significant share of O&M costs is expected to be annual water purchase costs. All costs are reported in current 2019 dollars.

Table 4-33. TTWD Pipeline Projects Estimated Costs.

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Capital costs	$5,200,000	Start of construction	
O&M Costs			
Water purchase costs and other O&M	$4,550,000	All	Average annual cost; O&M costs are higher in years when water is available

4.4.3 TTWD Project Financing

TTWD intends to finance capital costs through its authorized borrowing mechanisms, most likely by issuing bonds. Costs to repay bonds, purchase water, and cover other operating costs will be funded through water rates or, as needed, other fees or assessments. TTWD will conduct the necessary studies and decision processes (including Proposition 218 elections) to approve rates, fees, or assessments to provide the required funding.

4.4.4 Coordination with Other GSAs and Planning Agencies

As part of the Chowchilla Subbasin GSP, TTWD GSA will coordinate with all other GSA's in the GSP, as well as neighboring GSAs in the surrounding subbasins. Years of planning and coordination for the Poso Canal and CCC pipeline projects have occurred between the districts involved (TTWD, CCID, and CCC) and Madera and Merced Counties. Coordination will continue among these and other agencies as needed to implement projects successfully. TTWD and the Madera County GSA will work cooperatively to maximize the opportunities for recharge and benefits for this Management Area of the Subbasin. Coordination will include potential pursuit of joint water rights applications, joint facilities, grant funding, and design and construction efforts.

4.5 Subbasin Water Available for Recharge by Projects

Four sources of water are available for the recharge and water supply projects: combined flood releases and Section 215 water from Millerton Lake and Buchanan Dam, Eastside Bypass flows, Fresno River flood flows to Triangle T Water District, 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.

4.5.1 Combined Flood Releases and Section 215 Water from Millerton Lake and Buchanan Dam

The first source of water available for projects in the Chowchilla Subbasin is the combined flood releases and Section 215 water from Millerton and Buchanan Dam. Flood releases and Section 215 water are released from Millerton Lake and enter the Chowchilla Subbasin along Madera Canal at Miles 33.6 and 35.6. Flood releases from Buchanan Dam enter the Chowchilla Subbasin along Chowchilla River. Upstream of Chowchilla Water District, flood releases from both sources and Section 215 water merge and are distributed downstream through Ash Slough, Berenda Slough, and Chowchilla River.

Table 4-34 shows the average combined flood releases and Section 215 water from Millerton Lake and Buchanan Dam that are expected to be available by water year type during the 2019-2090 projected period. These flood releases and Section 215 water are expected only during wet and above normal years (25 years and 10 years expected between 2019-2090, respectively).

The total combined flood releases and Section 215 water from Millerton Lake and Buchanan Dam that are committed to projects in the Chowchilla Subbasin are summarized in **Table 4-35**. The remaining water available of this source type after project-related recharge is summarized in **Table 4-36**. In total, projects are expected to utilize much of the available water during winter and pre-irrigation season months (Nov-Apr) of average wet and above normal years. However, projects potentially overcommit available water during most irrigation season months (May, July-Oct) of average wet years.

Reclamation's approval will be needed for Section 215 water to be used to support the recharge projects. Recent 215 contracts have stated that water may be used for irrigation and municipal and industrial purposes and must be used within the contractor's water service boundary and within the Friant Division's Place of Use. The language of the Section 215 contract needs to state the water's intended use for recharge and the location(s) that it may be applied.

Table 4-34. Average Projected Buchanan Dam and Madera Canal Flood Releases and Additional Water Supply During Uncontrolled Season Water Supply Available to Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	95,200	35%	33,600
AN	8,200	14%	1,100
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	34,700

Table 4-35. Average Buchanan Dam and Madera Canal Flood Releases and Additional Water Supply During Uncontrolled Season Water Supply Committed to Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	90,700	35%	32,000
AN	7,500	14%	1,000
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	33,000

Table 4-36. Average Available Buchanan Dam and Madera Canal Flood Releases and Additional Water Supply During Uncontrolled Season Water Supply Remaining After Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	4,800	35%	1,700
AN	700	14%	100
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	1,800

4.5.2 Eastside Bypass

Eastside Bypass flows include all water entering the Subbasin along Chowchilla Bypass and Fresno River downstream of the Madera Subbasin. Chowchilla Bypass flows originate from the San Joaquin River below the control structure, approximately 5 miles east of the town of Mendota, at times when combined flood flows from the San Joaquin River and the Kings River through James Bypass approach the river's downstream capacity. Fresno River flows originate from Hensley Lake releases and Millerton Reservoir releases, which are, at times, routed to the Fresno River at Madera Canal Mile 18.8.

Average monthly Eastside Bypass flows projected for the 2019-2090 projected future period are shown in **Table 4-37** by water year type. Eastside Bypass inflows to Chowchilla Subbasin are expected to occur only during wet and above normal years (25 years and 10 years expected between 2019-2090, respectively).

The total Eastside Bypass flows committed to projects in the Chowchilla Subbasin and the remaining water available in Eastside Bypass following project-related recharge are summarized in **Tables 4-38** and **4-39**, respectively. In total, projects are expected to utilize much of the available water during pre-irrigation season months (Feb-Apr) of average wet years, though significant recharge potential remains for winter flood flows in December and January of wet years. Projects also utilize much of the available water in above normal years, even potentially overcommitting available water during some irrigation season months (April-June).

4.5.3 Water Purchases

The fourth source of water available for projects is water acquired from willing sellers. **Table 4-40** provides a summary of projected average monthly water purchases by water year type to be used as part of GSP projects. This water includes purchases by CWD GSA from Merced Irrigation District, contract water purchases by TTWD GSA from Exchange Contractors, and imported water to Madera County East GSA along 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.

Table 4-37. Average Projected Eastside Bypass Flows Available to Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	638,300	35%	223,400
AN	120,900	14%	16,900
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	240,300

Table 4-38. Average Eastside Bypass Flows Committed to Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	113,600	35%	39,800
AN	12,500	14%	1,800
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	41,600

Table 4-39. Average Available Eastside Bypass Flows Remaining After Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	524,300	35%	183,500
AN	108,500	14%	15,200
BN	0	8%	0
D	0	16%	0
C	0	27%	0
Avg. Annual		100%	198,700

Table 4-40. Average Water Volume Assumed to Be Purchased for Chowchilla Subbasin Recharge Projects, by Water Year Type (2040-2090).

Year Type	Total Annual Volume	% of Years	Weighted Avg.
W	18,700	35%	6,600
AN	19,700	14%	2,800
BN	9,900	8%	800
D	11,800	16%	1,900
C	9,900	27%	2,700
Avg. Annual		100%	14,700

4.6 Implementation of Projects and Management Actions Since Initial GSP Development

The implementation of PMAs is critical for achieving and maintaining groundwater sustainability. Since development of the initial GSP, GSAs and local agencies in the Chowchilla Subbasin have made substantial progress toward implementing the PMAs described in the sections above. Updates to these PMAs are summarized in each of the GSP Annual Reports.

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 2021).

4.6.1 Chowchilla Water District GSA

Updates to the implementation of PMAs proposed and planned by the CWD GSA are summarized below.

4.6.1.1 Updates in the 2020 Annual Report (Water Year 2019)

4.6.1.1.1 Groundwater Recharge Basins

- CWD purchased a 56-acre parcel for dedicated groundwater recharge. Of the total area, CWD planned to develop 38 acres as a dedicated groundwater recharge basin; the remaining 18 acres are in Berenda Slough. Construction of the recharge basin began in February 2020 and was expected to be completed in 2020.
- A 65-acre parcel was also identified and purchase of the parcel was in progress as of April 2020.
- Two existing recharge basins within the CWD GSA, City Pond and Road 13 Pond, were used for groundwater recharge in 2019, providing nearly 3,800 AF of recharge with no costs incurred outside of normal CWD operational costs.

4.6.1.1.2 Flood-MAR (Winter Recharge)

- In 2019, CWD diverted surplus flows through the existing CWD distribution system and delivered them to lands whose landowners elect to participate in the program. The process for monitoring the program was in progress, so there were no reported costs or benefits of the program.

4.6.1.1.3 New Projects and Management Actions Since the Initial GSP

- Operation of the CWD Distribution System for Recharge
  - In 2019, CWD utilized its distribution system and the Chowchilla River, Ash Slough, and Berenda Slough to recharge an estimated 95,000 AF.
- Enhanced Management of Flood Releases for Recharge
  - In 2017 and 2019, CWD strategically operated its distribution system for recharge during periods when flood flows were available and when the distribution system was not at its operational capacity with deliveries to landowners. Diverted water was spread throughout unlined portions of the distribution system, allowing for increased groundwater recharge . This was initiated in 2017 and also done in 2019, with an estimated annual recharge benefit of approximately 26,800 AF in wet years (approximately 9,400 AF, on average, in all years).

4.6.1.2 Updates in the 2021 Annual Report (Water Year 2020)

4.6.1.2.1 Groundwater Recharge Basins

- As reported in the previous Annual Report, CWD purchased a 56-acre parcel for dedicated groundwater recharge. Construction of a 38-acre dedicated recharge basins was ongoing as of the end of water year 2020.
- As reported in the previous Annual Report, CWD identified a 65-acre parcel for an additional recharge basin. As of the end of water year 2020, CWD successfully purchased the parcel, began removing existing almond trees, and began construction.
- Due to dry conditions, the two existing recharge basins within the CWD GSA, City Pond and Road 13 Pond, were not used for groundwater recharge in water year 2020.

4.6.1.2.2 Flood-MAR (Winter Recharge)

- No Flood-MAR occurred in water year 2020 due to dry conditions.

4.6.1.2.3 New Projects and Management Actions Since the Initial GSP

- Enhanced Management of Flood Releases for Recharge
    - No flood flows were available for recharge in water year 2020 due to dry conditions.

4.6.1.3 Updates in the 2022 Annual Report (Water Year 2021)

4.6.1.3.1 Groundwater Recharge Basins

- In 2021, CWD completed construction of three groundwater recharge basins:
    - The Road 19 Groundwater Recharge Basin, on a 56-acre parcel near Berenda Slough
    - The Wood Groundwater Recharge Basin, a 67-acre recharge basin
    - The Acconero Groundwater Recharge Basin, a 63-acre recharge basin.
- No water was delivered for recharge in 2021 due to drought conditions.

4.6.1.3.2 Flood-MAR (Winter Recharge)

- No Flood-MAR occurred in water year 2021 due to dry conditions.

4.6.1.3.3 Buchanan Dam Capacity Increase

- CWD initiated discussions with the United States Army Corps of Engineers to discuss the potential to increase the capacity of Eastman Lake.

4.6.1.3.4 New Projects and Management Actions Since the Initial GSP

- Enhanced Management of Flood Releases for Recharge
    - No flood flows were available for recharge in water year 2020 due to dry conditions.
- Land Fallowing
    - CWD GSA proposed a land fallowing program that would be implemented by growers on a voluntary basis. Benefits would be measured by the reduction in the total volume of groundwater previously used to irrigate the fallowed lands.
    - CWD began planning a study, with plans to initiate the program in 2023. The target reduction in groundwater pumping from land fallowing was anticipated to be 5,000 to 10,000 AFY, with estimated program costs between $1,000,000 to $2,000,000 per year.

4.6.1.4 Updates in the 2023 Annual Report (Water Year 2022)

- In water year 2022, USBR declared an additional 20% Class 1 water (approximately 11,000 AF) that had to be used prior to March 1, 2022. CWD took delivery of this water for various recharge purposes (described below).

4.6.1.4.1 Groundwater Recharge Basins

- More than 1,000 AF of water was delivered to CWD’s recharge basins for recharge in 2022.

4.6.1.4.2 Flood-MAR (Winter Recharge)

- Approximately 2,300 AF of water was delivered to CWD’s customers for Flood-MAR in 2022.

4.6.1.4.3 New Projects and Management Actions Since the Initial GSP

- Enhanced Management of Flood Releases for Recharge
    - The remaining Class 1 water available to CWD in 2022 was used for enhanced recharge in CWD’s canals.

4.6.2 Madera County GSA

Updates to the implementation of the PMAs proposed and planned by the Madera County GSA are summarized below.

4.6.2.1 Updates in the 2020 Annual Report (Water Year 2019)

4.6.2.1.1 Madera County West: Recharge Basins

- Madera County had begun actively discussing options and approaches with local landowners and DWR's Flood-MAR project team to initiate recharge projects in the western portion of the Subbasin along the Chowchilla Bypass and Berenda Slough.

4.6.2.1.2 Madera County East: Water Purchase

- Madera County had begun working with the United States Bureau of Reclamation (Reclamation) to modify its current CVP contract to enable access to additional CVP supplies (e.g. Section 215 water) and to open up opportunities for acquiring CVP supplies from outside the Subbasin.

4.6.2.1.3 Management Action: Demand Management

- As of April 2020, Madera County GSA had begun preparations for implementing a demand management program that would oversee a managed reduction in the volume of groundwater consumed by irrigated agriculture over the 20-year GSP implementation period. As support for this program, Madera County began work on two studies (SALC study and water markets study) and began implementing a demand measurement program. Those supporting efforts are described below.

4.6.2.1.4 New Projects and Management Actions Since the Initial GSP

- Sustainable Agricultural Lands Conservation (SALC) Study
  - The Madera County GSA received a grant to fund a planning project to explore the feasibility of adopting an agricultural easement process within Madera County. The Madera County GSA issued a request for proposals (RFP) for a consultant to assist with the work and was *evaluating responses* as of April 2020, with plans to begin work in spring/summer 2020.
- Water Markets Study
  - The Madera County GSA applied for and was awarded a grant from the Reclamation to develop a comprehensive water marketing strategy. An RFP was issued, a contractor was selected, and work began in late 2019. As of April 2020, the contractor was working closely with Madera County, stakeholders, and technical experts to conduct an economic analysis to support development of a comprehensive water marketing strategy.
- Demand Monitoring
  - Madera County began obtaining extended satellite-based ET datasets to help design and manage demand reduction efforts.

4.6.2.2 Updates in the 2021 Annual Report (Water Year 2020)

4.6.2.2.1 Madera County West: Recharge Basins

- Madera County GSA initiated a recharge planning study to refine the costs, benefits, and schedule for recharge projects described in the GSP. The recharge planning study also includes the costs, benefits, and schedule to construct additional basins and conduct additional Flood-MAR to recharge winter floodwater diverted from the Eastside Bypass.

- Madera County GSA submitted a grant application on behalf of the Chowchilla Subbasin to build four turnouts on the Eastside Bypass to supply two recharge basins and Flood-MAR on farmland. This project was developed in close coordination with TTWD GSA and Clayton Water District landowners in Madera County who offered to use their farmland for recharge. The project was recognized with a draft award recommendation of $4,197,600 on March 5, 2021.

4.6.2.2.2 Madera County East: Water Purchase

- No updates in water year 2020.

4.6.2.2.3 Management Action: Demand Management

- In water year 2020, Madera County GSA continued its preparations for implementing a demand management program. Madera County continued work on two studies (SALC study and water markets study) and continued implementing a demand measurement program and developing an allocation framework. Those supporting efforts are described as "New PMAs Since the Initial GSP," below.

4.6.2.2.4 New Projects and Management Actions Since the Initial GSP

- SALC Study
    - In 2020, Madera County conducted stakeholder interviews to provide feedback on the structure of the SALC program. Interviews were conducted with representatives of groups including: California Milk Producers Council, Madera County Cattlemen's Association, Leadership Counsel for Justice and Accountability, Self-Help Enterprises, Madera County Farm Bureau, and Madera Ag Water Association (MAWA). Feedback from these groups was summarized into an SALC Assessment Interview Summary, and was used to inform GSA and County decisions about the timing, flexibility, incentives, and areas for the program. In January 2021, a stakeholder meeting was held to share the results of the study, present similar cases in other GSAs, and discuss options and next steps.
- Water Markets Study
    - In 2020, Madera County GSA continued work on the water markets study efforts that begin in 2019. Three partner workshops were held in 2020 to define opportunities, understand concerns, and develop solutions. Interviews were conducted with local stakeholders to voice opinions and concerns and legal frameworks were also developed in cooperation with the consulting team. In January 2021, a virtual pilot water market was initiated. The goal of the pilot program is to test effectiveness and implications of the potential market rules over a multi-year time period. Approximately 60 local landowners had signed up for the virtual pilot program as of April 2021.
- Demand Monitoring
    - Madera County GSA selected the IrriWatch program to measure consumptive water use on irrigated acres. The Madera County GSA's main objective in using the program was to track evapotranspiration of applied water (ET_{aw}) against an allocation of ET_{aw}.
    - In water year 2020, worked with IrriWatch to develop protocols for using satellite-based estimates of ET_{aw} to monitor demand and for offering irrigation scheduling advice to farmers. The Madera County GSA also hosted trainings to inform growers about the program.
- Allocation Framework

    - In water year 2020, the Madera County GSA developed an allocation framework through a series of public meetings with the Madera County GSA Advisory Committee. The Madera County GSA Board of Directors adopted the allocation framework at their December 2020 meeting.
- Rate Study
    - As of April 2021, Madera County had a contract with a consultant to quantify implementation costs and move through a Proposition 218 process for a water rate for extraction of groundwater.

4.6.2.3 *Updates in the 2022 Annual Report (Water Year 2021)*

4.6.2.3.1 Madera County West: Recharge Basins

- Madera County GSA continued the recharge planning study, which yielded two grant proposals to DWR between 2020-2021.
- The first grant proposal, described above, received a final grant award in 2021. As of April 2022, those funds were being used toward planning, design, and construction of turnouts on the Eastside Bypass that will supply flood water to recharge areas. This project has been developed in close coordination with TTWD GSA and Clayton Water District landowners in Madera County who offered to use their farmland for recharge. The recharge sites were surveyed in March 2022. Further designs are anticipated to be completed later in 2022, and construction is anticipated to begin in 2022-2023, pending successful completion of CEQA and permitting.
- The second grant proposal – a spending plan that would fund implementation of phase 2 of the recharge program – was submitted to DWR in February 2022 as part of Round 1 of the 2022 SGMA Implementation Grant program. The spending plan received approval in spring 2022.

4.6.2.3.2 Madera County East: Water Purchase

- No updates in water year 2021.

4.6.2.3.3 Management Action: Demand Management

- In water year 2021, Madera County GSA continued its preparations for implementing a demand management program. Supporting efforts are described as “New PMAs Since the Initial GSP,” below.

4.6.2.3.4 New Projects and Management Actions Since the Initial GSP

- SALC Study
    - In 2021, interviews and feedback on the SALC program structure continued to be used to inform GSA and County decisions about the timing, flexibility, incentives, and areas for the program.
- Water Markets Study
    - 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 Madera County GSA in both the Madera and Chowchilla Subbasins. A total of 57 unique participants from the Madera and Chowchilla Subbasins were enrolled in in the overall simulation, with about 25 regular participants each month.
- Demand Monitoring

  - On January 1, 2021, IrriWatch began calculating and making data available to the Madera County GSA and growers that enrolled.
  - As of April 2022, all irrigated parcels in the Madera County GSA had been auto-enrolled in the program. More than 1,200 irrigated parcels were enrolled as of early 2022, representing nearly 120,000 irrigated acres across the Chowchilla, Madera, and Delta-Mendota Subbasins.
- Allocation Framework
  - The Madera County GSA Board of Directors adopted resolutions in December 2020, June 2021, and August 2021 that describe “per-acre” allocations and rules for credits.
- Rate Study
  - In water year 2021, the Madera County GSA continued development of a Rate Study that will result in a water rate for extraction of groundwater within the Madera County GSA. A penalty for groundwater extraction above the allocation was also being considered separately.

4.6.2.4 Updates in the 2023 Annual Report (Water Year 2022)

4.6.2.4.1 Madera County West: Recharge Basins

- Madera County GSA continued the recharge planning study to refine the costs and benefits and schedule for recharge projects described in the GSP. In 2022, the Madera County GSA continued public outreach and engagement for the recharge program through ongoing solicitation of interested landowner participants and through a public workshop held in November 2022 to discuss the framework for landowner-initiated recharge operations. This study has resulted in two grant applications to DWR, resulting in two related grant-funded projects:
  - The first grant-funded project was initiated in 2021 through Proposition 68 funds. In 2022 and early 2023, recharge sites were surveyed and 60% designs were completed and reviewed by participating landowners. CEQA and permitting efforts were initiated, although MC is pursuing a CEQA exemption in accordance with Executive Order N-7-22 Action 13.
  - The second grant-funded project, initiated in 2022 through Proposition 68 funds, is planning and designing additional recharge facilities along the Chowchilla Bypass, expanding on work being developed through the first grant. As of April 2023, the Madera County GSA has developed 30% designs and has completed surveying of the recharge areas.

4.6.2.4.2 Madera County East: Water Purchase

- No updates in water year 2022.

4.6.2.4.3 Management Action: Demand Management

- In water year 2022, Madera County GSA continued its preparations for implementing a demand management program. Supporting efforts are described as “New PMAs Since the Initial GSP,” below.

4.6.2.4.4 New Projects and Management Actions Since the Initial GSP

- VLRP Project
  - MC continued work on the Voluntary Land Repurposing Project (VLRP), formerly referred to as the SALC 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.
- Water Markets Study
  - MC completed work to 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.
- Demand Monitoring
  - 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 applied water estimates developed form the IrriWatch remote sensing measurements. Findings and conclusions from the Madera Verification Project are provided in a final report completed in spring 2023.
- Allocation Framework
  - 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 Madera County 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.
- Funding Mechanisms
  - In 2022, the Madera County GSA completed the development of a rate study that was intended to result in an acreage-based rate for extraction of groundwater within the Madera County GSA. The GSA Board approved a rate package in spring 2022; however, the Proposition 218 process resulted in a majority protest and thus the rates were not approved.
  - Since the Proposition 218 process, the Madera County GSA has been working with a group of local growers to explore alternative funding mechanisms for GSP implementation.
  - In 2022, the Madera County GSA approved a penalty for groundwater extraction above the allocation that is being imposed as of 2023. Funds generated from these penalties are also available to support GSP implementation as directed by the GSA Board.

4.6.3 Sierra Vista Mutual Water Company

Updates to the implementation of a project proposed and planned by SVMWC are summarized below.

4.6.3.1 Updates in the 2020 Annual Report (Water Year 2019)

4.6.3.1.1 Recharge Basins to Capture Flood Water

- As of April 2020, SVMWC was in the early stages of developing up to 300 acres of dedicated recharge basins. Operation of the recharge basins is anticipated for 2023.

4.6.3.2 Updates in the 2021 Annual Report (Water Year 2020)

4.6.3.2.1 Recharge Basins to Capture Flood Water

- No updates in water year 2020. As of April 2021, SVMWC was still in the early stages of developing up to 300 acres of dedicated recharge basins.

4.6.3.3 Updates in the 2022 Annual Report (Water Year 2021)

4.6.3.3.1 Recharge Basins to Capture Flood Water

- In early 2022, SVMWC applied for and was awarded Proposition 68 funding to support further development and construction of this project.

4.6.3.4 Updates in the 2023 Annual Report (Water Year 2022)

4.6.3.4.1 Recharge Basins to Capture Flood Water

- The CEQA process is currently nearing completion, after which a geotechnical study will be completed. Construction of the reservoir is planned in 2023.

4.6.4 Triangle T Water District GSA

Updates to the implementation of projects proposed and planned by TTWD GSA are summarized below.

4.6.4.1 Updates in the 2020 Annual Report (Water Year 2019)

4.6.4.1.1 OES Project Recharge Basins to Capture Flood Water

- As of April 2020, TTWD was in the process of developing up to 310 acres of dedicated recharge basins under an OES grant. TTWD planned to obtain flood water rights for bypass water and divert this to existing recharge ponds (and later to the OES ponds once those were constructed).
- The OES ponds had not yet been constructed as of April 2020, but the total capital costs incurred at the time were roughly $220,000.

Poso Canal Pipeline and Columbia Canal Company Pipeline Projects

- As of April 2020, construction of two water conveyance pipelines to import additional surface water supplies to landowners in TTWD had been completed.
- The Columbia Canal pipeline did not convey water in 2019.
- In 2019, the Poso Canal pipeline was used to import 10,387 AF of surface water at a cost of roughly $2,240,000 (cost of purchasing the imported water, not for O&M). In 2018, the Poso Canal pipeline was used to import 7,515 AF at a cost of roughly $1,900,000.

4.6.4.1.2 New Projects and Management Actions Since the Initial GSP

- Utilize Existing Recharge Basins
    - TTWD diverted surplus flows into 508 acres of existing recharge basins within the GSA. The project provided 4,994 AF of recharge benefits in 2019, 180 AF of recharge in 2018, and 14,096 AF of recharge in 2017.

4.6.4.2 Updates in the 2021 Annual Report (Water Year 2020)

4.6.4.2.1 OES Project Recharge Basins to Capture Flood Water

- As of April 2021, TTWD was continuing the water rights application process. A temporary water rights permit had been granted and additional information in support of the permanent water right was submitted to the SWRCB.
- TTWD collaborated with the Madera County GSA to seek grant funding. The draft award (described above) will fund one recharge basin in TTWD.
- TTWD spent an additional $58,000 to develop the recharge basins.

4.6.4.2.2 Poso Canal Pipeline and Columbia Canal Company Pipeline Projects

- As of April 2021, approximately $6 million dollars in capital costs had been invested in the Poso Canal Pipeline and Columbia Canal pipeline construction projects.
- The Columbia Canal pipeline did not convey water in 2020.
- In 2020, the Poso Canal pipeline was used to import 7,498 AF of surface water at a cost of roughly $2,830,000.

4.6.4.2.3 New Projects and Management Actions Since the Initial GSP

- Utilize Existing Recharge Basins
    - No updates in water year 2020.

4.6.4.3 Updates in the 2022 Annual Report (Water Year 2021)

4.6.4.3.1 Additional Recharge Basins to Capture Floodwater (Formerly OES Project Recharge Basins to Capture Flood Water)

- As of April 2022, this project was funded under Proposition 68 and was renamed the "Additional Recharge Basins to Capture Floodwater" project.
- As of April 2022, TTWD was continuing efforts to secure a permanent water rights permit on the Chowchilla Bypass.
- In 2020-2021, TTWD GSA collaborated with the Madera County GSA on the Proposition 68 grant. One of the recharge basins being designed and planned for construction using those grant funds will be constructed in TTWD.
  In total, approximately $274,000 in capital costs had been incurred for the project through water year 2021.

Poso Canal Pipeline and Columbia Canal Company Pipeline Projects

No updates in water year 2021

4.6.4.3.2 New Projects and Management Actions Since the Initial GSP

- Utilize Existing Recharge Basins
    - No updates in water year 2021.
- Installation of Nested Monitoring Wells
    - TTWD installed six nested monitoring wells within the District area in 2021. These wells were planned to provide additional information about groundwater conditions in TTWD and the Western Management Area of the Chowchilla Subbasin.
- Poso Canal Pipeline Extension

   - TTWD initiated work on an extension of the existing pipeline project to deliver more purchased water for irrigation and recharge within TTWD and in adjacent areas prioritized for subsidence mitigation. The pipeline extension project would provide surface water access to approximately 3,800 acres of irrigated farmland that currently uses groundwater, primarily pumped from beneath the Corcoran Clay which is known to cause subsidence.
   - In early 2022, TTWD applied for and was awarded Proposition 68 funding to support further development and extension of the Poso Canal pipeline project.

4.6.4.4 Updates in the 2023 Annual Report (Water Year 2022)

4.6.4.4.1 Additional Recharge Basins to Capture Floodwater (Formerly OES Project Recharge Basins to Capture Flood Water)

- In 2020-2021, TTWD GSA collaborated with the Madera County GSA on the Proposition 68 grant. Two recharge basins that are currently being designed and planned for construction using those grant funds – the Vlot and Haynes basins – will be constructed in TTWD. Those basins are currently at 60% design, with construction anticipated to begin in fall 2023.
- TTWD is continuing efforts to secure a permanent water rights permit on the Chowchilla Bypass. Since GSP adoption, a temporary water rights permit has been granted and additional information in support of the permanent water right has been submitted to the SWRCB.

Poso Canal Pipeline and Columbia Canal Company Pipeline Projects

- The Poso Canal Pipeline and Columbia Canal Company Pipeline continue to be used when water is available for purchase.
- In 2022, approximately 1,400 AF of surface water was purchased and delivered through the pipelines.

4.6.4.4.2 New Projects and Management Actions Since the Initial GSP

- Utilize Existing Recharge Basins
   - No water was available for recharge in water year 2022.
- Installation of Nested Monitoring Wells
   - The nested monitoring wells continued to be used in 2022.
- Poso Canal Pipeline Extension
   - The project is currently in the final design stage, with construction expected to begin in late spring 2023.

4.6.5 Jointly Implemented Projects, Management Actions, and GSP Implementation Efforts

This section summarizes updates on PMAs and GSP implementations efforts that are jointly implemented by multiple GSAs.

4.6.5.1 Emergency Recharge Plan

In addition to the ongoing development of recharge projects proposed in the Chowchilla Subbasin GSP, the Madera County GSA has initiated work on an emergency recharge plan to achieve more immediate recharge benefits from flood flows available on the Chowchilla Bypass. Under this plan, Madera County GSA and TTWD GSA have worked collaboratively to secure temporary water rights and develop a plan for installation of temporary infrastructure to divert flood flows off the Chowchilla Bypass to the extent they are ahead of construction of permanent infrastructure. In winter 2021-2022, Madera County initiated the environmental permitting for the points of diversions (PODs) available for use as part of the emergency recharge plan. Madera County also continued development of the plan, and TTWD resubmitted the temporary water rights application used for this project. As of February 2022, approximately $40,000 in project development costs have been incurred, although no water was available for recharge in winter 2021-2022. The GSAs will continue collaborating and preparing for recharge efforts in the future.

4.6.5.2 Domestic Well Mitigation Program

The GSAs have proceeded with coordinating, planning, and implementing a Domestic Well Mitigation Program (Program) to support groundwater access for domestic well users and users of shallow wells that supply drinking water (e.g., public water systems and state small water systems) in the Chowchilla Subbasin. The Program has been developed to provide assistance to domestic wells and wells that supply drinking water users adversely impacted by declining groundwater levels since GSP implementation began (i.e., since 2020) that interfere with groundwater production that interfere with groundwater production or quality. The Program will be coordinated with the Madera County SB 552 Drought Plan that is under development.

The GSAs have proceeded with coordinating, planning, and implementing the Program beginning in 2023 and continuing as needed until groundwater sustainability is achieved, upholding their clear commitment as memorialized in the Program Memorandum of Understanding (MOU) (**Appendix 3.D**). The Program has been developed with review and consideration of the content and recommendations set forth by Self-Help Enterprises, the Leadership Counsel for Justice and Accountability, and the Community Water Center in their publication titled, “Framework for a Drinking Water Well Impact Mitigation Program” (SHE et al., 2020).

The GSAs began accepting applications for the Program in January 2023, and as of May 2023 the GSAs are proceeding with Program implementation. It is expected that the Program will be implemented during the GSP implementation period and that Program implementation would continue as needed until groundwater sustainability is achieved. Additional information about the Program is provided in Section 3.2.1 and in **Appendix 3.D**.

4.6.5.3 Domestic Well Inventory and Monitoring Well Installation

In addition to advancing the Domestic Well Mitigation Program, the GSAs in the Chowchilla Subbasin have conducted a Domestic Well Inventory and Monitoring Well Installation project to refine the understanding of domestic wells in the Subbasin and improve monitoring in areas where high densities of domestic wells exist. The GSAs applied for and were awarded a Proposition 68 grant from DWR to conduct the domestic well inventory and install nine new monitoring wells at three sites in the Chowchilla Subbasin. The Madera County GSA applied for the grant on behalf of the Chowchilla Subbasin and has led the project since its inception. The Madera County GSA issued an RFP and selected a consultant for the study in 2020. The domestic well inventory was conducted in 2021-2022. Three new nested monitoring well sites have been identified and are planned for installation in summer 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 aid further in filling data gaps in the monitoring and conceptualization of the Chowchilla Subbasin hydrogeology. The project will also improve understanding and management of groundwater in the Chowchilla Subbasin.

5 PLAN IMPLEMENTATION

To achieve the Subbasin sustainability goal by 2040 and avoid undesirable results through 2090 as required by SGMA and the GSP regulations, various projects and management actions (PMAs) have been developed and will be implemented by the GSAs. Chapter 4: Projects and Management Actions 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 periodic evaluations that must be provided to the California Department of Water Resources (DWR) (23 CCR § 356.2 and §356.4).
- The Subbasin data management system.

5.1 Estimate of GSP Implementation Costs

Total GSP implementation costs include both project-specific costs and costs for GSAs to administer and operate all other aspects of the GSP. The GSAs implementing the Chowchilla Subbasin 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.

5.1.1 GSA Administration

Administrative costs generally include 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 the sustainability objectives.

The GSAs implementing the Chowchilla Subbasin 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. 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 GSA committees.

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 periodic evaluations for DWR (§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 will 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 managements and the overall GSP. This may include cost-effectiveness assessments and preliminary investigations of proposed projects. Fiscal and economic 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 periodic evaluations.

- **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 evaluation reports. In contrast to the annual report, this report 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 periodic evaluations 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 projects and management actions to achieve sustainability. Evaluations and updates will occur annually (annual report) and every five-years (periodic evaluation) as required by the GSP regulations, but GSAs anticipate that planning, coordination, and studies will be continuous and ongoing.

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 or 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 minimum threshold (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. These costs are reported as of January 2020, and not include:

- The costs of implementing the Domestic Well Mitigation Program, although the GSAs have expressed their clear and firm commitment to funding the Program. As of July 2022, the total annual cost of implementing the Domestic Well Mitigation Program is anticipated to range between approximately $1.18 million and $10,000 per year between 2023-2032, with higher costs expected in the first several years. Additional information is provided in **Appendix 3.D.**
- The costs of implementing the two data gaps workplans that the GSAs identified and developed in 2022-2023 (**Appendix 3.H and 3.I**). Additional information about the ISW and subsidence workplans is provided in **Section 2.2.2**.
- The capital and annual operating cost of PMAs.

Costs are presented for each of the six cost categories identified above. 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.

5.2.1 Chowchilla Water District GSA

As of January 2020, the Chowchilla Water District GSA (CWD) estimates that annual implementation costs will be approximately $150,000 per year over the next five years (**Table 5-1**). This does not include project-specific costs described in Chapter 4 or costs to build and operate additional projects or management actions that may be required if CWD determines that its sustainability objectives are not being met. These costs do not include costs identified in 2022 for implementing the Domestic Well Mitigation Program (see **Appendix 3.D**, Exhibit C) or implementing the data gaps workplans developed in 2022-2023 (**Appendix 3.H and 3.I**). These costs also do not include costs for consultants to support technical content development, including annual reports. The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports.

CWD will recover GSP implementation costs through grants and local revenues that are yet to be determined. CWD is currently evaluating options. Section 5.3 provides a general description of how CWD and other GSAs may recover GSP implementation costs.

Table 5-1. Chowchilla Water District GSA Implementation Costs.

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$30,240	$40,320	$41,530	$42,780	$44,060	$45,380
GSP Studies	$5,000	$10,000	$10,300	$10,610	$10,925	$11,255
GSP Implementation and Updates	$30,240	$40,320	$41,530	$42,780	$44,060	$45,380
Project Planning	$30,000	$30,900	$31,825	$32,780	$33,765	$34,780
Monitoring	$48,000	$49,440	$50,925	$52,450	$54,025	$55,645
Contingency	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Total	$153,480	$180,980	$186,110	$191,400	$196,835	$202,440

5.2.2 Triangle T Water District GSA

As of January 2020, the Triangle T Water District GSA (TTWD) estimates that annual implementation costs will be approximately $240,000 per year over the next five years (**Table 5-2**). This does not include project-specific costs described in Chapter 4 or costs to build and operate additional projects or management actions that may be required if TTWD determines that its sustainability objectives are not being met. These costs do not include costs identified in 2022 for implementing the Domestic Well Mitigation Program (see **Appendix 3.D**, Exhibit C) or implementing the data gaps workplans developed in 2022-2023 (**Appendix 3.H and 3.I**). Costs include no contingency and assume a modest level of effort for annual updates and periodic evaluations. The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports.

TTWD will recover GSP implementation costs through grants and local revenues that are yet to be determined. TTWD is currently evaluating options. Section 5.3 provides a general description of how TTWD and other GSAs may recover GSP implementation costs.

Table 5-2. Triangle T Water District GSA Implementation Costs.

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$30,000	$33,000	$36,000	$39,000	$42,000	$45,000
GSP Studies	$100,000	$50,000	$51,500	$53,000	$54,600	$56,200
GSP Implementation and Updates	$85,000	$40,000	$41,200	$42,400	$43,700	$45,000
Project Planning	$30,000	$33,000	$34,000	$35,000	$36,100	$37,200
Monitoring	$75,000	$40,000	$41,200	$42,400	$43,700	$45,000
Contingency	$0	$10,000	$10,000	$10,000	$10,000	$10,000
Total	$320,000	$206,000	$213,900	$221,800	$230,100	$238,400

5.2.3 Madera County GSA

As of January 2020, the Madera County GSA estimates that its implementation costs for the Chowchilla Subbasin (excluding the costs of specific projects) would total $3.38 million through 2024, or an average of about $0.56 million per year. 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, performing satellite-based demand analysis, and data management. Contingency costs would cover cost overruns and unanticipated activities such as litigation. These costs do not include costs identified in 2022 for implementing the Domestic Well Mitigation Program (see **Appendix 3.D**, Exhibit C) or implementing the data gaps workplans developed in 2022-2023 (**Appendix 3.H and 3.I**). The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports (**Table 5-3**).

Table 5-3. Madera County GSA Implementation Costs.

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$0	$116,000	$116,000	$116,000	$116,000	$116,000
GSP Studies	$0	$220,000	$120,000	$120,000	$120,000	$120,000
GSP Implementation and Updates	$419,000	$20,000	$20,000	$20,000	$20,000	$20,000
Project Planning	$80,000	$100,000	$100,000	$100,000	$100,000	$100,000
Monitoring	$0	$150,000	$150,000	$150,000	$150,000	$150,000
Contingency	$0	$50,000	$50,000	$50,000	$50,000	$50,000
Total	$499,000	$656,000	$556,000	$556,000	$556,000	$556,000

5.2.4 Merced County GSA

The Merced County GSA estimates that its implementation costs for the Chowchilla Subbasin would total approximately $225,000 through 2024, or an average of about $37,000 per year. The Merced County GSA covers a small portion of land in the Chowchilla Subbasin and it is anticipated that some Merced County GSA cost will be included with Merced County work to support GSP development in the Merced Subbasin. In general, Merced County 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. These costs do not include costs identified in 2022 for implementing the Domestic Well Mitigation Program (see **Appendix 3.D**, Exhibit C) or implementing the data gaps workplans developed in 2022-2023 (**Appendix 3.H and 3.I**). The actual costs of GSP administration, monitoring, and reporting will be reassessed and reported in future GSP updates and Annual Reports (**Table 5-4**).

Table 5-4. Merced County GSA Implementation Costs.

Cost Category	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
GSA Administration	$0	$8,000	$8,000	$8,000	$8,000	$8,000
GSP Studies	$0	$15,000	$8,000	$8,000	$8,000	$8,000
GSP Implementation and Updates	$29,000	$1,000	$1,000	$1,000	$1,000	$1,000
Project Planning	$6,000	$7,000	$7,000	$7,000	$7,000	$7,000
Monitoring	$0	$10,000	$10,000	$10,000	$10,000	$10,000
Contingency	$0	$3,000	$3,000	$3,000	$3,000	$3,000
Total	$35,000	$44,000	$37,000	$37,000	$37,000	$37,000

5.3 GSP Financing

Administering the GSP and monitoring and reporting progress is projected to cost approximately $1.2 million per year across all Subbasin GSAs. Costs are expected to be higher during years in which five-year periodic evaluations 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 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 could 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, or other fees under Proposition 26.
- **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 assessment 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 for Fall 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

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 implemented by each GSA (Madera County East and West correspond to the portion of the Madera County GSA within each Management Area). The GSP implementation schedule also shows mandatory reporting and updating for all GSAs, including annual reports and five-year periodic updates (evaluations) prepared and submitted to DWR.

The Chowchilla 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 minimize impacts to businesses, individuals, and disadvantaged communities in Madera County.

Implementing PMAs to achieve 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 Chowchilla Subbasin. This will impact agriculture and create ripple effects across all sectors of the Madera County[72] economy, including County tax revenues and jobs that support many of the County's disadvantaged communities. The GSP implementation schedule, especially for the Madera County GSA's planned demand management program, allows time for the Madera County economy to adjust in order to minimize economic impacts to disadvantaged communities, businesses, and other individuals in the region.

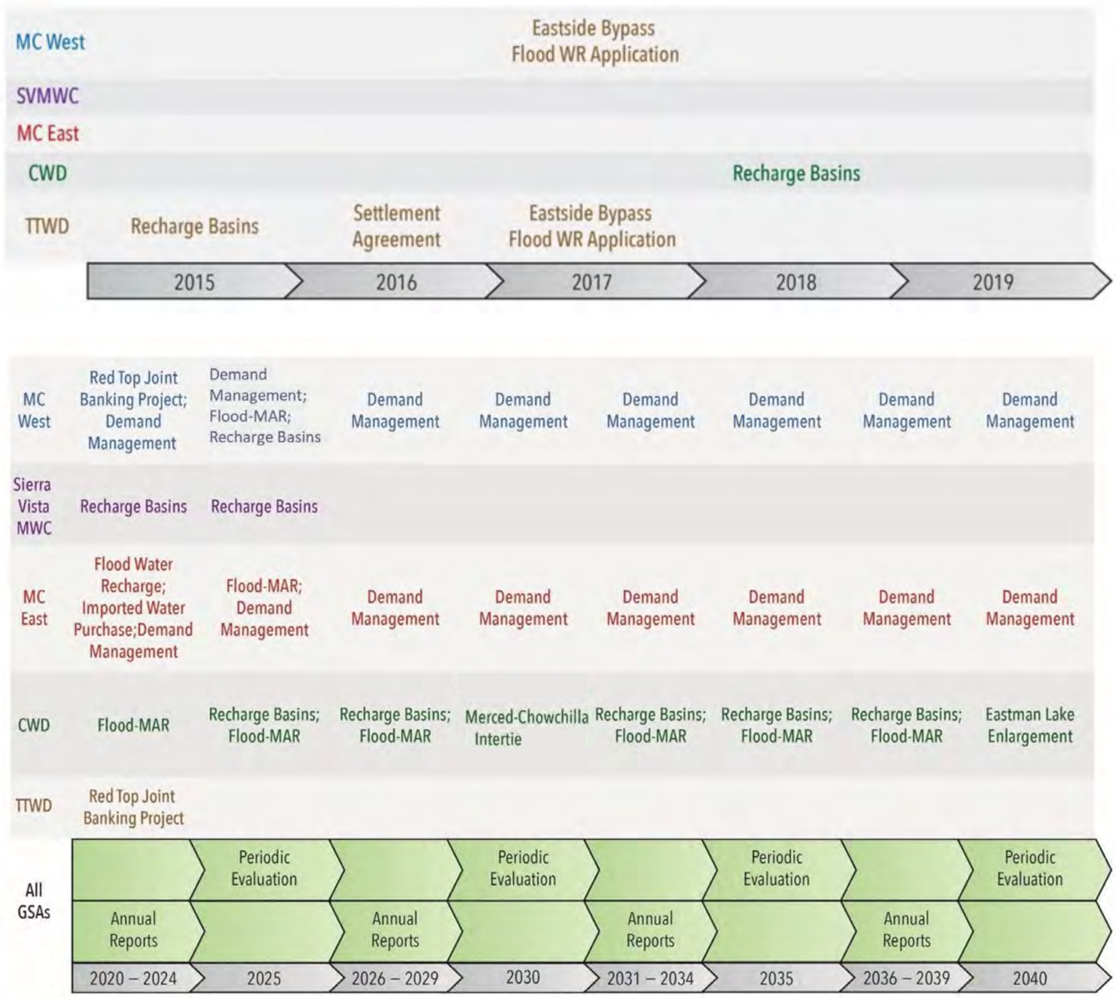

Figure 5-1. Chowchilla Subbasin Implementation Schedule.[1]

[1] Costs shown do not reflect any updates or changes to projects, management actions, or planned GSP implementation activities identified since January 2020. Updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.

Figure 5-2 illustrates the conceptual GSP implementation plan, showing the gross benefit (measured in average acre-feet per year (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 basin from the projects described in Chapter 4 is expected to equal approximately

[72] The Chowchilla Subbasin GSP covers a small portion of Merced County and some economic impacts would occur in Merced County.

55,000 AF in 2020, increasing to just over 140,000 AF by 2040 when the Subbasin will achieve all sustainability objectives. Gross benefit values shown in **Figure 5-2** include the demand management program implemented by the Madera County GSA, which anticipates an additional (approximately) 30,000 AF of benefit (demand reduction) by 2040.

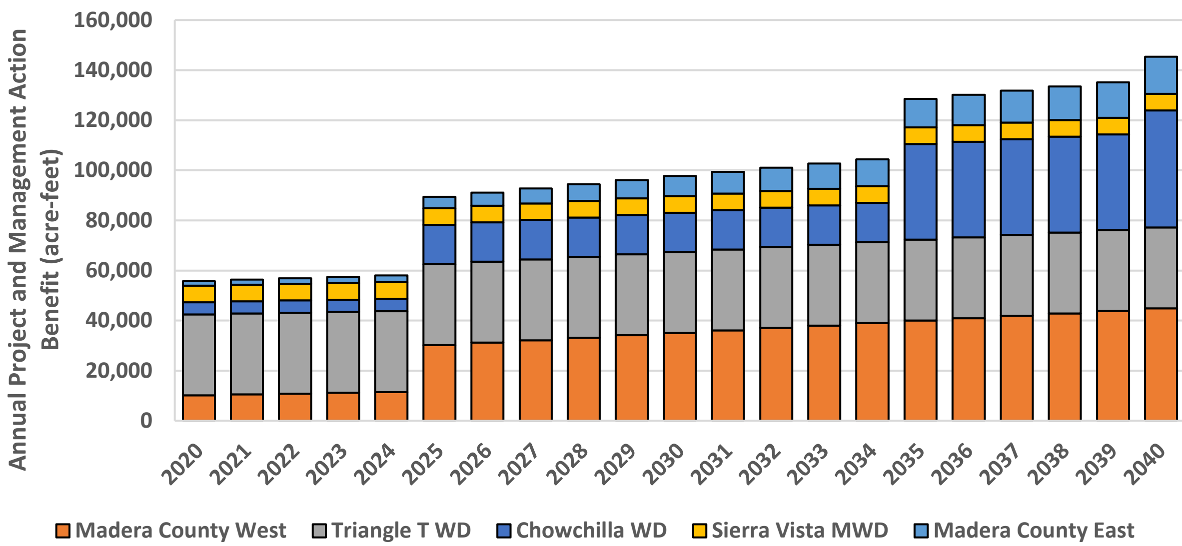

Figure 5-2. Chowchilla Subbasin Project Gross Benefit Timeline.[1]

[1] Costs shown do not reflect any updates or changes to projects, management actions, or planned GSP implementation activities identified since January 2020. Updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.

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 5-2). The annual gross benefit increases until it nearly reaches the projected shortfall in 2034 and then in 2035 and 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 2035 through 2040 annual gross project benefit values will be revised to reflect actual conditions being realized by the projects and actions implemented to-date, and to assure the Subbasin is able to meet the sustainability objective. The capital cost of each project and management action is summarized and discussed in more detail in Chapter 4. **Figure 5-3** 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 $254 million. The GSP implementation plan includes significant outlays when large recharge and storage projects are planned for development by multiple GSAs. These capital costs do not include the cost of developing the Madera County GSA demand management program or the cost of demand management (economic impacts from land idling and crop switching) under that program.

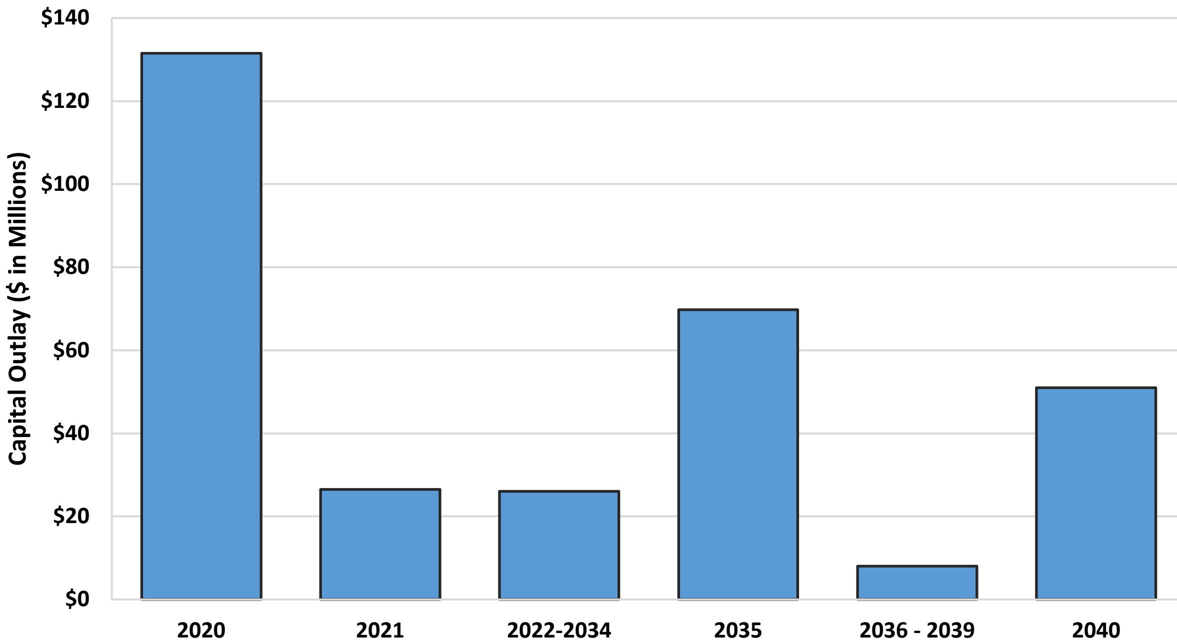

Figure 5-3. Chowchilla Subbasin Estimated Capital Outlay for Projects Only.[1]

[1] Costs shown do not reflect any updates or changes to projects and management actions since January 2020. Updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.

As projects are implemented, GSAs will incur additional operation and maintenance (O&M) costs. **Figure 5-4** 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 $6.5 million per year in 2020 to over $12 million per year by 2040. Project costs will be refined by GSAs as the GSP is implemented. GSA implementation costs total about $1.05 million per year.

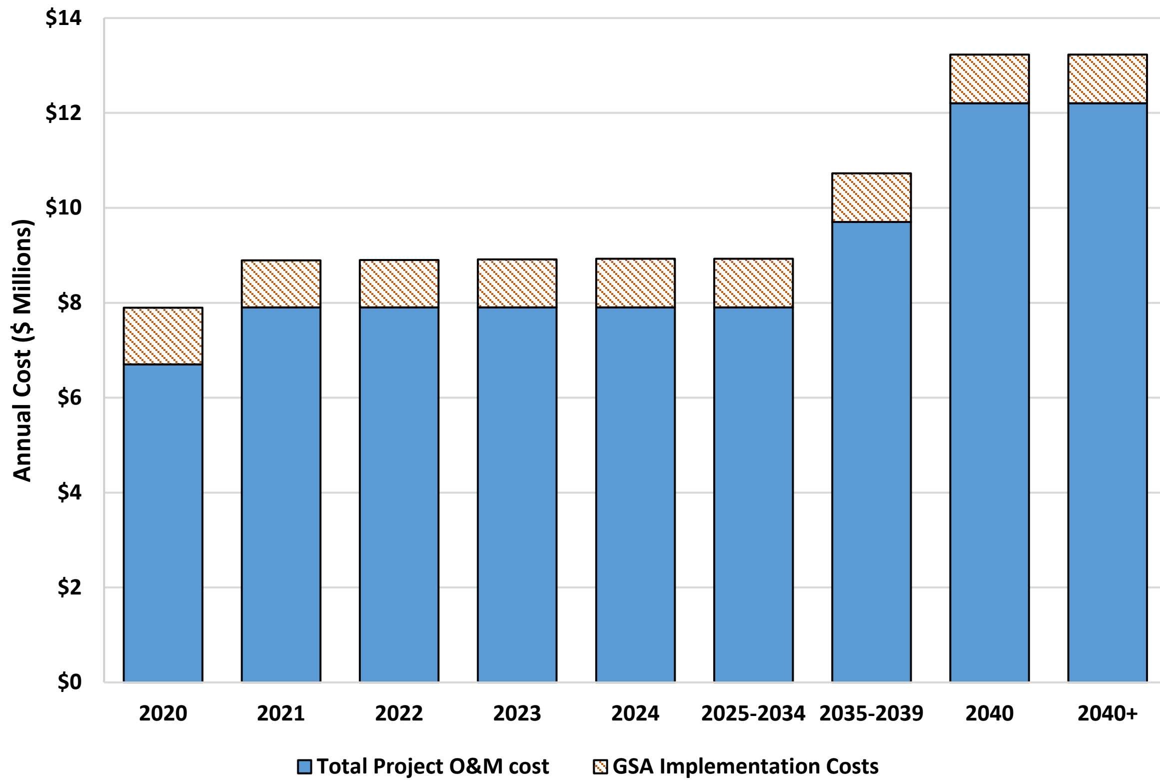

Figure 5-4. Chowchilla Subbasin Estimated Annual Costs for Project O&M and GSA Implementation.[1]

[1] Costs shown do not reflect any updates or changes to projects, management actions, or planned GSP implementation activities identified since January 2020. Updates since January 2020 are documented in the Chowchilla Subbasin GSP Annual Reports. Changes will be reported in the five-year GSP update.

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 §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 to complete the annual report and will incur joint and individual costs in the process. 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

The following subsections provide a general outline of what information will be provided in the annual report. The annual report provided to DWR will fully comply with the requirements of §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 principal 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 IMs 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 periodic evaluation to summarize GSP implementation, whether the GSP is meeting 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 periodic evaluation required by §356.4 is provided in the following subsections.

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 IMs 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 implementation timelines compared to the proposed timeline (Figure 5-1) 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 periodic evaluation. 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 periodic evaluation.

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 periodic evaluations. Any proposed revisions will be documented in the periodic evaluation.

5.6.2 Monitoring Network Description (23 CCR § 356.4l)

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 data gaps will be identified in future GSP updates. The periodic evaluations 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 GSP 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 sustainability goals 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 periodic evaluation will include a summary of state laws and regulations or local ordinances related to the GSP that have been implemented since the previous periodic evaluation 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 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 periodic evaluation. This will also include a summary of amendments that are being considered or developed at that time. Any changes to the basin setting, MOs, MTs, or undesirable results will be described.

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 an amended GSP.

5.7 Data Management System (23 CCR § 352.6)

The Chowchilla 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 5-5**). 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)

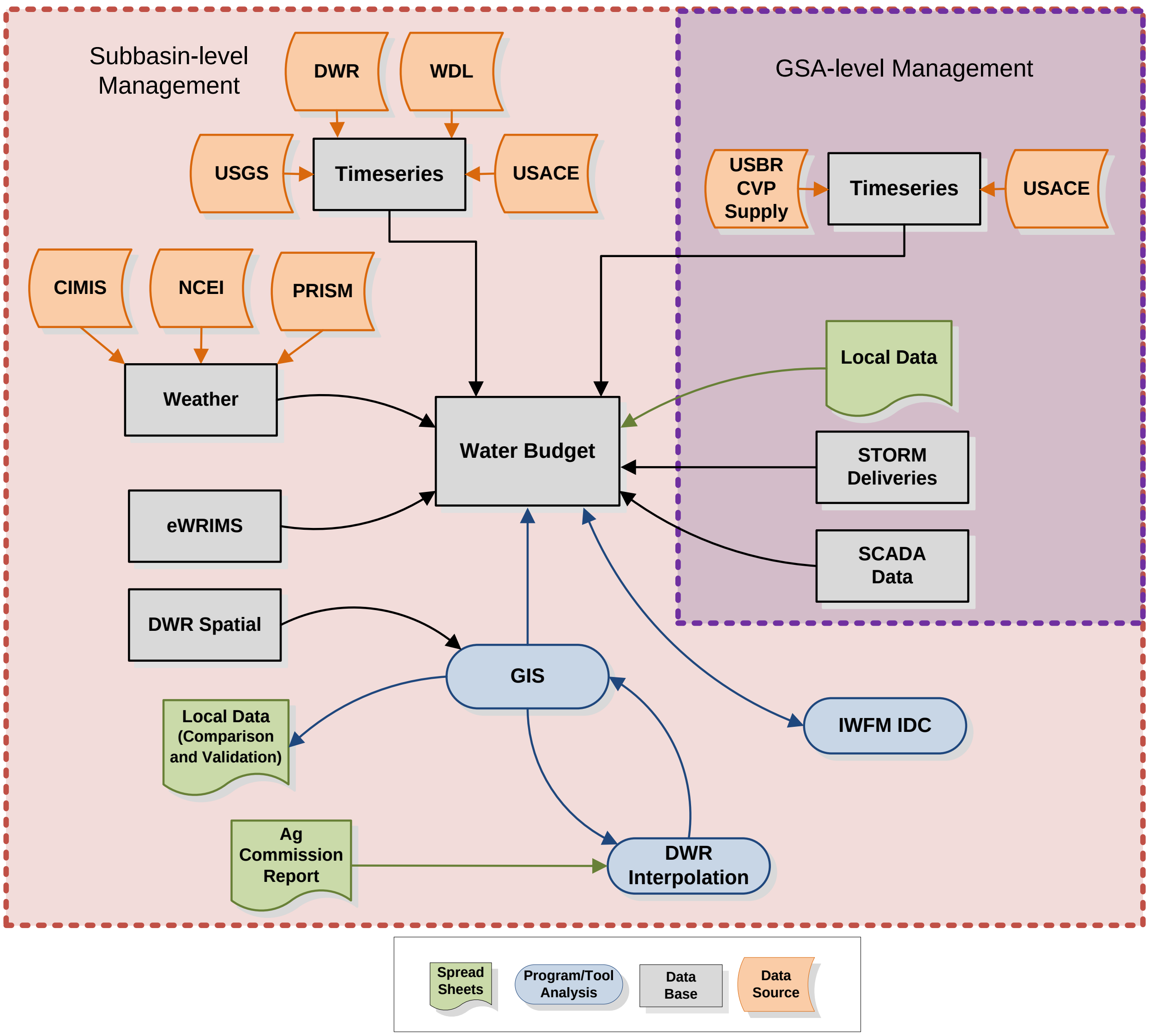

Figure 5-5. Chowchilla Subbasin Data Management System Structure.

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)
- **STORM Deliveries**: CWD deliveries data managed in a database structure and used to quantify surface water supply utilized for irrigation
- **SCADA Data**: CWD SCADA data managed in a database structure and used to quantify spillage from the CWD Conveyance System and inflows to the Rivers and Streams System

Data that is managed at the GSA-level is provided in further detail for each individual GSA in **Figure 5-6**. All GSAs will manage data related to GSP project implementation within their boundaries. CWD GSA additionally manages: time series data related to CVP supply received from Madera Canal (USBR records) and Buchanan Dam releases (USACE records), monthly water supply reports, crop data within their service area, well information, deliveries, spillage, and water rights credits/usage. TTWD GSA additionally manages: deliveries records from one or more San Joaquin River Exchange Contractors outside the Subbasin, crop data within their service area, and well depths. 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 periodic evaluations can be queried and provided to DWR.

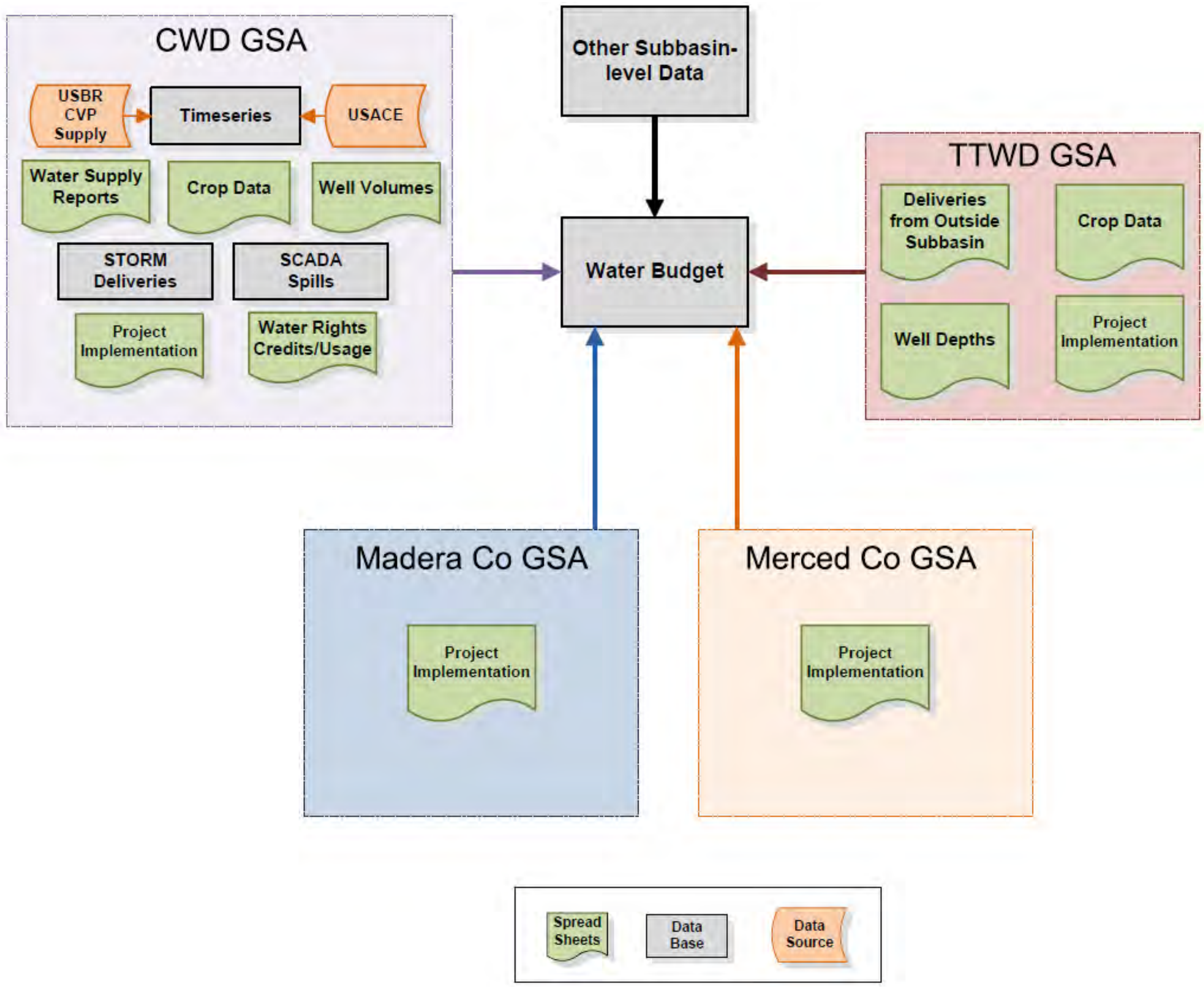

Figure 5-6. GSA-Level Data Management Structure.

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