Final Draft for Public Review

KCS

Kern County Subbasin
Groundwater Sustainability Agencies

GROUNDWATER SUSTAINABILITY PLAN

This page intentionally left blank.

TABLE OF CONTENTS

Table 1. Subbasin Plan GSPs

GSP Name	Area (acres)	Percentage of Subbasin Area	GSA	GSP Content
Kern Subbasin GSP	1,205,482	67.6%	Arvin GSA Cawelo Water District GSA Kern Groundwater Authority GSA Kern River GSA Kern Water Bank GSA Greenfield County Water Districts GSA North Kern WSD GSA Pioneer GSA Rosedale-Rio Bravo WSD GSA Shafter-Wasco ID GSA Southern San Joaquin MUD GSA Tejon-Castac Water District GSA West Kern Water District GSA Wheeler Ridge-Maricopa GSA	Kern Subbasin GSP
Buena Vista WSD GSA GSP	51,070	2.9%	Buena Vista WSD GSA	Kern Subbasin GSP Supplemental GSA information on blue pages identified in Executive Summary
Henry Miller GSA GSP	26,063	1.5%	Henry Miller GSA	
Kern-Tulare Water District GSA GSP	11,344	0.6%	Kern-Tulare Water District GSA	
Olcese Water District GSA GSP	3,199	0.2%	Olcese Water District GSA	
Semitropic Water District GSA GSP	224,350	12.6%	Semitropic Water Storage District GSA	
Westside District Water Authority GSA GSP	260,812	14.6%	Westside District Water Authority GSA	

This page intentionally left blank.

Acronyms and Abbreviations

Acronym or Abbreviation	Definition
1,2,3-TCP	1,2,3-trichloropropane
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter
AB	Assembly Bill
ACSD	Arvin Community Services District
AEWSD	Arvin-Edison Water Storage District
AF	acre-feet
AFY	acre-feet per year
AGR	Agricultural Supply
Al/Fe-	Aluminum- and Iron-Bearing
AOI	Area of Interest
Aqueduct	California Aqueduct
AWG	Attorney Working Group
AWMP	Agricultural Water Management Plans
bgs	below ground surface
BLM	Bureau of Land Management
BMP	Best Management Practice
bmsl	Below Mean Sea Level
BMWD	Berrenda Mesa Water District
BO	biological opinion
BVARA	Buena Vista Aquatic Recreation Area
BVC	Buena Vista Coalition
BVWSD	Buena Vista Water Storage District
C2VSim	California Central Valley Groundwater-Surface Water Simulation Model
C2VSimFG-Beta	C2VSim Fine Grid Public Beta model
C2VSimFG-Kern	C2VSim Fine Grid - Kern
C&E	Communications and Engagement Plan
CA	California
CAF	Confined Animal Facility
CalGEM	California Geologic Energy Management Division
CalOES	California Office of Emergency Services
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CASP	California Aqueduct Subsidence Program
CCED	California Conservation Easement Database
CCR	California Code of Regulations
CDEC	California Data Exchange Center

CDFW	California Department of Fish and Wildlife
CDMG	California Division of Mines and Geology
CE	Categorical Exemption
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGPS	Continuous Global Positioning System
CIMIS	California Irrigation Management Information System
CIWQS	California Integrated Water Quality System
CNRA	California Natural Resources Agency
COB	City of Bakersfield
COC	Constituent of Concern
CPAD	California Protected Areas Database
CPS	Crop Production Services
Cr^{3+}	Trivalent Chromium
Cr^{6+}	Hexavalent Chromium
CSD	Community Services District
CUP	Conditional Use Permit
CVC	Cross Valley Canal
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act of 1992
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternative for Long-Term Sustainability
CWC	California Water Code
CWD	Cawelo Water District
CWDC	Cawelo Water District Coalition
DAC	Disadvantaged Community
DBCP	Dibromochloropropane
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DDW	Division of Drinking Water
DEM	Digital Evaluation Map
DMS	Data Management System
DOGGR	California Division of Oil, Gas, and Geothermal Resources
DPR	California Department of Regulation
DQO	Data Quality Objective
DTSC	California Department of Toxic Substances Control
DTW	depth to water
DW	drinking water

DWR	California Department of Water Resources
EAP	Early Action Plan
ECI	Earth Consultants International
EDB	Ethylene Dibromide
EHS	Environmental Health Services
EIR	Environmental Impact Report
ENCSD	East Niles Community Services District
EO	Executive Order
EOR	Enhanced Oil Recovery
ESA	European Space Agency
ET	evaportranspiration
ETc	crop evapotranspiration
ETo	reference evapotranspiration
ER	Ecological Reserve
EWMA	Eastside Water Management Area
EWMP	Efficient Water Management Practice
FKC	Friant-Kern Canal
Flood-MAR	Flood-Managed Aquifer Recharge
ft	feet
ft/day	feet per day
ft/yr	feet per year
FWA	Friant Water Authority
FWUA	Friant Water Users Authority
GAMA	Groundwater Ambient Monitoring and Assessment Program
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information Systems
GMT	Generic Mapping Tools
GPM	gallons per minute
GPS	Global Positioning System
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWMP	Groundwater Management Plan
GW/SW	Groundwater/Surface Water
HBSL	Health-Based Screening Level
HCM	Hydrogeologic Conceptual Model
HEC-RAS	Hydrological Engineering Center - River Analysis System
HMWD	Henry Miller Water District
HR	Hydrologic Region
HR2W	Human Right to Water
ID	Irrigation District

ID4	Improvement District 4
IDC	IWFM Demand Calculator
ILRP	Irrigated Lands Regulatory Program
IM	Interim Milestone
IND	Industrial Service Supply
InSAR	Inferometric Synthetic-Aperture Radar
IPUMS	Integrated Public Use Microdata Series
IRWMP	Integrated Regional Water Management Plan
IS	Initial Study
ISW	Interconnected Surface Water
IRWM	Integrated Regional Water Management Plan
ITRC	Irrigation and Training Research Center
IWFM	Integrated Water Flow Model
JPA	Joint Powers Agreement
JPL	Jet Propulsion Laboratory
KCDEH	Kern County Department of Environmental Health
KCEHS	Kern County Environmental Health Services
KCWA	Kern County Water Agency
KDWD	Kern Delta Water District
KEDF	Kern Economic Development Foundation
Kern Fan	Kern Alluvial Fan
KFMC	Kern Fan Monitoring Committee
KGA	Kern Groundwater Authority
KGET	Kern Golden Empire Television
KNDLA	Kern Non-Districted Land Authority
KRGSA	Kern River Groundwater Sustainability Agency
KRWCA	Kern River Watershed Coalition Authority
KTWD	Kern Tulare Water District
KWB	Kern Water Bank
KWBA	Ker Water Bank Authority
KWC	Kern Water Collaborative
LANDSAT	Land Remote-Sensing Satellite
LBL	Lawrence Berkeley National Laboratory
LHWD	Lost Hills Water District
LLNL	Lawrence Livermore National Laboratory
LOI	Letter of Intent
LSCE	Luhdorff & Scalmanini Consulting Engineers
LUST	Leaking Underground Storage Tank
M&I	Municipal and Industrial
MA	Management Area
MAF	million acre-feet

Mc	Fanglomerate
MCL	Maximum Contaminant Level
MCWD	Mettler Country Water District
MDB&M	Mount Diablo Base and Meridian
METRIC	Mapping of Evapotranspiration with Internal Calibration
mg/l	milligrams per liter
MGD	million gallons per day
MGSA	McFarland Groundwater Sustainability Agency
MHI	Median Household Income
MIT	Mechanical Integrity Test
MND	Mitigated Negative Declaration
MO	Measurable Objective
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MP	Mile Post
MWELO	Model Water Efficient Landscape Ordinance
msl	mean sea level
MT	Minimum Threshold
MTBE	Methyl Tert Butyl Ether
MUD	Municipal Utilities District
MUN	Municipal and Domestic Supply
NASA	National Aeronautics and Space Administration
NCCAG	Natural Communities Commonly Associated with Groundwater
NCK	North Central Kern
ND	Negative Declaration
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NH_3	ammonia
NHD	National Hydrography Dataset
NHI	Nitrate Hazard Index
NKWSD	North Kern Water Storage District
NL	Notification Levels
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NOE	Notice of Exemption
NORMWD	North of the River Municipal Water District
NORSD	North of River Sanitary District
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSF	National Sanitation Foundation

NW	northwest
NWIS	National Water Information System
O&G	Oil and Gas
O&M	Operations and Maintenance
OCAP	Operational Criteria and Plan
OCPS	Organochlorine Pesticides
OMWC	Oildale Mutual Water Company
OPPS	Organophosphorus Pesticides
OSWCR	Online System of Well Completion Reports
OWD	Olcese Water District
P&O	Prioritization & Optimization
P/MA	Projects/Management Actions
PAHs	polynuclear aromatic hydrocarbons
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PCBS	Polychlorinated Biphenyls
PCE	Tetrachloroethylene
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanoic Sulfonate
ppb	parts per billion
ppt	parts per trillion
PRC	Public Resources Code
PRO	Process Supply
PUC	Public Utilities Commission
PUD	Public Utilities District
QA/QC	Quality Assurance/Quality Control
QGIS	Quantum Geographic Information System
PWRPA	Power and Water Resources Pooling Authority
R&R	Recapture & Recirculation
RRID	Rosedale Ranch Irrigation District
RRBWSD	Rosedale-Rio Bravo Water Storage District
RMS	Representative Monitoring Sites
RMS-LS	Representative Monitoring Site for Land Subsidence
RMW	Representative Monitoring Well
RMW-WL	Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WQ	Representative Monitoring Well for Degraded Water Quality
ROW	Right-of-Way
RPE	Reference Point Elevation
RPW	Recycled Produced Water
RWA	Recovered Water Account
RWQCB	Regional Water Quality Control Board

SAFER	Safe and Affordable Funding for Equity and Resilience Program
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCEP	Stakeholder Communication and Engagement Plan
SDAC	Severely Disadvantaged Community
SDFAR	Socially Disadvantaged Farmers and Ranchers
SDWA	Safe Drinking Water Act
SDWIS	State Drinking Water Information System
SGM	Sustainable Groundwater Management
SGMA	Sustainable Groundwater Management Act
SHE	Self-Help Enterprises
SJRRP	San Joaquin River Restoration Program
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMARA	California Surface Mining and Reclamation Act
SMCs	Sustainable Management Criteria
SMCL	Secondary Maximum Contaminant Level
SO_4	Sulfate
SOCs	Synthetic Organic Compounds
SOKR	South of Kern River
SOP	Standard Operating Procedures
SOPAC	Scripps Orbit and Permanent Array Center
SpC	Specific Conductance
SSB	Southern Sierran block
SSJMUD	Southern San Joaquin Municipal Utility District
SSURGO	Soil Survey Geographical Database
Subbasin	Kern County Subbasin
SWID	Shafter-Wasco Irrigation District
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWSD	Semitropic Water Storage District
TAF	thousand acre feet
TBA	Tert-butyl Alcohol
TCE	Trichloroethylene
TCWD	Tejon-Castac Water District
TD	total depth
TDS	Total Dissolved Solids
TNC	The Nature Conservancy
TPH	Total Petroleum Hydrocarbons
TWG	Technical Working Group
UAVSAR	Unmanned Aerial Vehicle Synthetic Aperture Radar
UC	University of California

UCANR	University of California Agriculture and Natural Resources
UIC	Federal Underground Injection Control
UNAVCO	University NAVSTAR Consortium
UR	Undesirable Result
URF	Unreleased Restoration Flows
USACE	United States Army Corp of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDW	Underground Source of Drinking Water
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
UST	Underground Storage Tank
UWMP	Urban Water Management Plans
UWUO	Urban Water Use Objectives
VIC	Variable Infiltration Capacity Model
VOCs	Volatile Organic Compounds
W&C	Woodard and Curran
WAKC	Water Association of Kern County
WCR	Well Completion Report
WD	Water District
WDL	Water Data Library
WDR	Waste Discharge Requirements
WDWA	Westside Districts Water Authority
WFB	West-Side Fold Belt
WKWD	West Kern Water District
WL	Water Level
WQ	Water Quality
WRMWSD	Wheeler-Ridge Maricopa Water Storage District
WSD	Water Storage District
WSCP	Water Shortage Contingency Plans
WSIP	Water Supply Investment Program
WTP	Water Treatment Plant
WWA	Westside Water Authority
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant
WY	Water Year

EXECUTIVE SUMMARY

ES.1. Introduction

On 16 September 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) for the primary purpose of achieving and maintaining sustainability within the State's high and medium priority groundwater basins. Key tenets of SGMA are preservation of local control, use of best available data and science, and active engagement and consideration of all beneficial uses and users of groundwater. SGMA requires local agencies to form Groundwater Sustainability Agencies (GSAs) tasked with managing basins sustainably through the development and implementation of Groundwater Sustainability Plans (GSPs). Under SGMA, GSPs must contain certain elements, the most significant of which include: a Sustainability Goal; a description of the area covered by the GSP (i.e., the "Plan Area"); a description of the Basin Setting, including the hydrogeologic conceptual model (HCM), historical and current groundwater conditions, and a water budget; locally-defined Sustainable Management Criteria (SMCs); monitoring networks and protocols for each applicable sustainability indicator; and a description of projects and/or management actions (P/MAs) that will be implemented to achieve or maintain sustainability. SGMA also requires active stakeholder outreach to ensure that all beneficial uses and users of groundwater have the opportunity to provide input into the GSP development and implementation process.

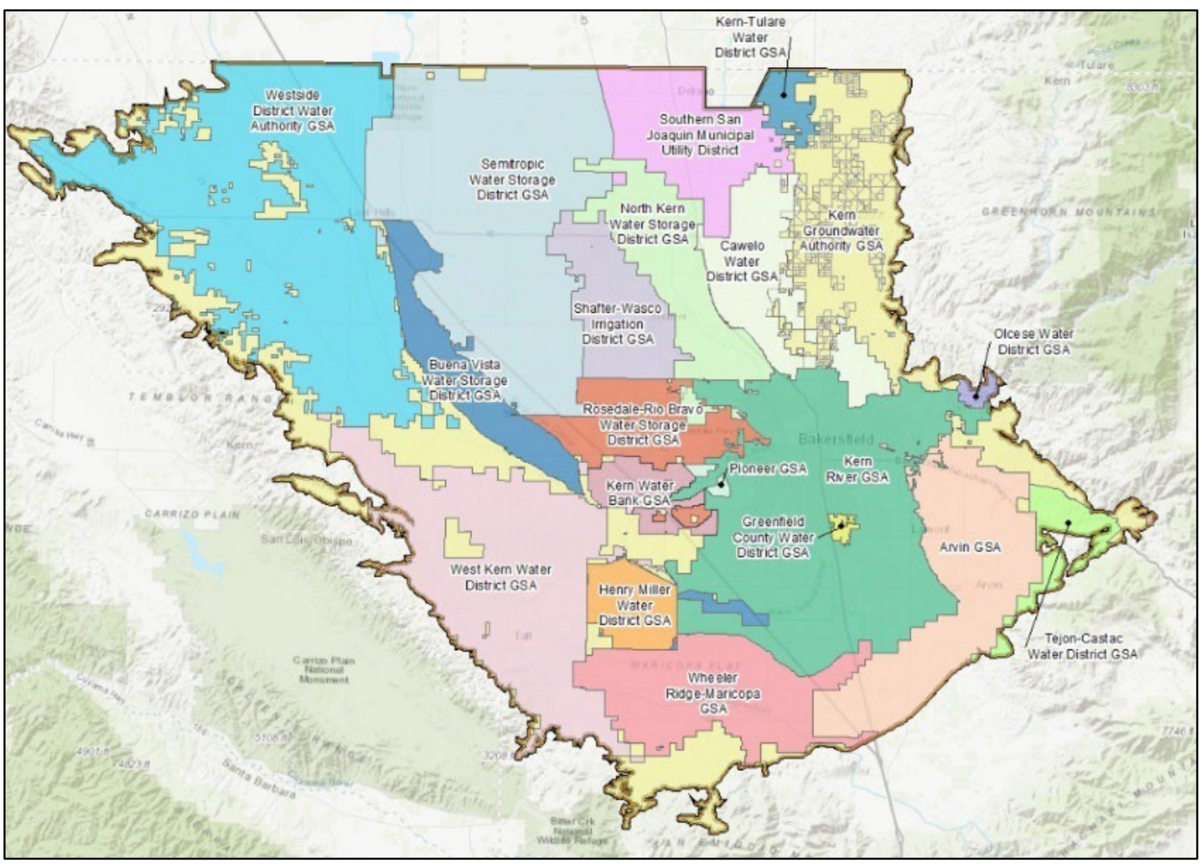


Figure ES-1. Kern County Subbasin GSAs

The Kern County Subbasin of the San Joaquin Valley Groundwater Basin[1] (referred to herein as the "Kern Subbasin" or "Subbasin"; Figure ES-1) is one of 21 basins and subbasins identified by the California Department of Water Resources (DWR) as being critically overdrafted. This designation triggered an accelerated timeline for GSP development by 2020 and long-term sustainability by 2040.

In compliance with this timeline, the Subbasin GSAs submitted five GSPs (collectively the "Plan") to DWR in January 2020 (2020 GSPs). DWR designated the Plan as "incomplete" in January 2022 and identified three main deficiencies with the Subbasin Plan. In July 2022, the GSAs amended and resubmitted six GSPs to DWR to address the identified deficiencies (2022 GSPs). In March 2023, DWR designated the Plan as "inadequate" after reviewing the 2022 GSPs. As a result, the Subbasin is subject to the state intervention process defined in SGMA regulations and under California Water Code (CWC) § 10735 *et seq*. The first formal step of the state intervention process would be a public hearing convened by the State Water Resources Control Board (SWRCB) to consider designating the Subbasin as probationary based on any specific deficiencies in its Plan that remain unresolved at the time of hearing.

Intra-Basin Coordination
Subbasin GSAs have implemented intra-basin coordination activities, including greater engagement regarding the development, planning, financing, environmental review, permitting, implementation, and long-term monitoring of GSP activities.

Technical Working Group (TWG)
In May 2023, the Subbasin GSAs assembled the TWG to produce Subbasin-wide technical solutions to address DWR deficiencies. The TWG meets weekly to discuss work products and to develop technical recommendations.

In response to the DWR determination, the 20 Subbasin GSAs worked together to develop amendments to the 2022 GSPs and accompanying Coordination Agreement, resulting in this "Amended Subbasin Plan", which has been designed to meet the SGMA regulatory requirements, respond to the three deficiencies identified by DWR, address comments provided by SWRCB staff during technical meetings, and increase coordination among the Subbasin GSAs, other local agencies, and stakeholders.[2] The Amended Subbasin Plan provides a clear and coordinated path to achieve sustainable groundwater management.

Revisions made in response to DWR's Corrective Actions are highlighted throughout the Executive Summary using icons specific to each deficiency and are further detailed in the "crosswalk" Table 1-3 in Section 1 and the relevant sections of the Amended Subbasin Plan.

Deficiency #1: The GSPs do not establish Undesirable Results (URs) that are consistent for the entire Subbasin.

[1] Kern County Subbasin (DWR No. 5-022.14) located within San Joaquin Valley Groundwater Basin (DWR No. 5-022).
[2] The Amended Subbasin Plan is being submitted as multiple plans with a Coordination Agreement. The Kern Subbasin GSP is being adopted by fourteen (14) GSAs, which collectively manage the majority of the Subbasin (67.6 percent). Six (6) GSAs are each separately adopting a version of the Kern Subbasin GSP that includes supplemental information specific to the portion of the Subbasin it manages. This supplemental information is provided on blue pages so differences between the versions can be readily identified by reviewers.

Deficiency #2: The Subbasin's Chronic Lowering of Groundwater Levels Sustainable Management Criteria (SMCs) do not satisfy the requirements of SGMA and the GSP Regulations.

Deficiency #3: The Subbasin's Land Subsidence SMCs do not satisfy the requirements of SGMA and the GSP Regulations.

In addition to revisions that were made to address the DWR Corrective Actions, the GSAs updated this Amended Subbasin Plan to incorporate current data and information and made revisions that address feedback received during the nine technical meetings with SWRCB staff or other comments in DWR's determination letter. These revisions are noted in this Executive Summary using the icon shown below and are further detailed in the "crosswalk" Table 1-2 in Section 1 and the relevant sections of the Amended Subbasin Plan.

Additional Revision: Revision to incorporate new data or information or respond to DWR and SWRCB comments that were not identified as Corrective Actions.

ES.2. Sustainability Goal

The Subbasin GSAs share a common groundwater management Sustainability Goal for the Subbasin, which is foundational to the development and implementation of the Amended Subbasin Plan. The sustainability goal for the Kern County Subbasin is to implement the Amended Subbasin Plan to achieve sustainable groundwater management within the 20-year implementation schedule. Achieving the sustainability goal will be demonstrated by eliminating chronic lowering of groundwater levels caused by overdraft conditions and avoiding Undesirable Results for groundwater levels, groundwater storage, land subsidence, and groundwater quality. This goal will be accomplished through the following objectives:

- Implement the Subbasin Community Engagement Plan.
- Eliminate long-term groundwater overdraft and attain sustainability through conjunctive use, water banking, and demand management programs.
- Continuously monitor and evaluate groundwater conditions to avoid undesirable results.
- Maintain long-term sustainability of water resources available to the Subbasin.
- Maintain a comprehensive database of beneficial uses and users to inform on the efficacy of groundwater management policies and programs.

ES.3. Agency Information

The Amended Subbasin Plan has been prepared by 20 GSAs and one coordinated groundwater management area. Each GSA applied for and was granted exclusive GSA status for a portion of the Subbasin under CWC §10723(c) and §10723.8. The Coordination Agreement establishes the governance structure for the GSAs' cooperative and coordinated exercise of authorities and responsibilities under SGMA. Each GSA has designated representative(s) to help lead or participate in coordination activities among Subbasin GSAs, State agencies, local governments, local water suppliers, neighboring entities, non-governmental organizations, and other stakeholders. Pursuant to 23 CCR §357.4(b)(1), a single Subbasin "Plan Manager" (Point of Contact) has been established as shown in Table ES-1, for the purposes of organizing the various coordination and Technical Working Group (TWG) activities and ensuring cohesion between GSA activities.

Table ES-1. Plan Manager Contact Information

Plan Manager	E-mail	Phone
Kristin Pittack	kpittack@rinconconsultants.com	559-228-9925 (O) 760-223-5062 (C)

ES.4. GSP Organization

The Amended Subbasin Plan details and consolidates the GSAs' plans for achieving long-term sustainability in the Subbasin. The Amended Subbasin Plan also addresses DWR's inadequate determination and feedback provided by the SWRCB staff. It follows the organizational structure required under the GSP regulations, including Introduction (Section 1), Sustainability Goal (Sections 2 and 12), Agency Information (Section 3), GSP Organization (Section 4), Description of Plan Area (Section 5), Basin Setting (Sections 6 through 9), Management Areas (Section 10), Sustainable Management Criteria (Sections 11 through 13), Projects and Management Actions (Section 14), Monitoring Networks (Section 15), and Plan Implementation (Section 16). Several figures, tables, and sources are provided which outline the GSAs' analyses and review that was used to formulate the implementation actions and the planned P/MAs to achieve the Sustainability Goal.

ES.5. Plan Area

The 1.78-million-acre Subbasin covers a large portion of the southern end of the Tulare Lake Hydrologic Region, including most of the San Joaquin Valley area within Kern County. As shown on Figure ES-2, the Subbasin neighbors four separate and distinct groundwater subbasins: (1) the Tulare Lake Subbasin (DWR 5-022.12), (2) the Tule Subbasin (DWR 5-022-13), (3) the Kettleman Plain Subbasin (DWR 5-022.17), and (4) the White Wolf Subbasin (DWR 5-022.18), all also located within the San Joaquin Valley Groundwater Basin. The Tulare Lake and Tule subbasins are similarly categorized as "high priority" and "critically overdrafted" by DWR. The adjacent Tulare Lake, Tule, and White Wolf subbasins are each managed according to separate GSPs and SGMA-related activities but the Subbasin GSAs have consulted with

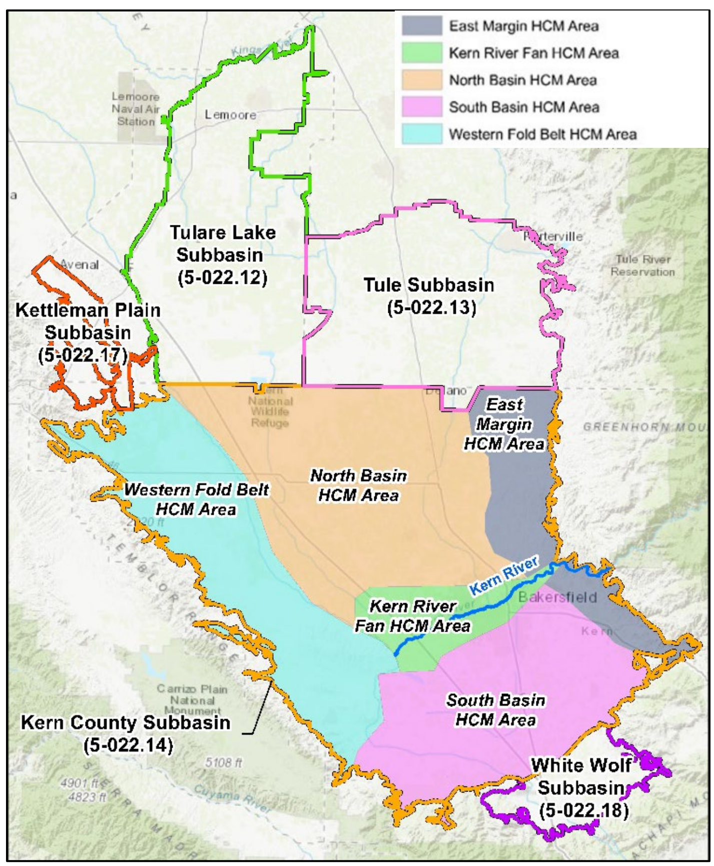


Figure ES-2. HCM Areas and Adjacent Subbasins

these subbasins to coordinate cross-boundary interactions (e.g., accounting for groundwater subsurface inflows and outflows and evaluating consistency of SMCs).

For purposes of this Amended Subbasin Plan, the Subbasin has been separated into five HCM areas that are characterized by specific geologic and hydrogeologic attributes that dictate land and water uses in the area. The HCM areas include the Western Fold Belt, East Margin, Kern River Fan, North Basin (North of Kern River Fan), and South Basin (South of Kern River Fan), as shown on Figure ES-2.

As shown on Figure ES-3, the 1.78 million acres of land within the Subbasin (the "Plan Area") are predominately irrigated agriculture, including a diverse array of crop types dictated largely by the economics of private farming and water supply availability. Actively cropped agricultural lands encompass around 644,000 acres of the Subbasin, or approximately 36 percent of the total area. Roughly 15 percent of the Plan Area includes idle agricultural lands not actively irrigated (256,000 acres), another eight percent includes urban, suburban, and rural communities (81,000 acres), five percent of lands are industrial oil fields (159,000 acres), and the remaining 36 percent of land uses include native and riparian vegetation, refuge, recharge basins, and other land uses. Water demands are met with diversions from the Kern River and other local creeks, imported surface water from the State Water Project (SWP) and Central Valley Project (CVP), groundwater, and in more recent years, recycled water.

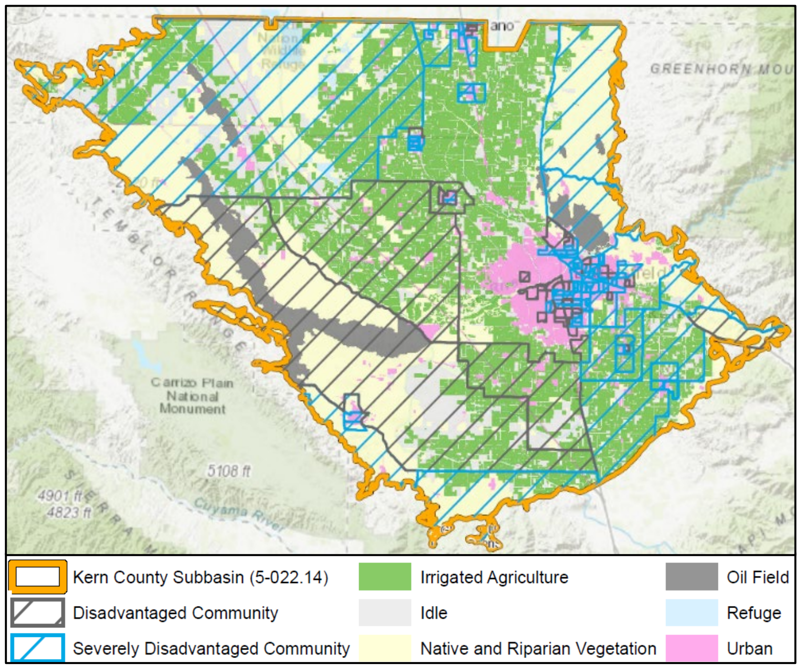


Figure ES- 3. Land Use and Disadvantaged Communities

The Subbasin is completely contained within Kern County and includes eight incorporated cities (Arvin, Bakersfield, Delano, Maricopa, McFarland, Shafter, Taft, and Wasco) as well as numerous unincorporated communities (census designated places), including: Buttonwillow, Cherokee Strip, Derby Acres, Dustin Acres, Edison, Edmundson Acres, Famoso, Fellows, Ford City, Fuller Acres, Greenacres, Greenfield, Lamont, Lost Hills, McKittrick, Mettler, Mexican Colony, Oildale, Rosedale, Smith Corner, South Taft, Taft Heights, Tupman, Valley Acres, and Weedpatch, as shown on Figure 5-8 in Section 5.

Disadvantaged communities (DACs) or severely disadvantaged communities (SDACs) identified based on the median household income (MHI) of the area compared to the statewide MHI, cover approximately 1.445 million acres, or 81 percent of the Subbasin.

ES.6. Basin Setting - Hydrogeologic Conceptual Model

Situated within the topographic horseshoe that is bordered on the east and southeast by the Sierra Nevada, on the west by the Southern Coast Ranges, and on the south by the San Emigdio and Tehachapi Mountains, the Subbasin is large and geologically complex with regional faulting, folding, and three principal aquifers.

The three principal aquifers within the Subbasin include the Primary Alluvial Principal Aquifer, the Santa Margarita Principal Aquifer, and the Olcese Principal Aquifer. The Primary Alluvial Principal Aquifer extends over most of the Subbasin and consists of the Tulare and Kern River Formations plus the overlying recent alluvium. It exhibits varying groundwater conditions and is classified as confined in areas with laterally extensive clay aquitards, semiconfined where vertical flow is impeded, and unconfined in various portions of the Subbasin. The Primary Alluvial Principal Aquifer is the most productive freshwater aquifer and the source of nearly all groundwater used within the Subbasin. The Santa Margarita Principal Aquifer is a confined unit located in the northeastern portion of the Subbasin and is comprised of both the Santa Margarita Formation and Olcese Sand. The Olcese Principal Aquifer is a confined unit located in the vicinity of where the Kern River enters the eastern portion of the Subbasin and consists of the Olcese Sand.

The Subbasin contains several surface water features. The Kern River is the largest river in the Subbasin and flows east to west through the center of the Subbasin, as shown on Figure ES-2. The Subbasin also contains significant infrastructure that conveys imported water supplies, including the Friant-Kern Canal, California Aqueduct, and local canals.

Significant direct recharge in the Subbasin occurs through managed conjunctive use projects and water banking (storage) projects along the Kern River and in other areas of the Subbasin. The conjunctive use projects are dedicated to the replenishment of the Subbasin, while the water banking projects store surplus surface water supplies from the SWP, CVP, Kern River, and other flood waters for subsequent recovery for beneficial uses. [3]

A series of hydrogeologic cross-sections have been developed to illustrate the Subbasin physical characteristics and the formations present in the Plan Area. An example cross section is provided on Figure ES-4 to illustrate the conditions parallel to the southern Subbasin boundary. Cross sections for other portions of the Subbasin are shown in Section 7. This example shows the prevalence of Tulare and Kern River Formations, with the Santa Margarita Formation and Olcese Sand shallowing in the East Margin, and the extent of clay layers which tend to dictate groundwater percolation and lateral flows. The cross sections developed improve understanding of Subbasin conditions across the HCM Areas and provide the information necessary to develop water budgets from the Subbasin's local numerical model, establish representative monitoring networks, develop applicable SMCs, and effectively convey hydrogeologic conditions to stakeholder groups.

---

[3] "The storing of water underground … constitutes a beneficial use of water if the water so stored is thereafter applied to the beneficial purposes for which the appropriation for storage was made." CWC § 1242.

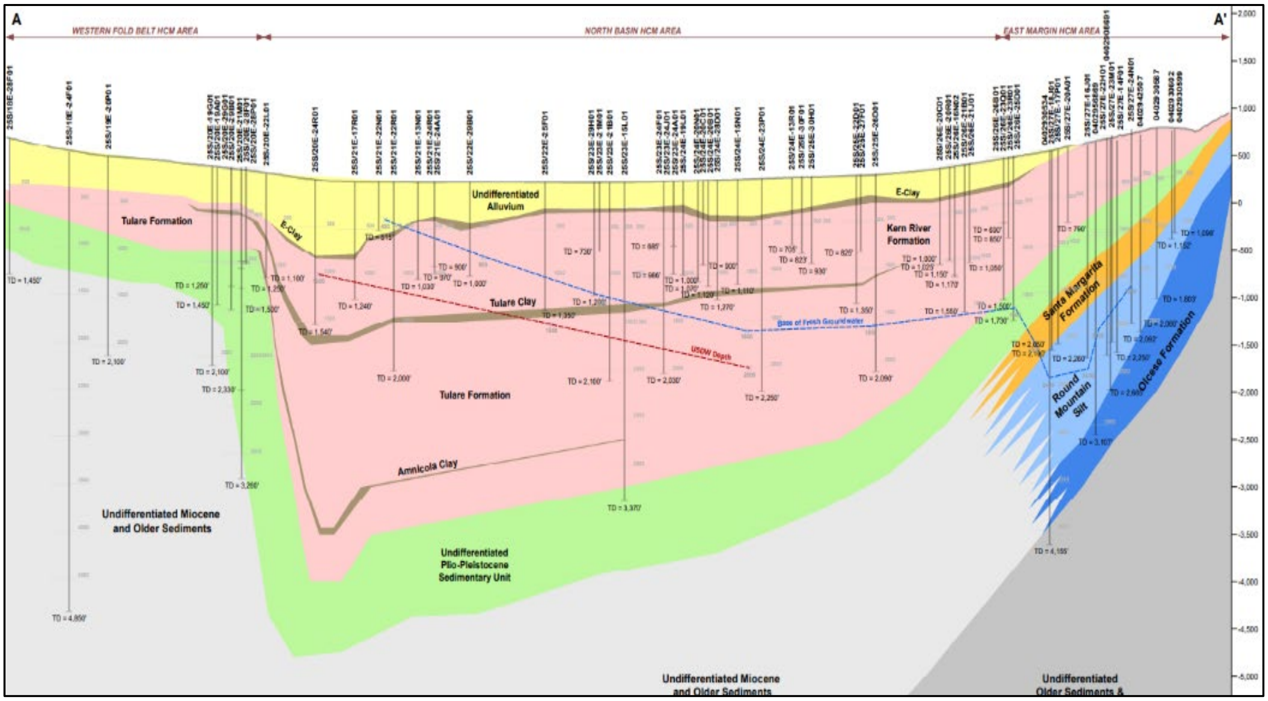


Figure ES-4. Subbasin Cross Section

ES.7. Basin Setting - Current and Historical Groundwater Conditions

Information on the Subbasin's current groundwater conditions with respect to the SGMA-defined "Sustainability Indicators" are presented in the Amended Subbasin Plan and summarized below.

Groundwater Levels: Groundwater levels within the Subbasin are presented using contour maps depicting the current (2023) seasonal high and seasonal low for each principal aquifer (Primary Alluvial Principal Aquifer, Santa Margarita Principal Aquifer, and Olcese Principal Aquifer) and hydrographs for various wells across the Subbasin depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers. The available data indicate that the Kern River effectively bisects the Plan Area (as shown in Figure ES-2) and acts as a groundwater divide whereby groundwater tends to diverge from the river, with groundwater north or south of the river flowing toward extraction areas. Relative highs and lows appear to be controlled, at least in part, by the distribution of groundwater pumping and surface water deliveries. Hydrographs show the long-term positive effects of surface water importation and managed aquifer recharge and water banking activities in raising groundwater levels, tempered by the effects of the recent severe droughts.

Groundwater Storage: Changes in groundwater storage over selected time periods were calculated from the Subbasin's local numerical model (C2VSimFG-Kern) and validated through a groundwater storage calculation that considers changes in measured groundwater elevations across the Subbasin. The estimated total usable storage in the Primary Alluvial Principal Aquifer ranges from 90 to 260 million acre-feet (AF). The change in groundwater storage over the historical and current water budget periods of Water Years (WYs) 1995-2023 generally corresponds with the variation in climatic conditions and surface water supply availability. The most significant annual changes in overall storage have historically occurred in the Subbasin's water banking areas where significant surface water storage occurs in wet years, and significant recovery pumping occurs in dry years.

Groundwater Quality: Certain constituents of concern (COCs) have been identified in the Subbasin above drinking water standards and/or agricultural water quality goals. The Subbasin employed the SWRCB's methodology for identifying COCs from State and Regional Water Board datasets, and assessed the following constituents: 1,2,3-trichloropropane (1,2,3-TCP), arsenic, benzene, dibromochloropropane (DBCP), ethylene dibromide (EDB), gross alpha radiation, nitrate (as N), nitrate + nitrite (as N), nitrite (as N), perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), selenium, total dissolved solids (TDS), and uranium. A potential correlation with groundwater elevations and/or groundwater pumping has been identified in some localized areas of the Subbasin for 1,2,3-TCP, arsenic, and nitrate. The GSAs have identified several Representative Monitoring Wells for Degraded Water Quality (RMWs-WQ) to collect coincident groundwater elevation and groundwater quality data in these areas to better understand the relationship between COC concentrations and groundwater management in the future. SMCs have been established for a subset of the COCs assessed (arsenic, nitrate, nitrite, nitrate + nitrite, TDS, 1,2,3-TCP, and uranium).

Land Subsidence: Land subsidence has been documented within the San Joaquin Valley over both historical and recent timeframes, with the greatest documented subsidence occurring north of the Subbasin (see Figure ES-5). Land subsidence rates within the Subbasin range from 0 to 0.3 feet per year resulting in a cumulative land subsidence of 0 to 2.41 feet since 2015. Land subsidence caused by factors within the GSAs' authority to manage is due to aquitard depressurization following groundwater withdrawal, which tends to be greater in the areas that rely solely on groundwater for water supply (agricultural and urban pumping) and are underlain by a greater proportion of fine-grained deposits. Additional causes of subsidence that are outside of the GSAs' control, include oil and gas extraction, natural processes (i.e. faulting), expansive soil types susceptible to hydrocompaction, and others (e.g., deficient Aqueduct pre-construction hydro-compaction, age of infrastructure, etc.). Recent technical studies commissioned by the GSAs have been able to differentiate the subsidence signals associated with these other causal factors.

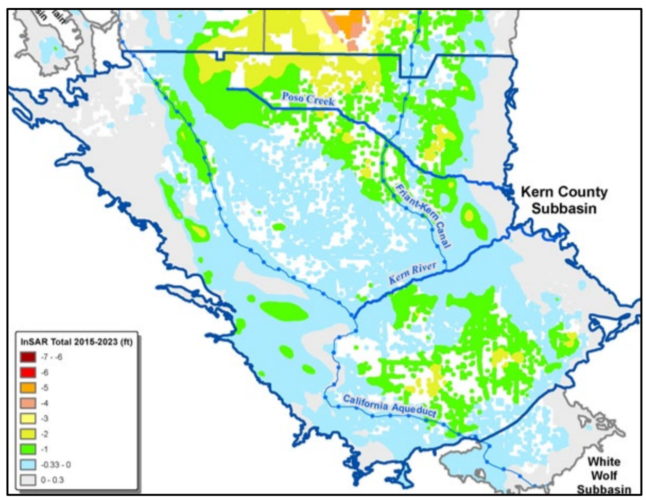


Figure ES-5. Cumulative Subsidence between 2015 – 2023 (ft) based on InSAR data

Land subsidence has the potential to affect Regional Critical Infrastructure (i.e., the California Aqueduct and Friant-Kern Canal) and local GSA Area Critical Infrastructure, including gravity-driven water conveyance systems (canals). To assess subsidence, the Subbasin has conducted a series of studies and continues on-going collaboration and communication with the California Aqueduct Subsidence Program (CASP) and the Friant Water Authority.

Seawater Intrusion: The Subbasin is located far from coastal areas, and therefore seawater intrusion is not considered to be a relevant Sustainability Indicator.

Interconnected Surface Water: Data on depth to groundwater and other local conditions indicate that the vast majority of surface water features in the Subbasin are not connected to groundwater, and in the few limited areas where a connection may occur, the connection is likely transient, short-lived, and involves shallow or perched groundwater that is not part of the principal aquifer systems. As such, the areas of vegetation mapped as Natural Communities Commonly Associated with Groundwater (NCCAG) are not likely groundwater dependent ecosystems (GDEs) but rather supported by irrigation water infiltration and agricultural return flows. In these areas, infiltration of irrigation water and agricultural return flows is impeded by clay soils and subsurface clay sediments creating shallow perched groundwater that is disconnected from groundwater in the principal aquifers that are the focus of SGMA.

ES.8. Basin Setting – Water Budget Information

The GSAs coordinated on the development of a single, coordinated Subbasin-wide water budget presented in this Amended Subbasin Plan using a local numerical model (C2VSimFG-Kern) based on the California Central Valley Groundwater/Surface Water Simulation Model (C2VSim).

The model was extended to incorporate recent conditions and estimate the current water budget over WYs 2015-2023. Modeling results show that the Subbasin, as a whole, had a total storage deficit of approximately 274,200 acre-feet per year (AFY) over the historical period (i.e., WYs 1995-2014) and approximately 344,000 AFY over the current period (i.e., WYs 2015-2023). The Sustainable Yield has been conservatively estimated to be approximately 1.31 million AFY based on results for the historical period using model-calculated groundwater pumping and recharge to quantify the volume of water that, if pumped over the water budget period of interest, would have resulted in zero change in storage.

Water budget information under projected (future) conditions has also been developed for the Subbasin using C2VSimFG-Kern with DWR-provided inputs for climate variables (i.e., adjusted precipitation and evapotranspiration) and water supply assumptions (i.e., changes to imported water supplies). This approach allows for inclusion of more complex variables, including factors influenced by climate change, resulting in more accurate projections. The projected water budget assesses the magnitude of the net water supply deficit under future conditions that would need to be addressed through P/MAs to prevent URs and achieve the Sustainability Goal. Three projected water budget scenarios have been developed for this analysis: (1) a Baseline Scenario, (2) a 2030 Climate Change Scenario, and (3) a 2070 Climate Change Scenario. The P/MAs developed by the Subbasin GSAs have also been incorporated into the C2VSimFG-Kern 2030 Climate Change Scenario input files to evaluate their effectiveness in addressing the projected deficit of 372,000 AFY by 2040 (identified as "With Projects" scenarios in Table ES-2 below). The results in Table ES-2 demonstrate that the planned P/MAs, once fully implemented, provide a reasonable approach to achieve sustainable groundwater management.

There are inherent limitations in using models to predict future conditions given the uncertainties surrounding input variables (e.g., uncertain future hydrologic conditions, recharge, and pumping volumes). A revised Subbasin-wide model is being developed and calibrated as part of Plan implementation and as additional information becomes available through the Basin Study (P/MA KSB-4, see Appendix P).

Table ES-2. Summary of Simulated Change in Groundwater Storage Results

Period / Scenario	General Hydrologic Conditions of Period	Change in Groundwater Storage (acre-feet per year)
Historical Period (WYs 1995-2015)	Average	-274,200
Current Period (WYs 2015-2023)	Dry	-344,019
Projected Period (WYs 2041-2070) Baseline	Average	-324,326
Projected Period (WYs 2041-2070) Baseline with Projects	Average	85,578
Projected Period (WYs 2041-2070) 2030 Climate Change	Average with DWR climate change adjustments	-372,120
Projected Period (WYs 2041-2070) 2030 Climate Change with Projects	Average with DWR climate change adjustments	46,829
Projected Period (WYs 2041-2070) 2070 Climate Change	Average with DWR climate change adjustments	-472,336
Projected Period (WYs 2041-2070) 2070 Climate Change with Projects	Average with DWR climate change adjustments	-45,969

Note: a negative change in groundwater storage indicates a deficit and a positive change in groundwater storage indicates a surplus.

ES.9. Sustainable Management Criteria

SMCs are the metrics by which groundwater sustainability is evaluated under SGMA. Uniform definitions for the following SMC components have been developed in the Amended Subbasin Plan through a coordinated effort of the GSAs.

- **Undesirable Results (URs):** URs are the significant and unreasonable occurrence of conditions, for any of the six Sustainability Indicators (shown in Table ES-3), that adversely affect beneficial uses and users and substantially interfere with surface land uses in the Subbasin.
- **Minimum Thresholds (MTs):** MTs are the numeric criteria for each Sustainability Indicator that, if exceeded in a locally defined combination of monitoring sites, may constitute an UR for that indicator.
- **Measurable Objectives (MOs):** MOs are specific, quantifiable goals for the maintenance or improvement of groundwater conditions. MOs use the same units and metrics as the MTs allowing for direct comparison.
- **Interim Milestones (IMs):** IMs are a set of target values representing measurable groundwater conditions in increments of five (5) years over the 20-year statutory timeline for achieving sustainability.

Table ES-3 summarizes the revised SMCs for each applicable Sustainability Indicator in the Subbasin.

Table ES-3. Summary of Sustainable Management Criteria

Sustainability Indicator	Undesirable Result	Minimum Threshold	Measurable Objective
Chronic Lowering of Groundwater Levels	One of the following occurs: (1) More than 15 drinking water wells are reported dry in any given year. If 15 drinking water wells were impacted every year, no more than 255 drinking water wells cumulatively would be impacted by 2040, or (2) MTs are exceeded in at least 25% of RMW-WLs over a single year (i.e., two consecutive seasonal measurements)	The lower of: (1) Groundwater level in 2030 if the regional trend is extended from the 2015 low (the MO), or (2) Groundwater level that allows for operational flexibility below the 2015 low, based on an RMW-WL-specific record of groundwater level fluctuations	The 2015 low groundwater elevation.
Reduction of Groundwater Storage	A cumulative reduction in usable groundwater storage of 9.3 MAF in the Primary Principal Alluvial Aquifer relative to the baseline (WY 2015) total usable groundwater storage volume.	MTs for Chronic Lowering of Groundwater Levels used as a proxy	MOs for Chronic Lowering of Groundwater Levels used as a proxy
Seawater Intrusion	Groundwater conditions in the Subbasin show that Seawater Intrusion is not present and is not anticipated to be present in the future, and therefore, the Sustainability Indicator is not applicable.		
Degraded Water Quality	MTs for a groundwater quality COC are exceeded in three RMW-WQs in an HCM area based the average of confirmed seasonal samples and can be attributed based on a technical analysis to groundwater management actions (e.g., groundwater level changes).	The greater concentration of: (1) The applicable health-based screening standard, or (2) The maximum pre-2015 baseline concentration at each RMW-WQ. For wells with insufficient pre-2015 data, 2010-2023 data is used to determine maximum baseline concentrations at each RMW-WQ. For wells with insufficient 2010-2023 data, the MT is set as the 90th percentile 2010-2023 baseline concentration in the applicable HCM area.	The greater concentration of: (1) The applicable health-based screening standard, or (2) The median pre-2015 baseline concentration at each RMW-WQ. For wells with insufficient pre-2015 data, 2010-2023 data is used to determine median baseline concentration at each RMW-WQ. For wells with insufficient 2010-2023 data, the MO is set as the 90th percentile 2010-2023 baseline concentration in the applicable HCM area.

Sustainability Indicator	Undesirable Result	Minimum Threshold	Measurable Objective
Land Subsidence	MT extent of subsidence is exceeded at any RMS-LS or as measured using InSAR data published annually by DWR averaged across an HCM area. Note: The GSAs' management authority does not extend to all activities and processes that cause Subbasin subsidence..	MTs are established along critical infrastructure as a rate and extent based on specific impacts to critical infrastructure or as an observed or allowable rate of subsidence, as determined by the Subbasin's risk-based approach. Additionally, MTs are set for the Subbasin as the average historical rate of subsidence in each HCM area from 2015-2023.	50% of the MT rate and MT extent.
Interconnected Surface Water	Groundwater conditions in the Subbasin show that there are a few areas with potential Interconnected Surface Waters. However, data show the connection is likely transient, short-lived, and involves shallow or perched groundwater that is not part of the principal aquifer systems. Therefore, the Sustainability Indicator is not applicable to the Subbasin.		

<u>Justification of Sustainable Management Criteria:</u>

The primary beneficial uses and users of groundwater in the Subbasin include agricultural users, industrial users, domestic well owners, small community wells, and municipal well operators. Additionally, surface land uses susceptible to land subsidence (infrastructure) have been categorized based on their subsidence vulnerability and impacts to beneficial users (critical regional, GSA area, and other). The SMCs in Table ES-3 have been developed to prevent significant and unreasonable impacts to groundwater uses and users and surface land uses and are justified (i.e., will not result in significant and unreasonable impacts) as follows for all applicable Sustainability Indicators.

Chronic Lowering of Groundwater Levels

- <u>Impacts to Beneficial Users:</u> A robust Subbasin-wide well impacts analysis has been conducted using the revised MTs and the Subbasin well inventory to quantify potential impacts to beneficial users at the MTs as compared to the Chronic Lowering of Groundwater Levels URs definition. The most likely scenario shows 77 total drinking water wells being potentially impacted by 2040 at the projected MTs, a potential impact that can be addressed effectively by the Well Mitigation Program. The Subbasin calculated the "depletion of supply" for this scenario to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. With implementation of the proposed P/MAs, the model shows that only 13 drinking water wells would potentially be dewatered, which corresponds to < 0.01 percent of the Subbasin's urban pumping. By January 2025, the Subbasin GSAs plan to implement a Well Mitigation Program to address potential impacts from Chronic Lowering of Groundwater Levels to domestic and small community wells.
- <u>Consideration of Adjacent Basins:</u> Groundwater level SMCs were compared to those in the neighboring Tule, Tulare Lake, and White Wolf Subbasins and are not projected to

cause a change in historical gradients or prevent neighboring subbasins from achieving their Sustainability Goals.

Reduction of Groundwater Storage: A cumulative reduction of 9.3 MAF (up to 10 percent) of the total usable storage in the Subbasin relative to the 2015 baseline equates to the difference in storage between the MT and MO groundwater levels. This decline in groundwater storage, which allows for a four-year drought, is not unreasonable given the large size of the basin and total usable storage estimates, and it is similar to the storage change observed during recent multi-year droughts without unreasonable dewatering of wells. Therefore, the Chronic Lowering of Groundwater Levels SMCs serve as a reasonable proxy for Reduction of Groundwater Storage. The four to ten percent reduction of total usable storage is calculated by assuming that all Primary Alluvial Principal Aquifer Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) exceed the MTs. However, URs for Chronic Lowering of Groundwater Levels are defined to occur when 25 percent of RMW-WLs exceed their MTs, which would correspond to a lower decline in storage than the UR criteria for Reduction of Groundwater Storage, thus sufficiently protecting against impacts to beneficial uses and users.

Degraded Water Quality

- Impacts to Beneficial Users: The MTs for Degraded Water Quality are based on the greater of (a) the primary Maximum Contaminant Levels (MCLs) or (b) pre-2015 baseline concentrations for each RMW. Where pre-2015 historical data is insufficient, the HCM area baseline is used as proxy for pre-2015 baseline concentrations. MTs are identified for six COCs, including arsenic, nitrate, nitrite, TDS, 1,2,3-TCP, and uranium. Primary MCLs are health-based regulatory drinking water standards set to protect drinking water use, which is the most sensitive beneficial use. In some areas of the Subbasin, water quality has been historically degraded and not used for drinking water. For those areas of the Subbasin it is appropriate to set MTs as a baseline condition, as “the plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015” (CWC § 10727.2(b)(4)).
- Consideration of Adjacent Basins: The Chronic Lowering of Groundwater Levels MTs are not predicted to cause significant changes to local groundwater gradients and are thus should be protective in terms of preventing migration of poor-quality water within the Subbasin. Groundwater flow exits the Subbasin across the northern Subbasin boundary (Figure 8-1). The adjacent subbasins similarly have SMCs established for key COCs that impact drinking water users.

Land Subsidence: The SMCs for Land Subsidence have been developed in recognition that subsidence in the Subbasin has been caused by several factors, some of which are within the GSAs’ authorities to control (“GSA-related” subsidence - e.g., groundwater pumping for agricultural and urban uses), and others that are outside of the GSAs’ authorities to control (“non-GSA” subsidence – e.g., oil and gas extraction, natural processes, and expansive soil types susceptible to hydro-compaction). The SMCs for Land Subsidence have been developed to avoid impacts of subsidence caused by GSA-managed activities through a risk-based approach that considers subsidence potential and vulnerability.

- Impacts to Beneficial Users: MTs for Regional Critical Infrastructure were developed in coordination with operators of the infrastructure (i.e., Friant Water Authority and CASP) and designed to avoid significant and unreasonable impacts to infrastructure functionality. The MTs for GSA Area Critical Infrastructure are based on subsidence rates that have historically occurred and have been managed by Subbasin GSAs through ongoing maintenance and improvements to facilities. A change in slope analysis shows that for 98 percent of the Critical Infrastructure, the change in slope between 2024 and 2040 MTs is not projected to exceed typical safety factors. In addition to infrastructure specific MTs, MTs for the entire Subbasin are set based on HCM Area historical average subsidence rates. As such, the Subbasin will continue to monitor and report subsidence throughout the entire Subbasin, and coordinate with other entities that have interests in and responsibilities for land subsidence \ caused or influenced by activities or processes outside of the GSAs' management authorities.
- Consideration of Adjacent Basins**:** MT extents in the Subbasin are half the MT extents in the adjacent northward Tule and Tulare Lake subbasins. Therefore, implementation of the Amended Subbasin Plan would not prevent neighboring subbasins from achieving their Land Subsidence sustainability goal(s). Although Land Subsidence MTs in the adjacent southern White Wolf Subbasin are currently set using groundwater levels as a proxy, Subbasin GSAs are actively collaborating with the White Wolf GSA to ensure consistency as the White Wolf GSA develops more specific Land Subsidence SMCs.

Relationships Between Sustainability Indicators:

- **Chronic Lowering of Groundwater Levels** and **Reduction in Groundwater Storage** are directly, if not linearly, related. As shown in Table ES-3, groundwater level MTs are used as a proxy for Reduction of Groundwater Storage. If water levels in all Primary Alluvial Principal Aquifer RMW-WLs were to exceed MTs, a four to ten percent decline in total usable groundwater storage would occur relative to the baseline, which is not considered to be unreasonable.
- A trending analysis between **Degraded Water Quality** and **Chronic Lowering of Groundwater Levels** (and **Reduction of Groundwater Storage**, by proxy) shows no correlation for the majority of the Subbasin, except in some localized areas. RMWs have been selected in these areas to facilitate ongoing monitoring of the potential relationship between groundwater levels and water quality.
- An analysis has been conducted using historical groundwater level declines and cumulative **Land Subsidence** to project the future subsidence that would occur at **Chronic Lowering of Groundwater Level** MTs. The analysis shows that subsidence projected to occur at groundwater level MTs is less than the MTs for Land Subsidence along all critical infrastructure, which are considered protective of the functionality of critical infrastructure. Therefore, groundwater level MTs are protective of URs caused by Land Subsidence. However, it is noted that other non-GSA related subsidence could still contribute toward potential URs. The GSAs are integrating subsidence into the Subbasin's groundwater flow model as part of implementation of the Amended Subbasin Plan; results of which will be used to ensure that MTs for Chronic Lowering of Groundwater Levels are protective of MTs set for Land Subsidence.

- A potential effect of URs due to **Land Subsidence** is a **Reduction of Groundwater Storage** due to compaction of fine-grained subsurface layers during groundwater pumping. Through the correlation with Chronic Lowering of Groundwater Level SMCs, it is reasonable to conclude that Land Subsidence MTs will not cause an unreasonable Reduction of Groundwater Storage.
- Studies suggest that consolidation of subsurface layers with high clay content may liberate arsenic and cause **Degradation of Groundwater Quality**. However, there has been no observed correlation between **Land Subsidence** and any water quality COCs in the Subbasin. RMW--WQs have been selected in areas with historical subsidence to continue to monitor the potential relationship between subsidence and arsenic.

ES.10. Monitoring Network

The objective of the SGMA Monitoring Networks is to continue to collect sufficient data to allow for assessment of the Sustainability Indicators relevant to the Subbasin and determination of potential impacts to the beneficial uses and users of groundwater. The proposed SGMA Monitoring Network has been improved to ensure sufficient spatial distribution and spatial density. In the Subbasin, the SGMA Monitoring Network consists of 185 RMWs for groundwater levels (RMW-WL) and (by proxy) groundwater storage, 51 RMWs for monitoring groundwater quality (RWM-WQ), and 144 representative monitoring sites (RMSs) for monitoring land subsidence (including extensometers, benchmarks, and GPS). Additionally, the Subbasin will continue to rely on InSAR data to assess land subsidence across the Subbasin.

The SGMA Monitoring Networks for the Subbasin supplement other active monitoring networks and programs such as DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) program, Irrigated Lands Regulatory Program (ILRP), Central Valley-Salinity Alternatives for Long-term Sustainability (CV-SALTS), and local groundwater monitoring programs, etc.

Data collected from the SGMA Monitoring Networks for the Subbasin will be uploaded to the Kern Subbasin Data Management System (DMS) that is maintained for the Subbasin and reported to the DWR in accordance with the Monitoring Protocols developed for the Subbasin. Data collected will undergo quality assurance and quality control at the GSA level prior to being uploaded in the DMS. In the instance of a single MT exceedance, all Subbasin GSAs will be notified which will initiate the MT Exceedance Policy and associated investigations (see Appendix Q).

ES.11. Projects and Management Actions (P/MAs)

Achieving sustainability in the Subbasin will require the implementation of P/MAs to address projected water budget deficits that contribute to groundwater level and storage declines, land subsidence, and water quality impacts. As such, the GSAs have developed a portfolio of P/MAs, each with specific projected benefits, implementation triggers, and costs; the portfolio includes 48 demand reduction management actions and 82 water supply augmentation projects.

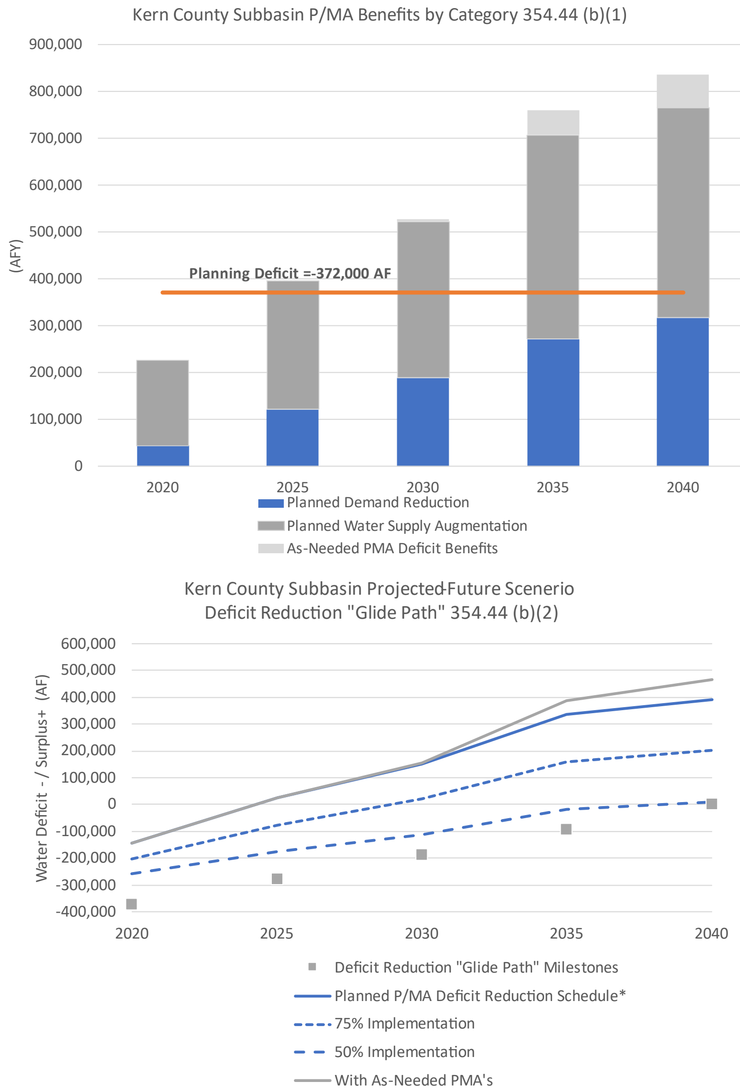


Figure ES-6. Projected-Future Scenario Overdraft Correction "Glide Path"

A linear "glide path" has been developed that will result in closing the projected Subbasin deficit[4] of approximately 372,000 AFY by 2040, of which over 80 percent is projected to be met with demand reduction P/MAs (see Figure ES-6). Subbasin GSAs have also included supply augmentation P/MAs. The Amended Subbasin Plan includes significantly more P/MAs than are required to address the projected deficit. In the event full estimated P/MA benefits are not ultimately realized, there is a built-in "safety factor" of nearly 2.0 and a plan to ensure the Subbasin projected deficit is reduced by 2040. Furthermore, under the MT Exceedance Policy, accelerated implementation of P/MAs could be triggered if MT exceedances occur.

The supply augmentation and demand reduction P/MAs identified by the Subbasin GSAs comprise a diverse portfolio of options that can be implemented as necessary to achieve sustainability from a total water quantity and water quality perspective. Additionally, eight Subbasin P/MAs establish Subbasin-wide programs, policies, collaborations, and ongoing data gap filling.

[4] The net deficit to be addressed by the 2040 GSP implementation deadline is the estimated deficit under the 2030 Climate Change scenario.

The modeled simulated results for the planned P/MAs indicate that P/MA implementation along the planned glide path will successfully achieve sustainability and avoid URs for Groundwater Levels (and by proxy for the other applicable Sustainability Indicators) throughout the Subbasin. Specifically, the local numerical model results have been used to compare simulated groundwater levels to the MTs and MOs for each RMW-WL. In general, across most of the Subbasin, groundwater levels fall near or below MTs without P/MAs implementation but are typically above the MT for the simulations that include P/MAs (see Figure ES-7).

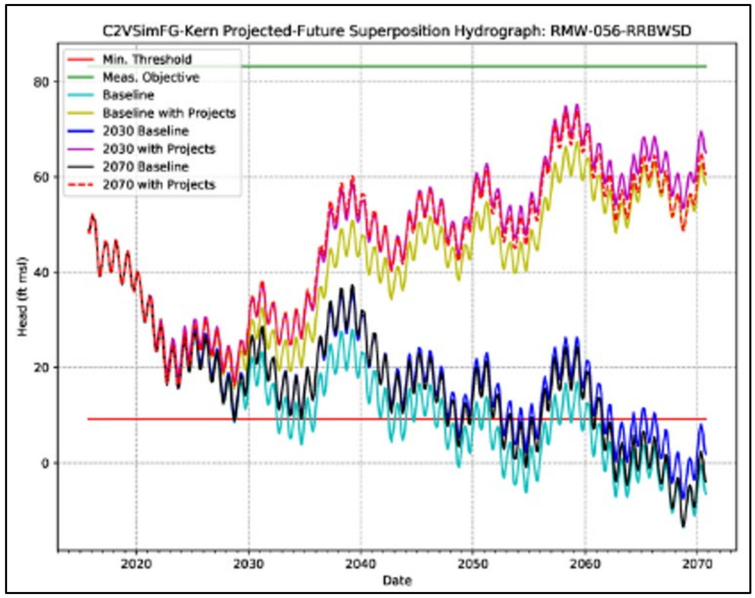


Figure ES-7. C2VSim-FG-Kern Projected Future Superposition Hydrograph (2030 Climate Change)

The implementation glide path identified by the Subbasin GSAs provides a general guide to how quickly these benefits are to be realized. To date the Subbasin GSAs have taken action on multiple P/MAs (e.g., development of new recharge basins). The exact schedule and order of implementation for other P/MAs, as seen in Figure ES-6, will be adaptively managed. Further analysis will be conducted to prioritize the P/MAs in consideration of factors such as permitting, engineering feasibility, cost effectiveness, need to prevent particular URs, funding opportunities, etc. In general, P/MAs being considered for implementation will be discussed during regular Board Meetings of each Subbasin GSA, which are noticed and open to the public. Additional stakeholder outreach efforts will be conducted prior to and during P/MA implementation, as required by law.

ES.12. Plan Implementation

Key SGMA and groundwater management implementation activities to be undertaken by the GSAs through 2040 include:

- Annual reporting.
- Monitoring and data collection.
- Data gap filling.
- P/MA implementation, including policy development to support Plan implementation.
- Technical and non-technical coordination with other water management entities within and outside the Subbasin.
- Continued outreach and engagement with stakeholders.
- Enforcement and response actions, including:

    - MT Exceedance Policy
    - Well Mitigation Program to be operational by 2025
- Evaluation and updates of this Plan as part of the required periodic evaluations (i.e., “five-year updates”).

Collectively, the SGMA implementation activities described herein demonstrate the Subbasin GSAs have been actively implementing specific P/MAs, policies, and programs to sustainably manage groundwater resources for all beneficial uses and users and continue to meet the Sustainability Goal defined for the Subbasin in Section ES.2 above, and in Section 2 and Section 12.

The costs associated with continued activities by the GSAs fall under two main categories: (1) costs for Subbasin-wide groundwater management activities, and (2) costs to individual GSAs to implement P/MAs within their jurisdictions, including capital/one-time costs and ongoing costs. Most costs for Subbasin-wide groundwater management activities are shared equally between the Subbasin GSAs and are estimated as an annual cost of approximately $1.4 million. For GSA-specific P/MA implementation, the GSAs intend to meet these cost obligations through a combination of landowner contributions (within their jurisdictions), partnering agencies, grant funding (DWR, United State Bureau of Reclamation, Federal Emergency Management Agency, etc.), locally available funds, and other available sources to be determined.

ES.13. Conclusion

The GSAs recognize that management of groundwater resources in California fundamentally changed with the passage of SGMA. SGMA has introduced well-defined concepts, actions, and deadlines necessary to achieve the stated goals and to avoid URs. For the “high priority” and “critically overdrafted” subbasins, there is a renewed sense of urgency to better monitor, prepare for, and respond to these issues. The GSAs are exercising their authorities to strategically plan and implement the coordinated groundwater management program established in this Amended Subbasin Plan within their jurisdictions. The Subbasin GSAs have committed to the coordinated SMCs established in this Amended Subbasin Plan to ensure that URs do not occur, and that any potential impacts to beneficial uses and users of groundwater that may occur as a result of groundwater management, especially to drinking water users, will be mitigated. Through the comprehensive monitoring network and P/MAs developed to meet modeled projected water budget under 2030 climate change conditions, the GSAs are confident they can achieve the Subbasin’s Sustainability Goal by the SGMA deadline. The GSAs are committed to long-term coordinated groundwater management, engaging with communities and stakeholders, and building consensus to ensure sufficient groundwater resources are reliably available for current and future generations.

1. INTRODUCTION

On 16 September 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) for the primary purpose of achieving and maintaining sustainability within the State's high and medium priority groundwater basins. Key tenets of SGMA are preservation of local control, use of best available data and science, and active engagement and consideration of all beneficial uses and users of groundwater. SGMA requires local agencies to form Groundwater Sustainability Agencies (GSAs) tasked with managing basins sustainably through the development and implementation of Groundwater Sustainability Plans (GSPs). Under SGMA, GSPs must contain certain elements, the most significant of which include: a Sustainability Goal; a description of the area covered by the Plan (i.e., the "Plan Area"); a description of the Basin Setting, including the hydrogeologic conceptual model (HCM), historical and current groundwater conditions, and a water budget; locally-defined Sustainable Management Criteria (SMCs); monitoring networks and protocols for each applicable sustainability indicator; and a description of projects and/or management actions (P/MAs) that will be implemented to achieve or maintain sustainability. SGMA also requires active stakeholder outreach to ensure that all beneficial uses and users of groundwater have the opportunity to provide input into the GSP development and implementation process.

The Kern County Subbasin of the San Joaquin Valley Groundwater Basin (referred to herein as the "Kern Subbasin" or "Subbasin") is located at the southern end of the Tulare Lake Hydrologic Region and is known for its rich soil and Mediterranean-like climate, which has made Kern County one of the top producing agricultural regions in the nation. The Subbasin contains 1.78 million acres and is the largest in the State. It is bounded by the Kern County line and the Tulare Lake, Tule, and Kettleman Plain Subbasins on the north; the Sierra Nevada foothills on the east; the Tehachapi mountains and White Wolf Subbasin on the southeast; and by the San Emigdio Mountains and Coast Ranges on the southwest and west (California Department of Water Resources [DWR], 2006; DWR, 2018). The Subbasin is identified by the DWR as Basin No. 5-022.14 and is classified as a high-priority, critically overdrafted basin (DWR, 2020).[1]

[1] https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization

1.1 Purpose of the Groundwater Sustainability Plan

The purpose of this collection of GSPs and Coordination Agreement (collectively “the Amended Subbasin Plan”) is to meet the requirements set forth in SGMA,[2] which 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” (DWR, 2017). Undesirable results (URs) are defined by SGMA as any of the following effects caused by groundwater conditions occurring throughout a basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater level or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The Amended Subbasin Plan meets the requirements of SGMA and implementing regulations while reflecting local needs and preserving local control over water resources. The Amended Subbasin Plan has been coordinated among the 20 GSAs and provides a path to achieve and document Subbasin-wide sustainable groundwater management by 2040, and to preserve the sustainability of locally managed groundwater resources into the future.

This Amended Subbasin Plan consolidates and substantially revises the Plan that was submitted to DWR in July 2022 (referred to herein as the “2022 Plan”). The revisions are focused on addressing deficiencies identified in DWR’s *Inadequate Determination of*

[2] Nothing in this GSP determines or alters surface water rights or groundwater rights under common law, any provision of law that determines or grants surface water rights, or otherwise (see, CWC § 10720.5(b)). This GSP shall be construed consistent with Section 2 of Article X of the California Constitution, and nothing provided in this GSP modifies rights or priorities to use or store groundwater except as expressly stated in CWC § 10720.5(a). The districts reserve and retain all rights to the use of water to the extent provided by law.

the Revised 2020 Groundwater Sustainability Plans Submitted for the San Joaquin Valley – Kern County Subbasin" (March 2, 2023) (referred to herein as "*Inadequate Determination*"). This coordinated, comprehensive Amended Subbasin Plan articulates how the GSAs will collectively and sustainably manage groundwater in the Subbasin based on the best available data and information.

As described further below, this GSP is one of the series of GSPs that, along with the Coordination Agreement (Appendix C), constitute the Amended Subbasin Plan that addresses the deficiencies identified in DWR's *Inadequate Determination*. The Amended Subbasin Plan presents a coordinated, comprehensive approach to sustainably manage groundwater in the Subbasin while recognizing significant variations in hydrogeology, available water supplies, groundwater usage, and the nature and distribution of beneficial users across the largest Subbasin in the state of California.

Table 1-1 shows the collection of GSPs that fully cover the Subbasin. 68 percent of the Subbasin is represented by the Kern Subbasin GSP. All other coordinated GSPs cover specific GSA areas, and supplement the information provided in the Kern Subbasin GSP with additional GSA-specific information inserted as blue pages throughout the document.

Table 1-1. Amended Subbasin Plan GSPs

GSP Name	Area (acres)	Percentage of Subbasin Area	GSA	GSP Contents
Kern Subbasin GSP	1,205,482	67.6%	Arvin GSA Cawelo Water District GSA Kern Non-Districted Land Authority GSA *(formerly Kern Groundwater Authority GSA)* Kern River GSA Kern Water Bank GSA Greenfield County Water Districts GSA North Kern WSD GSA Pioneer GSA Rosedale-Rio Bravo WSD GSA Shafter-Wasco ID GSA Southern San Joaquin MUD GSA Tejon-Castac Water District GSA West Kern Water District GSA Wheeler Ridge-Maricopa GSA	Kern Subbasin GSP
Buena Vista GSA GSP	51,070	2.9%	Buena Vista GSA	Kern Subbasin GSP Supplemental GSA information included on blue pages in the Executive Summary
Henry Miller GSA GSP	26,063	1.5%	Henry Miller GSA	Kern Subbasin GSP; Supplemental GSA information on blue pages identified in Executive Summary.

GSP Name	Area (acres)	Percentage of Subbasin Area	GSA	GSP Contents
Kern-Tulare Water District GSA GSP	11,344	0.6%	Kern-Tulare Water District GSA	Kern Subbasin GSP; Supplemental GSA information on blue pages identified in Executive Summary.
Olcese Water District GSA GSP	3,199	0.2%	Olcese Water District GSA	Kern Subbasin GSP; Supplemental GSA information on blue pages identified in Executive Summary.
Semitropic Water Storage District GSA GSP	224,350	12.6%	Semitropic Water Storage District GSA	Kern Subbasin GSP; Supplemental GSA information on blue pages identified in Executive Summary.
Westside District Water Authority GSA GSP	260,061	14.6%	Westside District Water Authority GSA	Kern Subbasin GSP; Supplemental GSA information on blue pages identified in Executive Summary.

1.2 Background

Pursuant to the SGMA regulatory requirements, five GSPs (coordinated through the Kern County Subbasin Coordination Agreement dated January 20, 2020) were submitted to DWR for the Kern Subbasin by the January 2020 deadline (referred to herein as the “2020 GSPs”). DWR responded with an *Incomplete Determination of the 2020 Groundwater Sustainability Plans Submitted for the San Joaquin Valley – Kern County Subbasin”* (January 28, 2022) (referred to herein as “*Incomplete Determination*”), listing the following deficiencies:

1. The GSPs do not establish undesirable results that are consistent for the entire Subbasin.
2. The Subbasin’s chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.
3. The Subbasin’s land subsidence sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.

As stipulated in the *Incomplete Determination* letter, the Kern Subbasin GSAs were directed to address the above deficiencies through recommended Corrective Actions provided in the GSP Assessment Staff Report within 180 days, by July 27, 2022. The *Incomplete Determination* letter and attached GSP Assessment Staff Report are provided in Appendix A. The Kern Subbasin GSAs amended the GSPs and Coordination Agreement and responded with five amended GSPs and one new GSP (referred to herein as “2022 GSPs”).

After reviewing the 2022 GSPs, DWR issued its *Inadequate Determination* in March 2023. In its findings, DWR stated that "Although the [2022 GSPs] made progress toward explaining a coordinated approach to sustainable groundwater management, especially regarding the development of consistent terminology, Department staff continue to find the Plan difficult to evaluate in terms of whether or not implementation will likely achieve the sustainability goals for the Subbasin." Because it was determined that the Subbasin GSAs did not take sufficient action to correct the deficiencies, primary jurisdiction shifted from DWR to the State Water Resources Control Board (SWRCB). The *Inadequate Determination* letter and attached Statement of Findings are provided in Appendix B.

Presently, the Kern Subbasin is subject to the SWRCB intervention process per California Water Code (CWC) § 10735 et seq. Under this statute, the SWRCB may designate a basin as “probationary” after holding a public hearing, which is anticipated to occur in January 2025 (CWC § 10735.2(a)). If a basin is designated as probationary, the SWRCB shall identify specific deficiencies and potential actions to address deficiencies, and the GSAs will have one year to remedy the deficiency that resulted in the probationary designation prior to the SWRCB developing an interim plan (CWC § 10735.6).

In response to DWR’s *Inadequate Determination*, and prior to the Subbasin’s probationary hearing, the Subbasin GSAs (through development and submission of this Amended Subbasin Plan) have made substantial progress to address the deficiencies and implement the Corrective Actions outlined by DWR. The Amended Subbasin Plan documents the Subbasin’s coordinated approach to groundwater management and SGMA implementation.

1.2.1 Coordination

DWR perceived a lack of consistency and coordination among the GSPs for the Subbasin, as described in both the *Inadequate* and *Incomplete Determination* letters. Each of the three deficiencies described in the *Incomplete Determination* fully or partially focused on this lack of consistency. In the *Inadequate Determination* letter, DWR noted that appreciable efforts and progress had been made to address each of the three deficiencies identified in the *Incomplete Determination*; however, concerns still remained regarding the cohesion and coordination of the plans. For example, DWR staff determined that: “the fragmented management area approach to groundwater management, particularly in establishing minimum thresholds and measurable objectives, undermines the GSAs ability to clearly define the Subbasin-wide significant and unreasonable effects they hope to avoid” (Deficiency # 1, Inadequate Determination, page 22); “the approaches used for developing chronic lowering of groundwater levels minimum thresholds and the level of analysis to support those approaches, is disparate across the various plans” (Deficiency #2, Inadequate Determination, page 40); “the Plan does not provide a coordinated, complete analysis of how the respective minimum thresholds could affect the conveyance operations of the

California Aqueduct or Friant-Kern Canal" (Deficiency #3, Inadequate Determination, page 52); and "the Subbasin still does not have a Subbasin-wide approach for managing subsidence because of the differing data and methodologies used to establish Management Area Critical Infrastructure and corresponding sustainable management criteria" (Deficiency #3, Inadequate Determination, page 54).

The Subbasin GSAs have identified coordination as a main area of focus for ongoing successful management of groundwater resources. Since April 2023, the Subbasin GSAs have participated in numerous and substantial Subbasin-wide coordination efforts to develop a coordinated response to DWR's Corrective Actions as incorporated into the Amended Subbasin Plan. Subbasin-wide coordination efforts have included the development of a Technical Working Group (TWG), an Attorney Working Group (AWG), intra-basin coordination efforts, Subbasin-wide stakeholder engagement and consultation with SWRCB staff. These efforts are explored below:

1.2.1.1 Technical Working Group (TWG)

In May 2023, the Subbasin GSAs assembled a Technical Working Group (TWG) to produce Subbasin-wide technical solutions to address DWR identified deficiencies. The TWG is composed of 17 hydrogeologists and engineers representing the Subbasin GSAs. The TWG's objectives include:

- Identify technical options and alternatives to address DWR deficiencies.
- Conduct independent analyses as needed.
- Provide technical options and recommendations for GSP revisions to the Subbasin GSAs.

The TWG meets weekly to review work products and develop technical recommendations. The TWG is further subdivided into six subcommittees to allow for concurrent, focused technical work and evaluations to address deficiencies and develop methodologies and approaches that are applicable Subbasin-wide.

1.2.1.2 Attorney Working Group (AWG)

In May 2023, the Subbasin GSAs established the Attorney Working Group (AWG) to develop legal recommendations. The AWG is composed of attorneys representing the Subbasin GSAs and/or Legal Counsel for GSA group(s). The AWG meets as needed to provide legal recommendations.

1.2.1.3 Intra-Basin Coordination

Subbasin GSA representatives meet twice a week to collaborate and provide feedback on the technical work products produced by the TWG. These meetings include ad-hoc

Managers and Subbasin coordination committee members and provide a forum wherein the GSAs discuss Subbasin coordination activities, including the development, planning, financing, implementation, and long-term monitoring of the Amended Subbasin Plan. Successful intra-basin coordination efforts include the comprehensive well inventory (see Section 1.3.1), coordinated SMC methodologies (see Sections 11 to 13), the Minimum Threshold (MT) Exceedance Policy (see Section 16.2.1), the Well Mitigation Program (see Section 16.2.1.1), water budgets (see Section 9), coordinated P/MAs to address the projected deficit (see Section 14), data management system upgrades, and a revised SGMA Monitoring Network (see Section 15).

1.2.1.4 Stakeholder Engagement

Subbasin GSAs continue to conduct stakeholder outreach and engagement activities with their stakeholders and members of the public throughout this coordinated Plan amendment process, as summarized in Section 5.10.

1.2.1.5 Consultation with SWRCB Staff

This section focuses on Subbasin consultation with SWRCB staff. As summarized in Table 1-2, the GSAs participated in 10 meetings with SWRCB staff to provide updates and seek input on the Subbasin's coordinated response to the DWR deficiencies, including technical justifications for SMCs and Subbasin Plan revisions. Revisions to this Amended Subbasin Plan in response to feedback received at SWRCB staff meetings are summarized below. In addition, the Plan Manager led ongoing communication efforts with SWRCB staff and Board Members seeking clarification on issues related to Plan review schedule and process, whether the Good Actor exclusion required submittal of individual GSPs, and to reiterate the GSA's anticipated Amended Subbasin Plan submittal date. These communications resulted in a request that the SWRCB staff focus their review on the Amended Subbasin Plan, not the 2022 GSPs.

Table 1-2. Crosswalk Summary of Subbasin Meetings with SWRCB Staff and Plan Additions

Meeting Date	Topic	Summary / Outcome	Plan Section
3/30/2023	DWR – SWRCB handoff	Subbasin GSAs sought clarification on the SWRCB intervention process and timeline for probationary hearing. *SWRCB Staff expressed their intention to focus on the DWR deficiencies. Staff encouraged technical meetings throughout the process to support the Subbasin to exit the SWRCB process.*	*N/A*
5/17/2023	Plan manager introduction and GSA questions	Subbasin GSAs introduced the Plan Manager and Technical Working Group (TWG), asked questions on GSP format, potential for additional deficiencies, and requirements for a Periodic Evaluation. *SWRCB Staff emphasized that consolidation of GSPs would facilitate a comprehensive and coordinated subbasin-wide approach and indicated a preference for demand management actions to meet the sustainability goal.* ➢ In response, GSAs considered Plan structure, striving for the majority of the Subbasin to be included under one plan. GSAs initiated plans to expand demand reduction P/MAs.	Section 5 Section 14

Meeting Date	Topic	Summary / Outcome	Plan Section
6/23/2023	Technical meeting #1 – Chronic Lowering of Groundwater Levels SMCs	The TWG presented background on the Basin, banking programs, chronic lowering of groundwater level minimum thresholds (MTs), well inventory and well impacts, and Projects/Management Actions (P/MAs) *SWRCB Staff continued to emphasize their preference for a single, Subbasin-wide plan. Staff stressed that MTs at levels lower than 2015 would require justification, requested analyses of additional wells, and voiced skepticism regarding the availability of "new water" sources as Projects to meet the sustainability goal.* ➢In response, GSAs initiated a well inventory to improve identification of beneficial users and revised the Undesirable Results (UR) definition to include dewatered drinking water wells.	Section 1.3.1 Section 5.6.1 Section 11.1 Section 13.1.1.1 Section 13.1.1.4
10/4/2023	Technical meeting #2 – Chronic Lowering of Groundwater Levels SMCs	The TWG presented the revised chronic lowering of groundwater levels SMCs to address DWR deficiencies #1 and #2, including undesirable results (URs) definition, MTs, and measurable objectives (MOs) *SWRCB Staff feedback was generally positive on methodologies, noted the much-improved coordination; however, requested additional analyses and justification on the relationship between MTs and URs definition.* ➢In response, GSAs expanded the justification for Chronic Lowering of Groundwater Levels SMCs to include a suite of five drinking water well impacts analyses and a "depletion of supply" calculation.	Section 13.1.1.4 Section 13.1.2.4
11/1/2023	Technical meeting #3 - Chronic Lowering of Groundwater Levels SMCs	The TWG presented follow up justification on chronic lowering of groundwater levels proposed MTs and URs definition including an expanded analysis of drinking water well and "depletion of supply" impacts. *SWRCB Staff feedback was generally positive and appreciative of the detailed work to evaluate multiple MT methodologies, refine the UR definition, and to assess potential well and water supply impacts. SWRCB Staff acknowledged that the existing DWR well database has limitations and agreed with the subbasin's ongoing efforts to reconcile with other datasets and sustainability indicators.* ➢In response, GSAs initiated an analysis to assess Chronic Lowering of Groundwater Level SMCs inter-relationship with Land Subsidence and Degraded Water Quality SMCs.	Section 13.1.2.2 Section 13.3.2.2. Section 13.5.2.2
12/13/2023	Technical meeting #4 – Land Subsidence SMCs	The TWG presented land subsidence SMCs proposed approach to address DWR deficiency #3. *SWRCB Staff requested clarification on the "SGMA" and "non-SGMA" nomenclature used to identify subsidence causes within and outside of the GSA's authority to address (now referred to as GSA-related and non-GSA causes), and that GSAs consider establishing SMCs for the entire Subbasin, not just along critical infrastructure.* ➢In response, GSAs clarified definitions for the potential causes of subsidence with the GSA's authority and outside the GSA's authority to manage and established Land Subsidence SMCs across the entire Subbasin.	Section 8.5.2 Section 13.5 Section 13.5.2.1

Meeting Date	Topic	Summary / Outcome	Plan Section
1/24/2024	Technical meeting #5 – Degraded Water Quality SMCs	The TWG presented degraded water quality SMCs proposed approach. *SWRCB Staff expressed their preference for a more robust representative monitoring network, indicated their preference that SMCs be established for all identified constituents included in their November 2022 letter, and requested additional detail on potential subsidence and P/MAs impacts on water quality.* ➢ In response, GSAs expanded the representative monitoring network for water quality, expanded constituents with SMCs to include 1,2,3-TCP, nitrite, and uranium, and examined the potential relationship between arsenic concentrations and land subsidence.	Section 8.4 Section 13.1.1.4 Section 13.3.2.2. Section 13.5.2.2 Section 15.2.4
3/6/2024	Technical meeting #6 – Well Inventory & Mitigation Program	The TWG presented the process and results of the well inventory which identifies beneficial users of groundwater and the structure of the Subbasin-wide well mitigation program. *SWRCB Staff stated that they would not recommend a Subbasin to exit the probationary process until GSAs had a funded and operational well mitigation program.* ➢ In response, GSAs expedited the timeframe for developing a well mitigation program framework, to be operational by January 2025.	Section 14.2.3 Appendices
4/3/2024	Technical meeting #7 – Monitoring Networks and SMCs Approach	The TWG presented the SGMA monitoring networks and the revised SMCs approaches for applicable Sustainability Indicators and outlined how these revisions address DWR deficiencies and incorporate SWRCB staff feedback received to date. *SWRCB Staff identified potential monitoring data gaps expressed that GSAs should include a plan for filling, acknowledged the significant improvement to the revised subbasin-wide UR definitions, and recommended that analysis of Depletions of Interconnected Surface Waters be robust even though it was not identified as a DWR deficiency, and DWR has not issued its complete guidance documents.* ➢ In response, GSAs expanded the representative monitoring network and identified data gaps, increased water quality sampling frequency to semi-annual, revised the UR definition for Degraded Water Quality, and expanded Depletions of Interconnected Surface Waters description to include ICONS dataset.	Section 8.6 Section 11.1 Section 13.3.1 Section 15.2.1 Section 15.2.4 Section 15.5.1 Appendices

Meeting Date	Topic	Summary / Outcome	Plan Section
4/23/2024	Technical meeting #8 – Water Budgets, P/MAs, and Water Banking Approach	The TWG presented the water budget approach to estimate projected future conditions, P/MAs and how estimated benefits exceed the projected deficit, and three example water banking approaches within the Basin. GSA representatives also sought clarification from SWRCB staff as to whether an entity could still apply for a "good actor" exception if they were part of a single GSP. *SWRCB Staff asked numerous questions regarding water banking operations and accounting and requested additional considerations of extreme climate change and recent SWRCB policies affecting delta in-stream flows be included in the projected water budget and expressed concerns with having both a Subbasin-wide P/MAs section and 20 individual GSA-specific P/MAs sections within the Amended Subbasin Plan. The SWRCB stated that a management area within a GSP could apply for the good actor exemption.* ➢ In response, GSAs summarized all planned P/MAs and expected benefits by category on the Subbasin level and moved GSA-specific details on P/MAs as supporting appendices.	Section 14 Appendices
5/29/2024	Technical meeting #9 – Final GSP Overview	The TWG presented an overview of the highly coordinated Amended Subbasin Plan.	*N/A*

1.3 Summary of Major Plan Updates

This Amended Subbasin Plan has been revised to address deficiencies, incorporate SWRCB staff feedback, incorporate new information and update data through Water Year 2023, and utilize the best available science. The revised Subbasin-wide approach to establishing and justifying SMCs in Section 13 directly addresses the deficiencies DWR identified in its *Inadequate Determination* letter. This Amended Subbasin Plan completely replaces the 2022 Plans.

Table 1-3 provides a "crosswalk" between the deficiencies and corrective actions DWR identified in its *Inadequate Determination* letter, a summary of major revisions to the 2022 Plans that have been incorporated into this Amended Subbasin Plan, and the section location of the revisions within this Amended Subbasin Plan.

Table 1-3. Crosswalk Summary of Major Plan Updates in Response to DWR Corrective Actions

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #1: The GSPs do not establish undesirable results that are consistent for the entire Subbasin.	**1a)** • "Explain how the undesirable results definitions are consistent with the requirements of SGMA and the GSP Regulations." • "Include descriptions of how the Plans have utilized the same data and methodologies to define the Subbasin-wide undesirable results and how the Plan has considered the interests of beneficial uses and users of groundwater."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for each applicable Sustainability Indicator. • The approaches to develop the UR definitions are consistent with the requirements of SGMA and the GSP Regulations and reflect feedback received from SWRCB staff during our multiple meetings to date. • Completely revised the Chronic Lowering of Groundwater Levels UR definition to a two-part definition that considers direct impacts on drinking water wells (no more than 15 dewatered per year or 255 total by 2040) and a Subbasin-wide percentage of MT exceedances (25%) to account for the variability of beneficial users and representative monitoring wells across the Subbasin. • Conducted a robust Subbasin-wide well impacts analysis using the revised MTs and the Subbasin-wide well inventory to quantify potential impacts to beneficial users at the MTs as compared to the Chronic Lowering of Groundwater Levels URs definition. Under the most likely scenario, a total of 77 drinking water wells are being impacted by 2040, at the projected MTs.	Section 11 Section 2 & 12 Sections 13.1.1, 13.2.1, 13.3.1, and 13.5.1 Section 13.1.2.4 Appendix Q
Deficiency #1: The GSPs do not establish undesirable results that are consistent for the entire Subbasin.	**1b)** • "Commit to comprehensively reporting on the status of minimum threshold exceedances by area in the annual reports and describe how groundwater conditions at or below the minimum thresholds may impact beneficial uses and users prior to the occurrence of a formal undesirable result."	• Established a Subbasin-wide MT Exceedance Policy to trigger GSA action in the event of a single MT exceedance for Chronic Lowering of Groundwater Levels, Degraded Water Quality, and/or Land Subsidence. • Updated functionality of the Subbasin Data Management System (DMS) so that all GSAs are notified when an MT exceedance is uploaded. • Established a detailed Subbasin-wide Well Mitigation Program to address impacts of Chronic Lowering of Groundwater Levels and Degraded Water Quality on domestic and small community groundwater users, in partnership with Self-Help Enterprises, to be operational by January 2025.	Section 5.10.3.4 Section 2 & 12 Section 16.2.1 Sections 13.1, 13.3, and 13.5 Appendices F, H, and W

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #1: The GSPs do not establish undesirable results that are consistent for the entire Subbasin.	**1c)** • "Adopt clear and consistent terminology to ensure the various plans are comparable and reviewable by the GSAs, interested parties, and Department staff. This terminology should also adhere to the definitions of various terms in SGMA and the GSP Regulations including the understanding that undesirable results are conditions occurring throughout the Subbasin." • "Clearly document how all of the various undesirable results definitions and methodologies achieve the same common sustainability goal."	• Used common language and templates (and data and methodologies) for all Amended Subbasin Plan chapters, demonstrating a high degree of coordination and collaboration. In this manner the review time by SWRCB, DWR and the public will be significantly shortened because the GSPs included in the Amended Subbasin Plan are essentially identical. • Used clear and consistent terminology for the Subbasin-wide definitions for URs, MTs, and MOs for each applicable Sustainability Indicator and to describe how the Subbasin will be managed to achieve the Sustainability Goal. • Defined and used consistent, Subbasin-wide terminology to establish SMCs for Land Subsidence, including Regional Critical Infrastructure and GSA Area Critical Infrastructure and "GSA-related" vs. "non-GSA" causes of subsidence.	Section 11 Section 13 Section 5 Section 2 & 12 Section 8.5.2

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. (All GSPs)** • "Demonstrate the relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the GSA has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators." • "The GSAs should address the specific corrective actions identified for the various GSPs and management area plans, as well as the corrective actions that apply to all the GSPs identified in Table 2. Where addressing those corrective actions includes modifications to the respective GSPs minimum thresholds, the GSPs should evaluate whether the Subbasin's 'with-projects' modeling scenarios still indicate that implementation of the projects and management actions would avoid minimum threshold exceedances. If not, the GSAs should modify their projects and management actions accordingly."	• Established a Subbasin-wide methodology for setting MTs and MOs for Chronic Lowering of Groundwater Levels using an iterative process that considered more than 11 potential MT methodologies that were vetted against the Subbasin UR definition, potential well impacts, and stakeholders, including SWRCB staff. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Identified potential impacts of lowered groundwater levels on other Sustainability Indicators. • Selected Representative Monitoring Wells (RMWs) in areas with a potential correlation between groundwater levels and water quality to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities. • Determined that groundwater level MTs are protective of URs for land subsidence through an analysis that projects the extent of subsidence that would occur under groundwater level MTs. This analysis will be refined in future Subbasin-wide modeling efforts. • Estimated the reduction of groundwater storage that would occur at MT groundwater levels and determined this decline in storage (4 to 10 percent) is not significant and unreasonable relative to the volume of total usable storage in the Subbasin. • Coordinated with neighboring basins on the MOs and MTs.	Sections 13.1 and 13.2 Section 8.1 Section 15.2.1 Appendix O

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (Areas Outside of Management Areas):** • "Provide a comprehensive discussion of areas covered by the KGA GSP, but that are not contained within the various management area plans. Among other items, provide maps of these areas, describe the uses and users of groundwater in these areas, and either set sustainable management criteria for these areas or include robust discussions justifying why sustainable management criteria are not required."	• Provided maps and descriptions of all areas covered by the Amended Subbasin Plan. • Described beneficial uses and users of groundwater across the entire Subbasin. • The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for each applicable Sustainability Indicator. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Added representative monitoring sites in under-represented areas that will be monitored for groundwater level and groundwater quality with SMCs established.	Section 1.3.1 Section 5.2.1 Section 13 Section 13.1.2.4 Section 15.5.1 Appendix Q
	2. Kern Groundwater Authority GSP (Cawelo Water District Management Area; Eastside Water Management Area) • "Describe how the minimum thresholds … may affect the interests of beneficial uses and users of groundwater or land uses and property interests."	• Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040.	Section 13.1.2.4 Appendix Q
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (Kern Water Bank Management Area)** • Provide an explanation of how the Joint Operation Plan meets the requirements of SGMA and the GSP Regulations. • The Joint Operation Plan expired on January 31, 2019. Provide an updated explanation if these thresholds have changed and the latest Joint Operation Plan if applicable."	• MTs for the area covered by the Kern Water Bank GSA are no longer set using thresholds in the Joint Operation Plan, and instead use the Subbasin-wide SMC approach.	Section 13.1

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
	2. Kern Groundwater Authority GSP (Kern-Tulare Water District Management Area) • "Provide an explanation of how minimum thresholds within the Kern-Tulare management area at the monitoring sites are consistent with the requirement to be based on a groundwater elevation indicating a significant and unreasonable depletion of supply at a given location. • Provide a discussion identifying how the minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040.	Section 13.1 Section 13.1.2.4
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (North Kern Water Storage District / Shafter-Wasco Irrigation District Management Area)** • "Establish sustainable management criteria for management area NKWSD-MA-2. • Explain how minimum thresholds … are consistent with the requirement to be based on a groundwater elevation indicating a significant and unreasonable depletion of supply at a given location. • Verify how the subset of wells used in the well impact analysis is representative of the wells in the management area. • Provide an explanation of the mitigation plan for domestic wells."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Established a detailed Subbasin-wide Well Mitigation Program to address impacts of Chronic Lowering of Groundwater Levels and Degraded Water Quality on domestic and small community groundwater users, in partnership with Self-Help Enterprises, to be operational by January 2025.	Section 13.1 Section 13.1.2.4 Section 16.2.1.1 Appendix Q Appendix K

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (Kern County Water Agency Pioneer GSA Management Area; Shafter-Wasco Irrigation District [7th Standard Rd] Management Area; West Kern Water District Management Area; Westside District Authority Management Area)** • "Explain the selection of groundwater level minimum thresholds for the Pioneer management area, including how they represent site-specific levels of depletion that could cause undesirable results, how they may affect the interests of beneficial uses and users of groundwater, and the relationship between this sustainability indicator and other sustainability indicators such as degradation of groundwater quality and subsidence, both of which can be exacerbated by lowering groundwater levels."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Identified potential impacts of lowered groundwater levels on other Sustainability Indicators. • Selected Representative Monitoring Wells (RMWs) in areas with a potential correlation between groundwater levels and water quality to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities. • Determined that groundwater level MTs are protective of URs for land subsidence through an analysis that projects the extent of subsidence that would occur under groundwater level MTs. This analysis will be refined in future Subbasin-wide modeling efforts. • Estimated the reduction of groundwater storage that would occur at MT groundwater levels and determined this decline in storage (4 to 10 percent) is not significant and unreasonable relative to the volume of total usable storage in the Subbasin.	Section 13.1 Section 13.1.2.4 Section 15.2 Section 16.2.1.1 Appendix Q Appendix K

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (Rosedale Rio Bravo Management Area)** • "Provide clarification regarding why minimum threshold exceedances are allowed to occur in one of the North, Central, or South of the Rive zones for this management area (i.e., why it takes two of those zones to exceed their threshold before the management area plan considers an undesirable result to have occurred). • Describe any projects or management actions that may be implemented if the minimum threshold is exceeded in one of those areas and users are impacted but an undesirable result is not triggered."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Established a Subbasin-wide MT Exceedance Policy to trigger GSA action in the event of a single MT exceedance for Chronic Lowering of Groundwater Levels, Degraded Water Quality, and/or Land Subsidence.	Section 13.1 Section 16.2.1 Appendix W

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern Groundwater Authority GSP (Semitropic Water Storage District Management Area; Southern San Joaquin Municipal Utility District Management Area:)** • "Explain the selection of groundwater level minimum thresholds … including how they represent site-specific levels of depletion that could cause undesirable results and the relationship between this sustainability indicator and other sustainability indicators such as degradation of groundwater quality and subsidence, both of which can be exacerbated by lowering groundwater levels. If minimum thresholds were not set consistent with levels indicating a depletion of supply, the minimum thresholds should be revised accordingly. • Verify how the subset of wells used in the well impact analysis is representative of the wells in the management area. • Provide an explanation of the mitigation plan for domestic wells."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Identified potential impacts of lowered groundwater levels on other Sustainability Indicators. • Selected Representative Monitoring Wells (RMWs) in areas with a potential correlation between groundwater levels and water quality to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities. • Determined that groundwater level MTs are protective of URs for land subsidence through an analysis that projects the extent of subsidence that would occur under groundwater level MTs. This analysis will be refined in future Subbasin-wide modeling efforts. • Estimated the reduction of groundwater storage that would occur at MT groundwater levels and determined this decline in storage (4 to 10 percent) is not significant and unreasonable relative to the volume of total usable storage in the Subbasin. • Established a detailed Subbasin-wide Well Mitigation Program to address impacts of Chronic Lowering of Groundwater Levels and Degraded Water Quality on domestic and small community groundwater users, in partnership with Self-Help Enterprises, to be operational by January 2025.	Section 13.1 Section 15.2 Section 16.2.1.1 Appendix Q Appendix K

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Kern River GSP** • "Provide clarification regarding the management action mentioned in the sustainable management criteria section of the GSP related to identification of well users, including domestic users and small water systems, in the agricultural subareas of the Agricultural Management Area."	• A Subbasin-wide well inventory was conducted to better understand the distribution of beneficial groundwater users in the Subbasin. The inventory includes records from DWRs Online System of Well Completion Reports (OSWCR), the Kern County Environmental Health Services (KCEHS), and United States Geological Survey (USGS). Additionally, data were downloaded from California Open Data including well information from the Department of Drinking Water (DDW) and Irrigated Lands Regulatory Program	Section 1.3
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Buena Vista GSP** • "Include sustainable management criteria, including groundwater level minimum thresholds, for the Maples Management Area." • "[Provide] similar detail regarding the hydrogeologic and beneficial user considerations as were provided for the Buttonwillow Management Area sustainable management criteria development."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Identified potential impacts of lowered groundwater levels on other Sustainability Indicators.	Section 13.1 Appendix Q

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. Henry Miller GSP** • "Provide a sufficient description of the selection of groundwater level minimum thresholds, including how they represent site-specific levels of significant and unreasonable depletion of supply that could cause undesirable results, how they may affect the interests of beneficial uses and users of groundwater, and the relationship between this sustainability indicator and other sustainability indicators such as degradation of groundwater quality and subsidence, both of which can be exacerbated by lowering groundwater levels."	• The Amended Subbasin Plan uses the same data and methodologies to define Subbasin-wide definitions for URs, MTs, and MOs for Chronic Lowering of Groundwater Levels that are based on a groundwater elevation indicating a significant and unreasonable depletion of supply at each RMW-WL. • Conducted a robust Subbasin-wide well impacts analysis using the Subbasin well inventory, MTs and the quantitative criteria for URs to better quantify potential impacts to beneficial users. Under the most likely scenario, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. • Conducted a "depletion of supply" analysis to quantify the percentage of urban supply that may be impacted at MTs and the UR definition. Under the most likely scenario, 1.2 percent of the total estimated urban water supply would be impacted by 2040. • Identified potential impacts of lowered groundwater levels on other Sustainability Indicators. • Selected Representative Monitoring Wells (RMWs) in areas with a potential correlation between groundwater levels and water quality to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities. • Determined that groundwater level MTs are protective of URs for land subsidence through an analysis that projects the extent of subsidence that would occur under groundwater level MTs. This analysis will be refined in future Subbasin-wide modeling efforts. • Estimated the reduction of groundwater storage that would occur at MT groundwater levels and determined this decline in storage (4 to 10 percent) is not significant and unreasonable relative to the volume of total usable storage in the Subbasin.	Section 13.1 Section 15.2 Appendix Q

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #2: The Subbasin's chronic lowering of groundwater levels sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**2. South of Kern River GSP (Arvin-Edison Water Storage District Management Area; Wheeler Ridge-Maricopa Water Storage District Management Area)** • Provide specific details, including timeline for implementation, of the [Well Mitigation] program. Describe the scope of the program and how users impacted by continued groundwater level decline, particularly early in implementation of the Plan, will be addressed.	• Established a detailed Subbasin-wide Well Mitigation Program to address impacts of Chronic Lowering of Groundwater Levels and Degraded Water Quality on domestic and small community groundwater users, in partnership with Self-Help Enterprises, to be operational by January 2025. • Established a Subbasin-wide MT Exceedance Policy to trigger GSA action in the event of a single MT exceedance for Chronic Lowering of Groundwater Levels, Degraded Water Quality, and/or Land Subsidence.	Section 16.2.1 Appendix K Appendix W
	2. South of Kern River GSP (Tejon-Castac Water District Management Area) • "Explain the selection of groundwater level minimum thresholds for the Tejon-Castac management area, including how they represent site-specific levels of depletion that could cause undesirable results, how they may affect the interests of beneficial uses and users of groundwater, and the relationship between this sustainability indicator and other sustainability indicators such as degradation of groundwater quality and subsidence, both of which can be exacerbated by lowering groundwater levels."	• Same revisions as listed above for the Henry Miller GSP.	Section 13.1 Section 15.2 Appendix Q

DWR Deficiency	DWR Corrective Actions	Summary of Plan Revisions	Revision Location
Deficiency #3: The Subbasin's land subsidence sustainable management criteria do not satisfy the requirements of SGMA and the GSP Regulations.	**3. (Subbasin)** • "Coordinate and collectively satisfy the requirements of SGMA and the GSP Regulations to develop the sustainable management criteria for land subsidence." • "Document the conditions for undesirable results for which the GSAs are trying to avoid, supported by their understanding of land uses and critical infrastructure in the Subbasin and the amount of subsidence that would substantially interfere with those uses." • "Identify the rate and extent of subsidence corresponding with substantial interference that will serve as the minimum threshold." • "Clearly identify the undesirable result parameters for each of the GSPs, management areas, and management area plans so it is clear how the various plans work together at the Subbasin level." • "Explain how implementing projects and management actions proposed in the various GSPs is consistent with avoiding subsidence minimum thresholds." • "If land subsidence is not applicable to parts of the Subbasin, provide supported justification of such."	• Referenced and discussed key findings from the six independent subsidence studies to fill data gaps, including the installation of a new extensometer. • Conducted extensive studies and data collection and provided and explained InSAR time series justification and methodologies to differentiate between subsidence caused by activities within and outside of the GSAs' authority to control (i.e., GSA-related vs. non-GSA-related), in coordination with State Water Project California Aqueduct Subsidence Program (CASP) and Friant Water Authority. • Developed Subbasin-wide definitions for Regional and GSA Area Critical Infrastructure. • Developed a Subbasin-wide approach to land subsidence SMCs, including a decision tree and risk-based matrix approach. • The GSAs have committed to minimize GSA-related subsidence by 2040. • Established land subsidence SMCs across the entire Subbasin based on a projection of the average historical subsidence rate across each HCM area. • Assessed the potential for differential subsidence using a change in slope analysis between 2024 and the MT extent to confirm minimal impacts to land surface uses and infrastructure. • Assessed potential impacts on regional critical infrastructure from future GSA-related subsidence, including impacts to canal freeboard that would cause substantial interference to conveyance capacity, and identified potential mitigation needs. • Coordinated with key beneficial users of regional critical infrastructure, including the Friant Water Authority and CASP. • Updated the Subbasin-wide Land Subsidence monitoring network.	Section 8.5 Section 13.5 Section 15.2.5

Additionally, the following updates were made in the Amended Subbasin Plan to incorporate new information, data, and the best available science:

- Updated the HCM and revised the Basin Setting chapters to incorporate new information based on the Basin Study work to date (see Sections 6 and 7).
- Developed updated Subbasin-wide water budgets using the Subbasin's numerical surface water-groundwater flow model, including impacts of climate change (see Section 9).
- Conducted a Subbasin-wide well impact analysis using the updated Kern well inventory to assess impacts to beneficial users at revised groundwater level SMCs (Section 13.1.2.4).
- Identified constituents of concern (COCs) for the Subbasin (Section 8.4) and established Degraded Water Quality SMCs for key COCs using common data and methodologies (see Section 13.3).
- Assessed potential impacts to surface land uses/infrastructure from differential subsidence (see Section 13.5).
- Conducted a Subbasin-wide assessment of the SGMA Monitoring Network for all Sustainability Indicators and updated the SGMA Monitoring Network (see Section 15).
- Updated the P/MAs based on the updated water budget forecasts and developed a consistent methodology for tracking progress and benefits (see Section 14). Estimated the benefits from all P/MAs to ensure the Subbasin GSAs will meet the targeted deficit reduction schedule to ensure sustainable groundwater management by 2040 (see Section 14).
- Established partnerships with Self-Help Enterprises and Kern Water Collaborative to assist in mitigating potential impacts to drinking water users (see Section 16.2.1.1, Appendix K and Appendix F).

1.3.1 Beneficial Uses and Users

SGMA requires that GSAs consider the interests of all beneficial uses and users of groundwater. CWC Section 10723.2 defines beneficial users as:

(a) Holders of overlying groundwater rights, including (1) agricultural users (farmers, ranchers, and dairy professions) and (2) domestic well owners.

(b) Municipal well operators.

(c) Public water systems.

(d) Local land use planning agencies.

(e) Environmental users of groundwater.

(f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.

(g) The federal government, including, but not limited to, the military and managers of federal lands.

(h) California Native American tribes.

(i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.

(j) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.

To quantify the beneficial users in the Subbasin, a well inventory that reconciles multiple datasets was conducted. While all beneficial users identified in the Water Code are acknowledged, some user categories were consolidated to align with the “type of well” options listed in Kern County Environmental Health’s Water Well Permit Application. Table 1-4 provides a cross reference to the consolidated user types and well counts for each type.

A Subbasin-wide well inventory was conducted to better understand the distribution of beneficial groundwater users in the Subbasin. The inventory started with obtaining records from DWRs Online System of Well Completion Reports (OSWCR), the Kern County Environmental Health Services (KCEHS), and United States Geological Survey (USGS). Datasets were processed to match records based on local permit numbers and well completion report number. Additionally, data were downloaded from California Open Data including well information from the Department of Drinking Water (DDW) and Irrigated Lands Regulatory Program.

The database was further reconciled through a collaboration between Subbasin water agencies, particularly Kern County Water Agency who maintains an inventory of wells in Improvement District No. 4 and municipalities who provided copies of the well completion reports in their records.

Since the OSWCR dataset provides construction information, this was maintained as the base record, but some adjustments were made to the data hierarchy to consolidate the best available information for each well. Details of the well inventory are presented in Section 5.6.1, *Well Inventory*. Prioritized data included:

- DDW data was used to identify all public supply wells, the use type (i.e., small community, municipal, or industrial), status (active, standby, inactive, destroyed), and was also found to provide the most accurate coordinates.

- For the remaining wells, where KCEHS data could be matched, well location and use type were prioritized over OSWCR data since KCEHS dataset provided actual coordinates and an inspector validates the intended use.

Table 1-4. Well Inventory User Category and SGMA Beneficial User Cross Reference

Well Type	# of Wells	Beneficial Users per SGMA (CWC Sec. 10732.2)	Description of User Type
Agricultural	4,290	(a)(1) Agricultural users	Groundwater wells typically constructed with large diameter casing (18 to 24-inch), designed to extract up to 2,500 gallons per minute (gpm), and are predominately used for crop irrigation or stock watering.
Domestic or Non-Public	2,501	(a)(2) Domestic well owners (h) California Native American Tribes (i) Disadvantaged communities	Groundwater wells typically have a small casing diameter (4.5 to 6-inch), designed to extract less than 100 gpm. Water supplies an individual residence or non-public water system (shared well) that has no more than four connections.
Municipal, Public Water Supply, Industrial	298	(b) Municipal well operators (h) California Native American Tribes (i) Disadvantaged communities (c) Public water systems	A municipality or public water system serving **more than 10,000 people**. Groundwater wells are typically constructed with large diameter casing, designed to extract an average of 1,000 gpm. Typically, these water systems have redundant sources of supply and wells are constructed to extract high quality water from the aquifer.
Small Community	41	(c) Public water systems (h) California Native American Tribes (i) Disadvantaged communities	A public water system that serves **less than 3,300 people**. Groundwater wells typically have a medium casing diameter (8 to 10-inch), designed to extract around 500 gpm, and often lack redundant supply that a municipality or public water system would have.
Industrial	97		Groundwater wells used for processing, heating, or cooling in a manufacturing process, or oil extractions from a Principal Aquifer. Typically, industrial wells do not require high-grade potable water.

Key elements of this Amended Subbasin Plan that consider potential impacts to beneficial uses and users of groundwater include:

- The process for developing SMCs related to Chronic Lowering of Groundwater Levels, Land Subsidence, Degraded Water Quality, and Groundwater Storage included the evaluation of potential impacts on local beneficial users and land surfaces. Results of impact analyses were presented at public meetings for stakeholder input including monthly GSA board meetings and GSA group meetings (e.g., South of Kern River Executive Committee), to key beneficial users of regional critical infrastructure, and to SWRCB staff during consultation meetings.
- Subbasin GSAs are working collaboratively to avoid impacts, especially to domestic and small community system wells. This Amended Subbasin Plan has

addressed potential impacts to drinking water users in the Subbasin through a robust well impacts analysis and establishment of a MT Exceedance Policy and Well Mitigation Program. Including a numeric threshold for dewatered drinking water wells in the undesirable result definition for Chronic Lowering of Groundwater Levels and the well impacts analyses presented in Section 13.1.2.4 demonstrates how the most sensitive beneficial users of groundwater (i.e., drinking water users) were considered during Amended Subbasin Plan development.

- The Subbasin's SGMA Monitoring Network, whose purpose is to collect sufficient data to assess relevant Sustainability Indicators and potential impacts to beneficial uses and users, demonstrates the GSAs' commitment to collecting sufficient data to ensure the P/MAs, policies, and programs are succeeding in sustainably managing groundwater resources for all beneficial uses and users of groundwater.

Subbasin GSAs continue to implement their local Stakeholder Communication and Engagement Plans to achieve active engagement and input of beneficial users within their respective jurisdictional areas.

2. SUSTAINABILITY GOAL

§ 354.24 *Sustainability Goal*
Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

☑ 23 CCR § 354.24

The sustainability goal for the Kern County Subbasin is to implement its GSPs to achieve sustainable groundwater management within the 20-year implementation schedule. Achieving the sustainability goal will be demonstrated by eliminating chronic lowering of groundwater levels caused by overdraft conditions and avoiding Undesirable Results for groundwater levels, groundwater storage, land subsidence, and groundwater quality. This goal will be accomplished through the following objectives:

- Implement the Subbasin Community Engagement Plan.
- Eliminate long-term groundwater overdraft and attain sustainability through conjunctive use, water banking, and demand management programs.
- Continuously evaluate groundwater conditions to avoid undesirable results.
- Maintain long-term sustainability of water resources available to the Subbasin.
- Maintain a comprehensive database of beneficial uses and users to inform on the efficacy of groundwater management policies and programs.

This page intentionally left blank.

3. AGENCY INFORMATION

*§ **354.6.** When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:*
(a) The name and mailing address of the Agency.
(b) The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.
(c) The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.
(d) The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.
(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

3.1 Agency Contact Information

☑ **23 CCR § 354.6(a)**

Sustainable groundwater management for the Subbasin is administered by 20 GSAs and one coordinated groundwater management area. Each agency has designated representatives to coordinate with municipalities, their neighboring entities, and stakeholders within and adjacent to their management area[3]. As described in this Amended Subbasin Plan, managers are collectively working to achieve sustainable groundwater management within the planning horizon. Table 3-1 provides contact information for each GSA. Figure 3-1 is a map showing GSA coverage.

Table 3-1. GSA Manager Contact Information

GSA	Address	GSA Manager and E-mail	Phone
Arvin GSA www.aewsd.org	20401 E. Bear Mountain Blvd. PO Box 175 Arvin, CA 93203	Jeevan Muhar Engineer-Manager jmuhar@aewsd.org	661-854-5573
Buena Vista GSA www.bvh2o.com	525 North Main Street PO Box 756 Buttonwillow, CA 93206	Tim Ashlock Engineer-Manager tim@BVH2O.com	661-764-2901
Cawelo Water District GSA www.cawelowd.org	17207 Industrial Farm Road Bakersfield, CA 93308	David Halopoff Assistant General Manager dhalopoff@cawelowd.org	661-393-6072
Greenfield County Water District GSA	551 Taft Highway Bakersfield, CA 93307	Nick Cooper ncooper@greenfieldcwd.org	661-831-0989
Henry Miller Water District GSA	101 W. Walnut Street Pasadena, CA 91103	Jeof Wyrick President / Chairman jwyrick@jgboswell.com	626-583-3000

GSA	Address	GSA Manager and E-mail	Phone
Kern Non-Districted Land Authority GSA[3] (formerly Kern Groundwater Authority GSA) www.kerngwa.com/	1800 J Street Sacramento, CA 95811	Valerie Kincaid[3] Manager vkincaid@pariskincaid.com	916-264-2046
Kern River GSA /www.kernrivergsa.org	1000 Buena Vista Road Bakersfield, CA 93311	Daniel Maldonado Assistant Director drmaldonado@bakersfieldcity.us	661-326-3715
Kern Water Bank GSA www.kwb.org	1620 Mill Rock Way, Ste 500 Bakersfield, CA 93311	Jonathan Parker jparker@kwb.org	661-398-4900
Kern-Tulare Water District GSA www.kern-tulare.com	5001 California Ave., Ste 102 Bakersfield, CA 93309	Vanessa Yap Staff Engineer vanessa@kern-tulare.com	661-327-3132
North Kern Water Storage District GSA www.northkernwsd.com/	33380 Cawelo Ave. Bakersfield, CA 93308	David Hampton General Manager dhampton@northkernwsd.com	661-393-2696
Olcese Water District GSA	15701 Hwy 178 Bakersfield, CA 93306	Jeff Siemens jsiemens@nfllc.net	661-872-5050
Pioneer GSA www.kcwa.com/	3200 Rio Mirada Drive Bakersfield, CA 93308	Michelle Anderson Geologist manderson@kcwa.com	661-634-1479
Rosedale-Rio Bravo Water Storage District GSA www.rrbwsd.com	849 Allen Road Bakersfield, CA 93314	Dan Bartel Engineer-Manager dbartel@rrbwsd.com	661-589-6045
Semitropic Water Storage District GSA www.Semitropic.com	1101 Central Ave. Wasco, CA 93280	Jason Gianquinto General Manager jgianquinto@semitropic.com	661-758-5113
Shafter-Wasco Irrigation District GSA www.swid.org	16294 Central Valley Hwy. Wasco, CA 93280	Kris Lawrence General Manager klawrence@swid.org	661-440-8559
Southern San Joaquin Municipal Utility District GSA	11281 Garzoli Ave. Delano, CA 93215	Roland Gross General Manager/Secretary roland@ssjmud.org	661-725-0610
Tejon-Castac Water District GSA	4436 Lebec Road Lebec, CA 93243	Angelica Martin Water Resources Director amartin@tejonranch.com	661-663-4262
West Kern Water District GSA	800 Kern Street Taft, CA 93268	Greg Hammett General Manager ghammett@wkwd.org	661-763-3151
Westside District Water Authority GSA	21908 7th Standard Road McKittrick, CA 93251	Mark Gilkey General Manager mgilkey@westsidewa.org	661-633-9022
Wheeler Ridge-Maricopa GSA	12109 Highway 166 Bakersfield, CA 93313	Sheridan Nicholas Engineer-Manager snicholas@wrmwsd.com	661-527-6075

[3] Eastside Water Management Area https://kernewma.com is covered by Kern Non-Districted Land Authority GSA. Eastside Water Management Area is managed by: Taylor Blakslee TBlakslee@hgcpm.com 661-477-3385.

3.2 GSA Organization and Management Structure

☑ **23 CCR § 354.6(b)**

The Coordination Agreement, provided as Appendix C, establishes a governance structure for how the GSAs will cooperate and coordinate in exercising their SGMA authorities to jointly develop and implement the Amended Subbasin Plan. Pursuant to the Coordination Agreement, each agency has designated representatives to participate in the coordination committee which, with the support of the agencies' respective staff and consultants, is responsible for guiding development and implementation of the Amended Subbasin Plan that achieves sustainable groundwater management within the planning horizon. To manage the ongoing activities of SGMA implementation, managers meet regularly to oversee SGMA-related expenses, address policy issues, and discuss implementation progress. Further, in some instances, the Basin GSAs have formed GSA Groups for locally coordinated implementation, as detailed in Table 3-2.

The coordination committee responsibilities also include encouraging public outreach and stakeholder engagement efforts of the GSA's and collaborating amongst the governing bodies of each agency so that they are informed and prepared to take all actions necessary to satisfy the requirements of SGMA. The Coordination Agreement provides ongoing cooperation and cost-sharing in undertaking activities related to sustainable groundwater management.

The coordination committee includes a representative from each agency's Board of Directors, one manager from each GSA or GSA Group. The format is designed to encourage participation and facilitate communication and collaboration among all GSA Managers and the stakeholders and other interested parties that they represent.

Table 3-2. GSA Groups in the Kern Subbasin

GSA Group	Member Agencies
Buena Vista GSA	Buena Vista GSA
Henry Miller GSA	Henry Miller GSA
Kern Fan Banking Group	Kern Water Bank GSA Pioneer GSA West Kern Water District GSA
Kern Non-Districted Land Authority	Eastside Water Management Area Non-districted lands not covered by another GSA
Kern River GSA	City of Bakersfield (KRGSA) Kern County Water Agency ID4 (KRGSA) Kern Delta Water District (KRGSA) Greenfield County Water Districts GSA California Water Service (Participating Agency) East Niles Community Service District (Participating Agency) Oildale Mutual Water Company North of the River Municipal Water District (Participating Agency) Vaughn Water Company (Participating Agency)

GSA Group	Member Agencies
Kern-Tulare Water District GSA	Kern-Tulare Water District GSA
North Central Kern	Cawelo Water District GSA North Kern WSD GSA Shafter-Wasco ID GSA Shafter-Wasco 7th Standard Annex Southern San Joaquin MUD GSA
Olcese Water District GSA	Olcese Water District GSA
Rosedale-Rio Bravo WSD GSA	Rosedale-Rio Bravo WSD GSA
Semitropic Water Storage District GSA	Semitropic Water Storage District GSA
South of Kern River	Arvin GSA Tejon-Castac Water District GSA Wheeler Ridge-Maricopa GSA Arvin Community Services District
Westside District Water Authority GSA	Westside District Water Authority GSA Belridge Water Storage District Berrenda Mesa Water District Lost Hills Water District

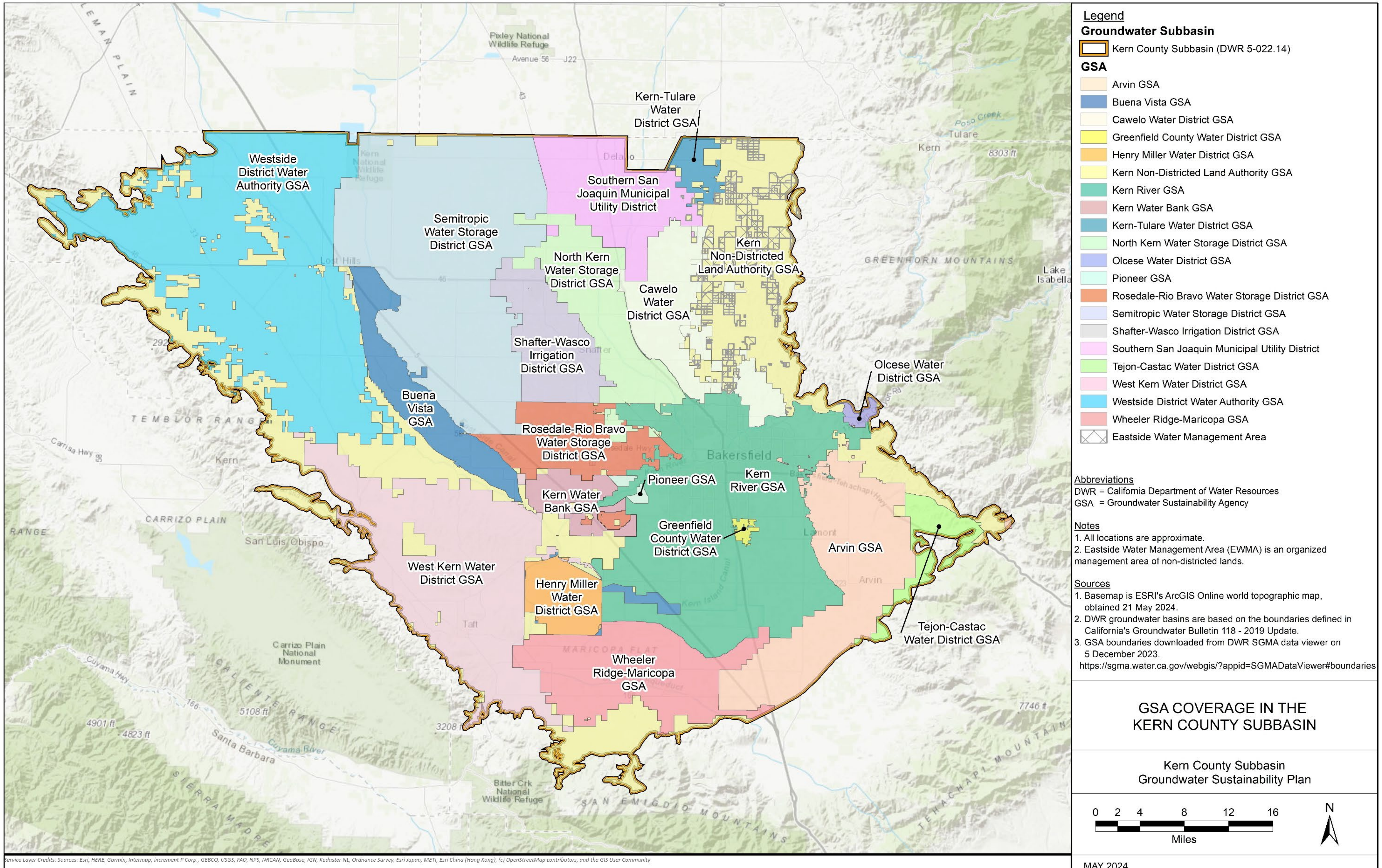


Figure 3-1. GSA Coverage in the Kern Subbasin

This page intentionally left blank.

3.3 Kern County Subbasin Plan Manager/Point of Contact

☑ **23 CCR § 354.6(c)**

Pursuant to 23 CCR § 357.4(b)(1), the Kern County Subbasin coordination committee established a "point of contact" for the Subbasin by unanimous agreement for a term of one calendar year, and annually thereafter, as described in the Coordination Agreement. The Plan Manager serves as the Point of Contact between the groundwater management entities. Additional responsibilities for this role include assisting with the submittal of the Amended Subbasin Plan, plan amendments, supporting information, monitoring data and other pertinent information, annual reports, and periodic evaluations to state agencies, when required. Additional duties directed by the coordination committee may include:

1. Organization of monthly coordination committee meetings (led by chair).
2. Organization of periodic (weekly/monthly) subbasin managers' meetings.
3. Facilitate and organize annual report preparation.
4. Facilitate meetings with state agencies (DWR/SWRCB) and others.
5. Facilitate coordination committee oversight of subbasin-wide projects, topics, project scoring, and future subbasin-wide grant efforts, including subbasin-wide coordination of meetings.

Table 3-3 Plan Manager Contact Information

Plan Manager	E-mail	Phone
Kristin Pittack	kpittack@rinconconsultants.com	559-228-9925 (O) 760-223-5062 (C)

3.4 Legal Authority of the GSA's

☑ **23 CCR § 354.6(d)**

The Subbasin includes 20 GSAs and one coordinated management area. Each GSA applied for and was granted exclusive GSA status under CWC Sections 10723(c) and 10723.8. As stated in CWC §10725, the GSAs have authority to determine the need for groundwater management, prepare and adopt a GSP, propose and update fees, and monitor compliance and enforcement. Further, GSAs may require registration and metering of groundwater extraction facilities, and annual reporting of groundwater extractions. Additional GSA authorities are outlined in CWC 10726.2 and 10726.4.

The Eastside Water Management Area (EWMA) was formed on May 7, 2018, and implements groundwater management through a Provision of Jurisdiction Agreements with the Kern Non-Districted Land Authority (KNDLA). The SGMA Jurisdiction

Agreement, executed on October 21, 2019, formally defines EWMAs roles and responsibilities as a partner to the other Subbasin GSAs.

3.5 Estimated Cost of Implementation

☑ **23 CCR § 354.6(e)**

The Subbasin GSAs are collectively funding the Subbasin-wide components of Amended Subbasin Plan development, as well as ongoing monitoring and annual reporting. Individually, the groundwater management agencies are responsible for addressing local SGMA considerations and funding projects and management actions. Table 3-4 summarizes actual and/or estimated costs of implementation for the Subbasin with a general description of each line item. Additionally, more detailed descriptions of planned SGMA implementation and the associated costs are provided in Section 16.

Table 3-4. Subbasin Costs of Implementation

Element	Description	Estimated Cost
Annual Administration	Describe plan manager responsibilities, grant administration.	$250,000 Annual
GSP Development	Actual cost for developing this Amended Subbasin Plan.	$1,300,000
IWFM-Kern Model Development	Used to develop historical, current and future projected water budgets for the Kern County Subbasin. Water budget numbers will be used to update the planning numbers to support P/MAs.	$770,000
Annual Report	Ongoing costs to conduct Annual Reporting	$100,000 Annual Cost
Data Management System	Developed to collect SGMA related data and improve efficiency and accuracy of reporting requirements.	$650,000 Initial Cost $40,000 Annual Cost
Monitoring	Coordinated InSAR, water quality sampling and water level data collection.	$75,000 Annual Cost
Mitigation Programs	Partnership with Self-Help Enterprises to conduct well mitigation, Kern Water Collaborative to ensure all users have access to safe drinking water. Maintain relationships with other Subbasin partners to achieve sustainability.	$900,000 Annual Cost
Periodic Evaluation and 5-Year GSP Update	Review Annual Report data, current groundwater conditions, and evaluate the Amended Subbasin Plan and adjust as needed to ensure interim milestones continue to be met.	$500,000
Implementation of all planned P/MAs	Implementing demand reduction and supply augmentation P/MAs to achieve the Subbasin sustainability goal. See Section 14 for details.	$1.3 Billion One Time $45 Million Annual Cost

4. GSP ORGANIZATION

This Groundwater Sustainability Plan (GSP) is organized as follows:

Executive Summary	
Introduction	*Section 1: Purpose of the Groundwater Sustainability Plan* *Section 2: Sustainability Goal* *Section 3: Agency Information* *Section 4: GSP Organization*
Description of the Plan Area	*Section 5*
Basin Setting	*Section 6: Introduction to Basin Setting* *Section 7: Hydrogeologic Conceptual Model* *Section 8: Current and Historical Groundwater Conditions* *Section 9: Water Budget Information* *Section 10: Management Areas*
Sustainable Management Criteria	*Section 11: Introduction to Sustainable Management Criteria* *Section 12: Sustainability Goal* *Section 13: Sustainable Management Criteria*
Projects and Management Actions	*Section 14*
Monitoring Network	*Section 15*
Plan Implementation	*Section 16*

This page intentionally left blank.

Appendices

Appendix A	Department of Water Resources 2022 Incomplete Determination Letter and GSP Staff Assessment Report
Appendix B	Department of Water Resources 2023 Inadequate Determination Letter and Statement of Findings
Appendix C	Second Amended Kern County Subbasin Coordination Agreement
Appendix D	Kern Non-Districted Lands Authority Joint Powers Agreement
Appendix E	Kern Subbasin Water Banking Programs
Appendix F	Kern Water Collaborative Draft Memorandum of Understanding for Groundwater Testing and Free Drinking Water to Residents Impacted by Nitrate Contamination
Appendix G	General Plan Relevant Policies, Goals, and Implementation Measures
Appendix H	Stakeholder Communications and Engagement Plan (placeholder, plan in development)
Appendix I	Summary of Outreach and Engagement Activities
Appendix J	Friant Water Authority Letter of Support for Subbasin Subsidence Mitigation on the Lower Reach of the Friant-Kern Canal
Appendix K	Self-Help Enterprises Letter of Intent to Administer Kern County Subbasin Well Mitigation Program
Appendix L	Groundwater Quality Considerations for High and Medium Priority Groundwater Basins letter to the DWR
Appendix M	Supporting Water Budget Tables C2VSimFG-Kern Model
Appendix N	Validation and Performance of C2VSimFG-Kern
Appendix O	Alternatives Evaluation for Chronic Lowering of Groundwater Levels Minimum Threshold Approaches
Appendix P	Chronic Lowering of Groundwater Levels Representative Monitoring Well Hydrographs with Sustainable Management Criteria
Appendix Q	Well Impact Analysis Results by Well Type
Appendix R	Degraded Water Quality Representative Monitoring Well Chemographs with Sustainable Management Criteria
Appendix S	Individual GSA Projects and Management Actions (P/MAs)
Appendix T	INTERA SOW to Support Subsidence Mitigation Cost Analysis for the FKC
Appendix U	Basin Study Scope of Work
Appendix V	LandIQ SOW for ET Data Analysis
Appendix W	MT Exceedance Policy
Appendix X	Monitoring Network
Appendix Y	Standard Operating Procedure, Water Level Measurement and Reporting
Appendix Z	Standard Operating Procedure, Water Quality Sampling and Reporting

This page intentionally left blank.

5. DESCRIPTION OF THE PLAN AREA

***§ 354.8.** Each Plan shall include a description of the geographic areas covered, including the following information:*
(a) One or more maps of the basin that depict the following, as applicable:
(1) The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.
(2) Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.
(3) Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.
(4) Existing land use designations and the identification of water use sector and water source type.
(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.
(b) A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.

This chapter describes the Kern County Subbasin (referred to herein as the "Kern Subbasin" or "Subbasin") including relevant jurisdictional boundaries, key land use features, water sources and uses, and beneficial users of groundwater. Information on regulatory programs relevant to the sustainable management of groundwater and stakeholders engaged to acquire the best available information to develop this Groundwater Sustainability Plan (Plan) are also identified. Additionally, this chapter introduces the Hydrogeologic Conceptual Model (HCM) Areas referenced throughout this Amended Subbasin Plan to briefly describe differences in groundwater conditions across the Subbasin.

5.1 Area Covered by the Plan

☑ 23 CCR § 354.8(a)(1)

The Kern County Subbasin (DWR Basin No. 5-022.14) is in the southern San Joaquin Valley Groundwater Basin (5-022) and the southern portion of the Tulare Lake Hydrologic Region. Covering about 2,834 square miles (1,782,321 acres), it is the largest groundwater Subbasin in California and shares boundaries with four other groundwater subbasins (refer to Figure 5-1). To the north are Tulare Lake Subbasin (DWR Basin 5-022.12), Tule Subbasin (DWR Basin 5-022.13) and Kettleman Plain Subbasin (DWR Basin 5-022.17), and to the south is the White Wolf Subbasin (DWR Basin 5-022.18).

As discussed in Section 1.1, the Amended Subbasin Plan is a collection of GSPs and Coordination Agreement. Therefore, the area covered by the Plan (i.e., “Plan Area”) is the entire Kern Subbasin.

5.2 Hydrogeologic Conceptual Model (HCM) Areas

☑ 23 CCR § 354.8(a)(1)

Because the Kern County Subbasin is a large and geologically complex basin with regional faulting and folding, and three principal aquifers, this Plan divides the Subbasin into five HCM Areas that each have similar geology and aquifer characteristics but have distinguishing differences from the other areas of the Subbasin. Defining these HCM Areas enables readers to understand the complexity of the Kern Subbasin, and for GSAs to succinctly explain why their management approach may be different from neighboring GSAs. The following points summarize the characteristics of each HCM Area:

- **Western Fold Belt**. This area corresponds to the Westside Fold Belt described in USGS Professional Paper 1501 (Bartow 1991). Key characteristics are extensive geologic folding and it’s dominated by large oil fields and poor-quality groundwater. Due to the naturally degraded groundwater quality and alkali soils, agriculture is limited. As such, there is only minimal groundwater pumping: all land surface uses rely on imported water supplies (i.e., State Water Project or groundwater from a neighboring HCM Area).
- **North Basin** (North of Kern River Fan). The large alluvial basin north of the Kern River Fan area is a major agricultural area. This area is underlain by a thick sequence of alluvial sediments that form a highly productive aquifer. The presence of clay layers, primarily the E-Clay, forms distinctive aquifer zones in some areas that influence the vertical flow of groundwater.
- **Kern River Fan.** This area corresponds to the Kern River alluvial fan. The Kern River is a large hydrologic feature that is a major surface water supply and source of surface water storage and groundwater recharge. The coarse alluvial sediments with limited clay layers make this a prime banking area for the Subbasin. The banking operations within the Kern River fan area form a distinctive water level response that is recognizable on hydrographs and is generated as banking operations cycle between periods of surface water storage and recovery.
- **South Basin** (South of Kern Fan). The large alluvial basin south of the Kern River Fan is the other major agricultural area underlain by a thick, highly productive alluvial aquifer.

- **East Margin.** This area lies along the eastern Subbasin margin where older geologic units taper and outcrop. The area includes large fault-bounded oil fields. In the northeast area, the Santa Margarita and Olcese Principal Aquifers provide water supply and together are designated as a local principal aquifer. In the southeast, the Edison Fault is a structural barrier to groundwater flow.

This page intentionally left blank.

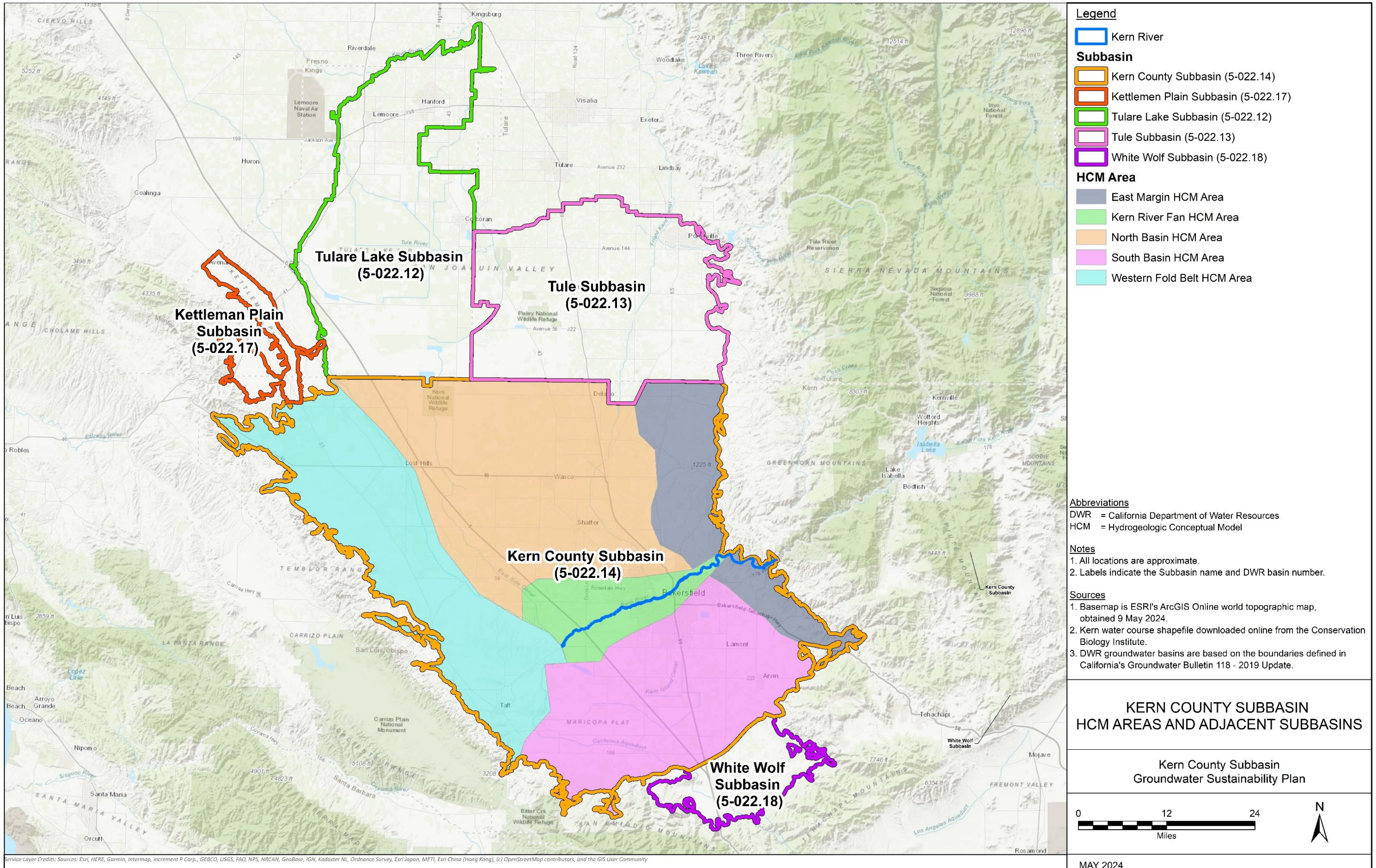


Figure 5-1. Kern County Subbasin HCM Areas and Adjacent Subbasins

This page intentionally left blank.

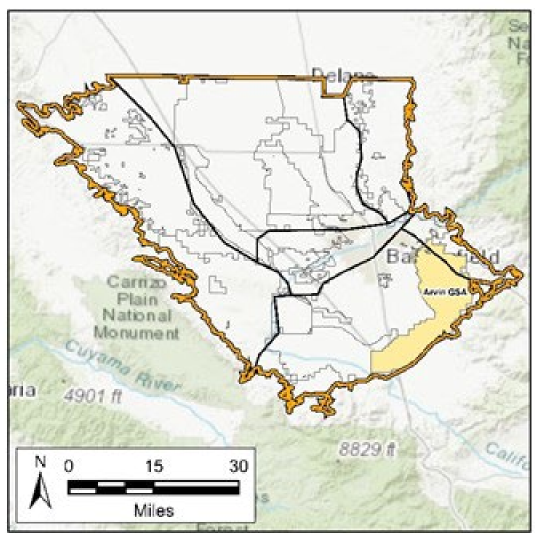
5.2.1 Jurisdictional Boundaries

☑ 23 CCR § 354.8(a)(3)

The Subbasin is entirely contained within Kern County. The majority of the agricultural areas are covered by a water district, as shown in Figure 5-2; most of which applied for and were granted exclusive Groundwater Sustainability Agency (GSA) status, as shown in Figure 5-3. However, the water district boundaries don't strictly align with GSA boundaries. Several water districts sent notices to landowners, located within or adjacent to their jurisdictional boundaries, offering an agreement for SGMA coverage when they formed their GSAs. When the County of Kern opted out of providing GSA coverage to non-districted lands, landowners who did not respond to water district agreements received coverage by the Kern Non-Districted Land Authority GSA, formerly the Kern Groundwater Authority, to ensure coverage across the entire Subbasin.

In this Plan, the distinguishing difference between lands within a water district or within GSA boundaries are access to water supply benefits, such as conjunctive use programs and access to surface water banking programs that directly benefit the participating landowner. Statistical information about each GSAs management areas and jurisdictional boundaries within it are provided below in alphabetical order of GSA name.

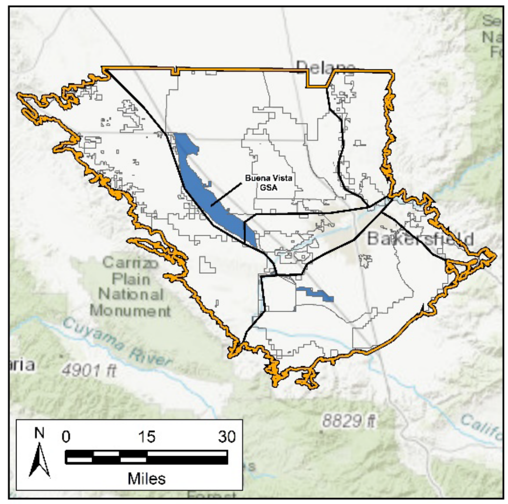
Arvin GSA



- Encompasses approximately 105,900 acres of the Arvin-Edison Water Storage District (AEWSD) service area.
- Includes all AEWSD lands within the Subbasin that are not significantly overlapped by the East Niles Community Services District (ENCSD).
- Includes the Arvin Community Services District (ACSD) urban area, which is approximately 2,000 acres.
- Includes approximately 1,860 acres of parcels outside of AEWSD service area (i.e., "non-districted lands").
- Overlaps the jurisdictional boundary of Mettler Country Water District (MCWD) and Wheeler Ridge-Maricopa Water Storage District (WRMWSD).

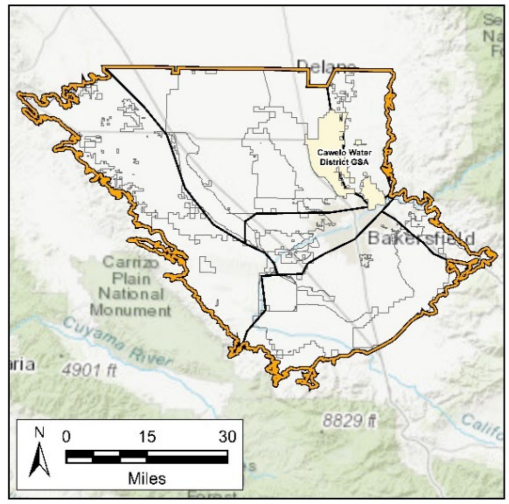
- Bordered by the Wheeler Ridge-Maricopa GSA, White Wolf Subbasin and GSA, Tejon-Castac Water District GSA, Kern River GSA, and Kern Non-Districted Land Authority GSA.
- Participating entity of the South of Kern River (SOKR) GSA Group.
- Lies mostly in the South Basin HCM Area, except where the Edison Fault transects the northeast corner of the GSA, delineating the East Margin HCM Area (see Section 5.2).

Buena Vista GSA



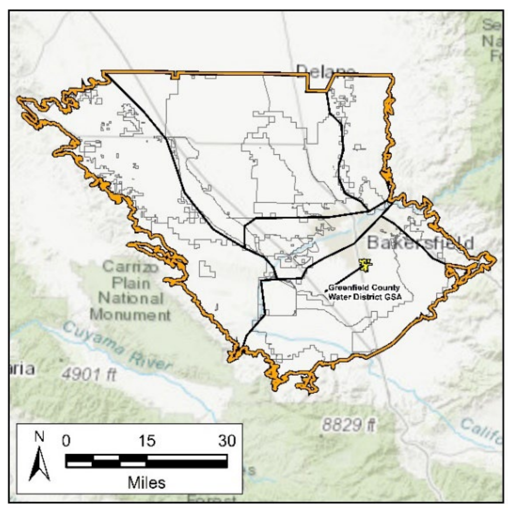
- Encompasses 50,560 acres of the Buena Vista Water Storage District (BVWSD) service area and includes all BVWSD lands.
- Bordered by the Semitropic Water Storage District GSA, the Kern Water Bank Authority GSA, the Westside District Water Authority GSA, the West Kern Water District GSA, the Kern River GSA, the Henry Miller GSA, and the Rosedale-Rio Bravo Water Storage District GSA.
- Divided into two physically separated service areas, the Buttonwillow Service Area and the Maples Service Area.
- The unincorporated community of Buttonwillow lies entirely within the GSA.
- The Buttonwillow Service Area lies within the North Basin, Western Fold Belt and Kern Fan HCM areas while the smaller Maples Service Area lies entirely within South Basin HCM Area.

Cawelo Water District GSA



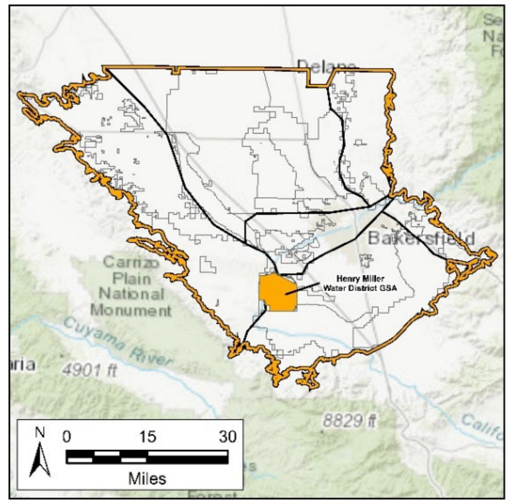
- Encompasses 62,935 acres of the Cawelo Water District (CWD) service area and includes all CWD lands.
- Includes approximately 18,521 acres of parcels outside of the CWD service area (i.e., "non-districted lands").
- Bordered by the North Kern Water Storage District GSA, the Southern San Joaquin Municipal Utility District GSA, the Eastside Water Management Area, the Kern Non-Districted Land Authority GSA, and the Kern River GSA.
- Participating entity of the North Central Kern GSA Group.
- The Cawelo Water District GSA lies mostly in the North Basin HCM Area, with some minor areas in the East Margin HCM Area and Kern Fan HCM Area.

Greenfield County Water District GSA



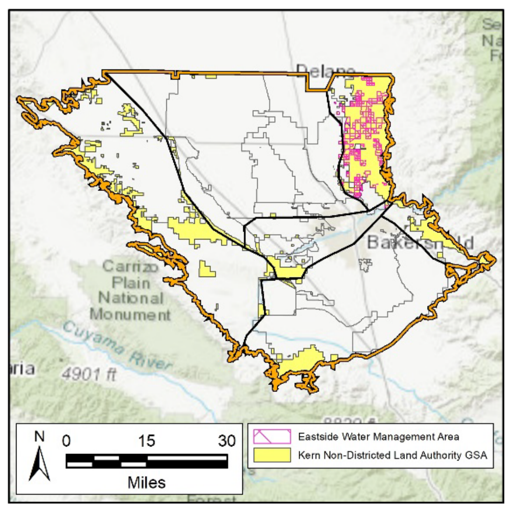
- Greenfield County Water District GSA is an exclusive GSA completely surrounded by KRGSA and coordinates with the KRGSA for SGMA implementation through a memorandum of understanding (MOU).
- Greenfield provides groundwater from six active local wells serving about 3,500 connections and delivers approximately 2,500 AFY of groundwater supply.

Henry Miller Water District GSA



- Encompasses 26,055 acres of the Henry Miller Water District GSA (HMWD) service area and includes all HMWD lands. The total area primarily consists of irrigated agricultural land, but also includes a manmade recreational lake, undeveloped land, the California Aqueduct, and land used for oil and gas production.
- Bordered by the West Kern Water District GSA, Buena Vista Water Storage District GSA, Kern River Groundwater Sustainability Agency, Kern Non-Districted Land Authority GSA, and Wheeler Ridge-Maricopa GSA.
- The majority of HMWD falls within South Basin HCM Area, with a small portion in the Western Fold Belt HCM Area.

Kern Non-Districted Land Authority



- The Kern Non-Districted Land Authority (Authority), formerly known as Kern Groundwater Authority, is governed by public agencies responsible for water management in the Kern Subbasin who have entered into a Joint Powers Agreement to provide regulatory authority for non-districted land, so those lands are able to be regulated under a GSP as required by SGMA (refer to Appendix D).
- Encompasses 279,277 total acres, of which 39,420 acres are managed by Eastside Water Management Area (pink hash on inset map; details provided below).
- Non-Districted Lands and EWMA are treated as separate management areas with regard to water budgets and Projects and Management Actions (P/MAs). Refer to Chapters 10 and 14 for additional information.

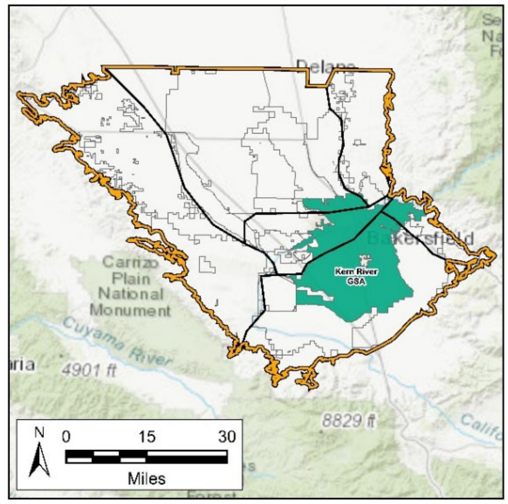
Non-Districted Lands

- The Non-Districts Lands encompass approximately 239,420 acres, just under 10,000 acres are irrigated.
- Land uses include oil/industrial (51 percent), urban and roads (27 percent), native or riparian vegetation (18 percent), trees (3 percent), and row crops (2 percent). A map of Kern Non-Districted Land Authority land uses is provided in Figure 5-5.
- Urban land uses include the Western Acres Mutual Water, Enos Lane, and Stoco Mutual in the Kern River Fan HCM Area; the Tule Elk Reserve transient non-community water system in the southern Western Fold Belt HCM Area; and Choctaw Valley Round Mountain, and Uplands of the Kern small community water systems in the Eastern Margin HCM Area. Additional water system information is provided in 5.6.3.
- Native vegetation includes the 93,170-acre Wind Wolves Preserve and 656-acres of the Buena Vista Aquatic Recreational Area (BVARA).

Eastside Water Management Area (EWMA)

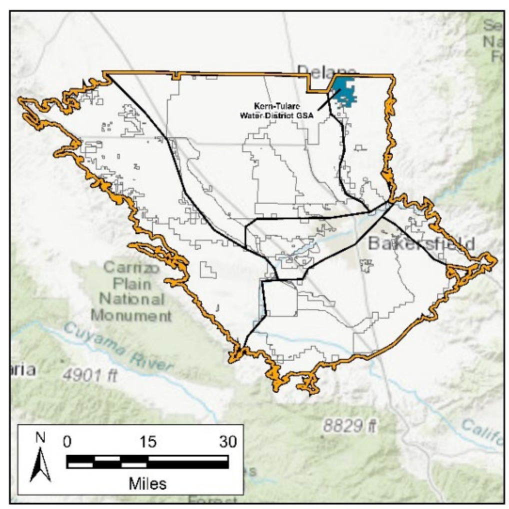
- EWMA is a non-profit corporation governed by a seven-member Board of Directors. This entity was formed to represent its members (organizations or individuals) under the GSA authority granted to the Kern Non-Districted Land Authority. EWMA is working to become a public agency and serve as the GSA for land within its boundaries.
- Encompasses 39,420 acres primarily in the East Margin HCM Area with a few non-districted parcels on the eastern edge of the North Basin HCM Area.
- Most lands are adjacent to Kern-Tulare Water District GSA and the Southern San Joaquin Municipal Utility District GSA.
- Land uses include oil/industrial (81 percent), trees (16 percent) urban and roads (7 percent), and idle land (2 percent).

Kern River GSA



- Encompasses approximately 232,499 acres of the Kern County Subbasin.
- Bordered by the Arvin GSA, the Henry Miller GSA, the Cawelo Water District GSA, the Kern Water Bank GSA, the Olcese GSA, Pioneer GSA, and the Rosedale – Rio Bravo GSA.
- The KRGSA lies within the South Basin and Kern Fan HCM areas.
- KRGSA is comprised of member agencies including the City of Bakersfield, Kern Delta Water District (KDWD), Kern County Water Agency (KCWA) Improvement District No. 4 (ID4), North of the River Municipal Water District/Oildale Mutual Water Company (NORMWD/OMWC) and East Niles Community Services District (ENCSD).
- Greenfield County Water District, which is its own GSA and is cooperatively participating in the KRGSA GSP through an MOU.

Kern-Tulare Water District GSA

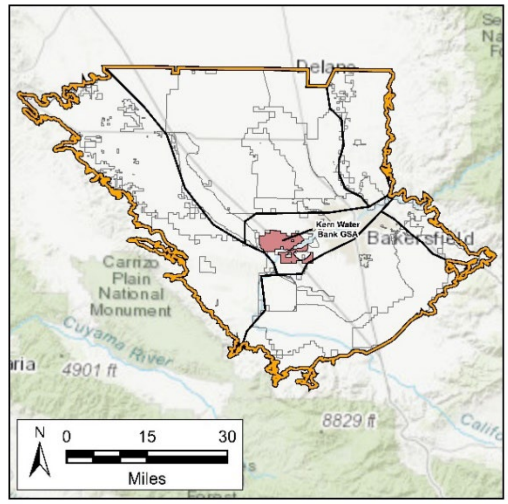


- Kern-Tulare Water District (KTWD) GSA is located on the eastern side of the Kern County subbasin, approximately 8 miles east of Delano and 27 miles north of Bakersfield. KTWD GSA encompasses all 19,700 acres of Kern-Tulare Water District service area and about 180 acres of non-districted land. KTWD GSA overlies two subbasins - the Kern County Subbasin and the Tule Subbasin. The Kern County Subbasin portion of the GSA is about 11,280 acres.
- Bordered by the Kern County Subbasin's Kern Non-Districted Land Authority GSA to the east including the Eastside Water Management Area, the Southern San Joaquin Municipal Utility District GSA to the west and Cawelo Water District GSA to the south.
- Bordered by the Tule Subbasin's Delano-Earlimart Irrigation District GSA to the northwest and Eastern Tule GSA to the northeast.

- KTWD GSA lies entirely within the East Margin HCM area and is comprised exclusively agricultural lands.

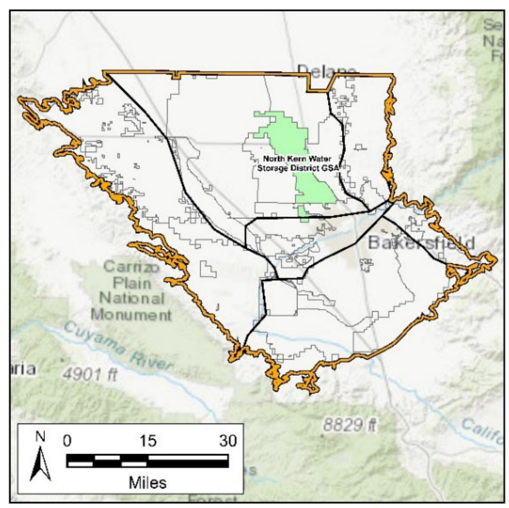
Kern Water Bank GSA

- The GSA encompasses all 20,600 acres of the Kern Water Bank Authority's lands. Except for local oil field activities, the lands are used exclusively for the Kern Water Bank's storage and recovery operations.
- The KWB GSA is bordered by the Kern Non-Districted Land Authority GSA, the Rosedale-Rio Bravo GSA, the Pioneer GSA, the Kern River GSA, and the West Kern GSA.
- The GSA lies entirely within the Kern River Fan HCM area.



North Kern Water Storage District GSA

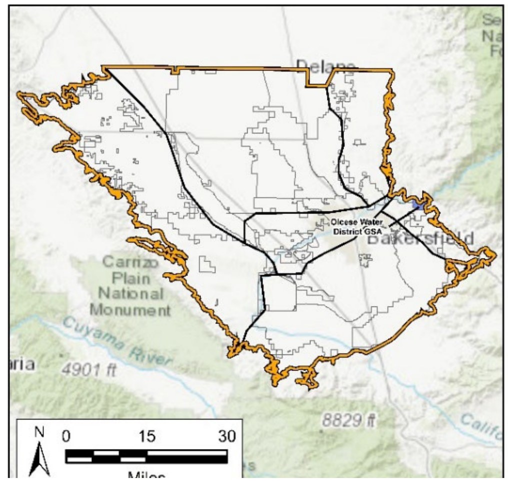
- Encompasses 67,543 acres of the North Kern Water Storage District (NKWSD) GSA service area and includes all NKWSD lands within the old district (61,741 acres) and portion of Rosedale Ranch Irrigation District (RRID, 5,802 acres).
- Bordered by the Shafter-Wasco Irrigation District, Semitropic Water Storage District, Southern San Joaquin Municipal Utility District, Cawelo Water District GSA, Pioneer GSA, and Rosedale-Rio Bravo GSA.



- Participating entity of the North Central Kern GSA Group.
- Lies entirely within the North Basin HCM Area.

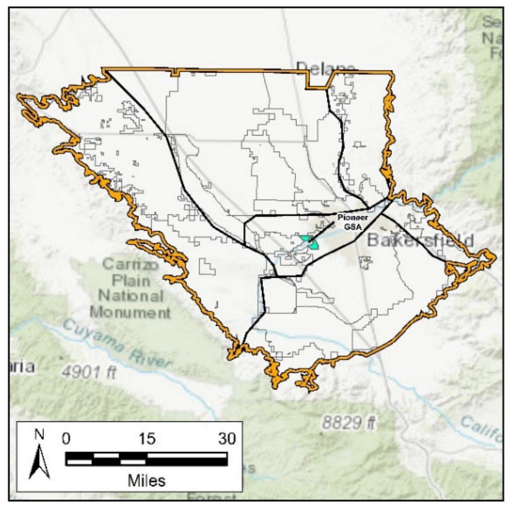
Olcese Water District GSA

- Encompasses 3,206 acres of the Olcese Water District (Olcese) service area. The Olcese Water District area extends to the north and east into areas not within any DWR groundwater basin.
- Bordered by the Kern Non-Districted Land Authority GSA and Kern River GSA.
- Lies entirely within the East Margin HCM Area.

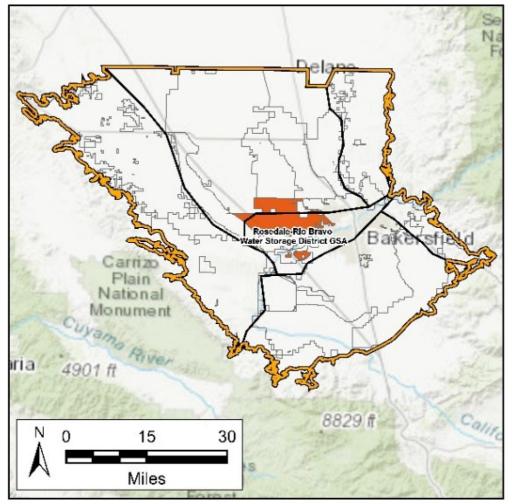


Pioneer GSA

- Encompasses 2,233 acres of the Pioneer GSA.
- Bordered by Non-Districted Lands, Kern River GSA, Kern Water Bank GSA, Rosedale-Rio Bravo Water Storage District GSA.
- The Pioneer GSA is located within the Kern River Fan HCM and is exclusively a banking operation. The Kern River is a large hydrologic feature that is a major surface water supply and source of surface water storage and groundwater recharge. The coarse alluvial sediments with limited clay layers make this the prime banking area for the Subbasin. The banking operations form a distinctive water level response that is recognizable on hydrographs and is generated as banking operations cycle between periods of surface water storage and recovery.

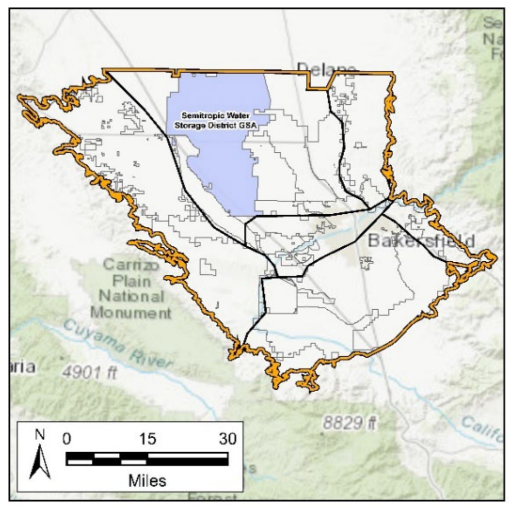


Rosedale-Rio Bravo Water Storage District GSA



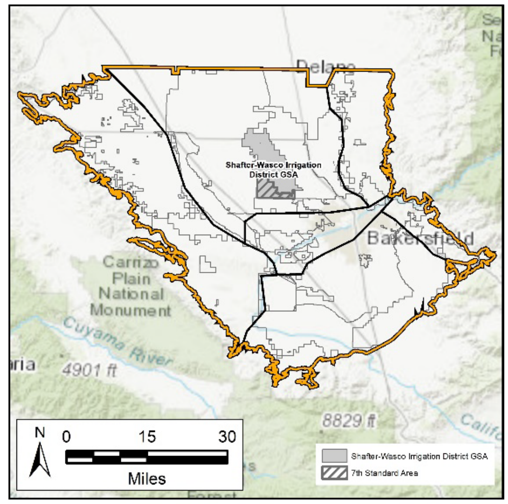
- Encompasses 40,958 acres of the Rosedale-Rio Bravo Water Storage District, plus 6,841 of non-districted lands.
- Bordered by the Shafter-Wasco Irrigation District GSA, North Kern Water Storage District GSA and the Semitropic Water Storage District GSA on the north, the Buena Vista Water Storage District GSA on the west, the Kern Water Bank GSA, Pioneer GSA, and West Kern Water District GSA on the south, and the, the Kern River GSA on the east.
- Lies within the North Basin and Kern Fan HCM Area.

Semitropic Water Storage District GSA



- Encompasses 222,573 acres of the Semitropic Water Storage District (SWSD) GSA service area and includes all SWSD lands.
- Bordered by the Tulare Lake and Tule Subbasins to the north; San Joaquin Municipal Utility District GSA, North Kern Water Storage District GSA, and Shafter-Wasco Irrigation District GSA to the east; Rosedale-Rio Bravo Water Storage District GSA and Buena Vista Water Storage District GSA to the south, and Westside Districts Water Authority GSA to the west.
- A large area in the northern portion of the GSA is federal and California Conservation Easement Area designated for the Kern National Wildlife Refuge and 3,174-acre Semitropic Ridge Preserve. Surface water is used to support the environmental benefits of the Wildlife Refuge (refer to Section 5.3.1).
- Lies entirely within the North Basin HCM Area.

Shafter-Wasco Irrigation District GSA



- Shafter-Wasco Irrigation District (SWID) GSA encompasses roughly 38,956 acres of SWID district lands, as well as approximately 10,000 acres of non-districted lands annexed into SWID in 2019 for the sole purpose of providing SGMA coverage and as a mechanism for collecting assessments necessary to prepare and implement a GSP.
- SWID and the 7th Standard Annex are treated as separate management areas with regard to water budgets and P/MAs. Refer to Chapters 10 and 14 for additional information.
- SWID GSA is bordered by Pond Poso Improvement District of Semitropic Water Storage District GSA, Rosedale-Rio Bravo Water Storage District GSA, and North Kern Water Storage District GSA.

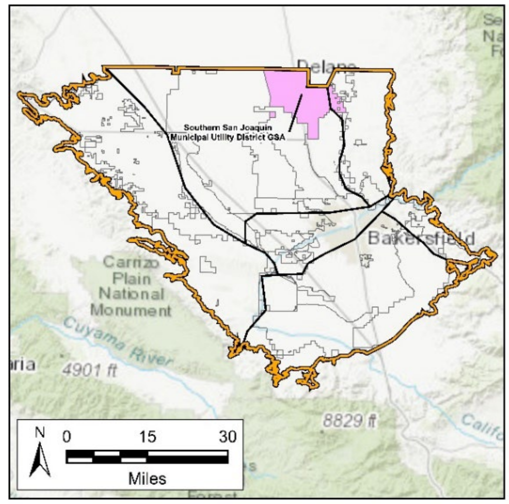
Shafter-Wasco Irrigation District

- SWID is a CVP Friant Division contractor with 50,000 AF of Class 1 allocation and 39,600 AF of Class 2 allocation.
- Encompasses 38,956 acres. Land use is predominantly agriculture with about 28,000 acres actively farmed and the remainder (10,956) is either fallowed or the urban areas of the cities of Shafter and Wasco.
- Participating entity of the North Central Kern GSP Group.
- Lies entirely within the North Basin HCM Area.

7th Standard Annex

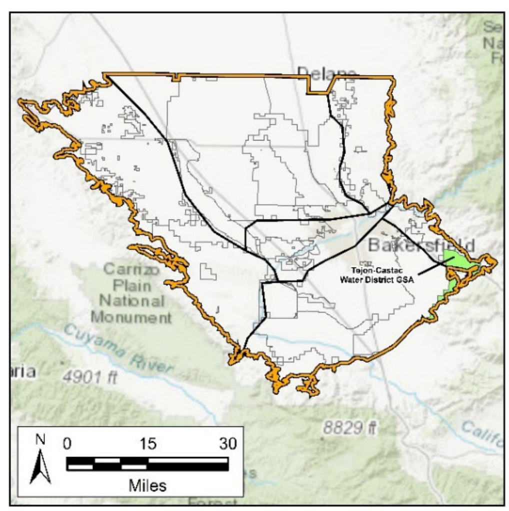
- Per the landowner agreement with SWID, 7th Standard Annex does not share benefit of SWIDs CVP allocation. However, NORSD wastewater treatment delivers recycled water that is used for crop irrigation (refer to Table 5-2) To cover the cost of SGMA implementation, SWID began collecting assessments necessary to prepare and implement a GSP.
- Encompasses about 10,000 acres. Land use is predominantly agriculture with 7,800 acres of permanent crops, row and field crops, and dairies. Other land uses include industrial (an oil field), limited rural, residential use, and the North of River Sanitary District (NORSD) wastewater treatment plant.

Southern San Joaquin Municipal Utility District GSA



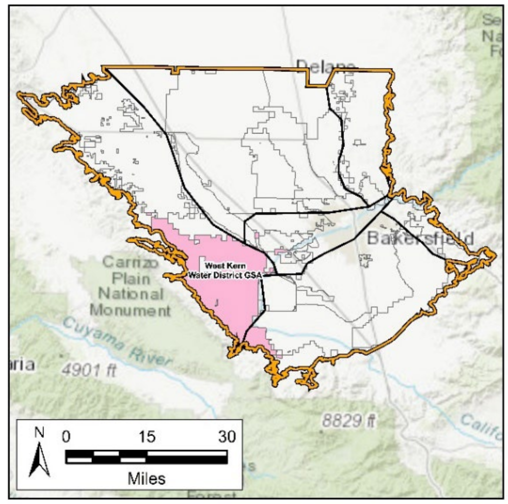
- Encompasses 66,000 acres of the Southern San Joaquin Municipal Utility District (SSJMUD) service area, plus 1,083 acres of non-districted lands. Total agricultural and irrigated acres is estimated at 54,126 acres.
- Bordered by the Tule Subbasin's Delano-Earlimart Irrigation District GSA to the north and northeast, and also shares boundaries with Kern-Tulare Water District GSA and Eastside Water Management Area to the east, Cawelo Water District GSA and North Kern Water Storage District GSA to the south, and Semitropic Water Storage District GSA to the west.
- Includes the cities of Delano and McFarland, which is 6,073 acres. Domestic and small community water users are estimated at 283 acres.
- Approximately 6,000 acres is classified as environmental which includes vacant land, native vegetation, and surface water bodies.
- Participating entity of the North Central Kern GSP Group.
- Lies entirely within the North Basin HCM Area.

Tejon-Castac Water District GSA



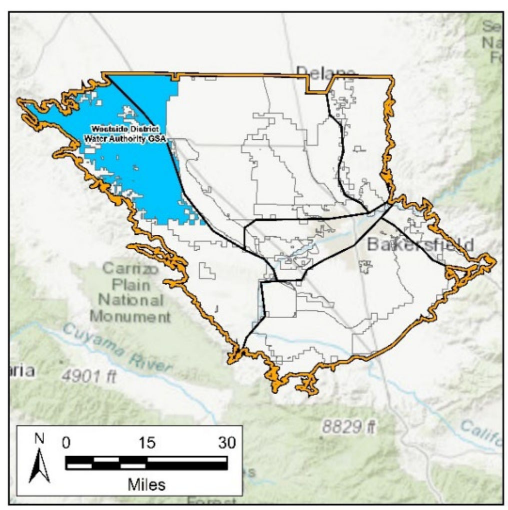
- Encompasses approximately 19,520 acres of the Tejon-Castac Water District (TCWD) annexed service area that is located within the Subbasin.
- Bordered by the eastern Subbasin boundary, the White Wolf Subbasin and GSA, Arvin GSA, and Kern Non-Districted Land Authority GSA.
- Participating entity of the SOKR GSA Group.
- Lies In the South Basin and East Margin HCM areas (see Section 5.2).

West Kern Water District GSA



- Encompasses 203,473 acres of the West Kern Water District (WKWD) GSA service area and includes all WKWD lands as well as some adopted white areas.
- Bordered by the Westside District Water Authority GSA, the BVGSA, the KWB GSA, the Henry Miller Water District GSA, and the Wheeler Ridge-Maricopa Water Storage District GSA.
- The WKWD GSA is located predominately within the Western Fold Belt HCM with a small portion located within the Kern River Fan HCM. All groundwater wells serving beneficial uses and users of groundwater within the GSA area, including banking operations, are within the Kern River Fan HCM, which corresponds to the Kern River alluvial fan (Kern Fan). The Kern River is a large hydrologic feature that is a major surface water supply and source of surface water storage and groundwater recharge. The coarse alluvial sediments with limited clay layers in the Kern Fan make this the prime banking area for the Subbasin. The banking operations create a distinctive water level response that is recognizable on hydrographs and is generated as banking operations cycle between periods of surface water storage and recovery.

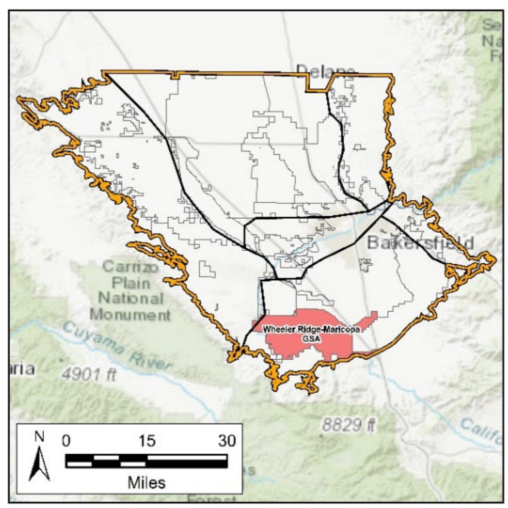
Westside District Water Authority (WDWA) GSA



- WDWA GSA is a joint powers authority comprised of three water districts (Lost Hills Water District, Berrenda Mesa Water District, and Belridge Water Storage District) and encompasses 277,193 acres. Only 28 percent of WDWA GSA acreage is irrigated agriculture, the remaining 72 percent consists of undeveloped native range land, the community of Lost Hills, and oil field activities.
- WDWA GSA is bordered by the Semitropic GSA and Buena Vista GSA, both to the east, the West Kern GSA to the south, and the Tulare Lake Subbasin to the north.

- Approximately 98 percent of WDWA GSA's water supply is imported surface water provided by State Water Project (SWP) entitlement, supplemental surface water purchases, and banked surface water supply recovery. The community of Lost Hills imports its municipal supply water from wells located in the adjacent Semitropic GSA (North Basin HCM Area).
- Due to the poor quality of groundwater underlying WDWA GSA, groundwater use is limited. In years of low SWP allocation, landowners purchase supplemental water, conduct deficit irrigation, utilize banked surface water assets, or fallow land. Since 2015 approximately 13,000 acres have been fallowed.
- WDWA GSA operates sustainably and carries a significant groundwater surplus as calculated by the water budget "checkbook" approach used for Subbasin planning. As such, WDWA GSA is not contributing to Subbasin groundwater deficits or unsustainable loss of groundwater storage.
- WDWA is predominately located within the Western Fold Belt HCM, an area of extensive geologic folding and historical oil field activity. These factors, along with naturally poor groundwater quality, have limited development of agricultural or other beneficial uses.

Wheeler Ridge-Maricopa GSA



- Encompasses approximately 87,350 acres of the WRMWSD service area.
- Bordered by the Arvin GSA, Kern River GSA, Henry Miller Water District GSA, Kern Non-Districted Land Authority GSA, West Kern Water District GSA, and the White Wolf Subbasin and GSA.
- Includes all WRMWSD lands within the Subbasin except lands that overlap with the AEWSD service area that lie within the Arvin GSA, and 2,809 acres that lie within the West Kern Water District (WKWD).
- Includes approximately 1,042 acres of parcels outside of WRMWSD service area (i.e., "non-districted lands").
- Participating entity of the SOKR GSA Group.
- Lies primarily in the South Basin HCM Area, with a small portion in the Western Fold Belt HCM Area.

Adjudicated or Areas Not Covered By a GSA

The Kern Subbasin is not adjudicated, and no portion is being managed pursuant to a plan approved as an Alternative GSP. Additionally, as described in the Kern Non-Districted Land Authority (Authority) statistical data, landowners who did not accept coverage by another GSA are covered by the Authority. All lands within the Kern Subbasin are covered by the Plan and represented by a GSA.

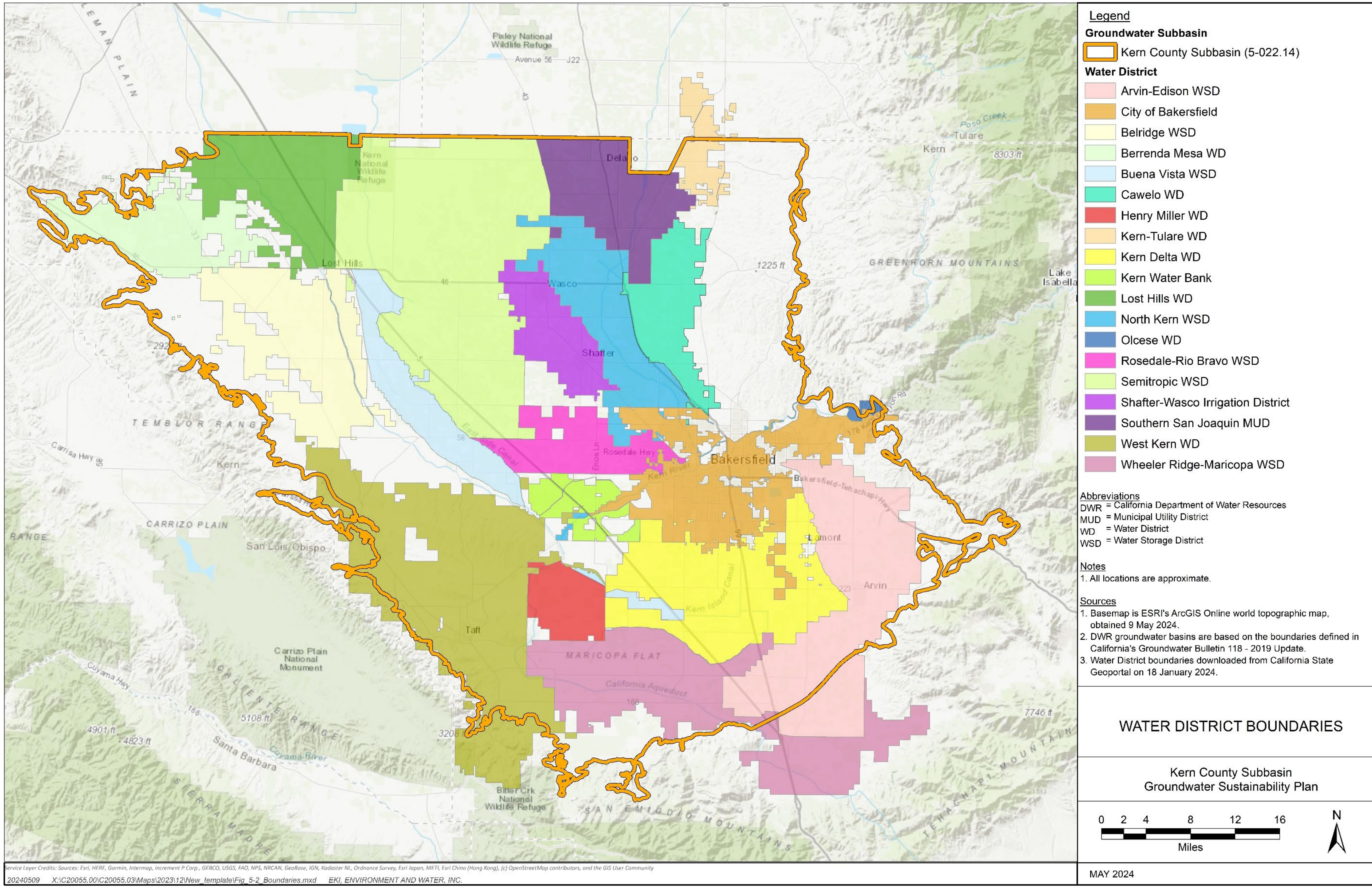


Figure 5-2. Water District Boundaries

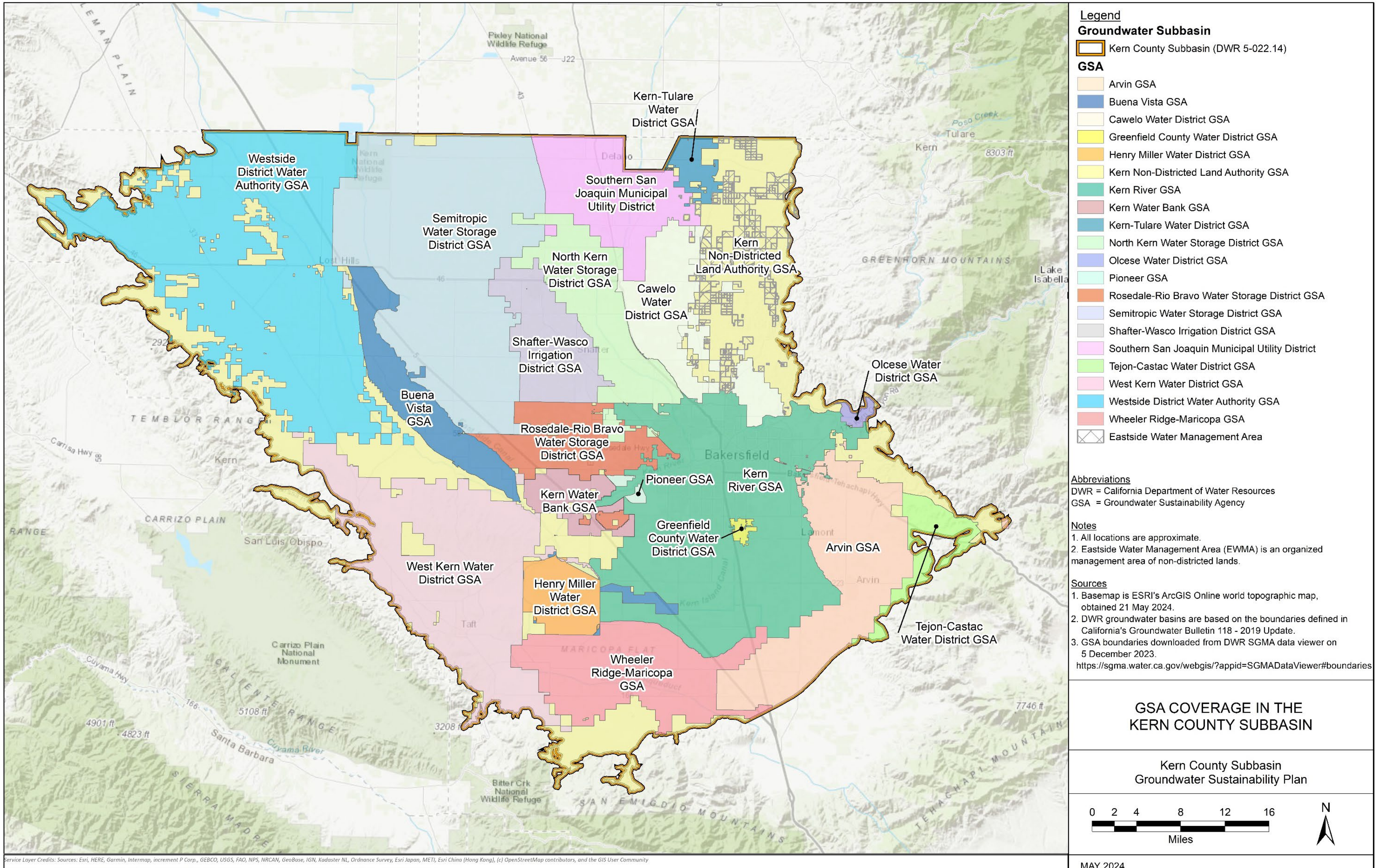


Figure 5-3. GSA Coverage of the Kern County Subbasin

5.3 Discussion of Land Use, Water Use, and Water Sources

☑ **23 CCR § 354.8(a)(4)**
☑ **23 CCR § 354.8(b)**

Land use designations are predominantly agricultural and industrial oilfields, followed by urban, suburban and rural communities. The largest metropolitan area is a medium-sized urban population in the City of Bakersfield with suburban sprawl in the unincorporated Kern County. The Subbasin also has several small urban areas and rural communities (refer to Section 5.3.1). Figure 5-4 provides geographic representation of land uses. A comprehensive, multisource dataset is maintained to tabulate land uses across the entire Subbasin. The primary land uses in the Kern Subbasin are:

- 657,000 acres of active agriculture (36.2% of plan area)
- 600,000 acres of native land (33.1% of plan area)
- 256,000 acres of idle agriculture (14.1% of the plan area)
- 149,000 acres of urban, suburban, and rural communities (8.2% of the plan area)
- 91,000 acres of industrial oil fields (5.0% of the plan area)
- 62,000 acres of other uses (3.4% of the plan area)

Table 5-1 summarizes land uses by HCM Area. Detailed descriptions of each primary land use category are provided in the text following the map series. Water uses and beneficial users associated with the land uses is discussed in Section 5.3.2.

Table 5-1. Summary of Land Uses by HCM Area

Subbasin Beneficial User Type	Western Fold Belt	North Basin	Kern River Fan	South Basin	East Margin
	% or Acres	% or Acres	% or Acres	% or Acres	% or Acres
Agricultural	63,304 14%	325,840 56%	23,249 19%	216,612 49%	27,623 13%
Agricultural - Idle	52,993 12%	100,832 17%	7,269 6%	81,740 19%	12,798 6%
Industrial (includes Oil Fields)	72,130 16%	264 0%	2,005 2%	0 0%	16,762 8%
Urban	10,401* 2%	38,256 7%	42,377 35%	50,855 12%	6,639 3%
Native	250,435 55%	106,545 18%	30,796 25%	66,061 15%	146,109 70%
Other	8,902 2%	10,602 2%	16,599 14%	25,581 6%	0 0%
Total	**458,165 100%**	**582,339 100%**	**122,295 100%**	**440,850 100%**	**209,932 100%**

*The urban area in the Western Fold Belt HCM area rely on groundwater pumped from the North Basin and South Basin HCM areas

5.3.1 California Protected Areas, Conservation Easement Areas, and Local, State, and Federal Lands

The Subbasin contains various state, federal, or locally owned public lands as shown in Figure 5-6. These lands are mostly preserved as open space areas for natural parks or monuments, managed resource protection areas, game refuge, or protected conservation easements with no associated water uses. The following sections describe each land use category and the associated water use.

Federal Lands

Approximately 43,509 acres of federally owned land, including national public lands or lands managed by the Bureau of Land Management (BLM), the Kern National Wildlife Refuge managed by the United States Fish and Wildlife Service, and a small area managed by the United States Bureau of Reclamation (USBR).

State Lands

Approximately 25,191 acres of state-owned land, including the California Department of Parks and Recreation Tule Elk State Reserve, land managed by the California State Lands Commission, and the following lands managed by the California Department of Fish and Wildlife: the southern portion of the Allensworth Ecological Reserve (ER), the Bakersfield Cactus ER, Buttonwillow ER, California Aqueduct, Elk Hills, a portion of the Lokern Ecological Reserve, the Semitropic Ecological Reserve, and the South Coles Levee Oilfields.

Locally Owned Lands

Approximately 11,824 acres of locally owned land, including land owned by cities, counties, and special districts. These lands include areas such as parks, community centers, recreation centers, and golf courses.

Conservation Easement Areas

Approximately 39,064 acres of California Conservation Easement Areas, such as the Antelope Plains and Alkali Flats managed by the Sequoia Riverlands Trust and the Coles Levee and Elk Hills Conservation Easement managed by the CDFW, amongst others. (CPAD/ CCED: California Protected Areas Database (calands.org).

Non-Profit Trust

Non-profit lands are located within the Subbasin including 28,407 acres of Land Trust areas (Lokern Preserve, Sand Ridge Preserve, Semitropic Ridge Preserve, Tollhouse Ranch, and Wind Wolves Preserve), and other Non-Profit lands such as Goose Lake and Panorama Vista Nature Preserve.

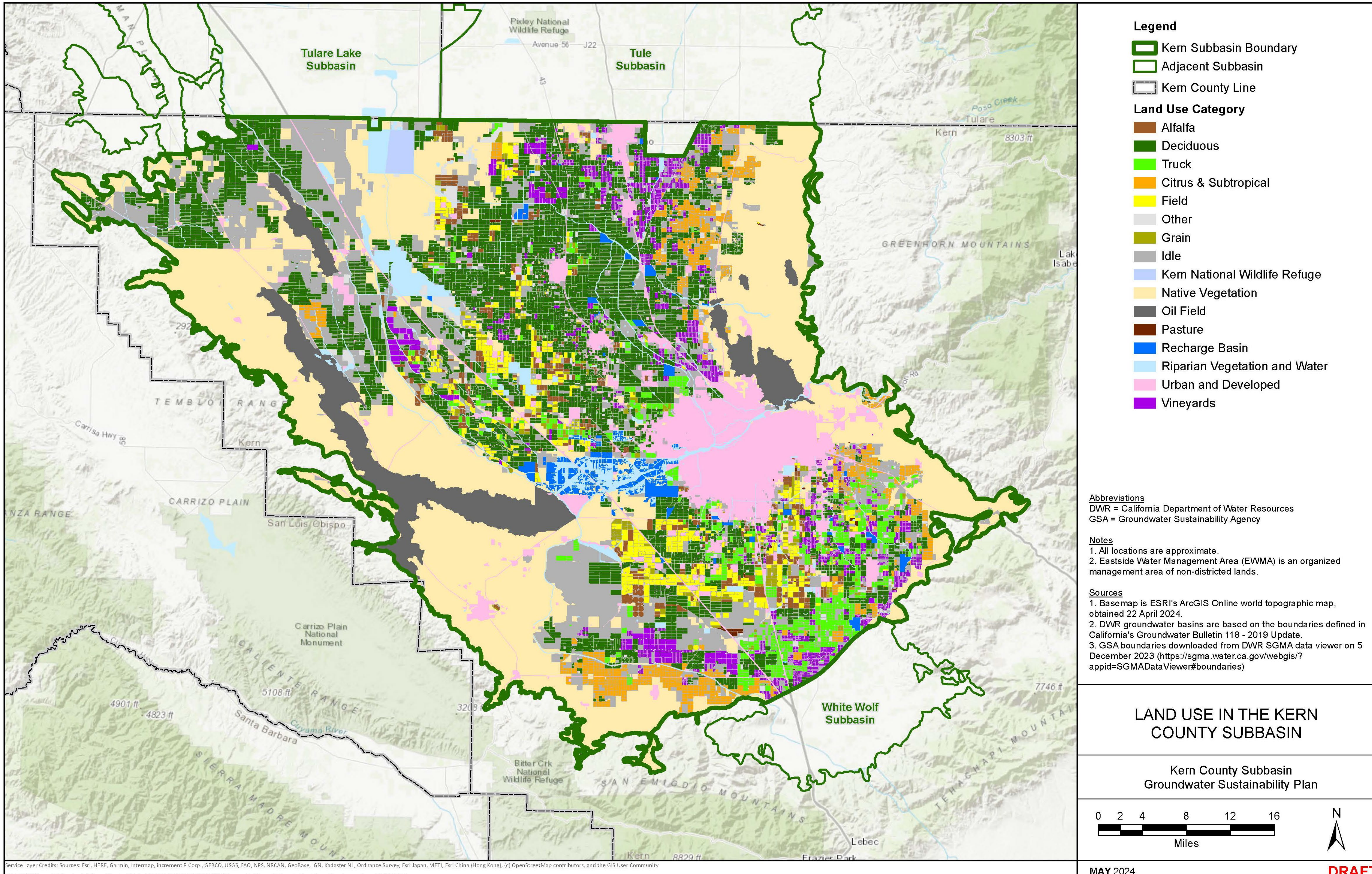


Figure 5-4. Land Use in the Kern County Subbasin

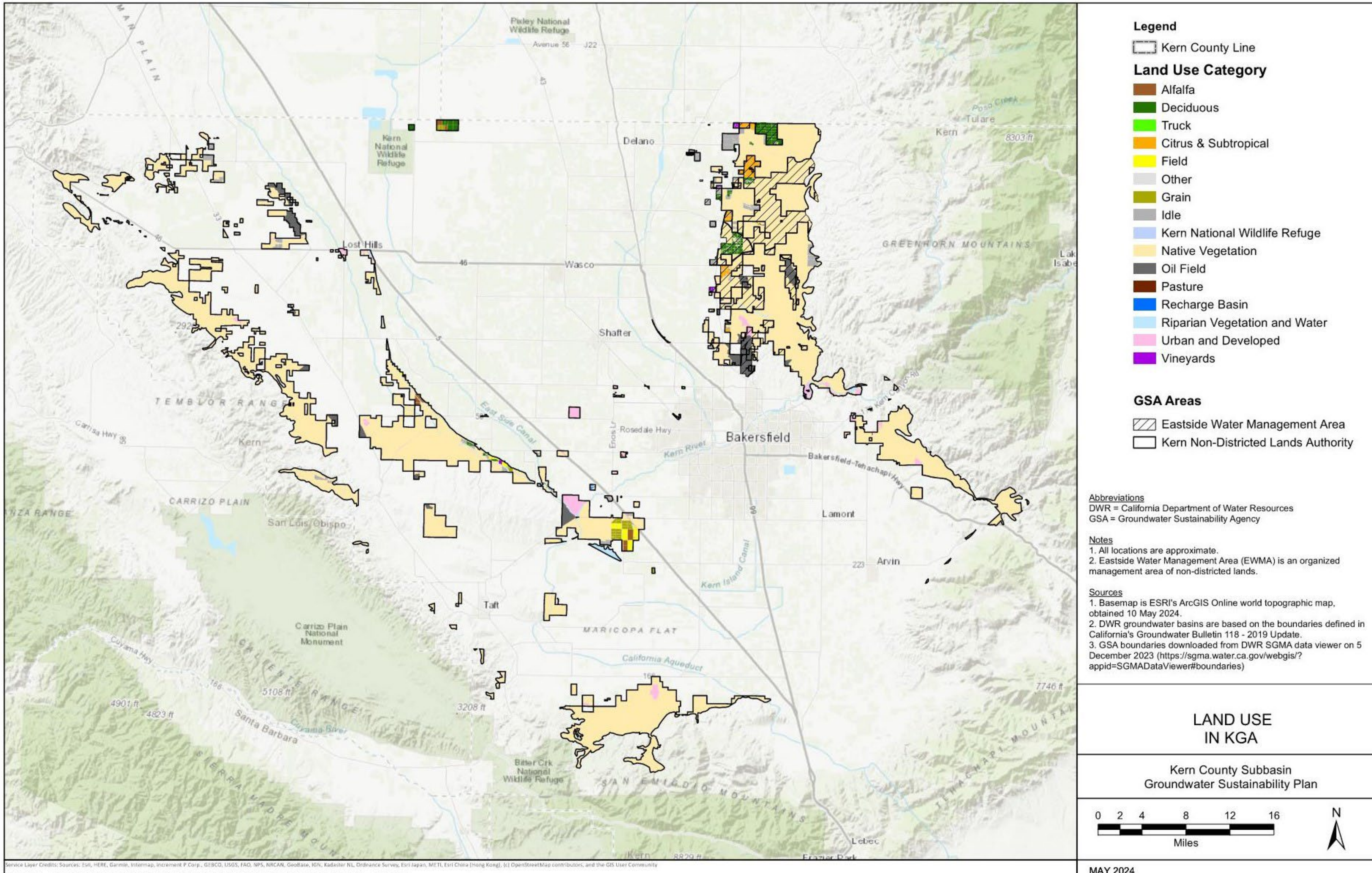


Figure 5-5. Land Use in Kern Non-Districted Land Authority

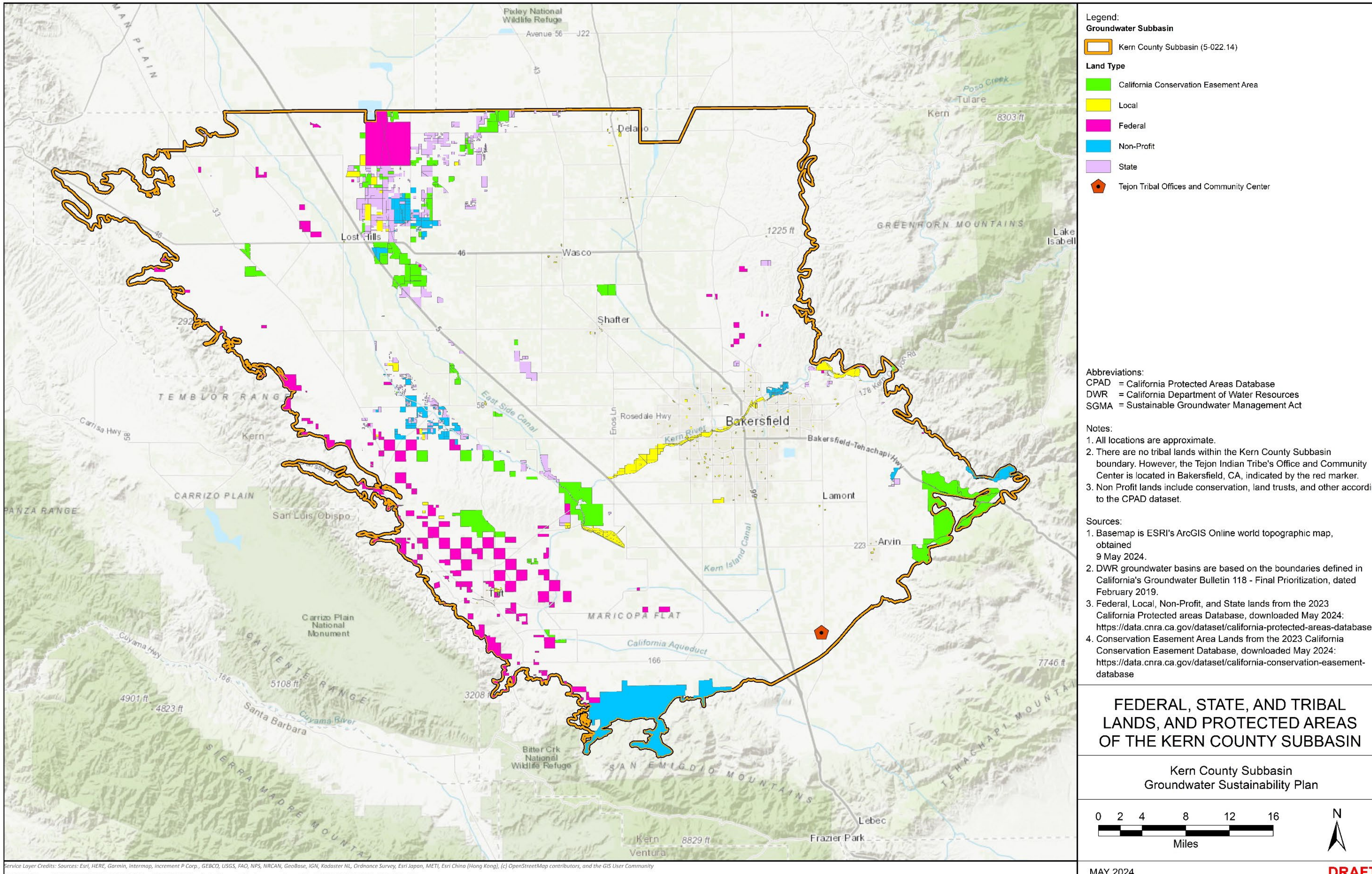


Figure 5-6. Federal, State, and Tribal Lands, and Protected Areas of the Kern County Subbasin

This page intentionally left blank.

5.3.2 Descriptions of Privately Owned Lands

Agriculture. Agriculture is the primary land use in the Kern County Subbasin, representing about 50 percent of the total land area, including idle fields. There are approximately 644,000 acres of active agriculture (36 percent of Subbasin) and 256,000 acres of idle agriculture (15 percent of the Subbasin). The series of Figure 5-4 through Figure 5-5 show the dominance of local agriculture in the Subbasin. Major crops include almonds and pistachios, grapes, carrots, potatoes, and citrus. The total acreage has remained steady over the past ten years but changes in crops include a decrease in field crops and grapes and a slight increase in almonds and pistachios. Idle agricultural land has increased from 1995 to 2021. Drought conditions in 2021 may have contributed to short term fallowing.

Agricultural preserves and agricultural lands protected under the Williamson Act encompass a significant portion of the Subbasin (Figure 5-7). The Williamson Act (California Land Conservation Act of 1965, Section 51200) was adopted to encourage preservation of the state's agricultural lands and to discourage its conversion to urban uses. The other major land uses are urban and oil field operations, which account for about 8 percent and 5 percent of the Subbasin, respectively. Other land uses (native, water, and unknown) account for about 36 percent of the Subbasin.

Oil Field Land Use. The oil field land use occurs in the eastern and western regions of the Plan Area. This is shown as mineral and petroleum land use on Figure 5-4. The surface operations of oil fields overlie the Subbasin, but, with some exceptions on the Westside, the subsurface activity occurs in hydrocarbon reservoirs below the usable groundwater basin (refer to Basin Setting, Section 7.3.4 for further information). Oil extracted from oilfield operations contains entrained water referred to as "produced water." Produced water is used in enhanced oil recovery operations. It may also be treated for beneficial reuse as described below in Section 5.4.3. Excess produced water may be disposed of by treatment to conform with the Central Valley Regional Water Quality Control Board's (CVRWQCB) waste discharge requirements before injection into an EPA approved exempt aquifer.

5.3.3 Disadvantaged Communities

Disadvantaged communities (DACs) or severely disadvantaged communities (SDACs) are identified based on the median household income (MHI) of an area compared to the statewide MHI.[1] DACs are those with a MHI that is no more than 40 percent of the statewide MHI, and SDAC communities are those with a MHI that is no more than 20 percent of the statewide MHI (California Code, Public Resources Code § 75005(g)). Figure 5-8 tracts designated as DACs and SDACs based on the 2020 MHI from the 2016 to 2020 American Community Survey 5-Year Estimates, provided by the California

[1] https://gis.water.ca.gov/app/dacs

Department of Water Resources (DWR). More refined information is provided in the Section 5.6.5.

5.3.4 Native American Tribal Communities and Lands

The Tejon Indian Tribe is the only federally recognized tribe within Kern County.[2] The Tribe does not have communal land, however there is a parcel located near Mettler, within the Arvin GSA area, that is proposed to be developed in 2025 into the Hard Rock Hotel & Casino Tejon. The Tejon Indian Tribe has an office located in Bakersfield.

[2] https://www.tejonindiantribe.com/

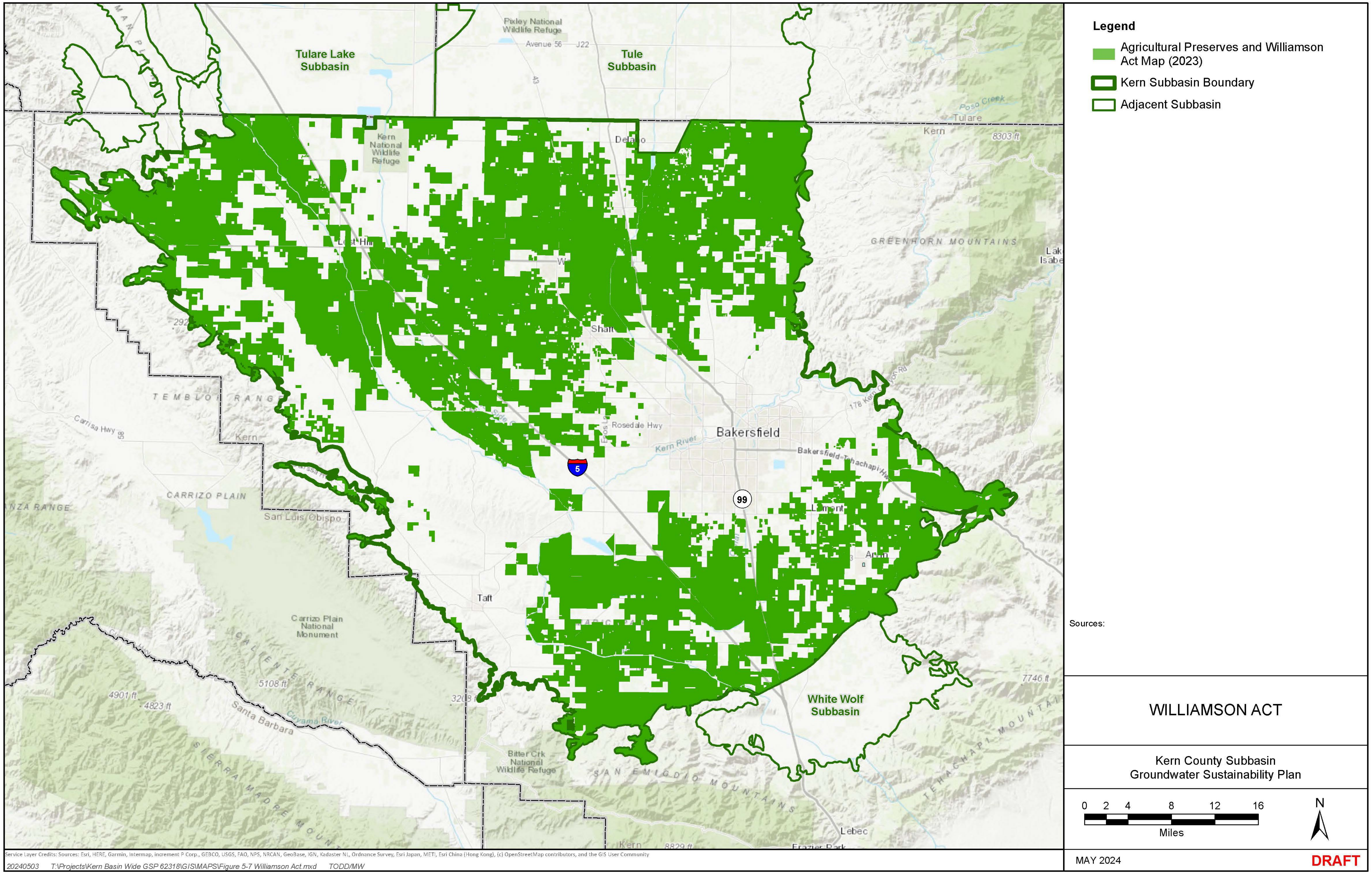


Figure 5-7. Williamson Act

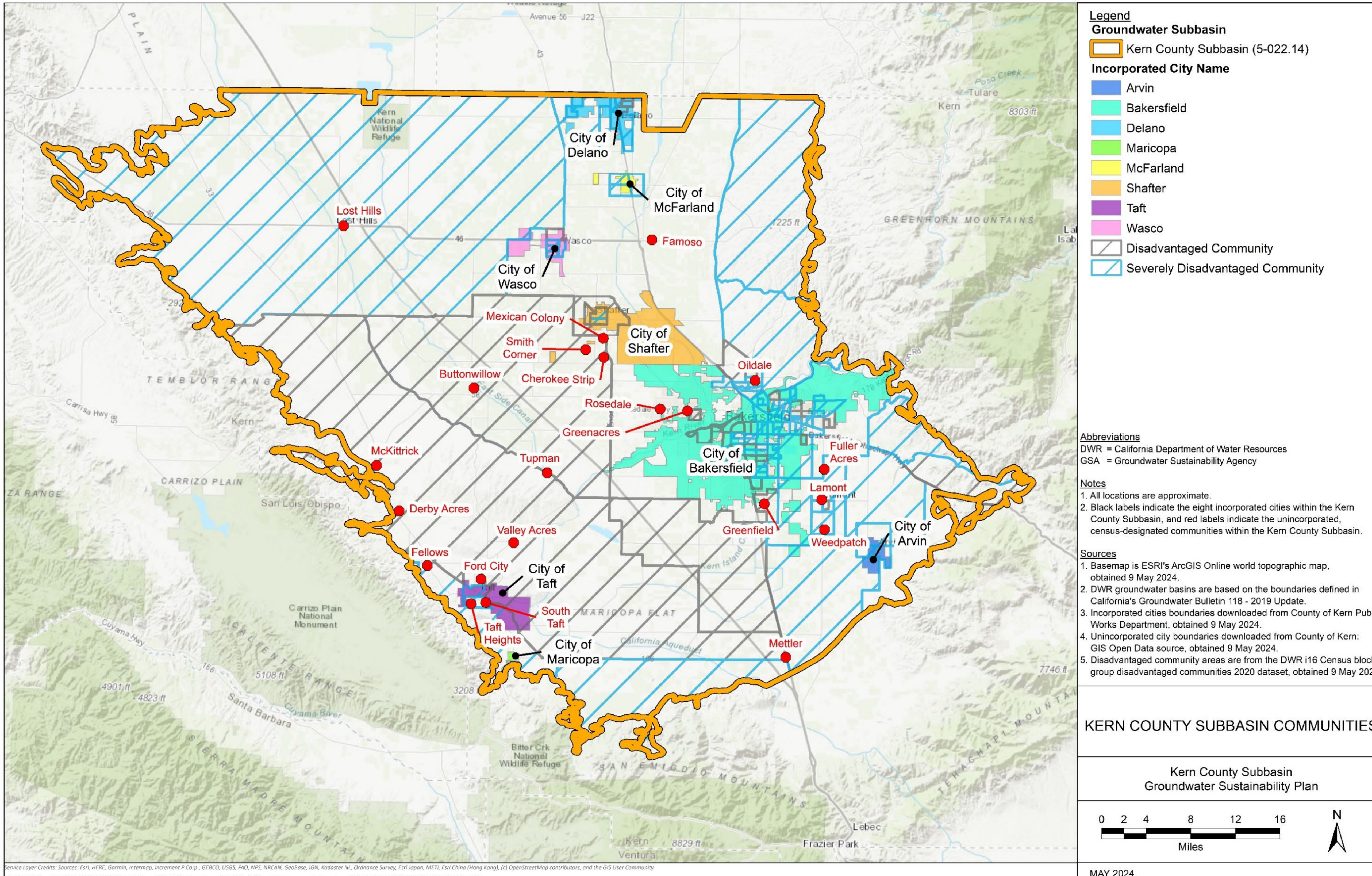


Figure 5-8. Kern County Subbasin Communities

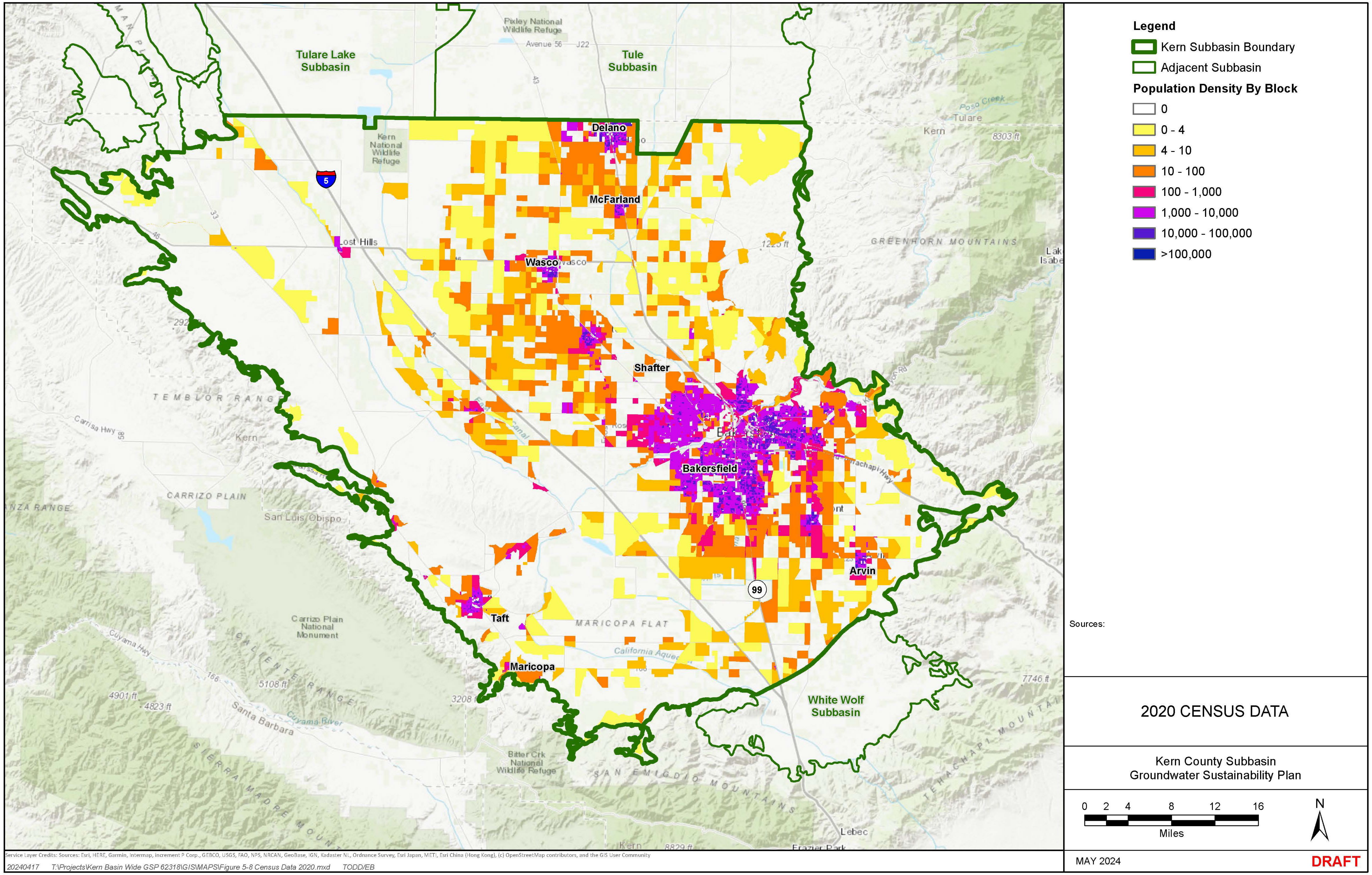


Figure 5-9. Census Data 2020

This page intentionally left blank.

5.4 Water Sources

Hydrologic systems in the Subbasin include numerous rivers, lakes, and canals, many of which are used to supply water to the entire Subbasin. The prominent natural surface water body in the Subbasin is the Kern River, which originates in the Sierra Nevada to the northeast of the Subbasin. Canals and conveyance systems within the Subbasin supply water for beneficial uses throughout the Subbasin.

Historical overdraft of the Kern County Subbasin's groundwater was noted as early as the mid-1940s. Due to chronically declining groundwater levels, water districts were formed to protect surface water rights to the Kern River and provide a means for contracting through the SWP and Central Valley Project (CVP). Diversions from the Kern River and imported surface water enabled water districts to operate conjunctive use programs where surface water available in wet years could be used to replenish groundwater storage, a vital source of supply during dry years. Access to surface water also supports water banking, recovery, and exchange projects to optimize available water supplies. In more recent years, water districts are adding recycled water sources to their water supply portfolios. This section of the Plan describes the available water sources to each district.

5.4.1 Surface Water

Kern River

The main source of surface water supply for the Kern Subbasin is the Kern River, which flows east to west through the center of the Subbasin's boundaries from the Sierra Nevada Mountain range and extends across the Subbasin. Headwaters of the Kern River originate from the base of Mount Whitney, where the river splits into two forks (North Kern and South Kern) and merge at Lake Isabella. The Kern Subbasin receives surface water below Lake Isabella Dam (constructed in 1953) where controlled flows are managed daily to prevent flooding through a series of canals, weirs, and levees.

As early as the 1850s, lands within the Kern Subbasin were drained and diverted through canals and levees to control flooding to support agriculture and urban development within the region. Today, operations and management of Kern River surface water to areas within the Kern Subbasin are overseen by the City of Bakersfield (COB) in coordination with the United States Army Corps of Engineers and Kern River Watermaster. For more than 150 years, the Kern River has provided most of the surface water supply to the Subbasin, including water for irrigation, drinking water, and other uses Figure 5-10 identifies the various canals, weirs, and diversion points.

The only major stream supplying the Subbasin is the Kern River, and two smaller streams: Poso Creek and Caliente Creek. Kern River and Poso Creek are fully allocated streams.

Flows in the river consist of regulated releases from Lake Isabella, approximately 25 miles upstream of Subbasin's eastern boundary (Figure 5-10). Isabella Dam was constructed by the U.S. Army Corp of Engineers (USACE) in 1953 to control downstream flooding. Since that time, the dam has been operated for flood control, hydroelectric power, water supply, and conservation storage. Reservoir storage and Kern River flow management are coordinated by the Kern River Watermaster, working with the USACE, participating water districts, and the City of Bakersfield. Except for periods of high runoff, releases from Lake Isabella are regulated through requests, or "calls" for water by the city on behalf of the Kern River Watermaster. The city monitors, manages, and records flows and diversions in the river on behalf of the Kern River Watermaster for all water users.

Districts holding or managing rights to Kern River include NKWSD, COB, KDWD, BVWSD, HMWD, Olcese WD, and KCWA. The water is diverted through main canals and laterals. Diversions are monitoring and reported daily are reported in the annual Kern River Hydrographic Reports which provide accounting of monthly diversions, deliveries, and losses along the canals among all First Point diverters with records extending back to the 1890s.

Ephemeral Creeks

Poso Creek, Caliente Creek, and other significant ephemeral streams, springs, and seeps are sources of recharge. Figure 5-10 (Surface Water Features from National Hydrography Dataset) displays the locations of seeps and springs based on data extracted from the National Hydrography Dataset at the base of the mountains and foothills in the southeast, southwest, and northwest edges of the Subbasin.

The Natural Communities Commonly Associated with Groundwater (NCCAG) dataset shows spring-fed streams in the southwest along the perimeter of the Subbasin: Santiago Creek to San Emigdio Creek situated in the Wind Wolves Preserve. In the southeast corner of the Subbasin, in the highlands, is Tejon and Caliente Creek drainage. Notable creeks along the northeastern boundary are Poso, Little, Deer, and Rag Gulch Creeks.

Poso Creek

Poso Creek runs from the Greenhorn Mountains of the Sierra Nevada Mountain Range on the east side of the Kern Subbasin and drains to the North Basin HCM Area. In most years, the creek flows seasonally from November through May in its upper reaches and becomes an ephemeral wash in the valley floor where it flows between Wasco and McFarland. During very wet years, excessive flows that cannot be captured eventually discharge north of the Kern County Subbasin into the Tule and Tulare Lake Subbasins. Drainage from Poso Creek is fully allocated and issued for managed recharge in the Cawelo, North Kern, and Semitropic Water Districts.

Streamflow is measured at several points. USGS and Kern County have operated a gage at Coffee Canyon northeast of Oildale since July 1959. Cawelo Water District (CWD) monitors Poso Creek at Trenton Weir near State Highway 65. North Kern Water Storage District monitors at Highway 99. And Semitropic Water Storage District monitors Poso Creek it at Leonard Ave, Schofield Ave and one-half mile west of Gun Club Road.

Caliente Creek

Caliente Creek and its tributaries, Walker Basin Creek and Tehachapi Creek, and the smaller creeks of Little Sycamore, Commanche, and Tejon, drains the west slopes of the Tehachapi Mountains to the east side of the Subbasin into the South Basin HCM Area. Based on observations of ungauged flows and limited historical stream gauging data from Caliente Creek, surface water inflows to the area occur seasonally with some frequency. Storm-related flooding has been documented to occur in some areas such as Lamont and Arvin, as well as near AEWSD's spreading works and the David Road and Sebastian Road areas. There are no instream flow requirements for Caliente Creek nor reported water applications and permits issued from the SWRCB.

Drainage from Caliente Creek contributes to groundwater recharge. During wet years, drainage causes flood damage. Kern County certified a Notice of Exemption for the Caliente Creek Flood Protection Project in January 2022. The project will implement stormwater flood mitigation activities to uniformly distribute flood waters, increase silt deposition, and improve percolation to the groundwater table.

This page intentionally left blank.

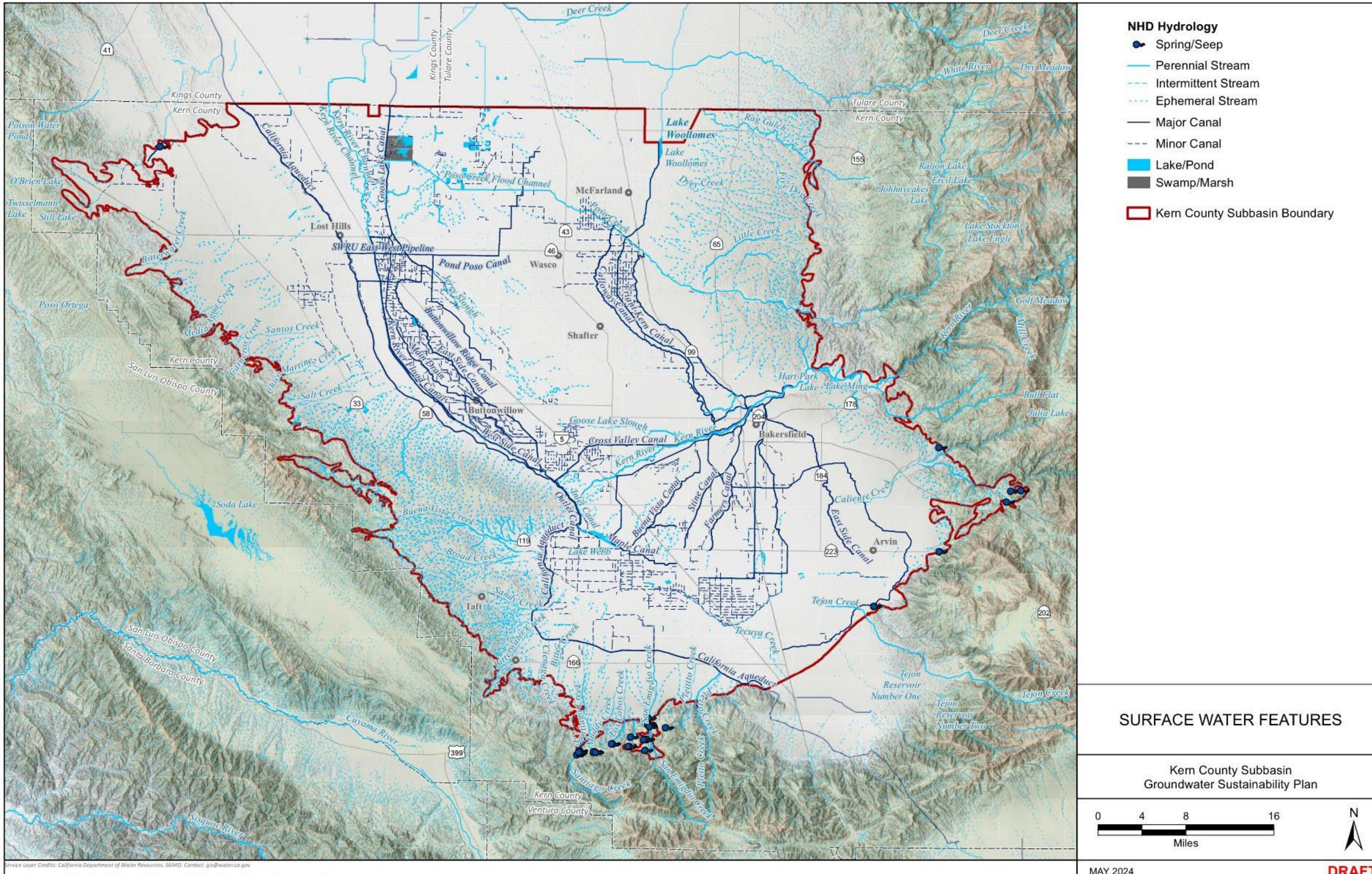


Figure 5-10. Surface Water Features

This page intentionally left blank.

5.4.2 Imported Water Deliveries

Imported water deliveries to wholesalers and retailers within the Kern County Subbasin are monitored. KCWA monitors all turnouts from the California Aqueduct in Kern County and all turnouts along the Cross Valley Canal. Measurements are taken daily (KCWA, Initial Water Management Plan, 2001).

The primary sources of imported water are the SWP via the California Aqueduct and the CVP through the Friant-Kern Canal. KCWA holds the SWP contract on behalf of 13 Member Units and the CVP provides water to four districts within the Kern Subbasin (refer to Table 5-3).

The conveyance facilities for the SWP and CVP provide access to the northern, central, and southern Sierra snowpack, respectively. In wet years, surplus water to these sources may be available to non-contract holders through sales and exchanges with contractors, maximizing access to surface water for banking projects. Figure 5-10 shows the conveyance system locations within the Kern Subbasin.

5.4.3 Wastewater Discharge and Recycled Water Delivery

Wastewater Treatment Facilities within the Subbasin discharge to ponds where the treated water evaporates and/or percolates back into the groundwater. With recent changes to recycled water regulation, increased use of recycled waters for crop irrigation is anticipated in future years. Recycled water plays an important role in the diverse water supply of Kern County. Over 48,000 AF of recycled water was used in WY 2022 which are briefly described below. Table 5-2 summarizes Municipal Wastewater Facilities with permitted volumes and beneficial uses, and the water district/GSA credited for the recycled water supply.

This page intentionally left blank.

Table 5-2. Recycled Water Facilities

Facility ID	Permitted Discharge	Water Use	Land Use Area	Receiving GSA/Entity
City of Arvin and Veolia Water West Operating Services, Inc, Arvin WWT Facility	1.10 - 2.0 MGD (Nov 1 to April 30) 1.28 - 2.3 MGD (May 1 to Oct 31)	Irrigation of Fodder Crops	240 acres	Arvin GSA
Buttonwillow County Water District, WWT Facility	0.2 MGD	Alfalfa or Sudan Grass	50 acres	BVGSA
Stoco Mutual Water & Sewer Company, WWT Facility	0.05 MGD	Groundwater recharge	2.67 acres	Kern Non-Districted Land Authority
City of Bakersfield WWTP 2	25 MGD	Irrigation to Alfalfa, Grain, and Corn	5,476 acres	KRGSA
City of Bakersfield WWTP 3	16 - 32 MGD	Irrigation to Fodder Crops	420 acres	25% to Green Acres Farm in Kern Delta Water District (KRGSA) and 75% to Green Acres Farm in Kern Non-Districted Land Authority
Lamont PUD WWTP & Recology Blossom Valley Organics South	2.0 MGD	Irrigation to Fodder Crops	130 acres	KRGSA
McMor Chlorination, Inc, I-5 and Hwy 58 WWT Facility	0.19 MGD	Irrigation to Pasture	50 acres	SWSD GSA
CDCR Kern Valley State Prison, WWT Facility	0.77-1.54 MGD	Seepage Irrigation of Fodder Crops	35 acres 200 acres	SSJMUD GSA
City of Delano	7.2 MGD	Irrigation to Fodder Crops	932 acres	SSJMUD GSA
City of McFarland	1.1 - 1.55 MGD	Irrigation of Alfalfa	270 acres	NKWSD GSA
City of Wasco	1.95 - 3.0 MGD	Irrigation of Alfalfa, corn, cotton, blackeye beans, and sugar beets	450 acres	SWID GSA
North of the River Sanitation District	2 MGD	Seepage	n/a	City of Shafter (SWID GSA)
North of the River Sanitation District & Sill Properties	5.5 MGD	Irrigation to Fodder Crops Seepage	391 acres 32.5 acres	7th Standard Annex (SWID GSA)
Wasco State Prison	0.81 MGS	Flood Irrigation of Alfalfa	230 acres	SWID GSA
City of Taft, Sanitary Sewer Overflow to Sandy Creek	Settlement Agreement and Stipulation for Entry of Administrative Civil Liability, Issued by the Executive Officer on 7 March 2016 - No active WDR			
City of Taft, Taft Federal Prison WWT Facility	0.46 MGD	Seepage	0.46 MGD	WKWD GSA

Facility ID	Permitted Discharge	Water Use	Land Use Area	Receiving GSA/Entity
City of Taft, Taft Height Sanitation District, Ford City Sanitation District, and USDOE, Taft WWT Facility	1.2 MGD	Seepage	1.2 MGD	WKWD GSA
TA Operating Corp, Blue Beacon and Tejon Ranch Corp, Travel Centers of America Complex	Order R5-2005-0168: Rescinding Cease and Desist Order 5-01-003			
Tejon-Castac Water District, Tejon Industrial Complex WWT Facility	0.1 MGD	Landscape Irrigation	14 acres	WRMWSD GSA

Oil and gas production includes the extraction of subsurface fluids in the form of oil, gas, and entrained water (referred to as “produced water”). Produced water is separated from the extracted oil through various filtration processes, then treated for beneficial reuse “Recycled Produced Water [RPW].” Recycled produced water from the Kern River and Kern Front Oilfields is of an acceptable quality for groundwater recharge or crop irrigation when blended with surface water.

Table 5-3 shows which water districts have access to these water sources. This shows the water source or sources directly available to each district, as well as indicate the primary avenues through which districts receive water. The table also indicates the sources of water available for implementation of projects needed to attain Subbasin-wide sustainability. Not shown are the transfers and exchanges that enable districts to receive water from sources to which they do not have direct access.

5.4.4 Groundwater

Native groundwater supplies are inadequate to support the present level of demand by overlying users, resulting in the Subbasin being deemed critically overdrafted. The Basin currently uses 0.15 AF as the native yield of groundwater. During dry years, groundwater serves as a critical buffer against the impacts of drought and climate change. With the Kern Subbasin’s conjunctive use and water banking programs, the Subbasin’s goal is to reach a condition of safe yield for the groundwater basin (refer to Section 5.5 Water Resources Management Programs). Safe yield occurs when the amount of water pumped from the basin is less than or equal to recharge into the basin.

This page intentionally left blank.

Table 5-3. Water Sources Available to Each Water District

Water District	Groundwater	Surface Water					Recycled or RPW	Notes
		Kern River	SWP	CVP	Project Wet Year Supply*	Minor Streams		
Arvin-Edison Water Storage District	X	X	X	X	X		X	Recovered Water Account (RWA), Unreleased Restoration Flows (URF), Recapture & Recirculation (R&R). AEWSD has access to Kern River supplies through direct purchases, such as occurred in 2023, and potential to access recycled water through Arvin.
Buena Vista Water Storage District	X	X	X		X		X	
Cawelo Water District	X	X	X		X	X	X	
City of Bakersfield	X	X					X	
Eastside Water Management Area								
Henry Miller Water District	X	X	X		X			Surface water supplies include regular annual supplies, and irregular annual supplies available in wet years
Kern County Water Agency	X	X	X		X			All member units have access to Kern River Water via agreement with KCWA.
Kern Delta Water District	X	X	X				X	
Kern Non-Districted Land Authority	X						X	

Water District	Groundwater	Surface Water					Recycled or RPW	Notes
		Kern River	SWP	CVP	Project Wet Year Supply*	Minor Streams		
Kern-Tulare Water District	X	X		X	X		X	
North Kern Water Storage District	X	X			X	X	X	
Olcese Water District								
Rosedale-Rio Bravo Water Storage District	X	X	X		X			
Semitropic Water Storage District	X	X	X	X	X	X		SWSD has access to Kern River water and CVP Section 215 as available
Shafter-Wasco Irrigation District	X			X	X		X	Recovered Water Account (RWA), Unreleased Restoration Flows (URF), Section 215
7th Standard Annex	X				X		X	
Southern San Joaquin Municipal Utility District	X			X	X		X	Recovered Water Account (RWA), Unreleased Restoration Flows (URF), Section 215
Tejon-Castac Water District	X							
West Kern Water District	X		X				X	
Westside District Water Authority		X	X		X			
Wheeler Ridge-Maricopa Water Storage District	X	X	X		X		X	WRMWSD has access to Kern River supplies as a Member Unit of the KCWA.

* CVP Section 215 and SWP Article 21 water which are both temporary supplies made available in large water supply years.

5.5 Water Resources Management Programs

§ 354.8. *Each Plan shall include a description of the geographic areas covered, including the following information:*

(a) Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.

(b) A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.

(c) A description of conjunctive use programs in the basin.

☑ 23 CCR § 354.8(c)

This section focuses on monitoring and management programs that will contribute to attainment and maintenance of sustainable groundwater management in the Kern County Subbasin. Although many of the monitoring programs predate SGMA, they will be enhanced to provide data that will aid GSAs in formulating and implementing projects and in determining whether projects are achieving their objectives. For example, information on climate, land use and cropping, and consumptive use will drive demand reduction efforts. Data on groundwater levels, water quality and subsidence will inform GSAs on the success of demand reduction and supply enhancement projects.

The water districts have been managing groundwater in the Kern Subbasin through a variety of long running programs, including conjunctive use and water banking. Numerous planning documents provide details on these programs. In brief, daily coordination among water managers, an interconnected web of conveyance canals and pipelines, and numerous water sources to balance and manage in real-time have provided each of the GSAs with the tools for flexible and reliable water management.

Additionally, Agricultural Water Management Plans and Groundwater Management Plans have been developed and maintained by water districts. Urban Water Management Plans (UWMPs) have been prepared by the larger water purveyors. Each plan describes numerous policies and programs being implemented by the member agencies for conjunctive management of surface water and groundwater; collectively, the plans demonstrate coordination at an intricate level to maximize beneficial use of water supplies.

5.5.1 Conjunctive Use

☑ **23 CCR § 354.8(e)**

Conjunctive management uses diverted surface water to meet demands across a range of hydrologic conditions. This is accomplished by using surface water to both meet demands and to replenish aquifers during years when surface water is abundant. Water stored in the principal aquifer during wet years can then be recovered during dry periods when surface water supplies are insufficient to meet demands. The practice of using the principal aquifer as a reservoir for storing surface water is one of the primary mechanisms that allows the Kern County Subbasin to maintain a reliable water supply during droughts and is an important component of the Subbasin's approach to sustainable groundwater management.

Conjunctive management has been a vital water management tool in the Kern Subbasin for over a century with Kern River diverters using seepage from natural waterways and earthen canals to supplement groundwater recharge, helping to maintain groundwater levels. Now surface water supplies include the Kern River, the SWP, and the CVP. Diversions from these sources are recharged using a variety of mechanisms ranging from canal seepage and recharge basins to Flood-Managed Aquifer Recharge (Flood-MAR) operations where supplemental water can be applied over agricultural lands contribute to recharge or input to subsurface recharge facilities, underlying active agricultural lands, for recharge.

Conjunctive management has evolved due to improvements in water management practices, changes in environmental regulations and the passage of SGMA. These drivers have led to better measurement and accounting for recharge and recovery, the introduction of FloodMAR, and expansion of the area devoted to recharge basins, a feature of many of the Subbasin's water supply P/MAs.

Conjunctive management facilities, such as recharge basins, are also used for water banking. However, the purpose of conjunctive management is to store surface water available under a district's rights or entitlements for the benefit of the district's landowners with a corollary benefit to nearby communities. By contrast, water banking is a service provided by banking entities who store surface water provided by project participants or banking partners for later recovery for the benefit of those entities.

5.5.2 Water Banking

☑ 23 CCR § 354.8(c)

Kern County entities have been involved in water banking for several decades. These programs have been developed to help secure more reliable water supplies due to California's wet- and dry-year cycles. They all involve storing surface water in wet years for later recovery for beneficial uses in dry years. As the availability of water supplies has diminished, more and more Kern entities have embraced water banking to offset these shortages such that now almost every water district in the Subbasin has either established a banking program or partnered with an entity that has. Some of these programs also involve storing water for others in the state, with the locations of partner agencies ranging from Santa Clara in the north to the Mexican border in the south.

The Water Resilience Portfolio, developed in response to the Governor's Executive Order (EO) N-10-19, recognizes storage Projects like those in Kern County as one of the primary means for regions to transition to sustainable use, and one of the overarching goals of SGMA is to correct conditions of long-term overdraft (e.g., Water Code Section 10735.8(b)1). SGMA recognizes the uniqueness of storage Projects and their role within a GSA in Water Code Section 10726.2.(b) which states: "…*the agency [GSA] shall not alter another person's or agency's existing groundwater conjunctive use or storage program except upon a finding that the conjunctive use or storage program interferes with implementation of the agency's groundwater sustainability plan*." Importantly, each of these programs has undergone public review under the California Environmental Quality Act (CEQA) to help mitigate any potential impacts from project operations.

There are two processes that these programs use to store water: 1) direct recharge, and 2) in-lieu recharge. Direct recharge is the process of storing surface water by using recharge basins to percolate water directly into the aquifer thereby establishing a storage account separate and apart from the basin's native groundwater. In-lieu recharge is the process of establishing a bank account by providing surface water to overlying users in wet years in lieu of their groundwater pumping. Here, storage accrues based on the volume of stored surface water and native yield not pumped. Some GSAs may use both processes to store water.

Appendix E, *Kern County Subbasin Water Banking Programs*, is an overview of some of the Subbasin's banking programs including locations, process used to store water, beneficial uses of recovered water, participants, sources of water, facilities, monitoring, considerations for Sustainable Management Criteria (SMCs), accounting methods, and current storage account status. Table 5-4 lists the GSAs involved in banking, conjunctive use, and in-lieu recharge activities. Figure 5-11 shows the location of existing banking projects.

Table 5-4. Kern Subbasin Water Banking Programs

GSA or District Area	Direct Storage	Conjunctive Use	In-Lieu Storage
Arvin-Edison Water Storage District	X	X	X
Buena Vista Water Storage District	X	X	X
City of Bakersfield		X	
Cawelo Water District	X	X	X
Henry Miller Water District		X	
Kern Delta Water District	X	X	X
Kern Water Bank GSA	X		
Kern-Tulare Water District			
North Kern Water Storage District	X	X	
Olcese Water District			
Kern County Water Agency	X	X	
Rosedale-Rio Bravo Water Storage District	X	X	X
Semitropic Water Storage District	X	X	X
Shafter-Wasco Irrigation District	X	X	
Southern San Joaquin Municipal Utility District	X	X	
Tejon-Castac Water District			
West Kern Water District			
Westside District Water Authority	X		
Wheeler Ridge-Maricopa Water Storage District		X	

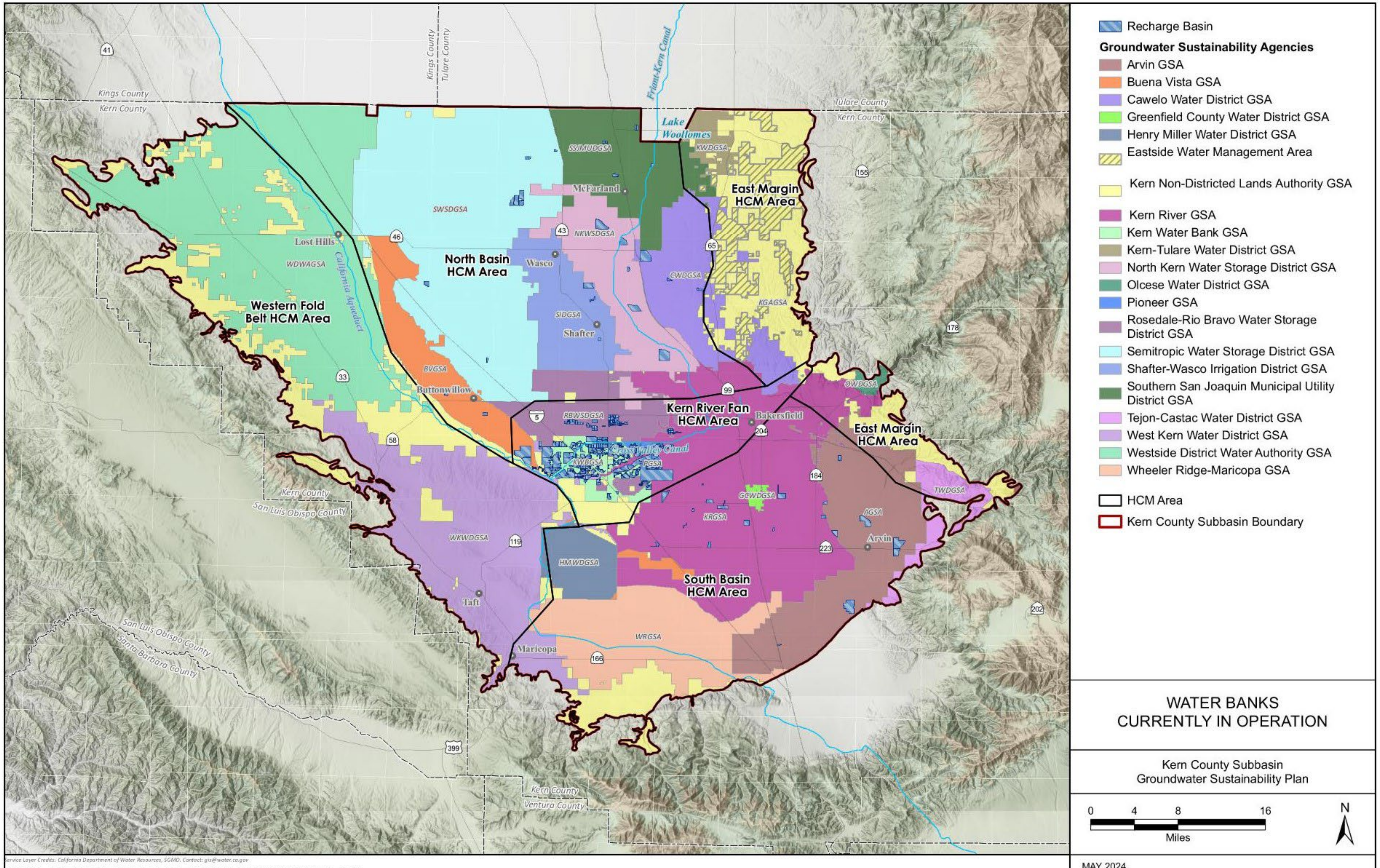


Figure 5-11. Water Banks Now in Operation

This page intentionally left blank.

5.6 Beneficial Uses and Users

☑ **23 CCR § 354.10(a)**

In the Kern County Subbasin, water is supplied to various beneficial users including agriculture, industry (energy and other sectors), drinking water users (municipal and other public water systems, small communities, and domestic or non-public users). Drinking water users are further defined in Section 5.6.1.

Since conjunctive use is employed throughout the Kern Subbasin, many users are supplied by a combination of stored surface water and native yield of groundwater, diversions from the Kern River and/or imported water. This section focuses on beneficial uses and users of stored surface water and native yield of groundwater, but also highlights users who rely on imported surface water supplies.

5.6.1 Well Inventory

GSP regulations require GSAs to identify the interests of all beneficial uses and users of groundwater, which includes all drinking water well users, and specifically to map the density of wells per square mile as well as the location and extent of communities dependent on groundwater. Recognizing that the Online System of Well Completion Reports (OSWCR) database is a system for maintaining records, not intended to serve as a well inventory, a Subbasin-wide well inventory was initiated to develop an accurate database with the location and type of beneficial users in the Kern County Subbasin. This effort filtered OSWCR records to remove duplicate and extraneous data, then reconciled the remaining records with Kern County Environmental Health Services (KCEHS) and Kern County Water Agency databases, as well as state records from United States Geologic Survey (USGS) and the Division of Drinking Water (DDW). Table 5-5 shows the well types identified in each dataset.

Table 5-5. Summary of Well Types by Database

User Type	OSWCR Database	USGS Dataset	KCEHS Records	Well Inventory
Agricultural/Irrigation	4,443	1,286	3,082	4,290
Industrial	275	62	79	97
Municipal/Public	245	214	589	298
Small Community [1]	---	---	433	41
Domestic	2,397	2,222	7,350 [2]	2,501
Other/Unknown	3,677	145	---	---
Total Wells	**11,037**	**4,244**	**11,533**	**7,227**

[1] Not a designation in DWR database; DDW database used to identify municipal, public, and small communities.
[2] Includes wells outside of the Kern Subbasin.

Since multiple datasets were used, it was necessary to establish a system to prioritize which fields would be used for the well inventory. The following points summarize the highest priority ranking to the lowest priority.

- DDW database was the highest priority source for well location (latitude and longitude coordinates) and status (destroyed, inactive, standby, or active) for Municipal and Public wells.
- KCEHS dataset was the highest priority source for intended use and well location since this information is field verified by an inspector. Status information was provided but it was not considered a consistent or reliable since it represents the point in time when the information was collected.
- USGS dataset provides information similar to OSWCR with slightly more refined location information.
- OSWCR records provide more accurate location information starting around 2017; all previous locations are typically at the centroid of a section. The variation in WCR formats over the years can cause the construction information to be inconsistent, which required quite a bit of manual verification.

The Kern Subbasin Well Inventory (2024) provides an improved understanding of the locations of drinking water wells, their locations, depth and construction details. However, further field verification is needed to complete the well inventory. As shown in Figure 5-12, there are still several wells with centroid of section locations (2,642 records) that require further verification to determine if the well exists, identify the accurate location, and determine the current use. This will be achieved using local surveys and outreach to residents to complete the well inventory. Once the inventory is complete, the Subbasin intends to develop a process for maintaining its database.

Water system information is readily available from State Drinking Water Information System Database (SDWIS) and through communications with Division of Drinking Water staff. However, some databases do not include information on industrial type of water systems (food processors, cold storage, etc.) or state small or non-public (water system with 2-5 service connections). These wells are collectively referred to as “public supply” wells. The Kern Subbasin well inventory reconciled data from all available sources to develop a comprehensive list of wells and persons or population served by all water systems.

This information will be used to evaluate and monitor how changing groundwater conditions (elevations and/or water quality) of the principal aquifers may impact these uses and users. Table 5-6 summarizes the wells identified by HCM Area. Figure 5-15 through Figure 5-18 show distribution of public supply and domestic wells.

5.6.2 *Well Density per Square Mile*

☑ **23 CCR § 354.8(a)(4)**
☑ **23 CCR § 354.8(b)**

As discussed in Section 5.6.1, a Subbasin-wide well inventory was conducted to better understand the location and type of beneficial users in the Subbasin. Figure 5-13 shows the density of wells per square mile. As tabulated in Table 5-6, most wells are located within the North Basin HCM Area and the fewest in the Western Fold Belt HCM Area.

Table 5-6. Summary of Beneficial Users and Land Uses by HCM Area

Subbasin Beneficial User Type	Western Fold Belt	North Basin	Kern River Fan	South Basin	East Margin	Total # of Wells
Agricultural	61	2,277	546	1,205	201	4,290
Industrial	11	15	28	30	13	97
Municipal / Public Supply	3	91	96	106	2	298
Small Community	0	9	14	12	6	41
Domestic / Non-Public	7	788	625	937	144	2,501
Subtotal	**82**	**3,180**	**1,309**	**2,290**	**366**	**7,227**

This page intentionally left blank.

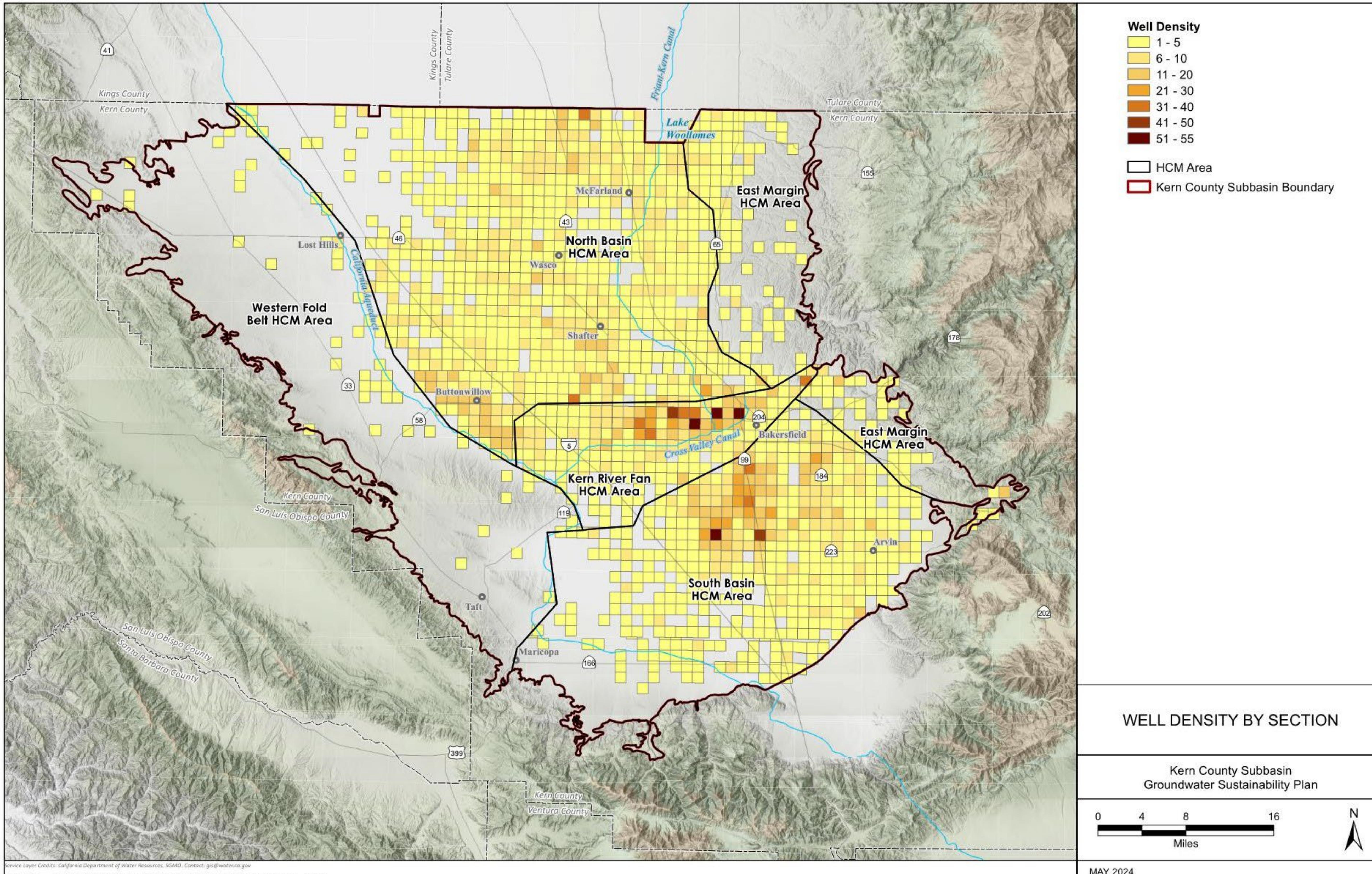


Figure 5-12. Well Density Per Square Mile

This page intentionally left blank.

5.6.3 *Overview of Public Water Systems*

As described in Section 5.6.1, the Kern Subbasin's Well Inventory includes efforts to identify all public water systems with the location and status of their wells. This process used records from the Open Data Portal, SDWIS, KCEHS, and communications with DDW staff. Nearly 500 public supply wells were identified to supply 146 water systems in the Kern Subbasin. Table 5-7 summarizes water systems with their classification.

Public water systems are characterized as supplying water for human consumption through pipes or other constructed conveyances that have 15 or more service connections or regularly serves at least 25 people daily at least 60 days out of the year. Systems classifications are an important differentiator to understanding water systems that may have significant variation in size and beneficial uses and user types. This Plan uses the following system classifications, which are based on Title 22, California Code of Regulations for Drinking Water and CA Health and Safety Code §116275.

- **Community** is a public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents of the area served by the system.
- **Small Community** is a water system that serves no more than 3,300 service connections or a yearlong population of no more than 10,000 persons.
- **Nontransient Noncommunity** systems are a broad category of facilities that are regulated as a public water system because they regularly serve at least 25 of the same persons over six months per year. Schools, prisons, and churches, who are typically de minimis users, are examples applied to this classification.
- **Industrial Community** are classified by DDW as Nontransient Noncommunity but differentiated in this Plan to separate high-consumption water users. Common examples are manufacturing, washing/cold storage, and food processing.
- **Transient Noncommunity** is a water system that serves transient public such as a truck stop, recreational areas, store, or restaurant.

Table 5-7. Number of DDW regulated water systems in the Kern Subbasin

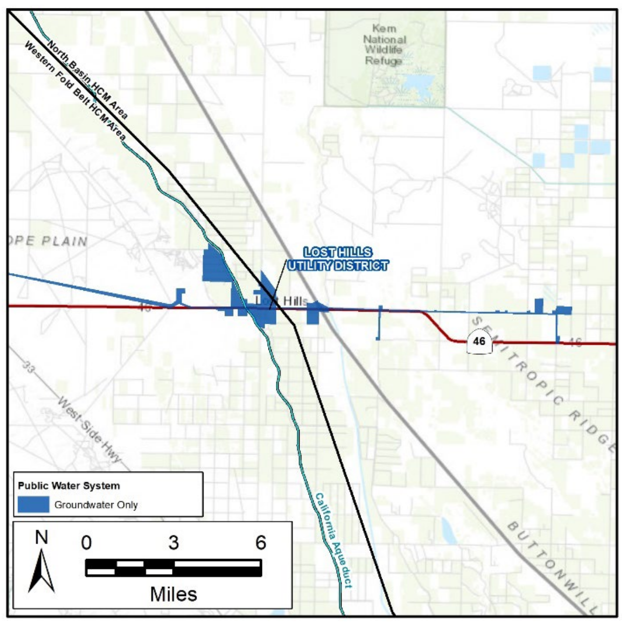
Classification	# of Systems	# of Wells [1]
Community	18	342
Small Community	46	48
Nontransient Noncommunity	8	16
Industrial Community	49	62
Transient Noncommunity	25	20
Subtotal	**146**	**488**

[1] Only 383 Wells are Active; 15 are Standby and 98 are Inactive.

5.6.4 Municipalities and Urban Water Purveyors

Community water systems include municipalities as well as purveyors serving unincorporated areas that are regulated by a local Board of Directors or the Public Utilities Commission (PUC). Figure 5-14 shows Community water system boundaries, or well location for the small community water systems. Not all water systems are represented in this figure because SDWIS generally does not include system boundaries for Noncommunity water systems. Figure 5-14 through Figure 5-17**,** which show well locations, provide a more accurate representation of all water systems in the Subbasin. Most community water systems are groundwater dependent. However, some of the systems within the metropolitan Bakersfield area rely on surface water supplies. Kern County Water Agency Improvement District 4 (ID4) is a wholesale supplier to its member units (California Water Service, City of Bakersfield, Oildale Mutual Water Co., and East Niles Community Services District). Additionally, California Water Service and the City of Bakersfield own and operate facilities to treat Kern River water which supplies their distribution systems in metropolitan Bakersfield. Average percentage of groundwater (dark blue shade) and surface water (light blue shade) are shown on Figure 5-13 and discussed in the following sections.

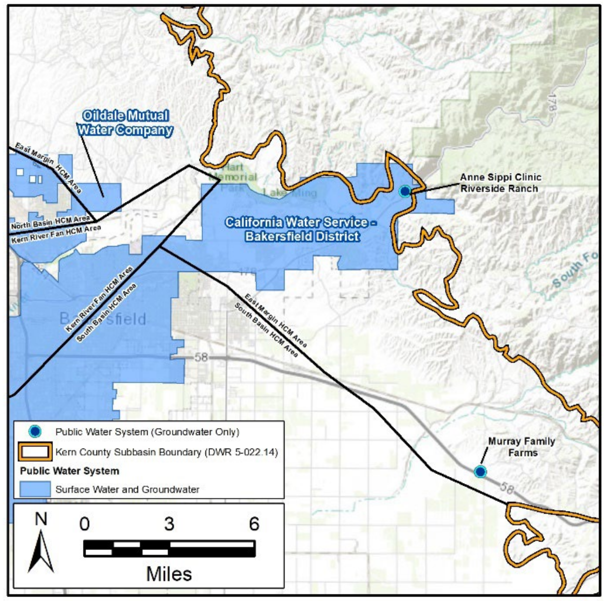
Drinking Water Supplies in the Western Fold Belt HCM Area



While Figure 5-13 shows water systems in the Western Fold Belt HCM Area, only one Industrial Community water system relies on underlying groundwater. In the northern HCM area, along Highway 46, water is supplied by groundwater imported from the North Basin HCM Area due to poor water quality underlying the community of Lost Hills (Western Fold Belt). Lost Hills Utility District has a groundwater extraction agreement with the Semitropic Water Storage District (North Basin HCM Area). Additionally, the Interstate 5 Utility Company (located at the border of the North Basin and Western Fold Belt HCM Area) is a wholesale supplier to Clean Harbors Buttonwillow and Aera Energy LLC facilities (both Industrial Community systems) that are in the Western Fold Belt HCM Area.

The southern half of the Western Fold Belt HCM Area is within the West Kern Water District service area. Water supplied to the communities of Derby Acres, Dustin Acres, Fellows, Maricopa, McKittrick, Taft, Tupman, and Valley Acres are supplied by groundwater extracted entirely from the Kern River Fan HCM Area.

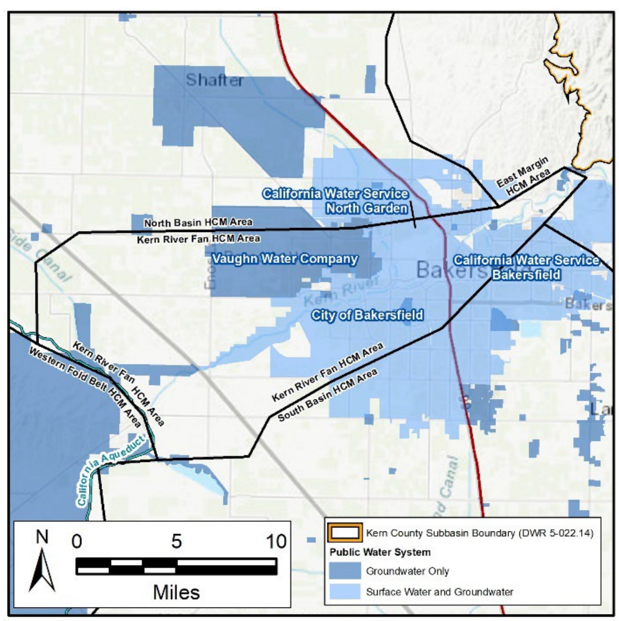
Drinking Water Supplies in the East Margin HCM Area



There are no public water systems relying on groundwater in the northern portion of the East Margin HCM Area. Oildale Mutual Water Company's service area extends into the East Margin HCM Area, but this system is supplied by 91 percent surface water purchased from ID4. Figure 5-13 shows a few small community water systems in the Kern River Fan HCM Area, which divides the northern and southern East Margin HCM Areas. These are groundwater dependent communities.

The large water systems extending into southern East Margin HCM Area is owned and operated by California Water Service, this area is entirely supplied by surface water from its northeast treatment plant. There are two groundwater dependent water systems in the southern East Margin HCM Area: the Anne Sippi Clinic Riverside Ranch is a groundwater dependent small community system within the California Water Service area; Murray Family Farms is a Transient Noncommunity water system in the southern East Margin HCM area that relies on groundwater to supply drinking water to its storefront.

Drinking Water Supplies in the Kern River Fan HCM Area



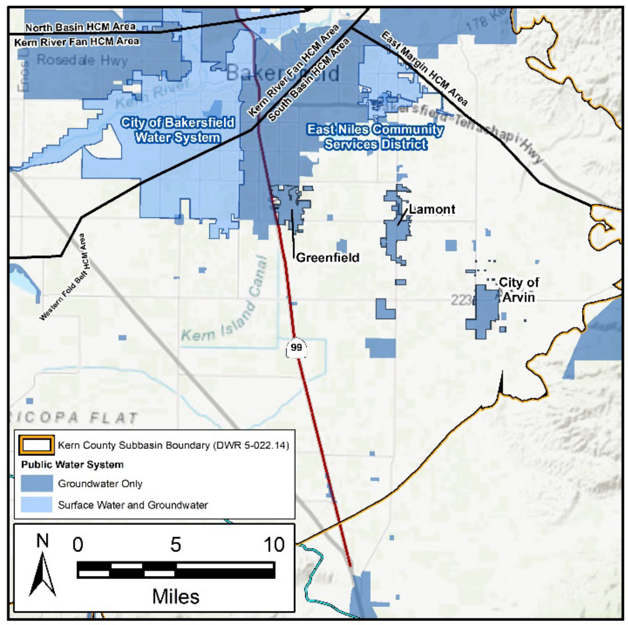
The highest quality of groundwater is within the Kern River Fan HCM Area, which supplies most of metropolitan Bakersfield. Purveyors in this area are California Water Service, City of Bakersfield, and Vaughn Water Company. On average, the service area east of Highway 99 is fully supplied by surface water. California Water Service uses an average of 48 percent surface water and 52 percent groundwater, which is supplied to their service area east of Highway 99 in the South Basin HCM Area. West of Highway 99 is the

City of Bakersfield water systems, which is predominately supplied by surface water north of Rosedale Highway and groundwater dependent south of Rosedale Highway. On average, the City of Bakersfield is supplied by 18 percent surface water and 82 percent groundwater.

Vaughn Water Company and the small community water systems interspersed within the California Water Service and City of Bakersfield service areas are groundwater dependent. In the western extent of the Kern River Fan HCM Area, there are several rural small community water systems that are also groundwater dependent.

Drinking Water Supplies in the South Basin HCM Area

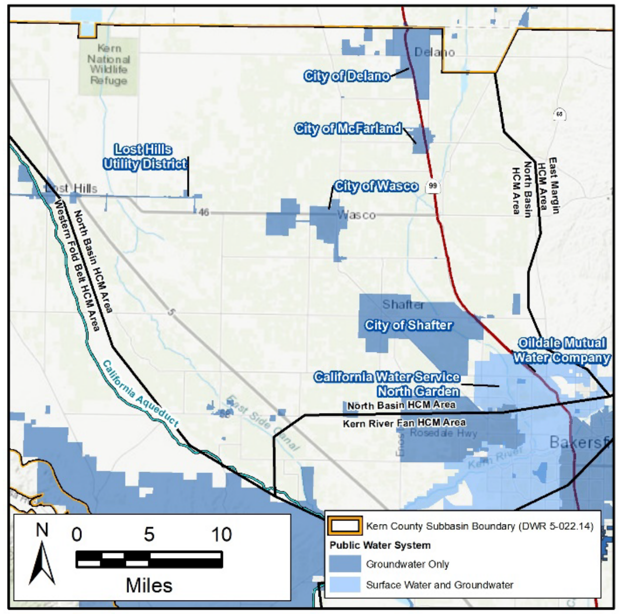
The South Basin HCM Area is almost completely groundwater dependent. The only exception is a portion of California Water Service that is supplied by surface water from its northeast treatment plant and ID4. East Niles Community Services District, which is adjacent to California Water Service's system, is supplied by 38 percent surface water purchased from ID4 and 62 percent groundwater.



The City of Bakersfield water system (west of Highway 99) that extends into the South Basin HCM Area is groundwater dependent. The City of Arvin and unincorporated communities of Lamont and Greenfield are also groundwater dependent. There are also several rural, small communities spread throughout the South Basin HCM Area.

Drinking Water Supplies in the North Basin HCM Area

The North Basin HCM Area is also primarily groundwater dependent. The exception is California Water Services North Garden system that is supplied by 82 percent surface water from its northwest treatment plant and ID4, and 18 percent groundwater. Oildale Mutual Water Company is predominantly supplied by surface water (91 percent) from ID4 with only 9 percent groundwater supply.



The cities of Shafter, Wasco, McFarland, and Delano are all completely groundwater dependent. There are several rural, small communities and Industrial Community water systems throughout the North Basin HCM Area.

5.6.5 Disadvantaged Community Water Systems

Disadvantaged Community is a reference to the financial status of a geographic area where the median household incomes are less than 80 percent of the statewide average. Section 5.3.3 identifies disadvantages communities based on township level data from DWRs 2020 census places, which indicates that the majority of the Kern Subbasin, as shown in Figure 5-8 is within the disadvantaged income threshold.

Figure 5-13 shows orange hash marks to represent water systems that likely meet disadvantaged community status based on block group level data from DWRs 2020 census places. Using non-continuous block group data provides a more accurate representation of the communities that are likely within the disadvantaged community income threshold. Based on block group data overlying community water systems:

- Most small community water systems in the Kern Subbasin are outside of the disadvantaged community block groups.
- Community water systems meeting the disadvantaged community income threshold are the municipal and unincorporated community areas or are within the California Water Service and Oildale Mutual Water Company service areas.

5.6.6 Non-Public Water Systems and Domestic Wells

KCEHS serves as the Local Primacy Agency for **Non-Public** water systems (identified as state-small systems in Title 22 and CA Code §116275), which is typically a shared well system that serves 2 to 5 residences or can be a business that serves less than 25 people for 60 or less days per year. Table 5-8 identifies the number of wells by HCM Area.

Table 5-8. Number of Domestic Wells by HCM Area

HCM Area	# of Wells
Western Fold Belt	7
North Basin	788
Kern River Fan	625
South Basin	937
East Margin	144
Subtotal	**2,501**

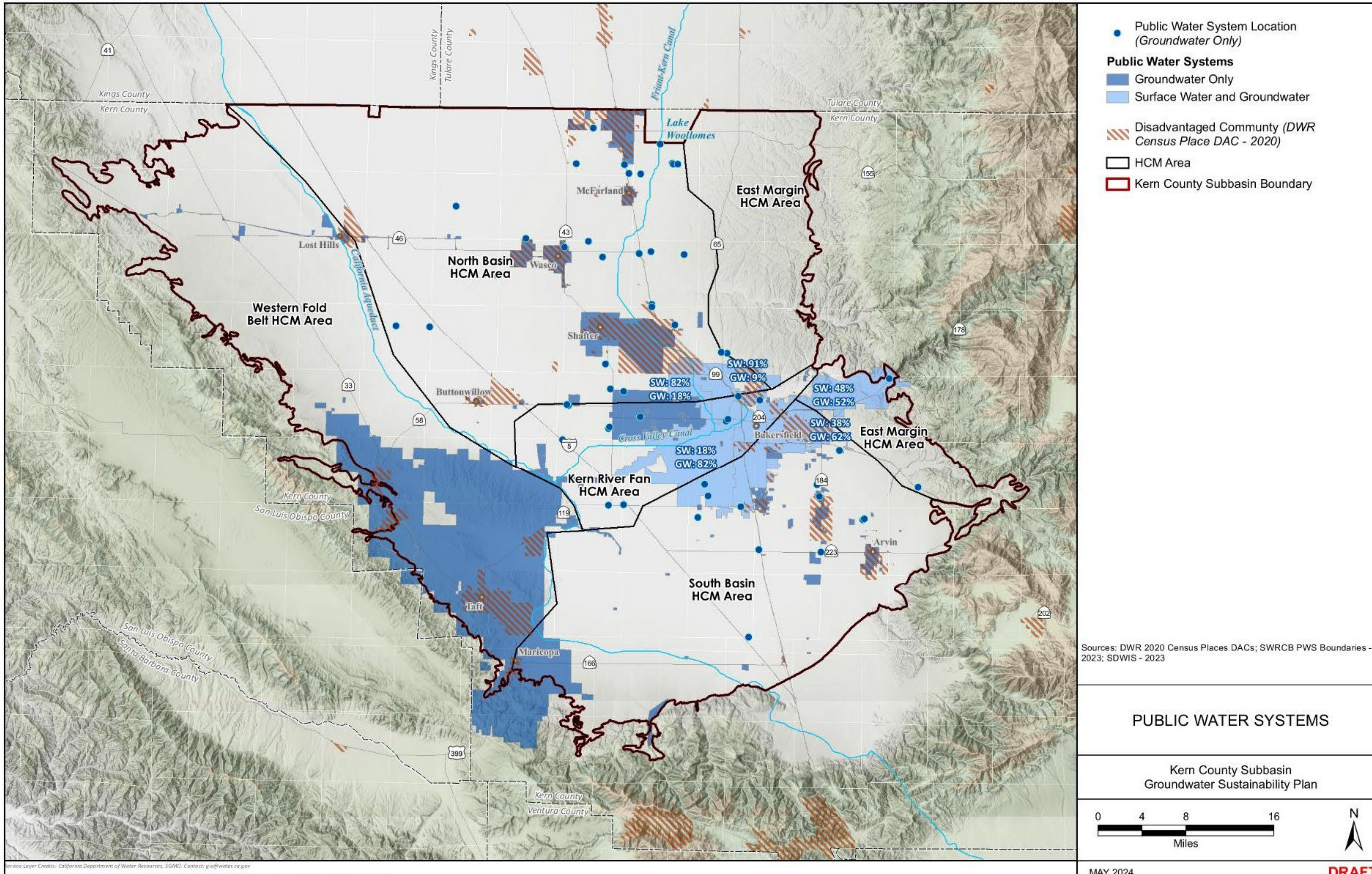


Figure 5-13. Community Water Systems

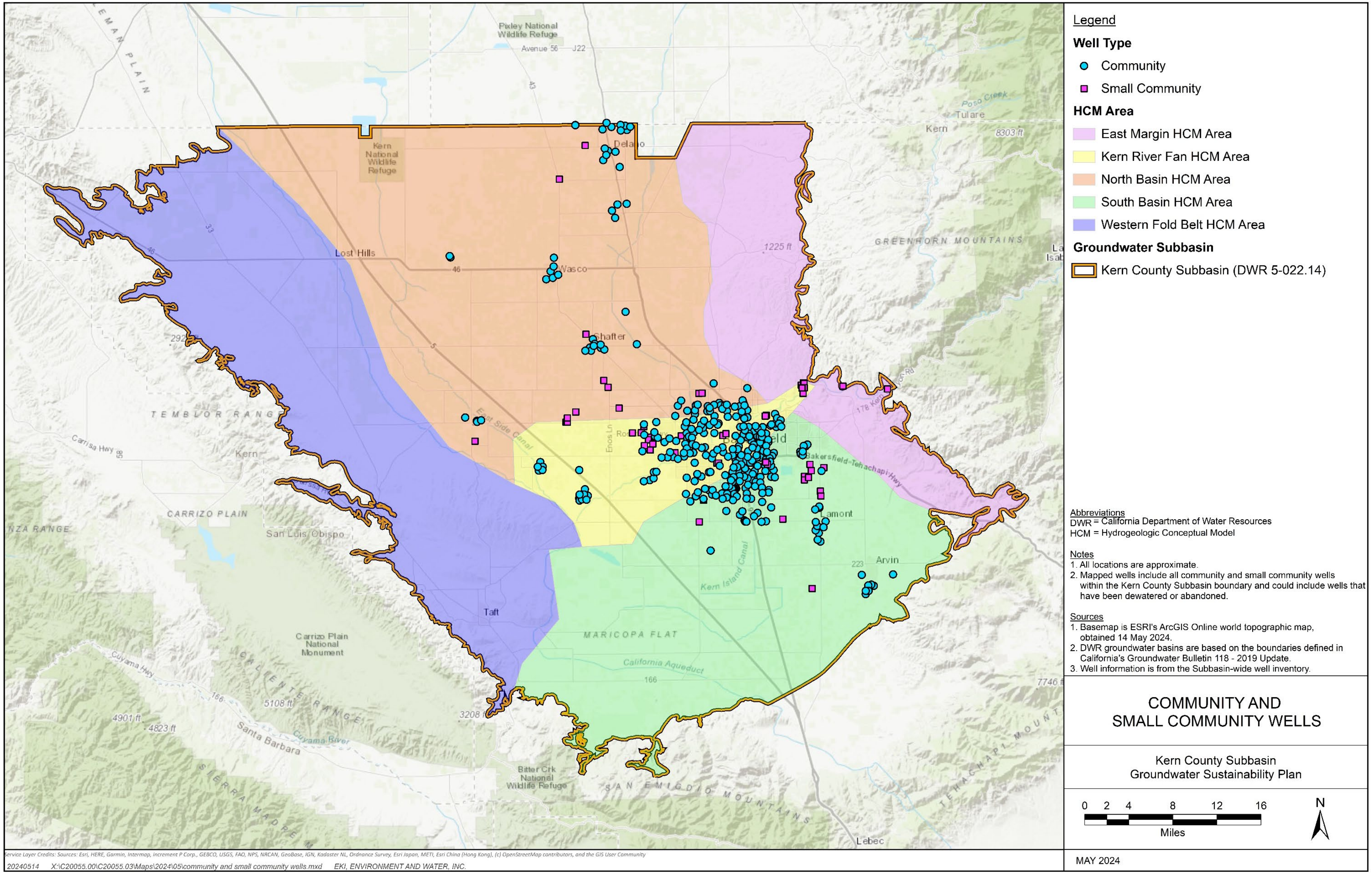


Figure 5-14. Community and Small Community Wells

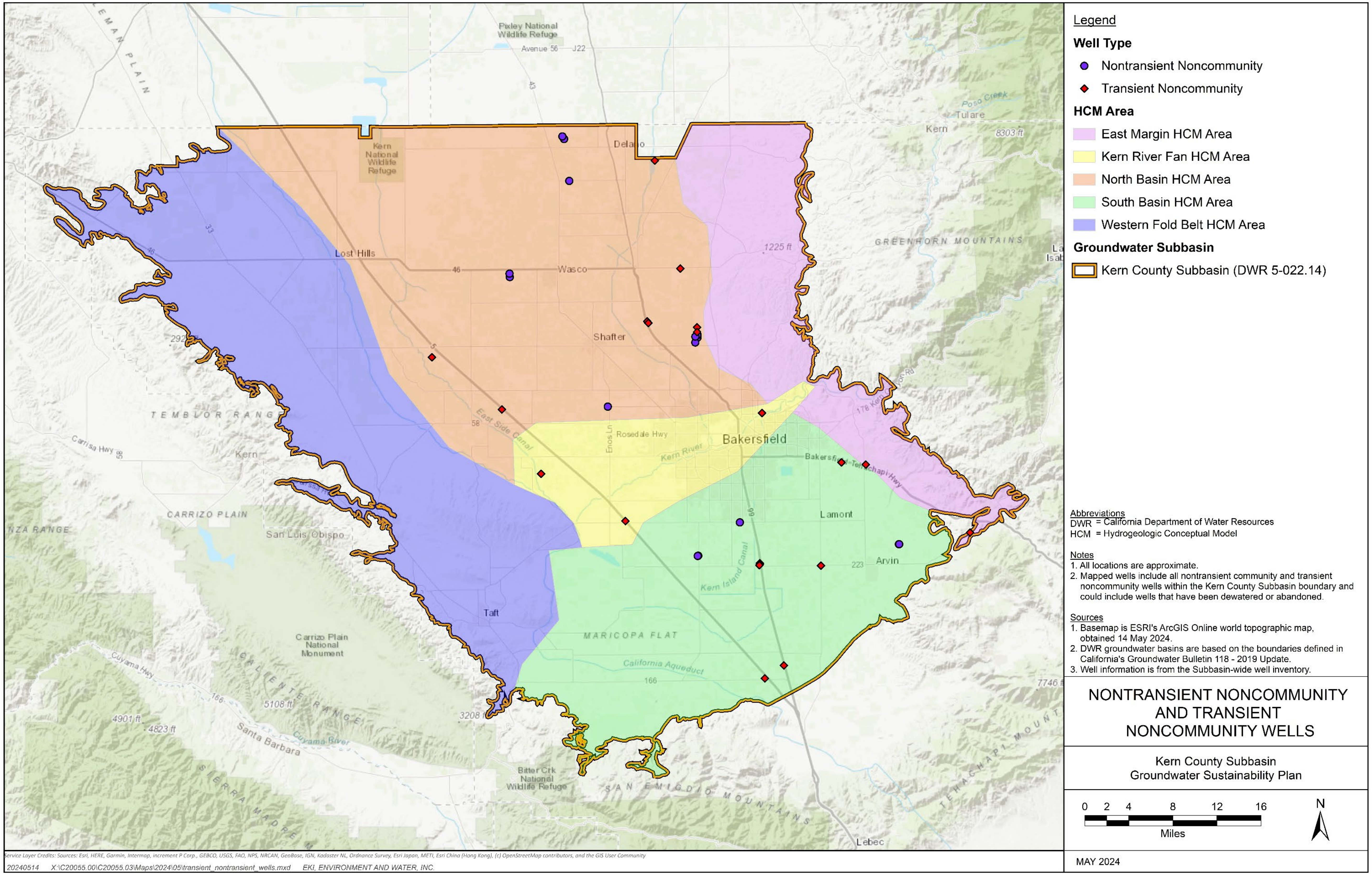


Figure 5-15. Nontransient Noncommunity and Transient Noncommunity Well

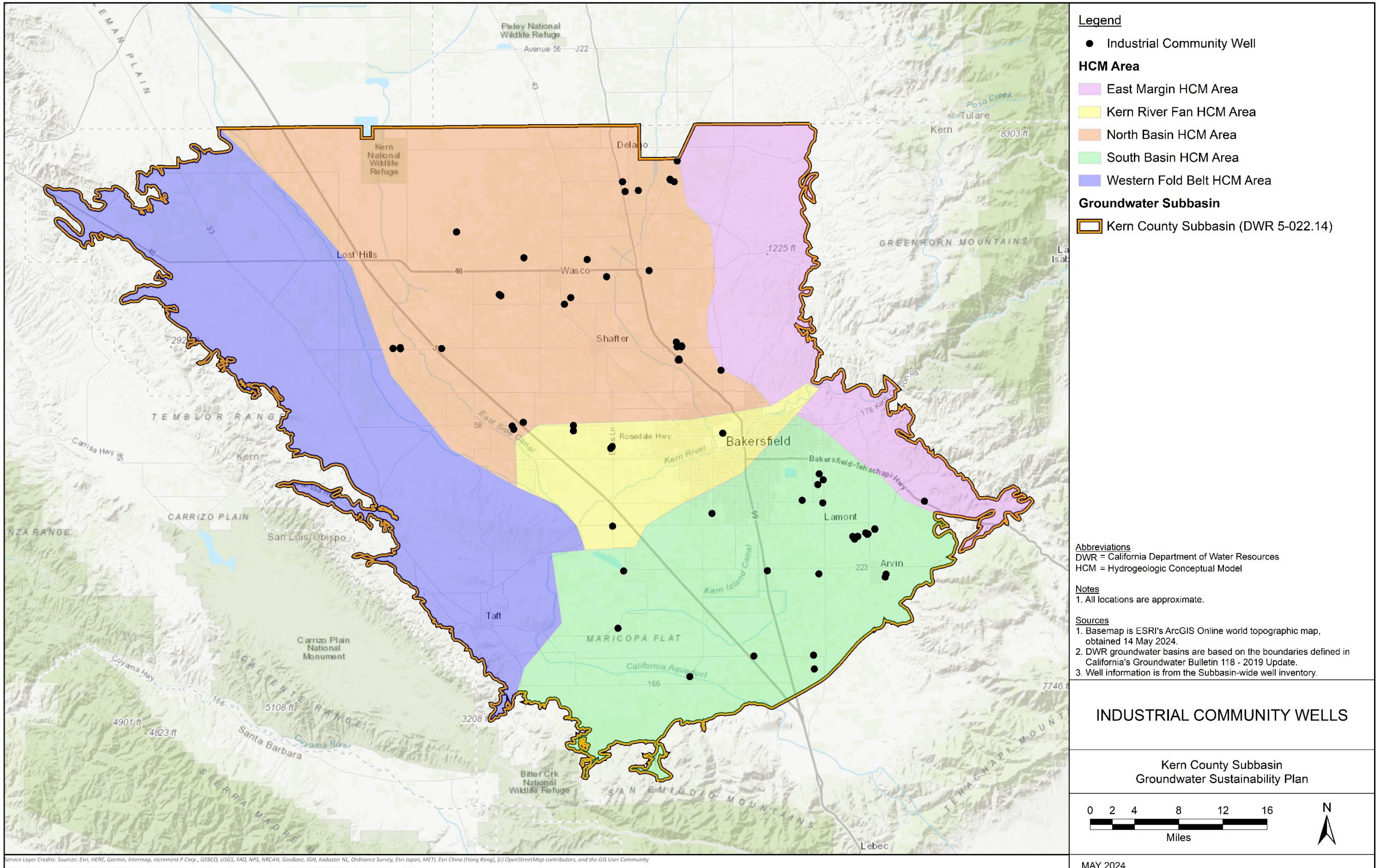


Figure 5-16. Industrial Community Wells

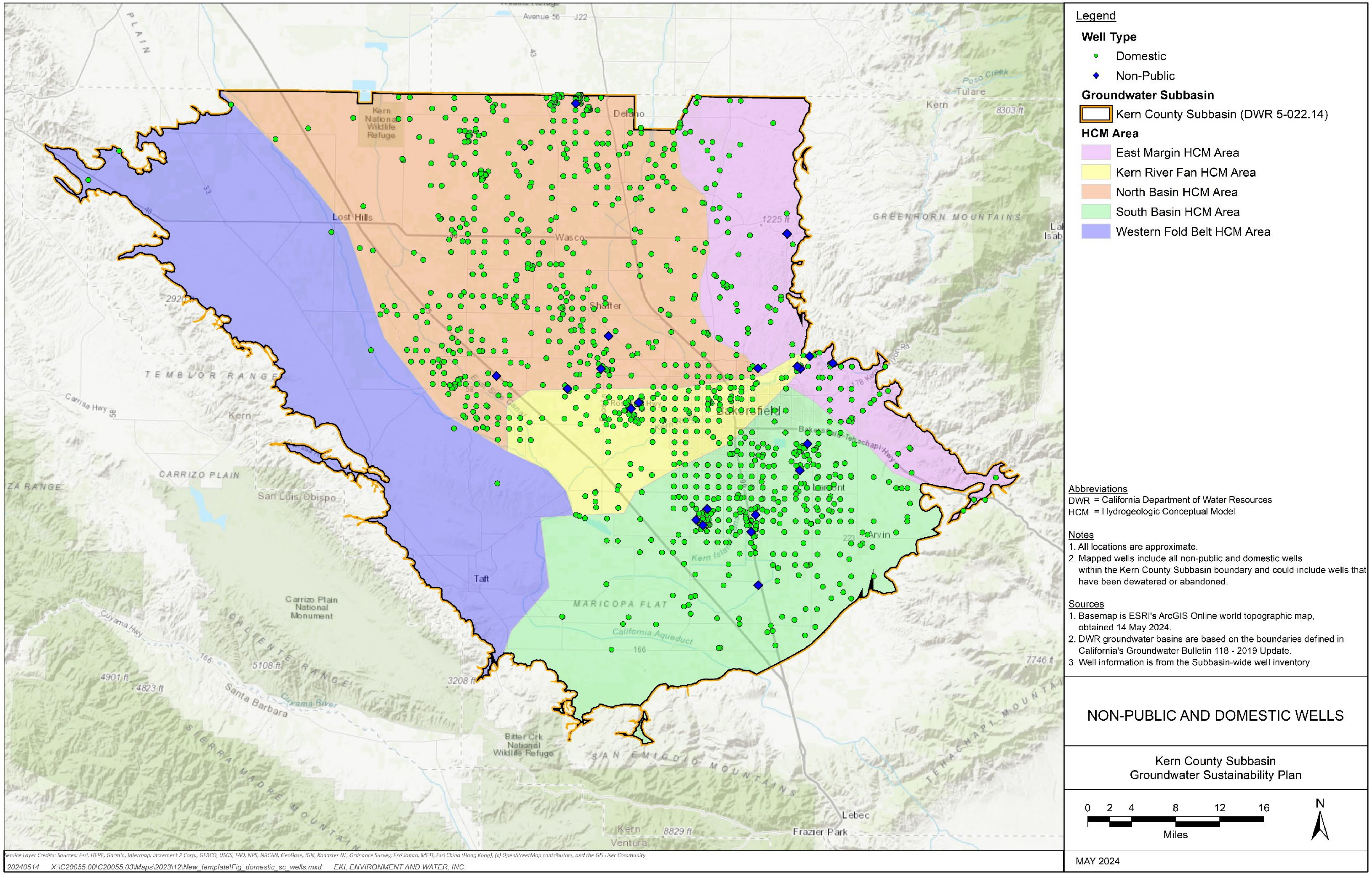


Figure 5-17. Non-Public and Domestic Wells

This page intentionally left blank.

5.7 Existing Monitoring and Management Programs

☑ **23 CCR § 354.8(c)**

There is a long history of water resources monitoring and management programs in the Kern County Subbasin. Such programs are conducted by local water agencies and public water suppliers at regional and local levels, ranging from participation in State programs (e.g., CASGEM) and regional plans (e.g., Integrated Regional Water Management Plan) to individual water system monitoring by local water suppliers. Details of the various programs are provided in the subsequent sections; Table 5-9 summarizes the programs, their goals, and data collected.

5.7.1 Water Resources Monitoring

Water resource monitoring programs considered in the Plan address:

- Climate.
- Groundwater levels and pumping.
- Imported water deliveries.
- Surface water flows and deliveries.
- Water banking.
- Wastewater discharge and recycled water delivery.
- Land use and cropping.
- Water quality.
- Land subsidence.
- Consumptive use.

Multiple agencies are involved in water resources monitoring, with data shared through several key annual reports. KCWA has assumed a major role in the collection of data on groundwater and surface water supplies and water quality in the Subbasin. Other key and regularly published documents are the Kern River Hydrographic Annual Reports produced by the City of Bakersfield, the Report on Water Conditions prepared by ID4, the Kern Fan Area Operations and Monitoring Report produced by the Kern Fan Monitoring Committee (KFMC), and the monitoring reports published by the Semitropic Water Storage District Water Banking Project Monitoring Committee.

Local agencies also monitor drinking water supplies in compliance with a variety of SWRCB monitoring programs. In addition, water districts have reported surface water and groundwater conditions in respective groundwater management plans and have documented monitoring objectives, methods, protocols, locations, and data management practices. The monitoring and reporting programs of these and other Kern County Subbasin organizations (summarized in Chapter 6) are being considered for incorporation into the SGMA monitoring networks.

5.7.2 Climate

Long-term climate data are available from key weather stations (UCANR, 2023) including the National Weather Service Bakersfield Airport station and the weather station at the Kern County Fire Department near Wasco. Both have precipitation and temperature records from 1951 to present.

The California Irrigation Management Information System (CIMIS) was developed by DWR to collect climate data relevant to agricultural operations. Several stations are active in the Subbasin including the CIMIS Shafter Station #5 located at a former USDA Cotton Research facility on Shafter Avenue. The station's record began June 1, 1982, with a one-year gap in 2012-2013 and is currently active. The Arvin-Edison Station #125 also is active with data available from March 22, 1995. Other stations are currently inactive (for example, CIMIS #31 – McFarland/Kern Farms and CIMIS #13 - Famoso near McFarland) but provide historical data. Information on CIMIS stations and CIMIS data are available online (CIMIS, 2018).

5.7.3 Groundwater levels and pumping

Groundwater levels have been recorded in the Subbasin outside of formal monitoring programs since at least the 1920s, but data before the 1950s and 1960s are sparse. Water levels are currently monitored by each of the GSAs. Water levels observed at approximately 185 Representative Monitoring Wells (RMWs) distributed throughout the Subbasin are managed using a Data Management System (DMS). These wells are part of the monitoring network described in Section 15, and groundwater levels recorded at these wells are reported to the SGMA portal.

Data on groundwater pumping is collected by some GSAs and is reported for urban pumpers at five-year intervals in UWMPs and in AWMPs. Groundwater extractions are reported to ID4 within its service area on a semi-annual basis. This program includes multiple municipal wellfields and accounts for a significant percentage of the active wells in the Kern River Fan HCM Area. Wells within ID4 are registered and the number of wells and well uses (commercial, domestic, irrigation, purveyor) are tabulated in the ID4 Report on Water Conditions (e.g., KCWA, 2019). Extractions are reported based on well meters, where available, or other estimates including electrical records or land use.

Since 2009, the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, as developed and coordinated by the DWR, has tracked seasonal and long-term groundwater elevation trends in groundwater basins statewide in collaboration with local monitoring entities. This program has served as a tool to monitor groundwater to help achieve the goals set out under SGMA. There are close to 3,300 monitoring wells within the Kern County Subbasin stored in the CASGEM database, with data from as far back as the 1920's. Over 750 of these wells are considered active and have data reported since 2015; of these, a little less than 100 wells are designated as observation wells.

5.7.4 Land Use and Cropping

Irrigated agriculture represents the largest water use within the Subbasin. Currently, agricultural water demands are determined based on evapotranspiration (ET). The Kern County Subbasin has partnered with Land IQ to determine ET for all areas of the Subbasin with a focus on irrigated agriculture. Several GSA's are verifying this number from their well readings. This provides a consistent basin-wide methodology for calculating ET based on local climatic and cropping data. In WY 2023, the Subbasin GSAs have received the first round of data and plan to incorporate the results in the Annual Report.

5.7.5 Water Quality

Water quality monitoring and reporting programs are administered by various agencies from the federal and state level to regional and local levels, including monitoring by member agencies. Major programs and sources of data are summarized below; all contribute to water quality monitoring and management activities being implemented in parallel with SGMA.

State-Wide Groundwater Quality Monitoring

State-wide sources of groundwater quality data include the DWR's Water Data Library (WDL), SWRCB's Groundwater Ambient Monitoring and Assessment (GAMA) program (in cooperation with USGS), SWRCB's GeoTracker data system and the State Drinking Water Information System Database (SDWIS) of the SWRCB Division of Drinking Water. Water quality data contained in these databases are collected from a variety of well types including irrigation, stock, domestic, and some public supply wells.

State and County Public Water Supply Monitoring

In accordance with the California Health and Safety Code, public water systems regularly monitor water quality and prepare an Annual Consumer Confidence Reports. The public water systems are required to routinely test for Title 22 regulated constituents. Water quality data for public water systems are available through the GAMA online tool and SDWIS. KCEHS administers the Small Water System Program that includes permitting and monitoring of non-public water systems (2 to 5 connections) and the state-small public water systems (6 to 14 connections). Data is available through a public records request.

Irrigated Lands Regulatory Program (ILRP)

The RWQCB's Irrigated Lands Regulatory Program (ILRP) regulates discharges from irrigated lands and focuses on priority water quality issues, such as pesticides and toxicity, nutrients, and sediments. The Program is administered by the Kern River

Watershed Coalition Authority (KRWCA) and its associate members Cawelo Water District Coalition (CWDC), the Buena Vista Coalition (BVC), Westside Water Quality Coalition, Westside Water Quality Coalition. Data collected and reported as a part of ILRP are provided to the SWRCB and are available in the GeoTracker database for download and use.

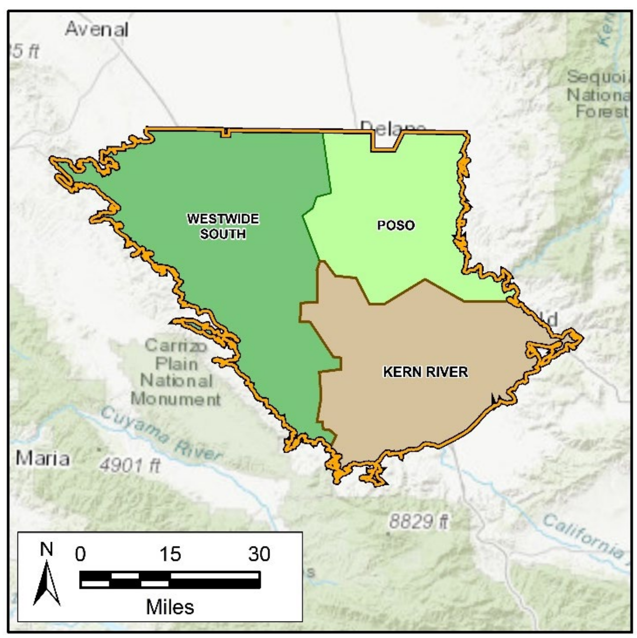
The ILRP issues Waste Discharge Requirements (WDRs) or conditional waivers of WDRs (orders) to growers that require water quality monitoring of receiving waters. KRWCA created a database with over 100,000 records for total dissolved solids (TDS), nitrate, and pesticides over the 1909 through 2014 period (Provost & Pritchard, et al., 2015).

Central Valley-Salinity Alternatives for Long-Term Sustainability (CV-SALTS)

CV-SALTS is a stakeholder led initiative established to address nitrate and salt accumulation in the Central Valley's groundwater supplies. The Nitrate and Salt Control Programs are being implemented on parallel paths. The over-arching goals of these programs are to:

- Identify short- and long-term solutions to ensure safe drinking water in communities where groundwater is high in nitrate.
- Reduce impacts from nitrate and salts to the groundwater.
- Where reasonable and feasible, restore groundwater quality.

Nitrate Control Program



Permittees with nitrate discharges may elect to comply with the requirements of the Nitrate Control Program through participation in a Management Zones, a discrete and generally hydrologically contiguous area where dischargers work collectively to meet the goals of the program. This effort requires implementation of an Early Action Plan (EAP) that includes a residential well monitoring program that identifies and mitigates domestic wells with nitrate levels greater than 10 parts per million (ppm).

Central Valley groundwater subbasins, including portions of the Kern Subbasin, are prioritized for implementation under the Nitrate Control Program. The Kern Subbasin has three delineated zones. Kern (Poso), which spans the East Margin and approximately one-half of the North Basin HCM Areas, and Kern (Westside South), which spans the North Basin and Western Fold Belt HCM Areas, are Priority 2 areas under the Nitrate Control Program. Implementation recently began in these areas. Kern (Kern River) spans a small portion of the North Basin, all of the Kern River Fan, and the South Basin HCM Areas. This zone is not currently prioritized for Nitrate Control Program implementation.

The Kern Water Collaborative was formed to administer the Nitrate Control Program in the Kern Subbasin and will begin implementation of an EAP that conducts outreach to residents that rely on domestic wells by March 2025. Appendix F includes a Memorandum of Understanding (also refer to Chapter 14 Management Action KSB-2) that explains the Subbasin's intent to coordinate with the Kern Water Collaborative to avoid duplication of efforts between the SGMA and Nitrate Control Program Implementation. The GSAs and Kern Water Collaborative have mutual interest in assessment of groundwater monitoring and data assessment and supporting residents who rely on domestic wells with access to safe water for consumption.

Salt Control Program

The Salt Control Program is a multi-phased effort to addresses the long-term problem of salt accumulation in the Central Valley. The program's approach is intended to protect beneficial uses by maintaining water quality that meets applicable objectives, allows salt accumulation in areas where salt can be stored without impairing beneficial uses of water, and through long-term management, restore water quality where reasonable, feasible, and practicable.

The Central Valley Salinity Coalition and its Consultant Technical Team are currently implementing the Salt Control Program's Prioritization & Optimization (P&O) Study: an estimated 10-year planning process to identify long-term solutions that will protect beneficial uses, improve salt management, and restore water quality where possible. A current activity of the P&O Study is reviewing all Central Valley GSPs to collect data on water budgets, water uses, and Projects & Management Actions. These data that will be to help validate model inputs and inform on the P&O Study analyses of future salt conditions, given implementation of potential salt management alternatives.

Local Monitoring Committees

The Kern Fan and Semitropic Monitoring Committees evaluate groundwater conditions (levels and quality) in and around banking projects. The Kern Fan Monitoring Committee evaluates the Kern Water Bank and other Kern Fan Banking projects in the Kern River Fan HCM Area. Semitropic Monitoring Committee evaluates groundwater conditions around banking projects in the North Basin HCM area.

These monitoring committees operate under an MOU amongst participants in local water banking projects and adjoining entities. Responsibilities include collecting data from participants and adjoining entities and reporting that data in a written report that is distributed to all participants, stakeholders, and interested parties.

Reports have been published every three to five years and include annual data for groundwater levels and annual and limited semi-annual data for groundwater quality. Monitoring reports are available beginning with data from 1991 and continuing to the present. Published data include deliveries for storage, recovery pumping, groundwater levels (presented as hydrographs and maps of groundwater elevations and depth to groundwater), and results of groundwater and surface water quality sampling.

Table 5-9. Existing Groundwater Quality Monitoring Programs

Programs or Data Portals	Parameters	Frequency	Objectives	Notes
AB-3030 and SB-1938	• Water levels are typically monitored annually. • An Ag Suitability analysis (limited suite of general minerals) monitoring frequency between annual to once every 3 years.	• Semiannual to Annual	•	• Monitoring is recommended as a part of groundwater management planning. Data availability is inconsistent between Districts.
ILRP	• annually: static water level, temperature, pH, electrical conductivity, nitrate as nitrogen, and dissolved oxygen. Once every five years, general minerals will be collected.	• Annual • Every 5 years	• Monitor impacts of agricultural discharges on first encountered groundwater	• Sampling began in Fall 2018 with a limited number of wells sampled, in the Kern Subbasin, 59 wells are sampled by KRWCA, 13 by Buena Vista and 15 by Cawelo. The program will be expanded and may incorporate a shared sampling program with SGMA.
CV-SALTS	• Sampling parameters required through individual WDR's: typically include monthly sodium, chloride, electrical conductivity, nitrogen species (N, NO_2, NO_3, NH_3), pH and other constituents of concern identified in the Report of Waste Discharge. A limited suite of general minerals is required quarterly from the source and annual from the wastewater.	• Most constituents sampled monthly, quarterly general minerals from source water and annual general minerals from waste discharge. • A portion of KCS is a Priority 2 Basin, meaning that management strategies will be initiated in 2025.	• To evaluate degradation potential from wastewaters discharged to land application areas and identify projects to aid with salt and nitrate management in the Central Valley.	• CV-SALTS studies rely on existing water quality monitoring programs. While no new monitoring is expected under these programs, it may influence new or changed requirements as determined by the Regional Board and implemented through permit modifications.

Programs or Data Portals	Parameters	Frequency	Objectives	Notes
SDWIS	• Database for all public water system wells and historical sample results. Data available includes all Title 22 regulated constituents.	• Title 22 General Minerals and Metals every 3 years; • Nitrate as N annually, if ≥ 5 ppm, sampled quarterly; VOCs and SOCs sampled every 3 years; Uranium sampling depends on historical results but varies between 1 sample every 3 (when ≥ 10 pCi/L), 6 (when < 10 pCi/L) or 9 (when no historical detection) years.	• Demonstrate compliance with Drinking Water Standards through monitoring and reporting water quality data.	• An abundant source of data because of the required testing frequency and list of parameters.
CalGEM (formerly DOGGR) Underground Injection Control (UIC) Program	• Older UIC permits required analysis of Primary and Secondary Title 22 Constituents. Newer UIC permits require full Title 22 testing.	• Annually	• Monitor the quality of water injected for the purposes of disposal or enhanced oil recovery, via the state's injection control program.	• While injected volumes are reported on a monthly basis for each injection site, and total volumes of produced water are reported quarterly (via DOGGR's SB 1281 program), the injectate is only analyzed on an annual basis with samples taken at the storage tanks for either produced water or treated feedwater for EOR activities. Unless specified by additional reporting, the water samples are **NOT** at discrete well locations.
CalGEM (formerly DOGGR) SB-4	• Title 22 constituents before and after the well stimulation event and disclosure of the composition of the fluid to be used in the well stimulation	• Reported Quarterly, but sampling occurs as needed before and after a well stimulation	• Develop groundwater monitoring criteria related to Oil and Gas Well Stimulation and implement a groundwater monitoring program.	• Baseline fluid testing is done of both the well-stim fluid and at the monitoring wells identified in an operator's well stimulation plan. Neighboring property owners may also request that the operator perform baseline testing and post-well stimulation testing at the wells on their property.

Programs or Data Portals	Parameters	Frequency	Objectives	Notes
Geotracker WDR for Oil fields	• Oil & Grease, Total Hydrocarbons, TDS, Chlorides, Boron, and Electrical Conductance (typical)	• Depending on the conditions for the WDR, it can be monthly, quarterly, or annual samples with annual reporting	• Monitor the quality of produced oil field water that is disposed of via percolation or, in some cases, by beneficial reuse in permanent tree crop or pasture irrigation.	• Typically, oilfield produced water that is discharged to a percolation pond is sampled on an annual basis. However, there are WDRs for Class I and Class V injection wells, which handle refinery waste. These WDRs require monthly samples with annual reporting. In the last 5 years the RWQCB has sent out 13267 Orders, requesting information from operators on the Title 22 constituents in their discharged water. O&G operators were required to submit analytical results of all Title 22 constituents for produced water subject to their WDRs.
GAMA. Collaboration with SWRCB, RWQCB, DWR, DPR, NWIS, LLNL	• Constituents sampled vary by the Program Objectives. Typically, USGS is the technical lead in conducting the studies and reporting data.	• The priority basin project performed baseline and trend assessments and sampled over 2,900 public and domestic wells that represent 95 percent of the groundwater resources in CA.	• Improve statewide comprehensive groundwater monitoring. • Increase the availability to the general public of groundwater quality and contamination information.	• USGS reports prepared for the Priority Basin Project were used to identify constituents of concern in the basin and confirm water quality trends prepared for groundwater characterization.
Geotracker and DTSC Envirostor	• Many contaminants of concern, organic and inorganic.	• Depends on program. Monthly, Semiannually, Annually, etc.	• Records database for cleanup program sites, permitted waste dischargers,	• Records available on GeoTracker includes cleanup sites for Leaking Underground Storage Tank (LUST) Sites, Department of Defense Sites, and Cleanup Program Sites. Other records for various unregulated projects and permitted facilities includes Irrigated Lands, Oil and Gas production, operating Permitted Underground Storage Tanks (USTs), and Land Disposal Sites.

Programs or Data Portals	Parameters	Frequency	Objectives	Notes
USGS California Water Science Center	• Conducted Multiple Groundwater Quality Studies of the Kaweah Subbasin	• Reports and fact sheet publications range from 1989 through 2018.	• Special studies related to groundwater quality that provide comprehensive studies to characterize the basin.	• Prioritization of Oil and Gas Fields for Regional Groundwater Monitoring (2018). • Preliminary Groundwater Salinity Mapping Near Select Oilfields (2018). • Groundwater Quality Data in 15 GAMA Study Units. (2015). • Preliminary Results from Exploratory Sampling in Select Oil Fields (2014-15). • Groundwater Quality in the Kern County Subbasin (2012). • Status and Understanding of Groundwater Quality in the Two Southern San Joaquin Study Units (2008). • The Effects of Oilfield Operations on Underground Sources of Drinking Water (1989).
Department of Pesticide Regulations	• Pesticides	• Annual	• DPR samples ground water to determine whether pesticides with the potential to pollute ground water are present in ground water, and • (2) the extent and source of pesticide contamination, and (3) the effectiveness of regulatory mitigation measures.	• https://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm

5.7.6 Land Subsidence

Subsidence monitoring programs and various studies are conducted by a range of agencies from the federal and state level to regional and local levels. Major programs and sources of data are summarized below. On-going monitoring and studies are being implemented alongside SGMA.

Land subsidence is monitored within and in the vicinity of the Subbasin through the following:

- University Navstar[3] Consortium (UNAVCO) Plate Boundary Observatory's continuous and conventional Global Positioning System (GPS) network.
- Remote sensing studies by National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).
- USGS San Joaquin Valley Land Subsidence Network. A subsidence monitoring network in the San Joaquin Valley was implemented in the 1960s to help quantify the extent and magnitude of the subsidence that was first discovered in the 1950s. To identify existing and future subsidence, a new monitoring network is currently being developed.[4]
- DWR's California Aqueduct Subsidence Project (CASP). A subsidence monitoring network along the California Aqueduct, with over 1,000 survey benchmarks monitored annually.
- Vertical displacement estimates derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA Inc. (TRE).

To assess the causes, extent and magnitude of subsidence, the Subbasin has conducted a series of studies in communication with the DWR and the CASP. The studies incorporated data from published academic and government studies and reports, oil field aquifer exemption applications prepared for the California Geologic Energy Management Division (CalGEM) and the U.S. Environmental Protection Agency (USEPA), DWR InSAR data, and InSAR studies conducted by Lawrence Berkeley National Laboratory (LBL) and Earth Consultants International (ECI) on behalf of the Subbasin. These studies and interactions with DWR, CASP, and most recently SWRCB staff, have informed the technology hierarchy used to measure Subbasin subsidence and have been incorporated into the Subbasin risk-based SMCs approach and monitoring plan (Section 8.5.2). The hierarchy of Subbasin subsidence monitoring technologies is:

[3] Navstar is a network of U.S. satellites that provide GPS services.
[4] From USGS California Water Science Center website: https://ca.water.usgs.gov/projects/central-valley/land-subsidence-san-joaquin-valley.html

1) InSAR (direct measurement), downloaded from DWR
2) InSAR time series at selected locations
3) CASP and Friant Water Authority benchmark surveys
    - CASP typically conducts benchmark surveys annually and will provide data upon request. The Subbasin GSAs will request and utilize this benchmark data to assess compliance with SMCs established along the California Aqueduct (see Section 13).
4) GPS
5) Other land-based methods (e.g., extensometers, tiltmeters, third party benchmark surveys, GSA benchmark surveys, etc.).

5.7.7 Operational Flexibility Limitations

☑ 23 CCR § 354.8(d)

The monitoring and management programs described in this Plan are integral to supporting operational flexibility and continued monitoring and reporting that will be conducted pursuant to SGMA implementation. Projects and management actions identified in this Plan will contribute to the sustainable use of water supplies, complimentary to other developed water management plans, and is not expected to limit operational flexibility of the GSAs. For example, the IRWMP and GSP development are complementary management processes, and most of the groundwater management objectives identified in the GWMPs and AWMPs are consistent with the issues and objectives identified in the following sections of this Plan. GSAs are actively coordinating with large public water systems as UWMPs are developed to align public water system water use projections with SGMA water budgets.

Demand Management

Another management action to avoid operational flexibility limitations is demand management programs. For agricultural uses, demand management measures include working with landowners to establish individual water budgets, implement district fallowing programs, and develop tiered pricing for groundwater pumping. For urban uses, purveyors are implementing demand management measures such as the Model Water Efficient Landscape Ordinance (MWELO), reductions in per capita demand through SB 20x20 and upcoming water conservation measures such as urban water use objectives (UWUO). In addition, 12 purveyors have developed Water Shortage Contingency Plans (WSCP).

5.8 Land Use Elements or Topic Categories of Applicable General Plans

§ 354.8. *Each Plan shall include a description of the geographic areas covered, including the following information:*

(f) A plain language description of the land use elements or topic categories of applicable general plans that includes the following:

(1) A summary of general plans and other land use plans governing the basin.

(2) A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects.

(3) A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.

(4) A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.

(5) To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.

☑ 23 CCR § 354.8(f)

The following section describes general plans and other planning documents (plans) with specific relevance to the Plan.

The agencies that developed and adopted the general and specific plans below have retained their jurisdiction over land use and zoning as well as the elements included in their respective general plans. The Subbasin GSAs do not have direct jurisdiction over the development of general plans within the Subbasin, however, as general plans are updated, the GSAs will actively participate in the coordination of general plan updates with the Plan implementation.

5.8.1 Summary of General Plans and Other Land Use Plans

☑ 23 CCR § 354.8(f)(1)

This section summarizes goals and policies of the plans relevant to this Plan located within the Subbasin boundaries. As defined here, goal is the “general, overall, and ultimate purpose, aim, or end toward which a city or County will direct effort”. This section includes a summary of the eight (8) plans within the Subbasin’s boundaries that were reviewed to assess the applicable elements or topic categories relevant to groundwater management. There are numerous specific and rural community plans within the Kern Subbasin’s boundaries; however, those plans are required to be compliant with the plans reviewed for this section and did not require separate analysis.

Future plans developed within the Subbasin boundaries are required for public comment prior to adoption, and the GSAs actively participate in public comment of plans within their specific boundaries.

In general, the goals, policies, and implementation measures established by existing plans within the Subbasin boundaries are complementary to sustainable groundwater management of the local management areas relative to future land use development and conservation. A common theme between the goals and policies of the plans discussed the conversion of agricultural land uses to either urban land uses or solar projects. These types of land use conversions result in a change in water demands and are further addressed by each GSA in Section 14, Projects and Management Actions.

5.8.1.1 Kern County General Plan

The Kern County 2004 General Plan (Amended 2009) is a policy document which provides long-range guidance to County officials making decisions affecting the growth and resources of unincorporated area of Kern County's jurisdiction. Kern County covers 8,202 square-miles and serves an estimated population of 909,235 people[5], which underlies the entire Subbasin boundaries for those unincorporated areas within Kern County jurisdiction.

Figure 5-18 shows the Kern County General Plan land use designations within the Subbasin boundaries include the following primary land use designations: intensive and extensive agriculture, residential, mineral and petroleum, and industrial. In comparison of the current land use designations in Figure 5-4, there are some portions of the Subbasin that are currently designated as agriculture within the incorporated City limits of both Shafter and Bakersfield. Water savings could be realized through the conversion of agriculture to urban.

Table 1 in Appendix G identifies relevant policies, goals, and implementation measures from the Kern County General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of General Plan land use policies.

[5] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html

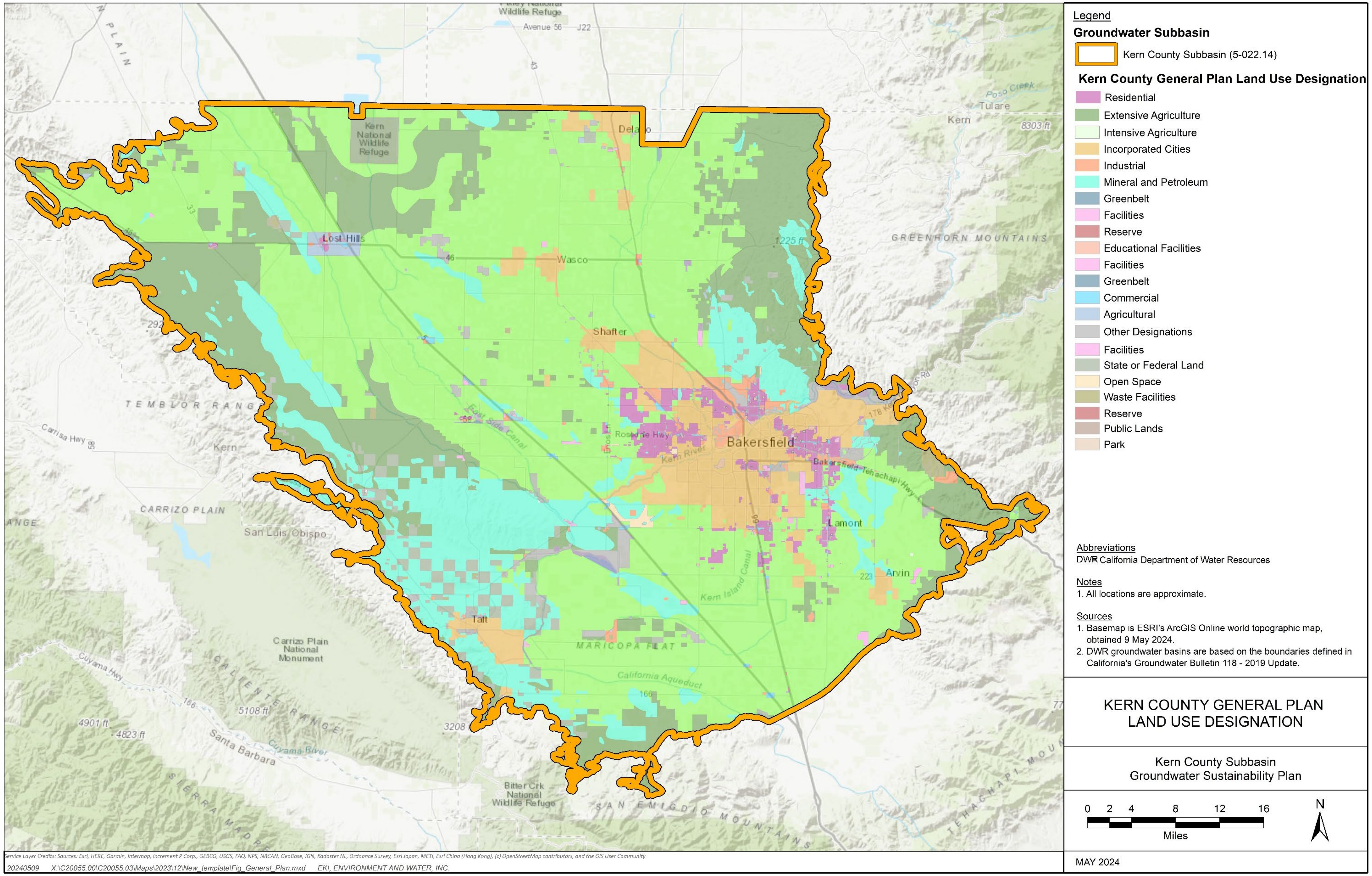


Figure 5-18. Kern County General Plan Land Use Designation

This page intentionally left blank.

5.8.1.2 Metropolitan Bakersfield General Plan

The Metropolitan Bakersfield 2002 General Plan (Amended 2016) is a joint City of Bakersfield and Kern County policy document which provides long-range guidance to City officials making decisions affecting the growth and resources within the City of Bakersfield limits and Sphere of Influence areas that include unincorporated areas of Kern County jurisdiction. The City of Bakersfield covers 408-square miles and serves an estimated population of 403,455 people[6], and is located in the central portion of the Subbasin (Figure 5-8).

The Metropolitan Bakersfield General Plan land use designations within the Subbasin boundaries include the following primary land use designations include residential - low density, residential - rural, residential - suburban, resource - extensive, open space - slopes (areas with greater than equal to thirty percent slope), open space (floodplains and resource management areas and agriculture uses).

Table 2 in Appendix G identifies relevant policies, goals, and implementation measures from the Metropolitan Bakersfield General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the Metropolitan Bakersfield General Plan land use policies.

5.8.1.3 City of Shafter General Plan

The City of Shafter 2005 General Plan is a policy document which provides long-range guidance to City officials making decisions affecting the growth and resources of within the City of Shafter's jurisdiction, which covers 38 square miles and serves an estimated population of 19,953 people[7]. The City of Shafter is located in the North Basin HCM Area, within the Shafter-Wasco Irrigation District GSA and North Kern Water Storage District GSA.

The City of Shafter General Plan land use designations include the following primary land use designations include agricultural/open space, rural residential, rural community, estate residential, low and very low density residential, medium and medium-high residential, commercial and professional office, business/industrial park, industrial, community facilities, parks and schools.

Table 3 in Appendix G identifies relevant policies, goals, and implementation measures from the City of Shafter General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence

[6] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html
[7] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html

the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the City of Shafter General Plan land use policies.

5.8.1.4 City of Arvin General Plan

The City of Arvin 2012 General Plan is a policy document which provides long-range guidance to City officials making decisions affecting the growth and resources within the City of Arvin's jurisdiction, which covers 5-square miles and serves an estimated population of 19,495 people[8]. The City of Arvin is located in the South Basin HCM Area, within the Arvin GSA.

The City of Arvin General Plan land use designations within the Subbasin boundaries include the following primary land use designations include estate residential, residential reserve, low density residential, medium density residential, high density residential, general commercial, light industrial, heavy industrial, parks, public facilities, schools, agricultural, and streets/ROW. These land use designations are consistent with the Kern County General Plan land use designations.

Table 4 in Appendix G identifies relevant policies, goals, and implementation measures from the City of Arvin General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the City of Arvin General Plan land use policies.

5.8.1.5 City of Wasco General Plan

The City of Wasco 2040 General Plan is a policy document which provides long-range guidance to City officials making decisions affecting the growth and resources within the City of Wasco's jurisdiction, which covers 18-square miles and serves an estimated population of 27,047 people[9]. The City of Wasco is located within the North Basin HCM Area, within the Shafter-Wasco Irrigation District GSA.

The City of Wasco General Plan land use designations within the Subbasin boundaries include the following primary land use designations include rural residential, estate residential, low, medium and high density residential, neighborhood commercial, community retail, highway commercial, central business district, professional office, agriculture, light and heavy industrial, public and institutional, and parks and open space.

Table 5 in Appendix G identifies relevant policies, goals, and implementation measures from the City of Wasco General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence

[8] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html
[9] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html

the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the City of Wasco General Plan land use policies.

5.8.1.6 City of Delano General Plan

The City of Delano 2005 General Plan is a policy document which provides long-range guidance to City officials making decisions affecting the growth and resources within the City of Delano's jurisdiction, which covers 14-square miles and serves an estimated population of 51,428 people.[10] The City of Delano is located in the North Basin HCM Area, within the Southern San Joaquin Municipal Utility District GSA.

The City of Delano General Plan land use designations within the Subbasin boundaries include the following primary land use designations include are a balanced mix of residential, commercial, industrial, and open space/public land.

Table 6 in Appendix G identifies relevant policies, goals, and implementation measures from the City of Delano General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the City of Delano General Plan land use policies.

5.8.1.7 City of McFarland General Plan

The City of McFarland 2040 General Plan is a policy document which identifies long-range guidance to City officials making decisions affecting the growth and resources of within the City of McFarland's jurisdiction which covers 3-square miles and serves an estimated population of 14,161 people,[11] and is located in the North Basin HCM Area, within the Southern San Joaquin Municipal Utility District GSA.

Figure 7 in Appendix G shows the City of McFarland 2040 General Plan land use designations within the Subbasin boundaries include the following primary land use designations include housing allocation and circulation improvements needed to meet the population growth projections and targets for job growth, open space, public facilities, economic development, community design, health, environmental justice, air quality, and sustainable agriculture.

5.8.1.8 City of Taft General Plan

The City of Taft 2010 General Plan (Amended 2017) is a policy document which identifies long-range guidance to City officials making decisions affecting the growth and resources of within the City of Taft's jurisdiction which covers 38.7-square miles and

[10] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html?fm=info_panel
[11] 2020 Decennial Census: https://www.census.gov/programs-surveys/decennial-census/about/rdo.html

serves an estimated population of 8,546 people,[12] and is located in the Western Fold Belt HCM Area, within the West Kern Water District GSA.

The City of Taft General Plan land use designations within the Subbasin boundaries include the following primary land use designations include natural resources, open space, low, medium, and high density residential, mixed use, commercial, industrial, and public facilities.

Table 8 in b identifies relevant policies, goals, and implementation measures from the City of Taft General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the Plan's ability to achieve sustainable groundwater use, and (3) affect implementation of the Metropolitan Taft General Plan land use policies.

5.8.2 Existing Land Use Plans Effects on Groundwater Management

☑ 23 CCR § 354.8(f)(2)

The above goals, policies and implementation measures established by the plans discussed above in Section 5.8.1 are complementary to sustainable groundwater management of the Subbasin relative to future land use development and conservation. For example (1) the Kern County General Plan encourages development of the County's groundwater supply to ensure that existing users have access to high quality water, and states that future growth should be accommodated only while ensuring that adequate high-quality water supplies are available to existing and future users, (2) the Metropolitan Bakersfield General Plan establishes as a general goal for groundwater management to reach a condition of "safe yield" for the groundwater basin, and (3) The City of Arvin General Plan establishes as a purpose for the Conservation and Open Space Element: "…to promote the protection, stewardship, and use of the City's natural resources and to prevent wastefulness, unsustainable usage, and neglect. Furthermore, all Elements of the General Plan reflect the principles of integration of SB 375, the Sustainable Communities Planning Act of 2008".

Furthermore, land use conversions, such as expansion of urbanized areas or agricultural to solar arrays, are effective demand management strategies that are included in the suite of Projects and Management Actions (P/MAs) whose benefits will contribute to offsetting the projected deficit. Refer to Section 14 for details.

Therefore, implementation of the plans above is not expected to affect the ability of the GSAs to achieve groundwater sustainability.

[12] 2020 Decennial Census, https://www.census.gov/programs-surveys/decennial-census/about/rdo.html

5.8.3 How Implementation of the Plan May Affect Water Supply Assumptions of Relevant Land Use Plans

☑ 23 CCR § 354.8(f)(3)

Successful implementation of this Plan will contribute to sustainable management of the Subbasin groundwater supply. Therefore, implementation of this Plan is not anticipated to significantly affect the County's current water supply assumptions or land use plans over the planning horizon. For example, given that the County General Plan is being updated concurrently with the development of this Plan, it is anticipated that the 2040 General Plan will take into account this Plan and utilize consistent water supply assumptions over the 2040 planning horizon. However, implementation of this Plan may limit the availability of potential local groundwater sources to be used in instances where future demands exceed current rates of groundwater extraction.

5.8.4 Well Permitting Process

☑ 23 CCR § 354.8(f)(4)

The KCEHS Water Well Program issues permits to construct, reconstruct and destroy water wells. All wells must be constructed in accordance with Kern County Ordinance Code, Section 14.08, and DWR's Bulletin 74-81 and Bulletin 74-90, except as modified by subsequent revisions. The ordinance requires, among other things, that domestic and agricultural wells be installed a minimum distance from potential pollution and contaminant sources, water quality be tested for new and reconstructed wells, an NSF 61 Approved flowmeter be installed, and the final well construction be inspected by County staff. Additionally, the ordinance requires that wells drilled where regionally confining clay is present are sealed to avoid contaminant migration between the locally confined aquifer zones.

Well Construction Policies

The well permitting program is conducted by the KCEHS in cooperation with local agencies. The permitting process consists of a county water well permit, the SGMA-implemented Overdraft Supplemental Well Application, and detailed site maps. Chapter 14 of the Kern County Ordinance Code ensures proper well design and construction. As referenced in the Guidelines for Kern County Water Agency Review, there are several conditions that trigger a well to be constructed in a manner that protects against groundwater contamination (i.e., depth of sanitary seal, distance from public supply wells, radius from a proposed groundwater recharge/recovery facility, distance from an active dairy or other contaminated site or area of poor water quality). Additionally, KCEHS requires inactive well owners to agree to keep the well capped to prevent groundwater contamination.

Executive Order N-7-22 and N-3-23

On 28 March 2022, Governor Newsom signed EO N-7-22 to amend prior proclamations of states of emergency due to California's ongoing drought conditions. EO N-7-22 requires that additional steps be taken by well permitting agencies to approve a permit of a new well or alternation of an existing well located in a medium- or high-priority basin subject to SGMA. For applicable wells[13], permitting agencies must obtain written verification from the GSA managing the area of the Subbasin where the proposed well is located that the well would not conflict with the Plan or decrease the likelihood of the basin reaching its Sustainability Goal.

On 13 February 2023, Governor Newsom signed EO N-3-23, superseding EO N-7-22. EO N-3-23 reenacts the requirements of EO N-7-22 that well permitting agencies obtain GSA approval of new wells, but additionally exempts new wells that replace existing, actively permitted wells with wells that will produce an equivalent quantity of water when the existing well is being replaced because it has been acquired by eminent domain or acquired while under threat of condemnation.

In response to the EO, KCEHS released a supplemental well application for wells intended to be installed in overdrafted basins. This new form additionally requires water district and GSA information, and grants GSAs review power. Starting in 2019, Subbasin GSAs adopted policies to provide a written response to Kern County Public Health Services Department and the well applicant when supplemental well application forms are received.

Public Supply Well Permitting Process

All public water systems operate under a water supply permit issued by the State of California via the Division of Drinking Water, which requires them to undergo a rigorous permitting process in addition to KCEHS permitting. Since the state process is more stringent than KCEHS, the process typically defaults to DDW guidance and inspection but issues a local permit and requires a copy of the well completion report is submitted to the EHS Water Well Program. DDW review considers the construction of the well and wellsite, discharge piping and disinfection equipment, a review of the risk of contamination of the new well from external sources of contamination, and the sanitary and security measures put in place to protect the well from accidental/unintended contamination (such as flooding) and from acts of terrorism and vandalism.

5.8.5 Implementation of Land Use Plans Outside the Basin

☑ 23 CCR § 354.8(f)(5)

The Subbasin shares its southern boundary with the White Wolf Subbasin, which prepared a GSP that was adopted in January 2022 and was conditionally approved by

[13] The EO is not applicable to wells that provide less than 2 AFY or public water systems.

DWR in 2023. Land use within the White Wolf Subbasin immediately adjacent to the southern portion of the Kern County Subbasin is largely agricultural and not projected to change over the planning horizon.

Similarly, the Subbasin shares its northern boundary primarily with the Tule and Tulare Lake Subbasins, which prepared Plans that were adopted in January 2020 and found inadequate by DWR in 2023. Land use within the Tule and Tulare Lake Subbasins (Kings and Tulare counties) immediately adjacent to the northern portion of the Kern County Subbasin is largely agricultural. While the Tule and Tulare Lake Subbasin Plans indicate that land use is expected to remain mostly agricultural, both Plans indicate in their projected water budgets that agricultural demand on groundwater resources will reduce. Groundwater flow is generally to the north towards these Subbasins (refer to Section 8 for details). The projected model results were adjusted to assess the potential influence of reduced demands and future implementation of P/MAs via stabilized groundwater levels (refer to Section 9 for details).

Therefore, this Plan has not made unique land use assumptions for areas outside of the Subbasin and has considered Plan implementation influences from adjacent subbasins.

5.9 Additional GSP Elements

> ***§ 354.8.*** *Each Plan shall include a description of the geographic areas covered, including the following information:*
> *(g) A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.*

☑ 23 CCR § 354.8(g)

Per CWC § 10727.4, a GSP shall include, where appropriate and in collaboration with the appropriate agencies, the following other elements:

5.9.1 Control of Saline Water Intrusion

The Kern County Subbasin is located in the Central Valley, far from coastal areas. As a result, seawater intrusion is not considered to be a current or future issue for the Subbasin. Therefore, it is not an applicable sustainability indicator and is not considered further in this Plan.

5.9.2 Wellhead Protection, Well Abandonment and Destruction Programs

KCEHS Water Well Program issues permits to construct, reconstruct, and destroy water wells (see Section 5.8.4). The Subbasin GSAs and districts assist their respective landowners to comply with well destruction policies and the County wellhead protection area program, which was implemented through the Safe Drinking Water Act and aims to prevent contamination in public water systems.

Well Abandonment and Well Destruction Program

Abandoned water wells (no longer in use or permanently inactive) can act as a conduit for surface and subsurface pollution to enter groundwater supplies. Subsequently, state law and county ordinance Code 14.08 requires any wells that are abandoned or wells with inadequate water supply must be destroyed. Furthermore, any abandoned wells on the site of an active new well construction permit must be destroyed prior to construction. Well destructions require a permit from KCEHS Water Well Program. At a minimum, the upper 50-feet must be sealed with an approved sealing material. Where regionally confining clay is present, depth of the annular seal is determined by Kern County Water Agency to avoid contamination between aquifer zones.

In some instances, when an inactive well is not a risk for migrating groundwater contamination, GSAs may work with landowners to convert production wells to monitoring wells. In some instances, districts have also obtained grants to partially fund the well conversion costs.

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

SGMA requires GSAs to develop processes to review land use plans and efforts to coordinate with agencies to assess land use activities and programs that potentially create risk to groundwater quality. This section describes existing programs and land uses and how they are addressed in this Plan and through the implementation period.

Groundwater Contamination Cleanup

The CVRWQCB and County of Kern oversee the cleanup of contaminated groundwater. Additionally, individual GSAs cooperate with state and county regulators on contaminated sites (see Section 8.4.2).

Recharge

Recharge policies exist across the Subbasin to encourage on-farm recharge and banking. The Subbasin’s history of water banking demonstrate that groundwater quality improves due to the high-quality of surface waters are used for the banking and conjunctive use programs. As stated in Section 5.4.2, surface water supplies from the SWP, CVP, Kern River and ephemeral streams (Poso and Caliente Creek) are all used for water banking.

The Kern Fan Banking programs use SWP, CVP, and Kern River, and have several years of monitoring data to evaluate impacts to receiving groundwater. Salt balance calculations on imported supplies and water returned via the SWP shows that for every ton of salt imported with surface water supplies, 1.5 tons of salt are exported. These calculations demonstrate that the exported salt is improving the quality of water in Kern

Fan Aquifer. Analysis of nitrate, arsenic, and total dissolved solids (TDS) has shown similar for each constituent. Refer to Section 7.2.3.1, General Groundwater Quality, and Appendix E (Water Banking Programs) for additional details.

Conservation

Through their conservation and irrigation efficiency practices, Districts are constantly pursuing water conservation at both the district and grower level. Efficient water management practices are described in each AWMP. As discussed in Section 5.9.4.1, there are 12 major Urban water purveyors with an adopted 2020 UWMP. The 2020 UWMPs present a framework for ensuring adequate water supply to meet current and future water demands. As part of the UWMP development process, each supplier was tasked with meeting state mandated per capita water use targets and discussing their plans to increase water conservation through demand management action.

In-lieu Use, Diversions to Storage, Water Recycling, and Extraction

In-lieu use, diversions to storage, water recycling, conveyance, and extraction projects are managed on a district level. Use of high-quality surface water diverted from the Kern River and CVP to substitute for groundwater extraction by in-lieu recharge and for direct aquifer recharge through recharge basins contributes to protection of groundwater quality by controlling the salt load entering the Subbasin. Treatment of recycled water also contributes to managing the loading of salts and other constituents.

Conveyance

The California Aqueduct and Friant-Kern Canal are both infrastructure critical for conveying imported water to the Subbasin. The Kern River, which originates in the Sierra Nevada Mountains east of the Subbasin, is another important source of surface water. The conveyance system in the Subbasin is highly interconnected allowing water to be exchanged among each of these sources.

Migration of Contaminated Groundwater

The Central Valley Regional Water Quality Control Board (CVRWQCB), the California Department of Toxic Substances Control (DTSC), and Kern County Department of Environmental Health regulate the mitigation, remediation, and management of groundwater contamination plumes in the Subbasin. The CVRWQCB GeoTracker and EnviroStor databases show a total of 86 active contaminated groundwater sites. Refer to Section 8.4.2 for further details.

5.9.4 Efficient Water Management Practices

The Subbasin's GSAs are constantly pursuing increased efficiency regarding their water management practices. Efficient water practices are outlined in the Urban Water Management Plans (UWMPs) and Agricultural Water Management Plans (AWMPs) of local agencies. The UWMPs and AWMPs document a series of measures for increased water use efficiency for urban water use and irrigated agriculture, respectively. These plans were developed to identify short and long-term water supply challenges throughout the region. Identified supply challenges were combatted with increased recharge capacities, improved conveyance, and coordinated operation of water management programs.

5.9.4.1 Urban Water Management Plans (UWMP)

UWMPs are long-term planning tool that provides information regarding an urban water supplier's existing and projected sources of water supply, existing and projected water demands, water service reliability, water conservation and demand management measures, and water shortage contingency planning. The UWMPs determine per capita water use, establish water use reduction goals, and document performance. Each UWMP requires reporting on the status of specific Efficient Water Management Practices (EWMPs) suitable for urban settings.

The following urban water purveyors prepared a 2020 UWMP:

- Arvin Community Service District
- Bakersfield City Of
- California Water Service Company Bakersfield
- Delano City Of
- East Niles Community Services District
- Kern County Water Agency Improvement District No. 4
- McFarland City of
- Oildale Mutual Water Company
- Shafter City Of
- Vaughn Water Company
- Wasco City Of
- West Kern Water District

5.9.4.2 Urban Water Use Objectives

As part of the Making Conservation a California Way of Life regulation (senate Bill 606 and Assembly Bill 1668), urban water suppliers are required to annually calculate their Urban Water Use Objective (UWUO), assess whether their actual water use for the previous year meets the UWUO, and report to the State annually the results of this assessment starting January 1, 2024. The UWUO is calculated as the sum of the efficient indoor residential water use, efficient outdoor residential water use, efficient water loss, efficient outdoor commercial/ industrial /institutional irrigation use, bonus incentives, and efficient variances. The purpose of the assessment is to ensure urban retail water suppliers eliminate unnecessary water uses through establishment of individualized efficiency goals that must be met by the supplier.

5.9.4.3 Agricultural Water Management Plans (AWMP)

Like UWMPs, Agricultural Water Management Plans (AWMP) are long-term planning tools, updated every 5 years, that provide information regarding an agricultural water supplier's existing and projected sources of water supply, demand, and conservation programs. Each plan includes required reporting on the status of EWMPs identified as suitable for the conservation of irrigation water supplies. There were 12 AWMPs submitted for non-exempt agricultural water suppliers in the Kern County Subbasin in 2020, including:

- Arvin-Edison Water Storage District
- Belridge Water Storage District (WDWA)
- Berrenda Mesa Water District (WDWA)
- Buena Vista Water Storage District
- Cawelo Water District
- Kern Delta Water District
- Lost Hills Water District (WDWA)
- North Kern Water Storage District
- Semitropic Water Storage District
- Shafter-Wasco Irrigation District
- Southern San Joaquin Municipal Utility District
- Wheeler Ridge-Maricopa Water Storage District

5.9.5 Relationships with State and Federal Regulatory Agencies

Consistent with water code 10727.4, the Kern Subbasin has developed relationships with state and federal regulatory agency who impact decision-making, operations, and groundwater management activities. These relationships are described throughout this Plan. Section 5.10.4 provides additional information on stakeholders and partnerships.

5.9.6 Land Use Plans and Efforts to Coordinate with Land Use Planning Agencies to Assess Activities that Potentially Create Risks to Groundwater Quality or Quantity

As discussed in Section 5.8.1, the existing land use plans outline goals, policies, and implementation measures that are complementary to sustainable groundwater management relative to future land use development and conservation. The discussion of land use plans in Section 5.8.1 highlights a common theme between the policies which shows the conversion of agricultural land uses to either urban land uses or solar projects. Because these types of land conversions result in reduction of water demands, the Subbasin GSAs have included the anticipated benefits as P/MAs to achieve sustainability.

5.9.7 Impacts on Groundwater Dependent Ecosystems

SGMA defines Groundwater Dependent Ecosystems (GDEs) as ecological communities or species that depend on near-surface groundwater for their existence. GDEs can form where groundwater discharges to the surface as springs or seeps, or where groundwater exists at shallow depths (but without discharging), such that plants can access it with their roots. Impacts on GDEs are discussed in Section 5.6.

5.10 Notice and Communication

> ***§354.10.** Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:*
> *(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.*
> *(b) A list of public meetings at which the Plan was discussed or considered by the Agency.*
> *(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.*
> *(d) A communication section of the Plan that includes the following:*
> *(1) An explanation of the Agency's decision-making process.*
> *(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.*
> *(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.*
> *(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.*

☑ **23 CCR § 354.10**

This section presents information related to the Basin's public noticing and outreach efforts that occurred between submittal of the 2022 Plans (i.e., from July 2022 to present), as well as the Subbasin's ongoing outreach and engagement efforts. To fulfill notice and communication requirements, Subbasin GSAs are developing a Subbasin-wide Stakeholder Communication and Engagement Plan (SCEP), which will be included as Appendix H.

5.10.1 Public Meetings

☑ **23 CCR § 354.10(b)**

The list below identifies public meetings, workshops, and direct outreach specific to SGMA and GSP development and implementation.

5.10.1.1 Board Meetings

The Subbasin GSAs and several GSA member agencies hold regular Board meetings that are open to the public and provide SGMA-related updates and information. Information and notices for GSA Board meetings can be found directly on the individual agency websites. Regular SGMA updates are provided by staff and/or their consultants. During these meetings, stakeholders are encouraged to provide input on Plan development information that was presented and on the implementation process. Refer to Table 1 of Appendix I for a list of board meetings where SGMA is discussed. GSA Board members typically represent multiple interests, consistent with the land uses of the water district.

5.10.1.2 Stakeholder Workshops

Since January 2023, several GSAs hosted stakeholder workshops, as summarized in Table 2 of Appendix I. A brief description of these workshops and stakeholder engagement opportunities is provided in the subsequent section.

5.10.1.3 GSA Group Meetings

South of Kern River (SOKR)

SOKR GSP Executive Committee. Pursuant to the SOKR Memorandum of Agreement (MOA), Arvin GSA, Arvin CSD, TCWD GSA, and Wheeler Ridge-Maricopa GSA each has designated representatives to participate in the SOKR GSP Executive Committee which, with the support of the respective agencies' staff and consultants, is responsible for guiding the joint development and implementation of the SOKR GSP in a manner that is coordinated with the other Subbasin GSAs to achieve sustainable groundwater management as required by SGMA. The Executive Committee responsibilities also include guiding public outreach and stakeholder engagement efforts and keeping the Governing Bodies of each agency informed and prepared to take any and all actions necessary to satisfy the requirements of SGMA. The Executive Committee meets monthly at AEWSD headquarters.

North Central Kern (NCK)

NCK GSP Steering Committee. Pursuant to the MOA by and Among North Kern WSD GSA, Shafter-Wasco ID GSA, Cawelo Water District GSA, and Southern San Joaquin MUD GSA representing the North Central Kern Groundwater Sustainability Plan (NCK GSP Group), each has designated a Steering Committee representative from their respective Board of Directors, with the support and the agencies' respective staff and technical consultants, to be responsible for making decisions concerning the development of the NCK GSP, enforcement of the GSP, and facilitating coordination with other GSAs in the Kern Subbasin. The cities of Delano, McFarland, Shafter, and Wasco are situated within the jurisdictional boundaries of the GSAs and have appointed a member to the Steering Committee. The Steering Committee's responsibility also includes guiding public outreach and stakeholder engagement efforts, informing respective governing bodies, and taking any and all actions necessary to satisfy the requirements of SGMA. The NCK Steering Committee meets regularly at the North Kern Water Storage District office.

Kern Fan Banking Group

Representatives from the Berrenda Mesa Spreading Grounds, the Kern Water Bank GSA, the Pioneer GSA, and the West Kern Water District GSA meet routinely to coordinate and compile technical information and data, and to provide guidance during the development of the Subbasin Plan. Each member participates in public outreach through their respective Board meetings (refer to Table 1 of Appendix I).

Kern Non-Districted Land Authority

The Kern Non-Districted Land Authority, formerly KGA, provides local policy makers, stakeholders, and the public a forum to monitor, report and/or discuss groundwater activities and identify and address any local groundwater issues. KGA was formed for the purpose of 1) coordinating groundwater management programs and activities; 2) identifying and addressing issues pertaining to sustainable groundwater management; and 3) establishing a framework for local groundwater management. Board meetings are held at 8 a.m. on the fourth Wednesday of every month. Refer to the Appendix D (Kern Non-Districted Land Authority JPA) for more information on roles and responsibilities. Member Agencies include:

- Kern County Water Agency
- Kern-Tulare Water District
- Kern Water Bank Authority
- Semitropic Water Storage District
- West Kern Water District
- Westside District Water Authority
- Associate Members:
- Eastside Water Management Area
- Shafter-Wasco 7th Standard Annex Area
- Cawelo Water District
- North Kern Water Storage District
- Rosedale-Rio Bravo Water Storage District
- Shafter-Wasco Irrigation District
- San Joaquin Municipal Utility District

Kern River GSA (KRGSA)

KRGSA holds monthly public board meetings, on the first Thursday of the month, to discuss SGMA and solicit public comment. Agendas and minutes are published to the http://www.kernrivergsa.org/. KCWA-ID4 and the City of Bakersfield participate in monthly Urban Bakersfield Advisory Committee meetings and provide monthly SGMA updates. Greenfield GSA (located totally within KRGSA) also holds monthly board meetings where SGMA updates are given. In addition, KRGSA has held regular GSA purveyor meetings to coordinate with local water retailers, update them on the SGMA process, and hear their feedback.

Westside District Water Authority GSA

Westside District Water Authority GSA (WDWA GSA) is a Joint Powers Authority comprised of Berrenda Mesa Water District (BMWD), Belridge Water Storage District (BWSD), and Lost Hills Water District (LHWD) ("Kern Districts"). The Kern Districts are also members of the Westside Water Authority (WWA) JPA, comprised of the Kern Districts and Dudley Ridge Water District. WDWA GSA, BMWD, BWSD, and LHWD hold separate quarterly regular board meetings, with special board meetings called as necessary. WWA holds monthly board meetings, with the exception of summer recess from June - September. District specific SGMA updates are provided, and stakeholder feedback collected, at WWA, BMWD, BWSD, and LHWD board meetings. Detailed SGMA and WDWA GSA operations updates (such as GSP development, management action/project implementation, financials, etc.) are presented and discussed at WDWA GSA board meetings. All board meetings are open to the public, Brown Act compliant, and noticed via interested party listservs and physical/online agenda posting. Stakeholder feedback is welcomed at all board meetings and considered when making WDWA GSA operational decisions. WDWA GSA maintains a regulatory email (regulatory@westsidewa.org) and phone line (661-633-9022) for any interested stakeholder to ask questions or provide feedback to the GSA's regulatory manager outside of board meetings. Additional information regarding board meetings can be found at the following websites:

- WDWA GSA: https://www.westsidedwa.org/
- Westside Water Authority: https://www.westsidewa.org/
- Berrenda Mesa Water District: https://www.bmwd.org/
- Belridge Water Storage District: https://www.belridgewsd.com/
- Lost Hills Water District: https://www.lhwd.org/

5.10.1.4 Direct Outreach

GSAs conduct targeted outreach and engagement to community members, interested parties, and stakeholders to secure local stakeholder input during the SGMA process. Outreach efforts have included direct mail and informational emails to provide updates on GSA activities.

5.10.2 Comments Received

☑ 23 CCR § 354.10(c)

Development of this Amended Subbasin Plan focused on addressing comments received from DWR (see Appendix B), SWRCB staff (see Section 1.2.1.5), DWR California Aqueduct Subsidence Program (CASP), and Friant Water Authority. In response to these comments, the Kern Subbasin developed this coordinated Plan which completely replaces the 2022 Plan.

This draft Plan will be released for a public comment period starting in June 2024. Public comments received on the Plan will be reviewed, and details regarding the comments received will be included in this Section 5.10.2 prior to adopting the final Plan.

5.10.3 Communication

☑ 23 CCR § 354.10(d)

Outreach and communication are conducted at the Subbasin, GSA Group, and individual GSA levels. This section describes the noticing and outreach conducted at the Subbasin-level for Plan development and implementation.

5.10.3.1 Decision-Making Process

The Subbasin decision-making processes involves coordination amongst the GSAs and their member agencies, governing body (i.e. Board of Directors) and consultation with stakeholders, the Technical Working Group (TWG), and Attorney Working Group (AWG). Issues and recommendations are publicly discussed during district and GSA Board meetings, which are open to the public. GSA representatives additionally participate in the coordination committee to make decisions pertaining to the entire Subbasin. Any decisions made at the coordination committee are brought to the attention of the Subbasin GSAs and discussed during public Board meetings.

Further, by their participation as either a GSA or in the GSA Groups, SDAC and DAC community members have been included in the decision-making process, and their input has been considered in the development of this Amended Plan, including in the development of all Sustainable Management Criteria (SMCs) and selection of the SGMA monitoring network. These SDAC and DAC community members include Arvin CSD (participating entity of the SOKR GSP Executive Committee), Greenfield County Water District GSA (Kern River GSA), Buttonwillow Community Water District (BVGSA), and the City of Shafter (NCK Steering Committee). The active participation of these entities is just one way in which the interests of DACs have been considered.

Additionally, as described below in Section 5.10.3.3, underrepresented farmers are included in the decision-making process through partnership with the Kern County Farm Bureau.

☑ 23 CCR § 354.10(d)(1)

The Kern Subbasin GSAs have maintained ongoing stakeholder engagement since the 2020 Plans were developed. These relationships facilitated a collaborative and engaged process for developing this amended Plan. This section describes the agencies and stakeholders that were consulted and how their input was considered. Ongoing outreach and engagement are also addressed.

5.10.3.2 Public Engagement Opportunities

Public engagement opportunities include, but are not limited to, Subbasin GSA board meetings, Subbasin GSA Group meetings, stakeholder workshops, planned public hearings, and various stakeholder surveys. Appendix I contains a list of all the public engagement opportunities since January 2023.

☑ 23 CCR § 354.10(d)(2)

5.10.3.3 Stakeholder Involvement

Throughout the process of developing this Plan, the Kern Subbasin has engaged stakeholders and have encouraged active involvement. This section describes that stakeholder engagement and how their feedback was incorporated into the Plan.

- Worked with KCEHS and Kern County Water Agency (KCWA) to obtain local well completion report datasets and other related records to develop a Subbasin-wide Well Inventory. Future efforts will continue working with KCEHS, KCWA, and the GSAs to finalize the well inventory. Refer to Section 14.2.3, Project/Management Action (P/MA) KSB-7 for details on actions to finalize the well inventory. Additionally, the Subbasin will work with DWR to identify opportunities to maintain the well inventory by linking the DMS with OSWCR.
- Worked with Division of Drinking Water staff in the Fresno Branch to develop a comprehensive list of public water systems in the Kern Subbasin and verify the accurate location and status of wells found in the GAMA and SDWIS databases.
- Engaged DWRs California Aqueduct Subsidence Program (CASP) staff on subsidence evaluation related to various non-GSA causes of subsidence and establishing Sustainable Management Criteria (SMC) for the California Aqueduct. Data derived from various Subbasin studies pertaining to the rate and cause of subsidence along the northern Aqueduct has been shared with CASP senior management in a series of technical meetings. These issues are further discussed in Section 8.5.2, including continued coordination on other areas of the Aqueduct that are likely experiencing non-GSA related subsidence, and future monitoring and studies that will be conducted in cooperation with CASP.
- Engaged the Friant Water Authority (FWA) on subsidence evaluation and establishing SMC criteria for the Friant-Kern Canal. FWA has a firm position that the Subbasin GSAs should minimize and mitigate lost conveyance capacity post-2020 due to ongoing subsidence attributable to groundwater pumping under GSA jurisdiction. Refer to **Section 14.2.3** for details on how FWAs concerns are incorporated into this Plan. Appendix J is a letter from FWA expressing their

appreciation for the Subsidence subcommittee's candor and transparency during the SMC development process, their understanding of the Subbasins remaining work, and their confidence that the proposed additional work will properly mitigate impacts to the FKC.

- Partnering with Self-Help Enterprises (SHE) to assist with the Subbasin-wide Well Mitigation Program. Throughout the Plan development process, the Subbasin presented their well inventory to SHE as well as the existing well mitigation program that is administered by the Kern Fan Banking Partners Joint Operations Committee. In response, SHE presented to the Subbasin GSA on their well mitigation program and outreach and engagement program. Refer to **Section 14.2.3**, P/MA KSB-5 for details about the Subbasin's Letter of Intent (LOI) to implement a domestic and small community well mitigation program starting January 1, 2025 (refer to the LOI in Appendix K).
- Partnering with Kern Water Collaborative (KWC) to facilitate data sharing and agree to a future partnership during program Implementation. Refer to Section 14.2.3, P/MA KSB-2 for details about the Subbasin's coordination efforts with various water quality regulatory programs and intent to partner with these programs on monitoring, data sharing, and mitigation when needed. Appendix F provides a Memorandum of Understanding with Kern Water Collaborative to document the ongoing partnership opportunities.
- Partnership and financial support to the Water Association of Kern County (WAKC), a non-profit organization whose mission is to inform and educate the public and water community about water issues in Kern County. GSAs will partner with WAKC to participate in community events such as water awareness fairs and other public events that will support inclusive public outreach and engagement. Examples of outreach events include Kern Talk Radio segments, Faces of Kern podcasts, bi-monthly luncheons where water professionals present on water management topics, TV series on a local lifestyle segment focused on water topics, social media posts, and participation in various community events.
- Coordination with ILRP Coalitions leadership to engage members in SGMA related topics. Similar to the Kern Water Collaborative partnership, this coordination is focused on data sharing and alignment of monitoring programs. Refer to Section 15.2.4, *Monitoring Network for Degraded Water Quality*, for additional information.
- Collaboration with Kern County Farm Bureau to engage its members in SGMA related topics. This local chapter of the California Farm Bureau Federation is a non-profit organization of farmers and ranchers whose mission is to *"… represent agriculture interests through public relations, education, and public policy advocacy in order to promote the economic viability of agriculture*…." Through

this collaboration, the Subbasin GSA seek to build relationships with Socially Disadvantaged Farmers and Ranchers (SDFAR) and Small-Scale farmers[14] to educate them on SGMA, and to solicit their input on GSP implementation.

Continual outreach to engage stakeholders and landowners.

In addition to individual GSA outreach efforts to their landowners and stakeholders, the Subbasin is coordinating on community-based outreach and engagement activities to inform the public about this amended Plan and seek input on it. Scheduled engagements, which are typically annual events, include:

- Kern County Farm Bureau e-blast notifying its members that a new Plan is available for review and comment, with hyperlinks to the Plan and information on upcoming public participation events.
- Tailgate Talk with Kern County Farm Bureau to present this Amended Plan to local farmers.
- Scavenger hunt in partnership with Second Saturday Downtown business association that asks people to identify their GSA based on where they live and to find water use facts.
- Water Awareness Day at Kern County Fair.
- Continued discussions, written reports, and updates presented during board and GSA Group meetings.

Representation of various stakeholders in each GSA

As identified in Section 5.6, the Subbasin contains diverse land uses and stakeholders reliant on groundwater, including agriculture, urban and rural communities, industrial and oil fields, DACs, and tribal communities, among others. Past, current, and future representation of these various stakeholders and outreach as part of this Amended Plan include:

- SDAC representation, for example Arvin CSD within the SOKR GSA Group holds a director position on the SOKR GSP Executive Committee; similar positions are held by the City of Shafter in NCK GSP Group, Greenfield County Water District in Kern River GSA, and Buttonwillow Community Services District in Buena Vista GSA.
- Urban representation is primarily provided by the City of Bakersfield and Cal Water participating in the Kern River GSA. Smaller municipalities in the South and North Basin HCM areas are disadvantaged communities and are represented through their positions in the GSA Group Executive Committees.

---

[14] SGMA and Underrepresented Farmers. Impacts of Groundwater Sustainability Plans on Underrepresented Farmers. May 2022.

- Non-agricultural community representation is primarily through stakeholders in the Eastside Water Management Area.
- Direct outreach with the Tejon Indian Tribe regarding water supply planning to support future development of the Hard Rock Casino.

☑ **23 CCR § 354.10(d)(3)**

5.10.3.4 Public Notification

As described above, outreach and communication with the public are conducted at the Subbasin, GSA Group, and GSA levels. The Subbasin GSAs and Subbasin GSA Groups inform the public on Plan updates, status, and actions. This includes making key Plan development and implementation (including P/MAs) decisions in an open and transparent fashion during public GSA Board meetings and GSA Group meetings, holding periodic stakeholder workshops to communicate progress on Plan implementation status and initiation to stakeholders, and receiving input on upcoming decisions and work efforts. As required, the Subbasin GSAs follow Prop 218 processes including proper public notification holding a public hearing, amongst other steps. The Subbasin GSAs will continue to publicize all Board meetings, Subbasin GSA Group meetings, and stakeholder workshops on their respective websites (see Appendix I).

Furthermore, this Plan was designed to ensure effective public notification regarding P/MAs. Specifically, given the large suite of Subbasin P/MAs, each GSA has individual P/MA tables and separate appendices containing details that can easily be extracted and disseminated to local stakeholders and interested parties.

The Subbasin DMS is available to the public and contains monitoring networks and associated data, geospatial datasets, and other information utilized during the Plan development process (https://dms.geiconsultants.com/kern/). Monitoring and compliance data for each applicable sustainability indicator is also available for public review through the DMS Map Viewer tools.

Various information is also available on the DWR SGMA Portal such as GSA Formational documentation, GSP submittals, and other SGMA Resources (https://sgma.water.ca.gov/portal/). Furthermore, anyone may subscribe to DWR's list serve and receive email notifications for SGMA related news.

☑ **23 CCR § 354.10(d)(4)**

5.10.4 Interagency Coordination

As discussed in Section 1.2.1, interagency coordination exists between the Kern Subbasin's GSAs to promote collaboration between the GSAs, develop and organize implementation and monitoring plans, and produce Subbasin-wide technical solutions.

Examples of this coordination include the Technical Working Group (see Section 1.2.1.1) and the Attorney Working Group (see Section 1.2.1.2), whose goals are to develop technical recommendations and provide legal counsel at a Subbasin-wide level.

In addition to these working groups, interagency coordination exists between the Subbasin's GSAs through ad-hoc advisory coordination committee and Managers meetings (see Section 1.2.1.3) to ensure coordination on major Plan development topics, including methodologies and data sources used to develop the Basin Setting, Water Budget, and Sustainable Management Criteria.

5.10.5 Interbasin Coordination

The Kern Subbasin GSAs have participated in interbasin coordination with the neighboring White Wolf Subbasin, Tule Subbasin, and Tulare Lake Subbasin. Examples of coordination topics include subsidence concerns along the Friant-Kern Canal, delineation of the White Wolf Fault, and cross-boundary flows between subbasins. Further, Subbasin GSAs have jurisdictional overlap over multiple basins (i.e., Kern-Tulare Water District GSA).

In development of the numerical flow model, technical consultants from Kern Subbasin met regularly with representatives from Tulare Lake and Tule Subbasins. These working meetings helped calibrate the subsurface flow simulated in the neighboring basins.

As part of the ongoing Basin Study, technical consultants from Kern Subbasin will continue to meet and collaborate with adjacent Subbasins to ensure consistent representation of cross-boundary flows.

This page intentionally left blank.

6. INTRODUCTION TO BASIN SETTING

6.1 Basin Setting Organization

*§ **354.12.** Introduction to Basin Setting*
This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

☑ **23 CCR § 354.12**

The basin setting provides the foundation on which to evaluate sustainability indicators, select appropriate sustainability criteria, and develop projects and management actions to achieve and maintain groundwater sustainability. As provided in the GSP regulations, the basin setting is based collectively on three related analyses:

- **Section 7 - Hydrogeologic Conceptual Model (HCM)** (§ 354.14). Provides a descriptive hydrogeologic conceptual model that summarizes the regional geologic and structural setting, lateral basin boundaries, definable bottom of the basin, principal aquifers, and aquitards and physical characteristics of the Subbasin.
- **Section 8 - Groundwater Conditions**. **(§ 354.16)**. Provides a description of current and historical groundwater conditions in the Subbasin from January 1, 2015 to current conditions including groundwater elevation contour maps and hydrographs, estimated change in storage, seawater intrusion, groundwater quality, land subsidence, interconnected surface water, and groundwater dependent ecosystems.
- **Section 9 - Water Budget (§ 354.18).** Provides an accounting of inflows and outflows of the groundwater system including an analysis of historical and current conditions to develop an estimate of sustainable yield for the Subbasin. The water budget analysis also provides a baseline on which to project the water budget analysis into the future using projected water supplies and reasonable estimates of land use and water demand.

6.1.1 DWR Groundwater Basin

The Kern County Subbasin (Subbasin 5-22.14, DWR, 2006) is one of 19 basins and subbasins identified in Bulletin 118 (DWR, 2006) as part of the greater San Joaquin Valley Groundwater Basin that extends over the southern portion of the Great Central

Valley of California. DWR Bulletin 118 identifies the Kern County Subbasin (Figure 6-1) as located within the Tulare Lake Hydrologic Region (HR) which covers approximately 10.9 million acres (17,000 square miles) of the southern San Joaquin Valley. The HR has 12 distinct groundwater basins and 7 subbasins of the San Joaquin Valley Groundwater Basin (Figure 6-1). These basins underlie approximately 5.33 million acres (8,330 square miles) or 49 percent of the entire HR.

The HR also corresponds to the Tulare Lake Basin that is used for the development of water quality control plans, or basin plans, which contain California's administrative policies and procedures for protecting state waters. Basin plans are required by the Porter-Cologne Water Quality Control Act (California Water Code, Section 13240). Basin plans complement water quality control plans adopted by the State Water Resources Control Board (SWRCB). In addition, Section 303 of the federal Clean Water Act requires states to adopt water quality standards that "consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses" (CVRWQCB, 2018).

Basin plans consist of designated beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives (California Water Code, Section 13050(j)). California's basin plans serve as regulatory references for meeting both state and federal requirements for water quality control (40 CFR Parts 130 and 131); however, California's basin plans also establish standards for groundwater in addition to surface waters (CVRWQCB, 2018).

6.2 Kern County Subbasin

The Kern County Subbasin (Subbasin 5-22.14, DWR, 2006) is one of the largest groundwater basins in the state, covering approximately 1,792,000 acres (2,800 square miles). The Subbasin's boundaries were defined by DWR (2016) and were described as geographically bounded to the east by the Sierra Nevada Mountain Range, to the west by the Southern Coast Ranges, and to the south by the Tehachapi and San Emigdio Mountains. The northern boundary of the Subbasin is a jurisdictional boundary, which is the border between Kern County and Tulare County and Kings County (Figure 6-2). The Kern County Subbasin borders four other DWR basins, these include:

- Tule Subbasin (Subbasin 5-22.13, DWR, 2006)
- Tulare Lake Subbasin (Subbasin 5-22.12, DWR, 2006)
- Kettleman Plain Subbasin (Subbasin 5-22.17, DWR, 2006)
- White Wolf Subbasin (Subbasin 5-22.18, DWR, 2018)

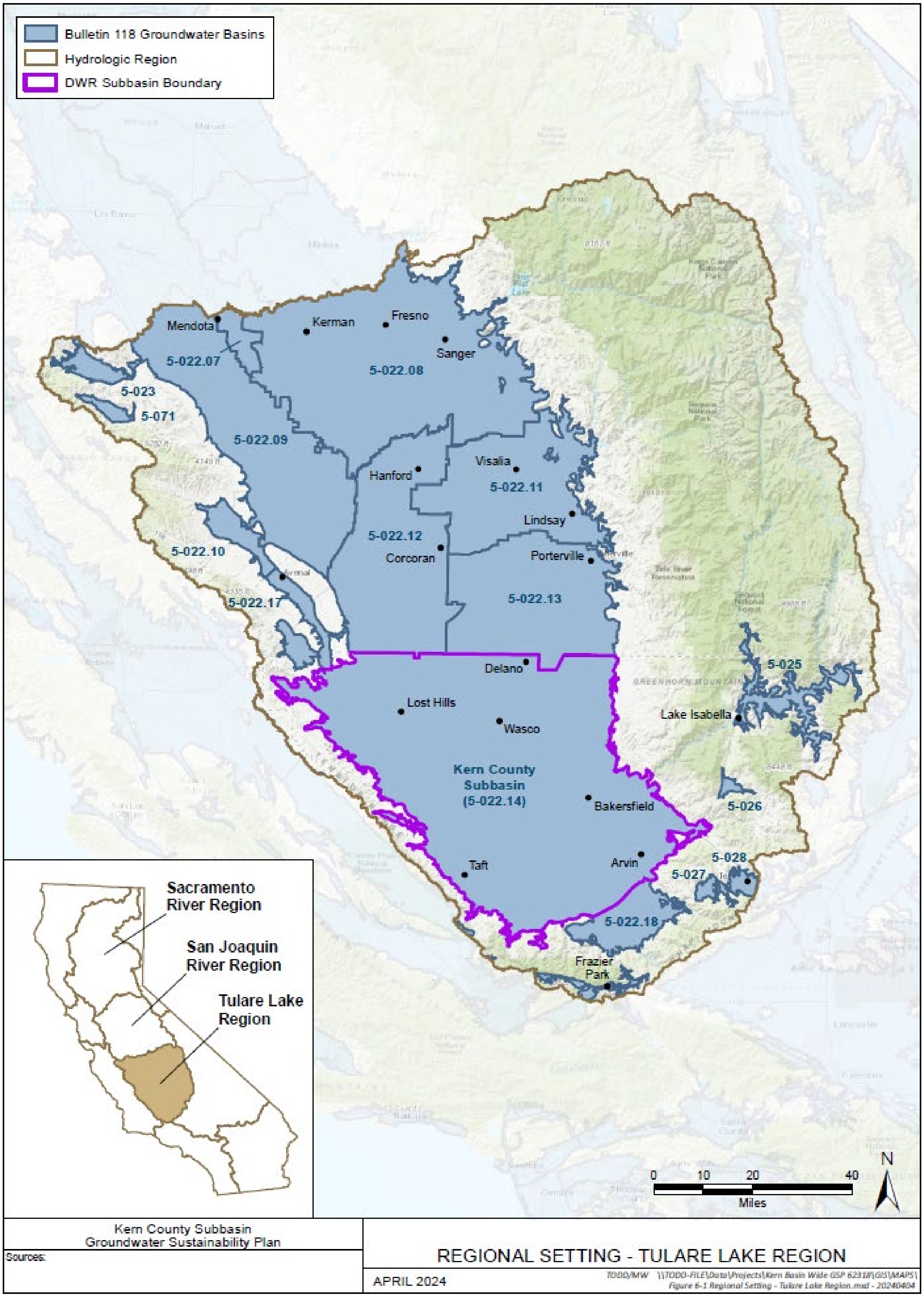


Figure 6-1. Regional Setting Tulare Lake Region

This page intentionally left blank.

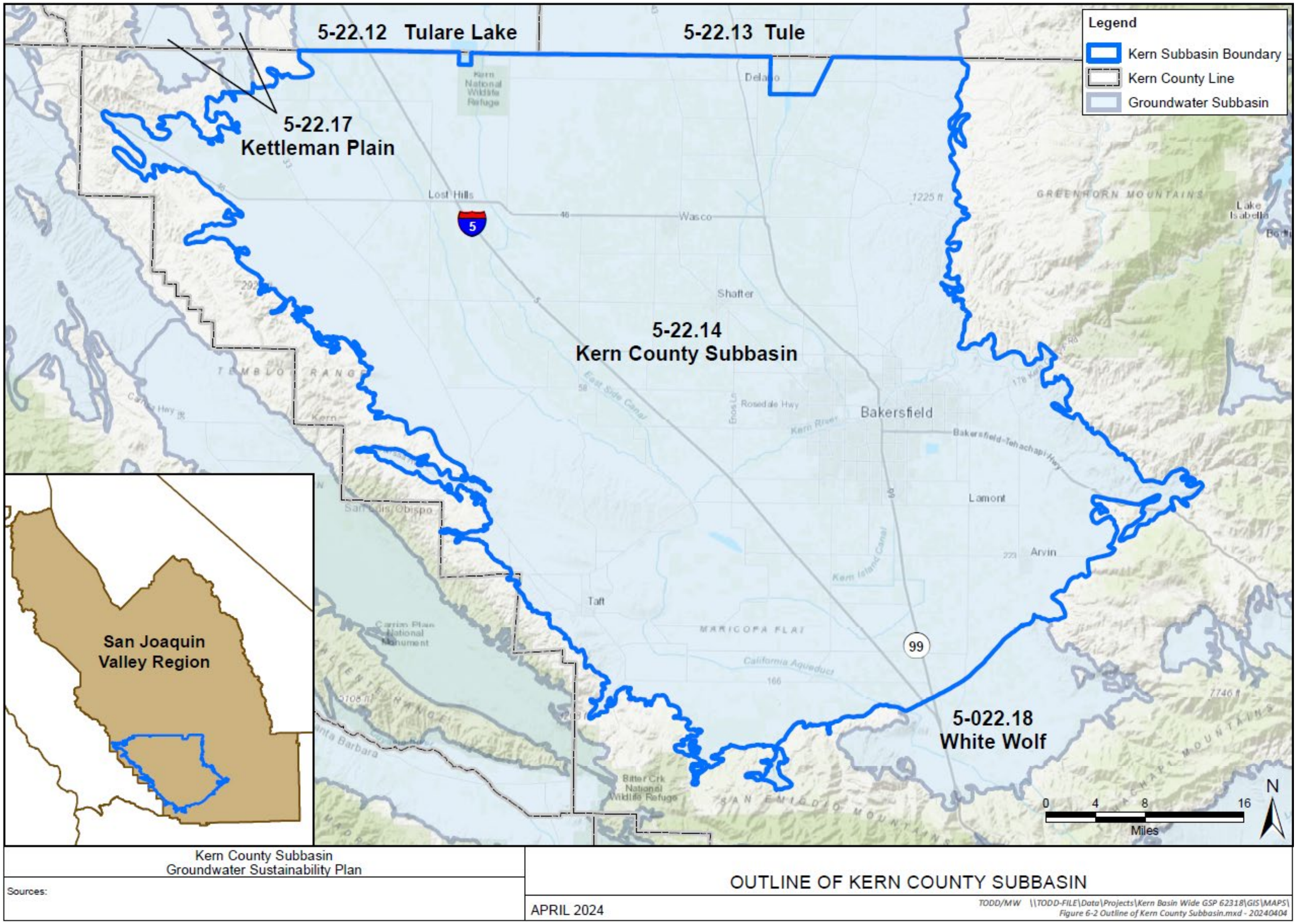


Figure 6-2. Outline of Kern County Subbasin

This page intentionally left blank.

The groundwater resources in the Kern County Subbasin are significant, and most of the water supply for the area comes from underground aquifers, usually occurring in the uppermost 3,000 feet (Page, 1973). The main sources of natural recharge to the groundwater system are precipitation in the form of rain and snow, and seepage from rivers and streams. An additional important contributor is imported water through infiltration and artificial recharge from water banking, which involves capturing and storing excess surface water in aquifers during wet periods for later use during dry periods (DWR, 2006).

6.2.1 Subbasin HCM Areas

The Kern County Subbasin is a large and geologically complex basin with regional faulting, folding and three principal aquifers. To help with presenting how this complex geology applies to various components of this Plan, five HCM areas have been defined within the Subbasin. The HCM areas include:

- **North Basin HCM Area** – This area corresponds to the large alluvial basin north of the Kern River Fan area that is a major agricultural area. This area is underlain by a thick sequence of alluvial sediments that form a highly productive aquifer. The presence of clay layers, primarily the E-Clay, influences vertical flow of groundwater to form distinctive aquifer zones in some areas. Kern County Environmental Health Services (KCEHSD) water well ordinance requires that wells drilled north of the Kern River Alluvial Fan seal to the E-Clay (Page 1986).
- **Kern River Fan HCM Area** – This area corresponds to the Kern River Alluvial Fan. The Kern River is a large hydrologic feature that provides both a major local surface water supply and source of groundwater recharge. The coarse alluvial sediments with limited clay layers make this the prime area for managed recharge and water banking. These operations generate a distinctive groundwater response seen on hydrographs.
- **South Basin HCM Area** – This area corresponds to the large alluvial basin south of the Kern River Fan area that is the other major agricultural area that is underlain by a thick highly productive alluvial aquifer. KCEHS water well ordinance requires that wells drilled south of the Kern River Alluvial Fan seal to the E-Clay (Page 1986).
- **Eastern Margin HCM Area** – This area along the eastern Subbasin margin where water supply is derived from older geologic units. In the northeast area, the Santa Margarita and Olcese Principal Aquifers provide water supply. This area includes several large fault-bounded oil fields. In the southeast, the Edison Fault forms a groundwater flow barrier.
- **Western Fold Belt HCM Area** – This area along the western Subbasin margin generally corresponds to the West Side Fold Belt of Bartow (1991). This is the more intensely folded area dominated by large oil fields and poor-quality water.

Only minimal groundwater pumping occurs in this HCM Area due to the poor water quality. Due to these factors, agricultural and urban water supplies are either imported or derived from other HCM areas.

The overall approach for the Subbasin is to have a series of organizing themes that will be emphasized throughout the GSPs. One of these themes is to discuss the Basin Setting in terms of the five HCM areas. These five areas are informal designations referring to hydrogeologically similar areas used for the Basin Study to help organize the HCM discussions (Figure 6-3). The HCM areas will provide a common framework for describing the hydrogeological variability of the Subbasin for various components of this Plan, including support of the definition of undesirable results and sustainability criteria. The defining characteristics of each HCM area are further presented in Section 7.

6.2.2 Subbasin Aquifer Types

Continental deposits that overlie the marine deposits provide the most productive freshwater aquifers in the Subbasin (Bertoldi and others, 1991). The marine sediments with confined fresh water provide local areas of productive freshwater aquifers in the Subbasin. The isolated marine rocks with saline connate water are not considered as usable water sources because of their poor water quality and lack of recharge. There are three distinct geology-based groundwater occurrences in the Subbasin (Davis and others, 1964, Hilton, 1963). These include:

1. Unconfined and semiconfined fresh water in continental alluvial deposits of Recent, Pleistocene, and possibly late Pliocene age. These continental deposits overlie the marine deposits and contain most of the freshwater in the Subbasin.
2. Confined fresh water, contained in marine sediments of Miocene age where surface recharge from outcrop areas has flushed the original saline connate (water trapped in the pores of sedimentary rocks since they were deposited) water and now contain freshwater. This condition occurs in limited areas, primarily along the eastern Subbasin margin that form locally important aquifers.
3. Saline, connate (water trapped in the pores of sedimentary rocks since they were deposited) water contained in marine sediments of middle Pliocene or older age, which underly the fresh-water body throughout the area. Most of the marine sediments in the Subbasin contain highly saline, connate water.

These aquifer types have been recognized by researchers and practitioners in the southern San Joaquin for decades (Davis and others, 1964, Hilton, 1963, Bertoldi and others 1991) and will be used in characterizing the aquifers in this Plan.

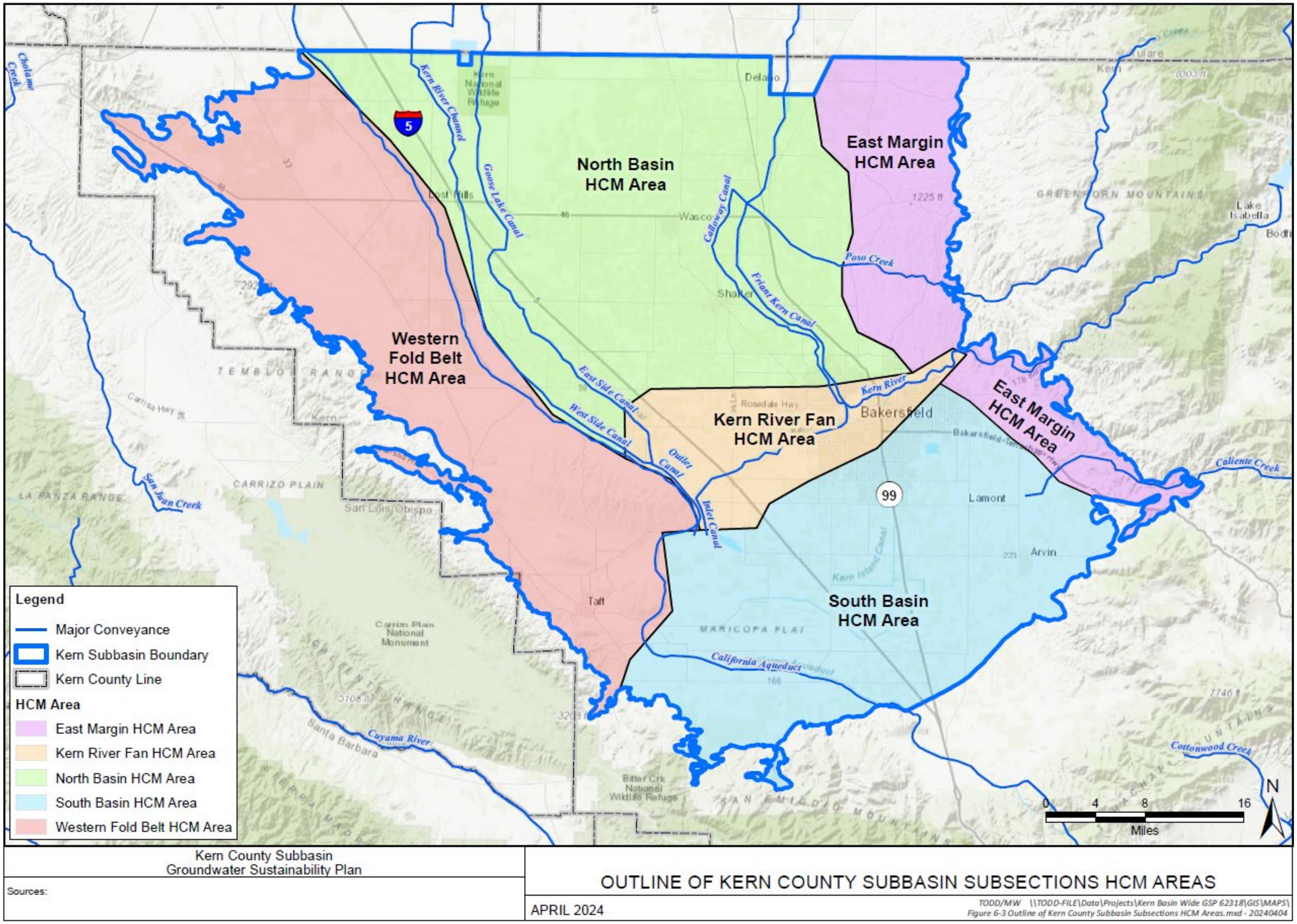


Figure 6-3. Outline of Kern County Subbasin Subsections HCM Areas

This page intentionally left blank.

7. HYDROGEOLOGICAL CONCEPTUAL MODEL

§ 354.14. *Hydrogeologic Conceptual Model*
Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

☑ 23 CCR § 354.14(a)

This section presents the hydrogeologic conceptual model (HCM) for the Kern County Subbasin. Numerous descriptions and reports of local hydrogeologic conditions are available for the Subbasin. The key reports used within this report to develop the HCM include: Wood and Davis, 1959; Dale, French and Gordon, 1966; Croft, 1972; Bartow and Pittmann, 1983; Page, 1986; Bartow and McDougall, 1984; Bartow, 1991. Details from previous investigations relating to the regional geologic and structural setting of the Subbasin; geologic features affecting groundwater flow; vertical and lateral boundaries; primary aquifers and aquitards; groundwater elevations and flow direction over time; and water quality are described below. A general illustration of the HCM is illustrated on the schematic diagram in Figure 7-1 from Bartow (1991) that shows the general subsurface conditions in the Subbasin and the surrounding highlands.

As described in the Hydrogeological Conceptual Model Best Management Practices (BMP) document (DWR, 2016), an HCM provides, through descriptive and graphical means, an understanding of the physical characteristics of an area that affect the occurrence and movement of groundwater, including geology, hydrology, land use, aquifers and aquitards, and water quality. This HCM serves as a foundation for subsequent Basin Setting (Section 6) analyses including water budgets (Section 9) and numerical models, monitoring network development (Section 15), and the development of sustainable management criteria (Section 13).

This page intentionally left blank.

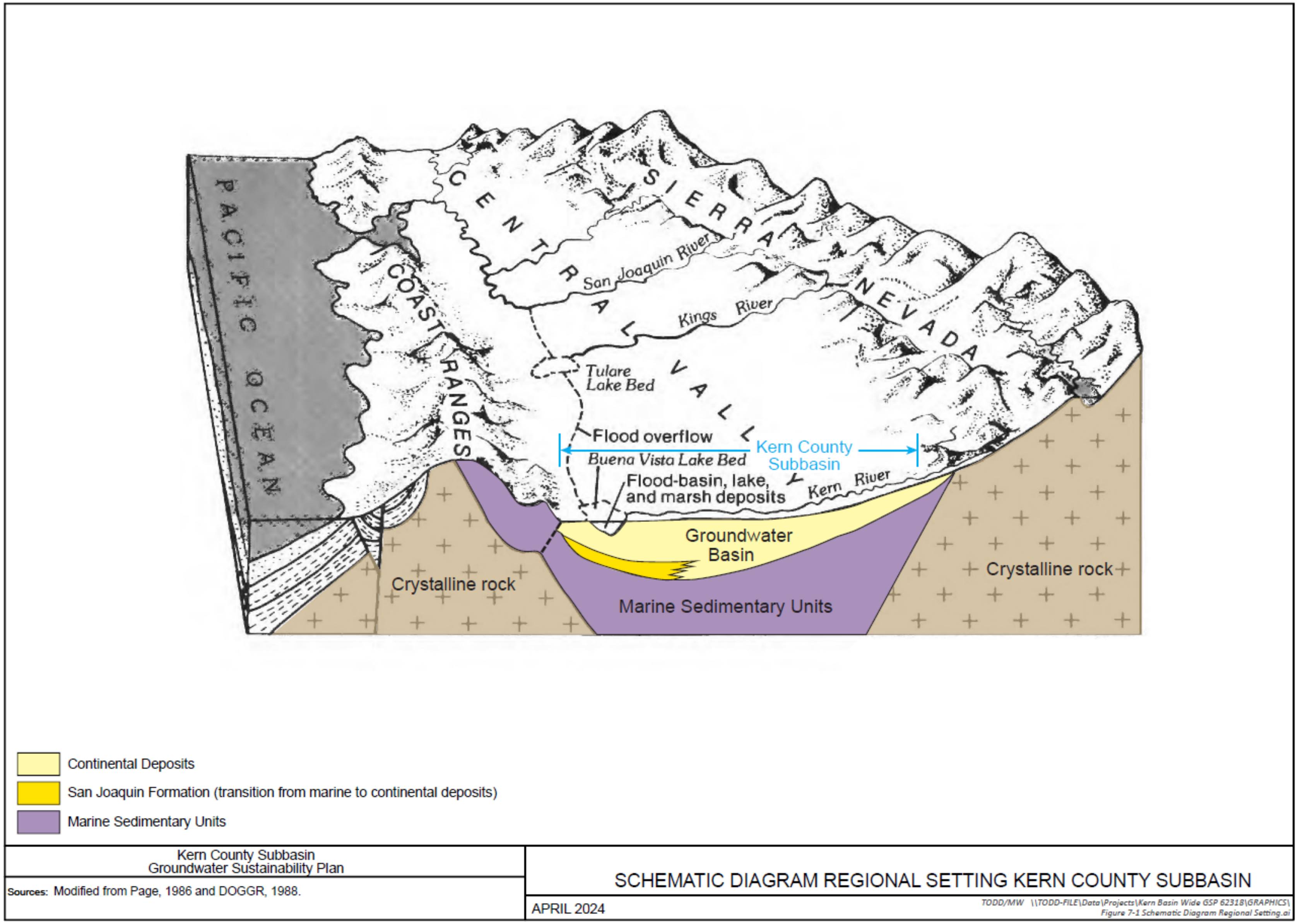


Figure 7-1. Schematic Diagram Regional Setting Kern County Subbasin

This page intentionally left blank.

7.1 Physical Characteristics

§ 354.14. *Hydrogeologic Conceptual Model*
(b) Physical characteristics of the basin shall be represented on one or more maps that depict the following:
- *(1) Topographic information derived from the U.S. Geological Survey or another reliable source.*
- *(2) Surficial geology derived from a qualified map including the locations of cross- sections required by this Section.*
- *(3) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.*
- *(4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.*
- *(5) Surface water bodies that are significant to the management of the basin.*
- (6) *The source and point of delivery for imported water supplies.*

☑ 23 CCR § 354.14(d)

The following summarizes the physical setting of the Kern County Subbasin.

7.1.1 Topography

☑ 23 CCR § 354.14(b)

The Kern County Subbasin, which is located in the southernmost part of the San Joaquin Valley, is both a topographic and a structural basin. The Subbasin is situated within the topographic horseshoe that is bordered on the east and southeast by the Sierra Nevada, on the west by the Southern Coast Ranges, and on the south by the White Wolf Subbasin and the San Emigdio and Tehachapi Mountains (Davis et al, 1959, Davis et al, 1964). A topographic contour map based on the Digital Elevation Map (DEM) of the topography from the United States Geological Society (USGS) National Elevation Dataset (NED) is also shown on Figure 7-2. Elevations within the Subbasin range from 1,500 to 2,000 feet in the mountain foothills along the basin margin to 215 feet at the Kern National Wildlife Refuge along the northern Subbasin boundary.

The surface of the valley floor is characterized by various types of topography which may be grouped into several geomorphic units. The valley floor is characterized by four geomorphic units (Figure 7-2) as defined by (Davis et al, 1959, Davis et al, 1964) as follows:

- Dissected upland geomorphic unit,
- Low alluvial plain and fan geomorphic unit,
- River flood plain and channel geomorphic unit, and
- Overflow land and lake bottom geomorphic units.

This page intentionally left blank.

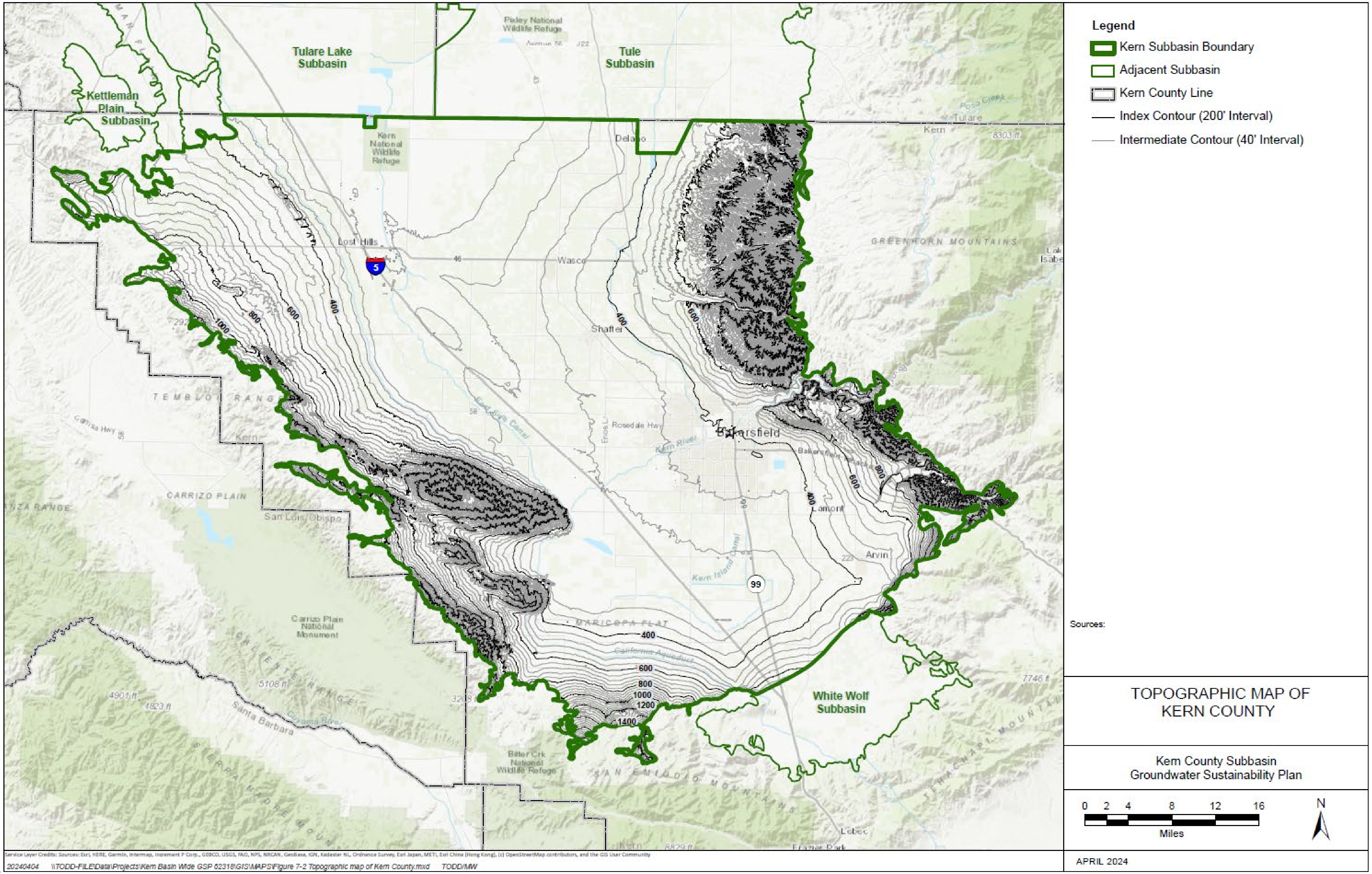


Figure 7-2. Topographic Map of Kern County

This page intentionally left blank.

The dissected upland geomorphic units are areas of deeply dissected hill land that are primarily located along the Subbasin margins; however, isolated low ridges occur in the western and central Subbasin. The topography ranges from gently rolling land to hilly areas with up to 500 feet of relief. Stream channels are typically incised by tens of feet; however, along the eastern Subbasin stream cuts of over a hundred feet occur along major streams such as Kern River, Poso Creek, and Caliente Creek (Davis et al, 1959, Davis et al, 1964).

The low plain and fan geomorphic units are generally flat areas that cover most of the valley floor. These plains are the site of the most intensive agricultural development. In the western portion of the Subbasin, the low plains and fans are areas of low relief that lie between the upland and foothill areas of the Western Fold Belt. Local relief is generally less than 10 feet and in most places is less than 5 feet (Davis et al, 1959, Davis et al, 1964).

The river floodplain geomorphic units typically occur as narrow, disconnected strips that cross the plains and uplands at approximately right angles to the Subbasin margin. They have been flooded in recent times and generally lie below the level of the surrounding country (Davis et al, 1959, Davis et al, 1964). Kern River, Poso Creek and Caliente Creek have narrow floodplains that extend several miles out onto the low plains and alluvial fan areas.

The overflow land and lake bottom geomorphic units include the historic lake beds of Tulare, Buena Vista, Kern and Goose Lakes along with the connecting areas of the Buena Vista and Jerry Sloughs (Davis et al, 1959, Davis et al, 1964). These are the topographic lowlands in the axial trough of the valley; therefore, these areas form the lowest topographic elevations in the Subbasin. These lowland areas were poorly drained under natural conditions when they were flooded periodically by the larger streams carrying runoff from the Sierra Nevada.

7.1.2 Surface Water Bodies

☑ 23 CCR § 354.14(d)(5)

The Subbasin is considered a closed hydrologic basin that is characterized by internal drainage (Davis et al, 1959, Davis et al, 1964). The principal rivers and streams within the Subbasin are the Kern River, Poso Creek, and Caliente Creek.

7.1.2.1 Rivers, Streams, and Watersheds

The Kern River is the largest river in the Subbasin (see Figure 7-3) and flows through the Kern Fan HCM. The Kern River is about 165 miles long and drains snowmelt and runoff from a watershed of approximately 2,400 square miles. The watershed extends to approximately 13,866 feet near Mt. Whitney in the Sierra Nevada (USGS Stream Stats, 2024). Since 1953, flows in the Kern River have been regulated at Isabella Dam, about 25 miles upstream of the Subbasin. The Kern River enters the Subbasin at the Kern Gorge fault and flows southeastward across the Subbasin. Two permanent stream gage stations (First Point and Second Point) were established to measure flow in the Kern River. The computed natural flow at First Point is used to allocate water among the various Kern River interests, referred to as First Point diverters, Second Point diverters, and Lower River diverters. The Second Point of measurement is approximately 20 miles downstream of First Point and is used to check upgradient water use (and entitlements) with diversion rights downgradient of Second Point (Boyle, 1975). In 1954, Isabella Dam was constructed for flood control on the Kern River. Since 1954, high flows in the Kern River exceeded 2,000,000 acre-feet per year (AFY) three times - in 1969, 1983 and 2023. During water years 1995 through 2022, computed natural flows at First Point have ranged from 2,442,481 AFY (1998) to 131,063 AFY (2015). The low flows observed in 2015 represent the historical low flow condition for First Point measurements dating back to 1954.

Poso Creek is an intermittent stream that cuts from east to west across the dissected foothill belt onto the valley floor mainly in the North Basin HCM and extends as a defined channel several miles westward to the Kern National Wildlife Area (Figure 7-3). Its watershed originates in the Greenhorn Mountains of the South Sierra Nevada Mountain Range at an elevation of approximately 8,000 feet (CWD, 2007). There are multiple stream gages on Poso Creek. Flows are measured at Trenton Weir near State Highway 65. The annual flow at this site has exceeded 120,000 AFY, but for many years it has little to no flow. While flows are variable, some landowners do occasionally exercise their riparian rights to divert water from Poso Creek during years of high flow. Starting in 1997, the use of Poso Creek water has been governed by an agreement between NKWSD, CWD, and SWSD, who collectively share the runoff of Poso Creek. Under this agreement, CWD is allocated the first 135 cfs of Poso Creek flow (as measured at the State Highway 65 gaging station) and NKWSD receives flows between 135 cfs and 300 cfs and when Poso Creek is flowing at greater than 685 cfs. In 2000, Cawelo Water District was issued a permit to divert water from Poso Creek for beneficial use at a rate of approximately 110 cubic feet per second (cfs), with the volume limited to 30,000 AF between November 1 and June 14 of the following year.

Caliente Creek, located in the southeastern part of the Subbasin, has a floodplain about one mile wide; however, about 5 miles into the Subbasin, the floodplain level is no longer incised below the surface of the alluvial fan and is difficult to distinguish from the fan itself. The USGS operated a stream gauge on Caliente Creek near the confluence of Tehachapi Creek from October 1961 through February 1983 (USGS gauge 11196400). The gauge had a contributing area of 165 square miles. Data from that gauge shows that monthly average streamflow ranged from a minimum of 0.39 cubic feet per second (cfs) in July and September to a maximum of 16 cfs in February. Average annual streamflow ranged from 0.224 cfs in 1977 to 13.3 cfs in 1969. Annual peak streamflow ranged from a minimum of 2.2 cfs in 1966 to 3,060 cfs in 1978, until a large storm event in 1983, with a peak flow of 15,500 cfs, washed out the gauge permanently. Storm-related flooding along the larger streams (i.e., Caliente Creek and Tejon Creek) is common in some areas such as Lamont and Arvin.

This page intentionally left blank.

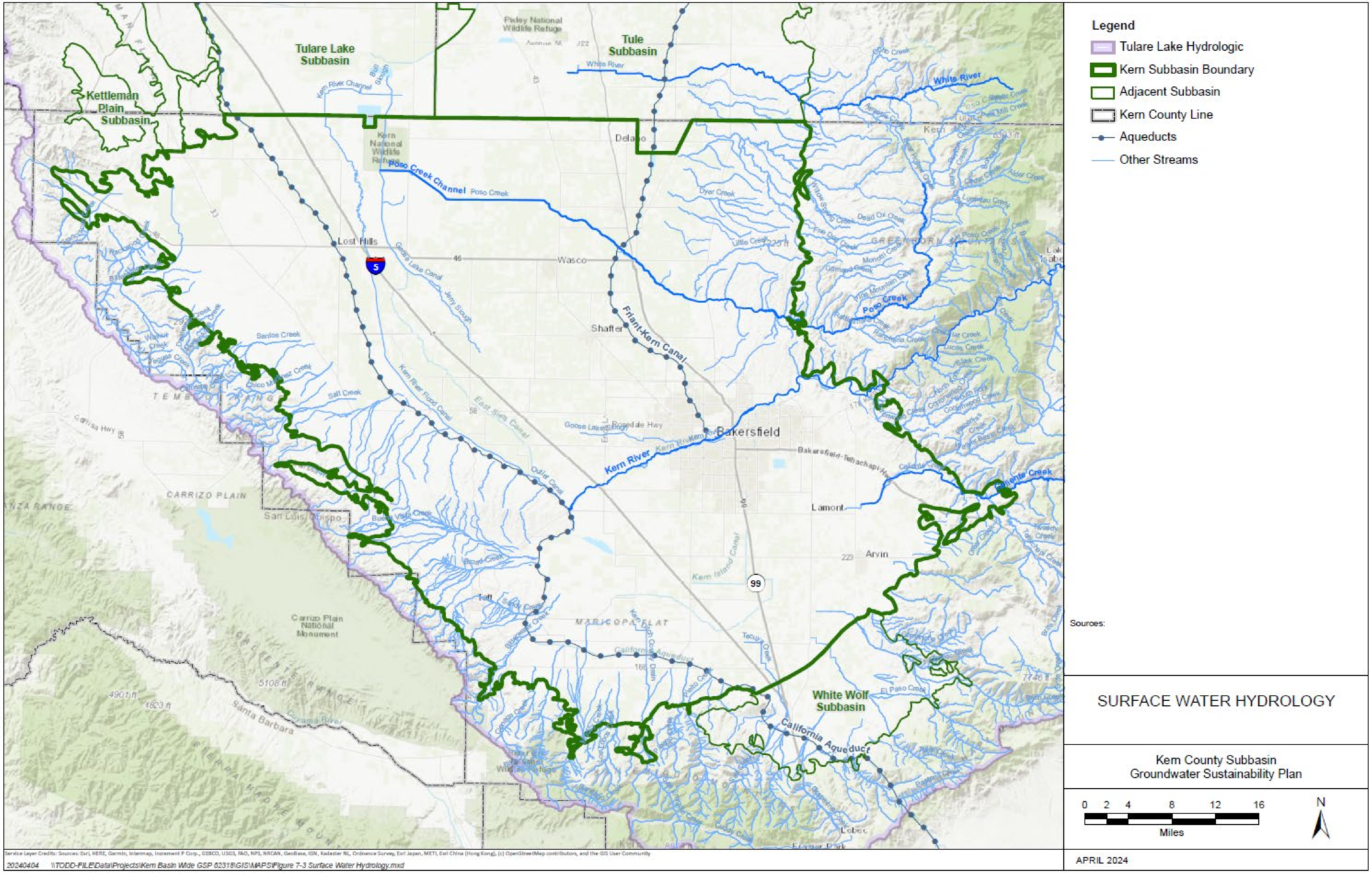


Figure 7-3. Surface Water Hydrology

This page intentionally left blank.

The streams that drain the Coast Ranges, Tehachapi, and San Emigdio Mountains are intermittent and typically flow only during the short rainy season (generally November through March). Numerous ephemeral streams occur along the Subbasin margin that may have locally incised channels that may continue several miles onto the alluvial fans and then vanish (Davis et al, 1959, Davis et al, 1964). The local ephemeral streams provide additional local surface water during above normal and wet water years. These streams are not gaged and generally only flow after precipitation events. A very small percentage of minor stream runoff is collected and used for irrigation; the majority of these irregularly occurring flows likely serve to recharge local groundwater basins (Kennedy and Jenks, 2011).

7.1.2.2 Lakes and Reservoirs

Flows in the Kern River consist of regulated and managed releases from Lake Isabella, approximately 25 miles upstream of the Subbasin (Figure 7-3). Isabella Dam and Lake Isabella were constructed by the U.S. Army Corp of Engineers (USACE) in 1953 to address downstream flooding. Since that time, Isabella Dam has been operated for flood control, hydroelectric power, water supply, and conservation storage. Reservoir storage and Kern River flow management are coordinated by the Kern River Watermaster, working with the USACE, participating water districts, and the City of Bakersfield. Except for periods of high runoff, releases from Lake Isabella are regulated through requests, or “calls” for water by the City of Bakersfield on behalf of the Kern River Watermaster.

The Subbasin is considered a closed hydrologic basin that is characterized by internal drainage (Davis et al, 1959, Davis et al, 1964). Surface water flows from the major rivers are generally toward one of several lakes including Buena Vista, Goose, and Kern lakes within the Subbasin and Tulare Lake in Kings County just north of the Subbasin. Historically, these lakes contained water, and the surrounding marshes and connecting sloughs were covered with rank vegetation (*e.g.*, weeds). Tulare, Buena Vista, Kern, and Goose lakes are typically dry, except during floods, because of diversions from tributary streams for irrigation (Davis et al, 1959, Davis et al, 1964). The narrow strip of land between Buena Vista Lake and Tulare Lake is referred to as the Buena Vista Slough. The slough, prior to development, was a marshy area. During extremely heavy runoff, flood flows in the Kern River may reach the Buena Vista Slough via the Kern River Floodway. Goose Lake and Jerry Slough are separated from the Buena Vista Slough by a series of low ridges of dissected uplands. Here the overflow lands trend northwest between the ridges and have a gentle slope toward the Kern National Wildlife Area and Tulare Lake.

Source and Point of Delivery for Imported Water Supplies

The sources of imported surface water used for irrigation in the Subbasin are the California State Water Project (SWP), the Federal Central Valley Project (CVP), and other supplemental surface water delivered via the California Aqueduct or Friant-Kern Canal (FKC) (Figure 7-4). The California Aqueduct, FKC and other local canals convey imported surface water to beneficial users in the Subbasin. Many of the present-day canals were developed along the ancestral sloughs and drainageways of the Kern River Alluvial Fan.

The California Aqueduct, the SWP's principal conveyance feature, transports water from the Delta along the west side of the San Joaquin Valley to the Subbasin. The California Aqueduct extends north to south across the entire Subbasin, entering in the northwest corner of the Subbasin and continuing along the Subbasin's western side. South of Buena Vista Lake, the California Aqueduct bends to the east and exits the Subbasin at the boundary with the adjacent White Wolf Subbasin. The Kern County Water Agency (KCWA) was formed in the 1960s to contract with the DWR for the importation of SWP water to Kern County. Individual water districts holding contracts with KCWA have turnouts directly from the California Aqueduct into their service areas or receive water via the Cross Valley Canal (CVC). CVP water from the Delta Division and San Joaquin River Restoration Program Recapture and Reciruclation supplies are also conveyed to the Subbasin via the California Aqueduct. The Kern National Wildlife Refuge is now sustained by CVP water that is wheeled through the California Aqueduct and conveyed by the Goose Lake Canal to the refuge (USFS, 2005).

The FKC, completed in 1951, is the principal conveyance for the eastside CVP. The FKC diverts water from Friant Dam and Millerton Reservoir, completed in 1944 on the San Joaquin River, and extends southward a distance of 152 miles through Fresno, Tulare, and Kern counties. Within Kern County, the FKC extends from approximately mile post 122 at the County line near the City of Delano and flows south for approximately 30 miles to mile post 152 near Bakersfield (with the FKC terminus at the Kern River). The capacity of Millerton Reservoir is about 520,000 acre-feet, but 130,000 acre-feet of this storage lies below the intake for the FKC. The majority of CVP imported water is from the Friant Division that is conveyed to users in the Subbasin through the FKC; however, additional water from northern rivers systems that cross the FKC have the ability to discharge flood flows into the FKC for conveyance south into Kern County.

In 1973, DWR completed the initial facilities of the SWP, including the main line of the California Aqueduct. Portions of the SWP were constructed for use in conjunction with the facilities of the CVP. As the state and federal projects developed, a group of water users planned the CVC as a means of taking delivery of SWP and CVP water conveyed through the California Aqueduct. The CVC was completed in 1975 and, in 1976, the water users entered three-party contracts with DWR and Reclamation. Under these contracts, CVP water available to Reclamation in the Delta and San Luis Reservoir can be pumped by SWP's Harvey O. Banks Pumping Plant into the California Aqueduct or released from San Luis Reservoir for delivery to the Tupman Turnout where this water is diverted into the CVC. This federal water, conveyance of which is subordinate to conveyance of SWP water, can then be delivered to water users in the Subbasin.

This page intentionally left blank.

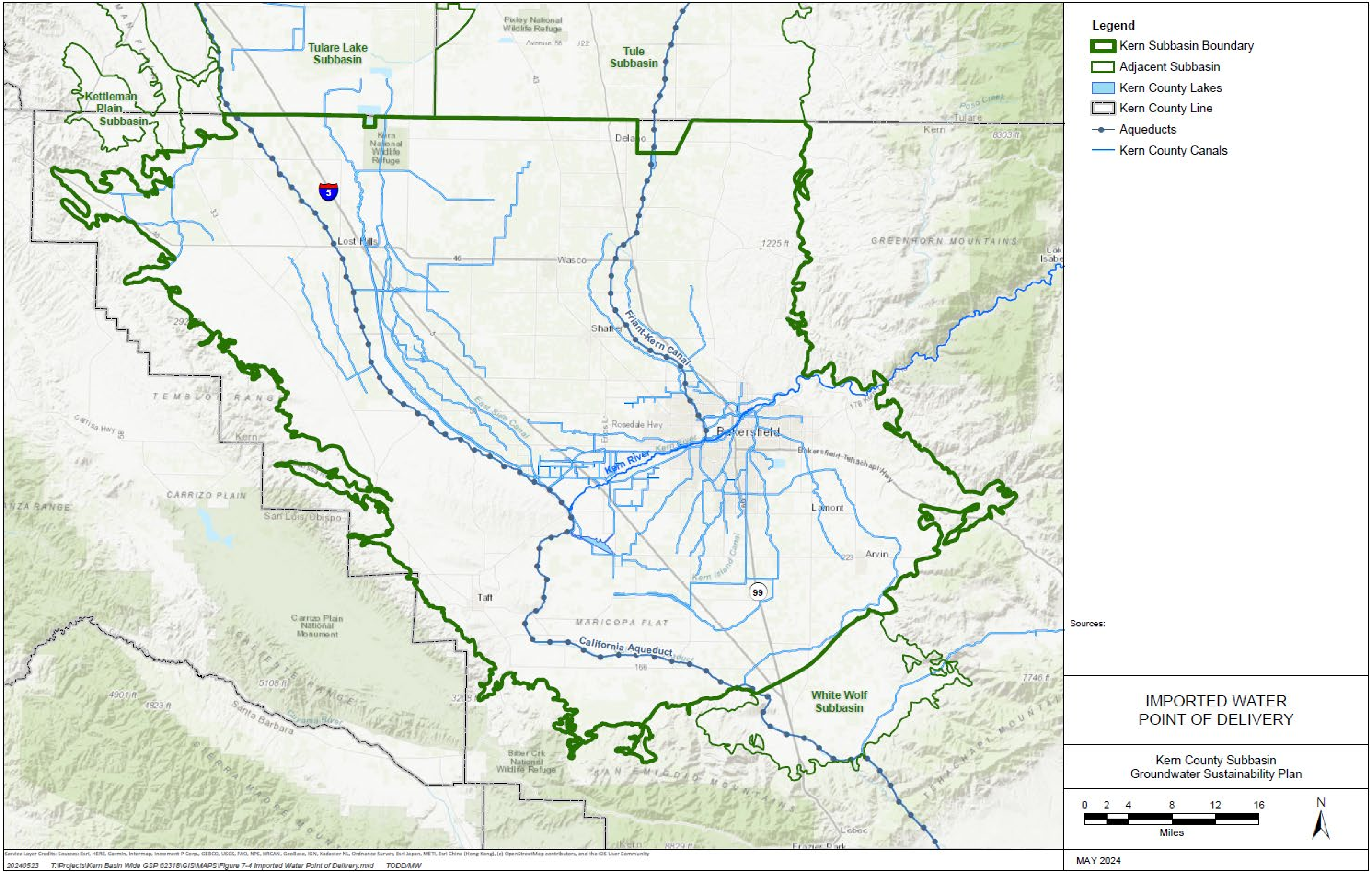


Figure 7-4. Imported Water Point of Delivery

This page intentionally left blank.

7.1.3 Delineation of Recharge and Discharge Areas

Direct recharge and potential recharge areas are differentiated in this section from natural recharge. Natural recharge occurs by groundwater underflow from adjacent sources, precipitation outgaining evapotranspiration in a Subbasin, or from natural surface waters flowing into the Subbasin. On the other hand, direct recharge is either planned or unplanned application of surface water by unlined conveyance, recharge basins and field application, managed recharge, and spreading/percolation operations. Figure 7-5 presents the location of surface water bodies in the Subbasin.

Natural recharge to the Subbasin is derived primarily from precipitation and surface runoff from the surrounding watersheds. Natural recharge is highest on the east side which receives higher precipitation and recharge from the Kern River and other smaller streams from the Sierra Nevada. Natural recharge is lowest on the west side of the Subbasin which receives less precipitation and lower runoff from the relatively smaller watersheds along the Coast Ranges. Other sources of recharge include ephemeral streams, springs, and seeps from the mountains along the east, southeast, and south fault margins of the Subbasin.

Significant direct recharge to groundwater in the Subbasin occurs through water banking and conjunctive use projects as well as unmanaged recharge through natural waterways, unlined basins and canals, regulating (balancing) reservoirs, percolation of applied water to crops and/or fallowed fields that descends below the root zone. Numerous sources of water are recharged by various projects, including local surface water (Kern River, Poso Creek, and other drainages), and imported water (SWP and CVP).

The major areas of direct recharge (facilities and drainages), presented in Figure 7-5, include agricultural land where excess irrigation water percolates below the root zone, wastewater treatment spreading areas, and urban drainage spreading areas. Additional locations of natural recharge from surface water features may include springs, seeps, and ephemeral/intermittent streams flowing into the Subbasin (Figure 7-3). The surface water features are described in more detail above (see Section 7.1.2). Groundwater discharge areas in the Subbasin are limited due to the depth of usable groundwater, typically greater than 100 feet throughout the Subbasin.

Since the late 1980s, large-scale water banking and conjunctive use projects have been constructed along the Kern River and in other areas of the Subbasin. Given the permeable nature of sediments within the Kern River Fan, most of the enhanced recharge projects involve surface spreading/percolation through ponds, low-lying fields including fallowed parcels, or basins. Some projects are dedicated to the replenishment of the groundwater basin, while other projects store surplus SWP, CVP, Kern River, and other (via FKC) floods waters for subsequent extraction (Todd, 2017).

This page intentionally left blank.

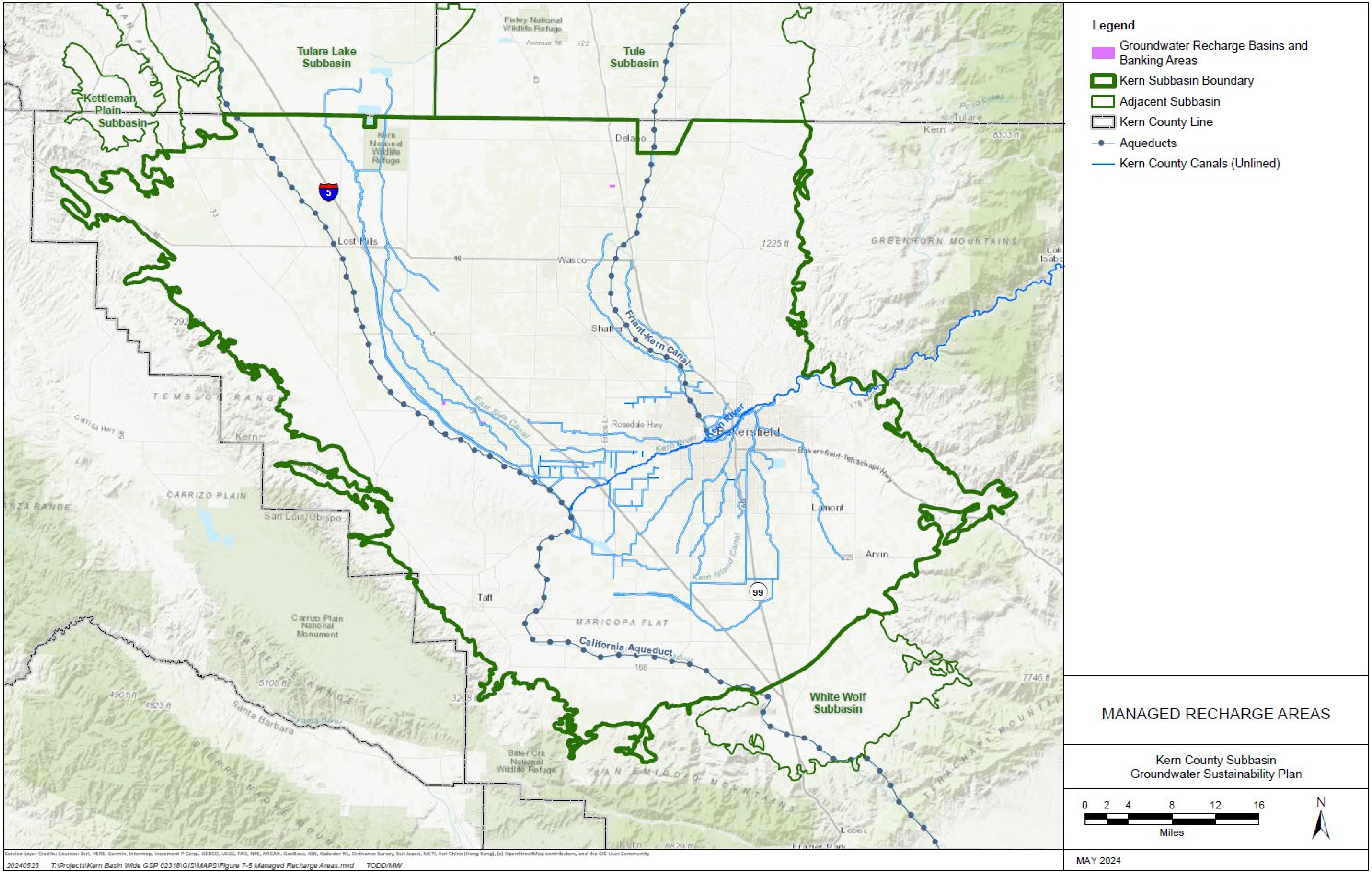


Figure 7-5. Managed Recharge Areas

This page intentionally left blank.

7.1.4 *Surficial Geology*

☑ **23 CCR § 354.14(d)(2)**

The surficial geologic maps for the Kern County Subbasin and surrounding areas (Figure 7-6) are regional geologic maps developed by the California Division of Mines and Geology (CDMG) as part of the Geologic Atlas of California that was published between 1958 and 1969. Although more recent and more detailed mapping is available in many areas, this set of maps is still the most detailed interpretation available for the entire state. It provides a complete, consistent view of the geology of the state, prepared at 1:250,000 scale. The Geologic Atlas uses a single set of rock units defined by geologic time, rather than geologic formations defined by time and lithology. This allows a simplified, uniform depiction of geologic units. The surficial geologic map for the Kern County Subbasin and surrounding areas (Figure 7-6) is based on three regional geologic maps developed as part of the Geologic Atlas of California. These include:

- Bakersfield (GAM 2) Sheet, Map compilation and Explanatory Data by Smith (1964).
- Los Angeles (GAM 8) Sheet, Map compilation and Explanatory Data by Jennings and Strand (1969).
- San Luis Obispo (GAM 18) Sheet, Map compilation and Explanatory Data (Jennings (1958).

The surficial geologic map shown on Figure 7-6 illustrates the age and composition of surficial deposits in the Subbasin. Most of the Subbasin is covered with continental deposits of Recent to Quaternary age. Some older units outside of the groundwater basin have been combined on Figure 7-6 for simplicity, but most geologic unit labels have been preserved from the source.

As shown by the yellow shading, most of the Subbasin is covered by Recent and Quaternary-age alluvial deposits. These units also closely correspond to the geomorphologic units described above. These include:

- Recent Alluvium (Qal) – unconsolidated valley, stream, and terrace deposits. Primarily associated with narrow band of sediments bordering major streams that correspond to the River Flood Plain Geomorphic Unit.

This page intentionally left blank.

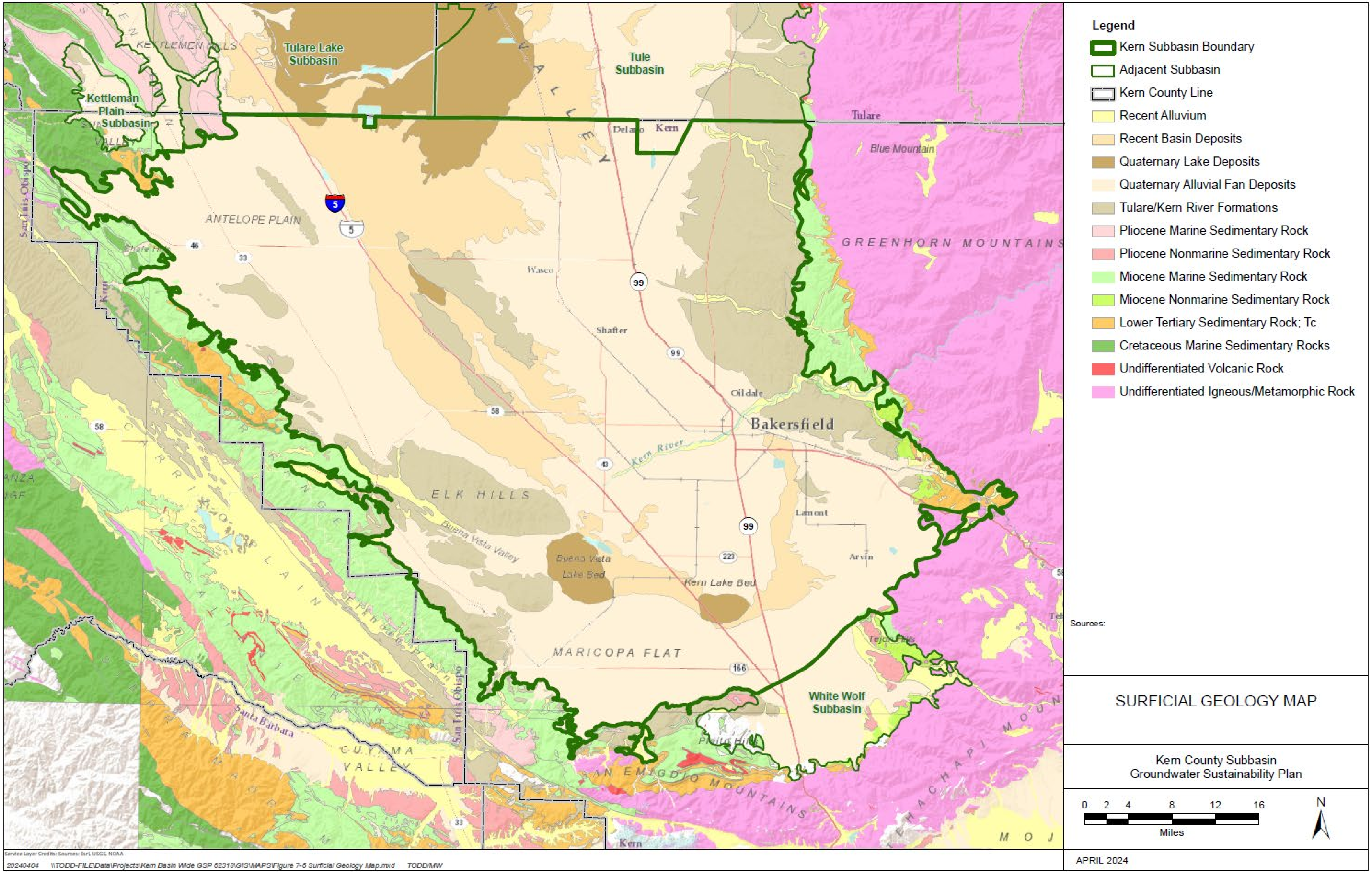


Figure 7-6. Surficial Geology Map

This page intentionally left blank.

- Quaternary Lake Deposits (Ql) – predominantly clay and silt deposits associated with lake beds that correspond to Lake Bottom Geomorphic Unit.
- Quaternary Basin Deposits (Qb) – sediments deposited during flood stages of major streams in the area between natural stream levees and fans that correspond to Overflow Land Geomorphic Unit.
- Quaternary Fan Deposits (Qf) – sediments deposited as alluvial fans from streams emerging from surrounding highlands and mountains that correspond to the Low Alluvial Plain and Fan Geomorphic Unit.

Plio-Pleistocene Nonmarine Sedimentary Deposits are underlain by older alluvial deposits of Pleistocene-Pliocene age (QPc) alluvial fan deposits originating from the surrounding mountains. The location of the outcrop of these units is typically found associated with geologic structures where these units have been tilted or folded. These older sediments are typically part of the Tulare Formation (western and southern parts of the Subbasin) or the Kern River Formation along the western flank Sierra Nevada. These areas typically correspond to dissected upland geomorphic units.

The Subbasin is flanked on the eastern, southern, and western margins of the valley by Miocene, Lower Tertiary, and Mesozoic marine sedimentary units and igneous and metamorphic basement rocks as shown on Figure 7-6.

7.1.5 Soils

☑ 23 CCR § 354.14(d)(3)

The Natural Resources Conservation Service has described the soils of the Subbasin (NRCS, 1988). Soil texture was assigned based on depth-weighted sand, silt, and clay percentages in the upper five feet of the soil profile. Initial soil hydraulic properties were assigned based on procedures reported by Saxton and Rawls (2006) and refined to provide drainage from saturation to field capacity within a reasonable amount of time and to predict minimal gravitational drainage once field capacity is reached. NRCS classifies soils into four hydrological soil groups (A, B, C, D) based on runoff and percolation potential with A group soils having the lowest runoff and highest percolation potential and D soils having the highest runoff and lowest percolation potential. Eight soil textures and their associated hydrological soil groups are shown on Figure 7-7 and summarized below:

- Loamy Sand, Sand and Sandy Loam soils cover about 750,000 acres or 38 percent of the Subbasin. Soils typically have about 10 percent or less clay and 60 percent to 90 percent sand or gravel. The saturated hydraulic conductivity is from 1 to 4 inches per hour. The hydrological soil group is typically A or B. These soils are typically associated with the Quaternary Fan Deposits (Qf) and the Low Alluvial Plain and Fan Geomorphic Unit.

- Sandy Clay Loam, Loam and Silty Loam soils cover about 850,000 acres or 42 percent of Subbasin. Soils typically have about 20 percent to 50 percent clay and 40 percent to 60 percent sand or gravel. The saturated hydraulic conductivity is from 0.2 to 0.7 inches per hour. The hydrologic soil group is typically C. Thess soils are associated with several of the surficial geologic and geomorphic units.
- Clay Loam and Clay soils cover about 400,000 acres or 20 percent of Subbasin. Soils typically have about 30 percent to 60 percent clay and 10 percent to 40 percent sand or gravel. The saturated hydraulic conductivity is from 0.05 to 0.15 inches per hour. Hydrologic soil group is typically D. These soils are associated with the Quaternary Lake Deposits (Ql) and Quaternary Basin Deposits (Qb) and the Overflow Land and Lake Bottom geomorphic units.

The Soil Agricultural Groundwater Banking Index (SAGBI) can further estimate groundwater recharge suitability to quantify recharge of deep percolated applied irrigation water and potential recharge from future managed recharge water banking and conjunctive use projects within the Subbasin. The California Soil Resource Lab at University of California Davis has developed an online application (https://casoilresource.lawr.ucdavis.edu/sagbi/) to present the SAGBI, which estimates groundwater recharge suitability based on five major factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition.

The application includes mapping coverage of the SAGBI and indicates a moderately good to excellent rating for:

- The Poso Creek alluvial fan in the north central Subbasin.
- The Kern River alluvial fan in the central area.
- Much of the southeastern to southwestern corners of the Subbasin.

SAGBI ratings are moderately poor to very poor.

- Along the eastern margin.
- Central western margin.
- The center of the valley from the former Kern and Buena Vista Lake beds, and
- North along the Goose Neck Slough to the Tulare Lakebed.

While moderately good to good SAGBI is shown for much of the western margin, this area is underlain by marine sediments and is not likely to be a useful area for recharge. The SAGBI ratings generally agree with mapped soil data where higher rated SAGBI soil corresponds with moderate to high infiltration soils.

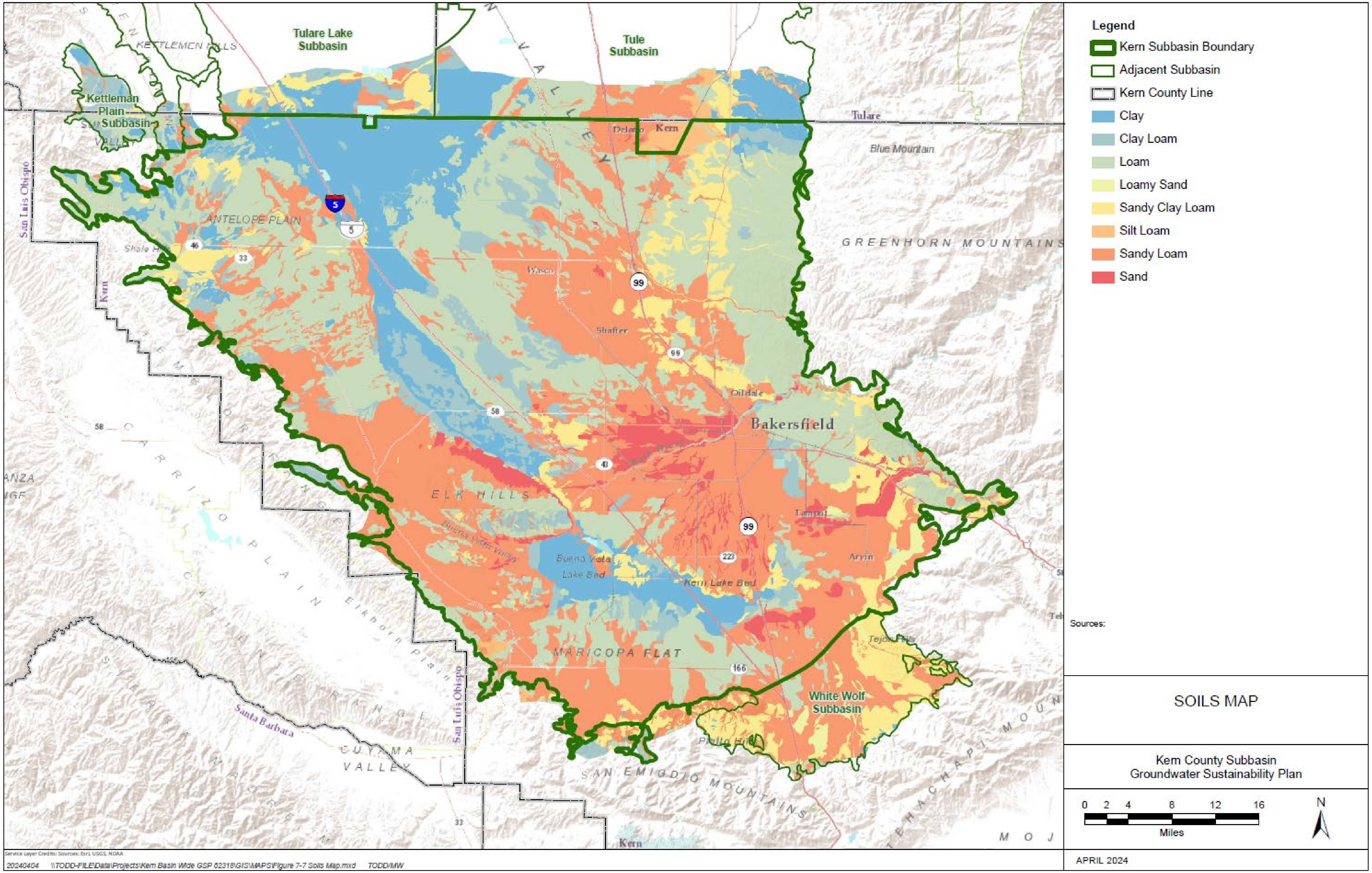


Figure 7-7. Soils Map

This page intentionally left blank.

7.2 Geologic and Structural Setting

☑ **23 CCR § 354.14(b)(1)**

The Kern County Subbasin can be described as an asymmetrical syncline, or a trough, which runs north-south, with the deepest section being toward the western edge. The most prominent differences between eastern and western borders are the high amount of folding of sediments toward the west and low deformation in the east (Davis and Green, 1962). The primary geological formations that make up the regional aquifer system are the surface and near-surface, recent-Holocene to Pleistocene alluvial/fluvial Recent Alluvium and the underlying Miocene to Pleistocene, fluvial Tulare Formation, and Kern River Formations.

7.2.1.1 Geologic Setting

The Kern County Subbasin consists of the upper portion of a deep structural trough between the crystalline rocks of the Sierra Nevada and the basement rocks of the Coast Ranges. The deeper portions of the trough contain mostly Miocene and older marine sedimentary units. The upper trough has been infilled over time with younger continental sediments. Continental deposits comprise over 6,000 feet of unconsolidated sediments south of the Kern River, and the base of the entire sequence of consolidated and unconsolidated sediments is over 18,000 feet deep (Davis et al., 1959).

The Kern County Subbasin has been described by Wood and Dale (1964) as being the product of structural downward warping and active tectonics in the greater San Joaquin Valley. The general structure and geology are illustrated on the schematic diagram in Figure 7-1 from Bartow (1991), which depicts the subsurface conditions in the Kern County Subbasin. The highlands surrounding the Subbasin are shown with folded beds separating the west side from the east side. The geology of the Subbasin is shown as deep marine sediments (purple) of pre-Pliocene age transition upward to Pliocene and younger deposits of continental origin (light yellow). Figure 7-1 displays the succession of marine deposition to more recent continental deposition and alluvium with fresher water deposits. These younger sediments contain most of the groundwater in the Subbasin.

The major external controls on sedimentation in the Subbasin are tectonism, eustatic sea-level change, and climate. The sedimentary record represents the complex interplay of all these factors, although tectonism is clearly dominant. Any thick accumulation of sediments, such as that found in the Southern San Joaquin region, implies tectonic subsidence. Furthermore, the location of this Subbasin along an active continental margin virtually assures tectonic activity in some form, throughout the Cenozoic. The other factors, sea-level change and climate also play important roles as well (Bartow, 1991).

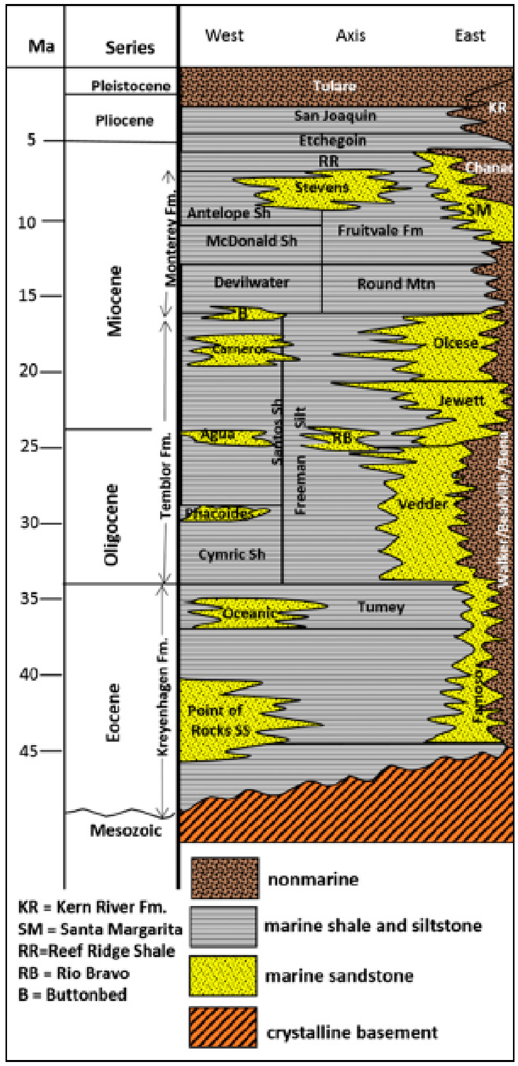
Tectonic activity throughout the Tertiary uplifted the surrounding Sierra Nevada, Tehachapi Mountains, and the Coast Ranges. Erosion and subsequent transport of sediment from the mountains into the basin occurred (Page, 1986). Tectonic movements also elevated the Coast Ranges to the west which created a marine embayment in the present-day Southern San Joaquin region. Although the San Joaquin Valley was created by the emergence of the Coast Ranges, the southern areas, including all the Kern County Subbasin, remained inundated by the Pacific Ocean. In contrast, only continental deposition occurred in the more northern areas of the San Joaquin Valley throughout the Miocene to Pliocene time. Figure 7-8 shows the general stratigraphic column, and Figure 7-9 shows the paleogeography for four different time periods which illustrates the inundated areas. These include:

- Early Miocene (about 30 million years ago (mya))
- Late Miocene (about 10 mya)
- Pliocene (about 3 mya)
- Pleistocene (about 0.6 mya)

As a result, both marine and continental sediments were deposited. Marine deposition was dominant in the Subbasin throughout the Miocene through the late Pliocene time. These inundated areas were continuously changing in size and shape due to sea-level change as the Coast Ranges emerged. During the Pliocene, uplift of Coast Range began to separate the Subbasin area from the Pacific Ocean so that by the Pleistocene only continental sediments were deposited.

The continental deposits that constitute the primary Subbasin aquifer system contain mostly fluvial deposits and interbedded lacustrine deposits. The continental deposits consist predominantly of lenses of gravel, sand, silt, and clay. The numerous lenses of fine-grained (silt, sandy silt, sandy clay, and clay) sediments are distributed throughout the Subbasin (Page, 1986). Most of these fine-grained lenses are not extensive; however, several major ones were mapped, principally near the axis of the San Joaquin Valley. The most notable is the E-Clay, which includes the Corcoran Clay Member of the Tulare Formation (Pleistocene).

Marine deposits underlie the Subbasin and outcrop along the west, southwest, south, and southeast Subbasin margins. Due to the many changes in depositional environment, the marine deposits differ greatly in sediment type, sorting, and thickness, and have been assigned different geologic formation names in different parts of the Subbasin. The most recent of which are the Pyramid Hills, Vedder Sand, Olcese Sand, Santa Margarita Formation, and San Joaquin and Etchegoin Formations.



Kern County Subbasin
Groundwater Sustainability Plan

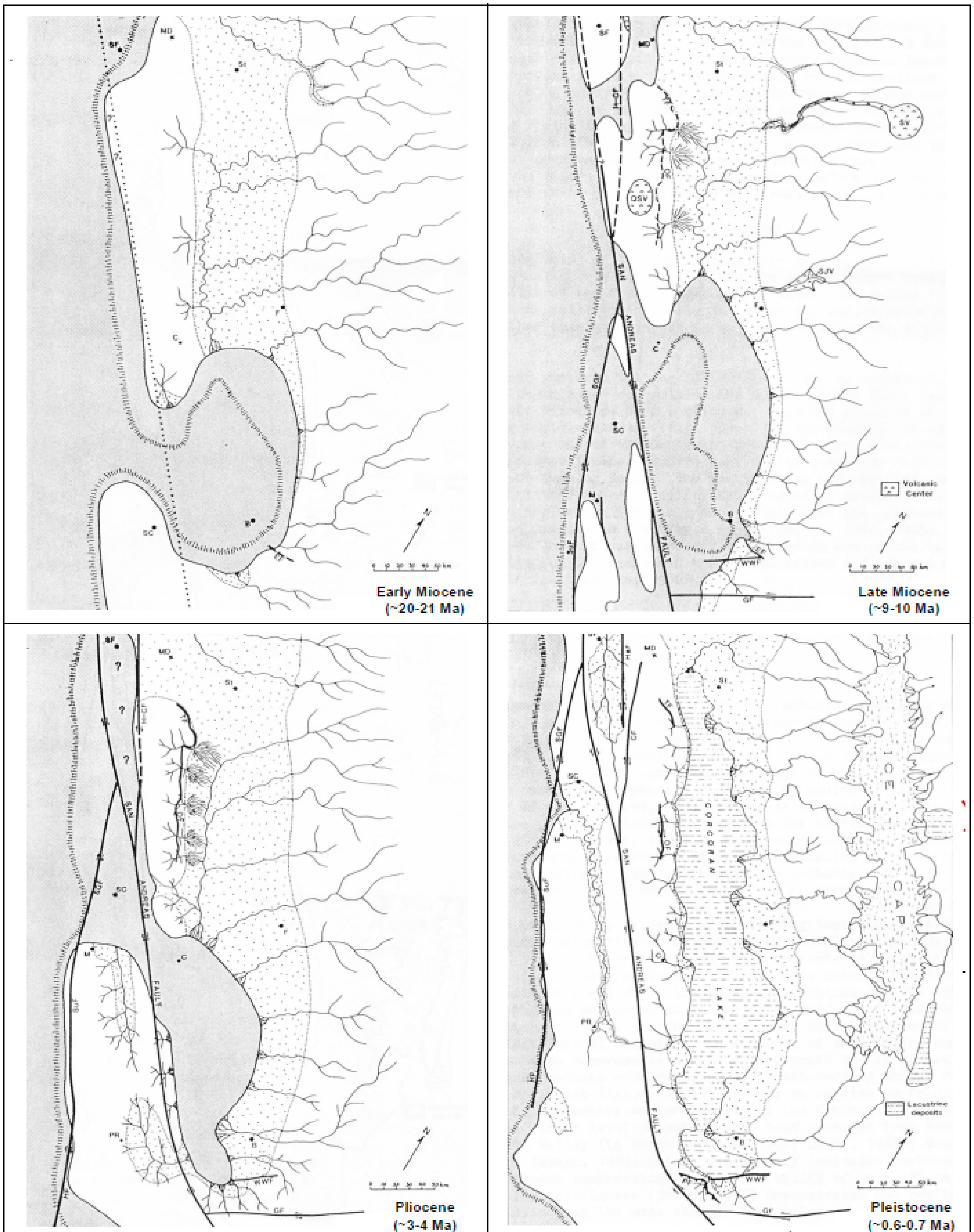
Source: Gillespie - GW Salinity SJV, 2017

GENERALIZED STRATIGRAPHIC COLUMN

APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\Figure 7-8 Generalized Stratigraphic Column.ai

Figure 7-8. General Stratigraphic Column



Kern County Subbasin Groundwater Sustainability Plan	GEOLOGIC HISTORY PANELS
Source: Bartow OFR 87-581 SJV Cenozoic History, Figures 8, 10, 11, 12	APRIL 2024 TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\Figure 7-9 Geologic History Panels.ai

Figure 7-9. Geologic History Panels

During the Tertiary period, fluctuating sea levels within the marine embayment resulted in shifting of deposition between transgressive (rising sea levels) and regressive (lowering sea levels) marine depositional sequences. During a transgressive sequence, rising sea levels increase the deep marine areas which are characterized by fine-grained deposition that forms shales and siltstones. Along the sea margins, shallow marine conditions lead to a mixture of fine and coarse-grained deposition including the formation of sandstones. As sea levels rise the shallow marine areas become deeper water environments leading to the deposition of shales and silts overlying the sandstones. The general transgressive sequence then is referred as “fining-upward” sequence where a basal sandstone transitions to fine-grained clays and silts.

During a regressive sequence, the opposite occurs. Lowering sea levels decrease the deep marine areas. As sea levels decline, shallow marine environments shift to previously deep-water environments leading to the formation of sandstones overlying shales. Areas no longer covered by the ocean are subject to erosion, so that previously deposited sediments are again eroded and transported out to the marine areas. This erosion event leaves a gap in the stratigraphic record that is referred to as an unconformity. Physical and geochemical changes at the unconformity surface often led to unconformities becoming restriction to subsurface fluid flow with subsequent overlying sediments.

Marine deposition typically leads to sandstones being encased in fine-grained, low-permeability shales and siltstones. Most marine sedimentary rocks in the Subbasin contain saline connate water. This indicates that the water in these rocks is not receiving recharge but is hydraulically isolated. Except for areas where the marine rocks outcrop at the surface and receive freshwater recharge, the marine rocks are not considered as potential sources of groundwater for beneficial use.

Continental deposits that overlie the marine deposits provide the most productive freshwater aquifers in the Subbasin (Bertoldi and others 1991). The marine sediments with confined fresh water provide local areas of productive freshwater aquifers in the Subbasin. The isolated marine rocks with saline connate water are not considered as usable water sources because of their poor water quality and lack of recharge.

7.2.1.2 Geologic History Summary

A brief description of the evolution of valley sediments and fill is included below, as it relates to the regional aquifer system of the Tulare Lake Region of the San Joaquin Valley Basin. Figure 7-8 provides a generalized stratigraphic column of the variation in geologic units across the Subbasin. During the Paleozoic to the Mesozoic, the area of the Subbasin was a part of a great linear trough that received sediments along the western coast of North America. During the Cretaceous period, tectonic forces formed a series of mountain ranges (Bartow, 1991), the formation of the San Andreas Fault, and several northwest-trending faults, such as the White Wolf and Garlock Faults (Ingersoll and Busby, 1995; Wakabayashi and Sawyer, 2001; Galloway and Jones, 2005).

Throughout the Tertiary until Pliocene, a large part of the Subbasin was continuously inundated by the Pacific Ocean with marine sediments deposited across the entire valley. Sea levels declined due to the uplift of the Coast Ranges and the subsequent closure of marine outlets (Williamson et al., 1989). During this time, the San Joaquin Valley experienced a period of tectonic subsidence that led to the accumulation of several thousand feet of sedimentary deposits (Bartow, 1991; Galloway and Jones, 2005).

During the mid-Tertiary, uplift of basement sediments occurred near present-day Bakersfield forming what researchers have termed the Bakersfield Arch. The Arch effectively resulted in depocenters for thick sequences of sediment to accumulate to the north and south of the Kern River (Bartow, 1991; Vasconcellos, 2016) during later Tertiary and Quaternary time. Tertiary crustal uplift and shifting caused faulting to occur along the margin adjacent to the Sierra Nevada, Temblor, and Coast Ranges (Bartow, 1991). Crustal deformation associated with the San Andreas Fault system led to the intensive deformation of the western side of the Subbasin forming a series of linear anticlines (a type of fold that is an arch-like shape) and syncline (a type of fold that is a trough-like shape) that is referred to as the West Side Fold Belt.

Also, during the mid-Tertiary, normal faults along the east side of the valley are concentrated around the Bakersfield Arch. These faults are associated with a period of uplift of the Sierra Nevada. These faults generally trend northwest to north, although a secondary west to west-northwest trend is apparent. The net displacement is down to the southwest, although down-to-the-northeast faults are present (Bartow, 1984). One of the principal faults of this group is the Kern Gorge fault, along which basement rocks to the southwest have been down-dropped more than 1,000 feet. An important exception to the northwesterly fault trend is the Poso Creek fault that trends in a westerly direction through the Tertiary outcrop belt and then curves to the northwest to merge with the concealed Pond fault. In the southeastern Subbasin, the Edison fault is an older Tertiary normal fault with significant vertical displacement (Dibblee and Chesterman, 1953; Bartow, 1984).

During the period of marine inundation of the Subbasin, fluctuating sea levels led to successive transgressive-regressive sequences. These produced multiple sequences of marine sandstones along the Subbasin margin and interior structural highs that are generally encased in marine shales and siltstones. In the western areas and other areas of deep marine conditions during the time of deposition, the sequence is composed almost exclusively of shales and siltstones with only minor sandstone occurrences. There were a series of transgression-regression sequences that occurred, that include:

- Eocene Sequence

- Lower Oligocene Sequence
- Upper Oligocene Sequence
- Lower and Middle Miocene Sequence
- Middle and Upper Miocene Sequence
- Upper Miocene Sequence
- Pliocene and Pleistocene Sequence

During the Tertiary period, fluctuating sea levels were present within the marine embayment, resulting in sequences of transgressive and regressive, continental, and marine sediments. Bartow (1991) provides a series of paleogeographic maps that illustrate the geologic history of the San Joaquin Valley. Four of these are shown in Figure 7-9.

The upper Miocene, Pliocene, and Pleistocene sequence was initiated with transgression of the Etchegoin Formation over older Miocene units (Figure 7-9). Alluvial fans and deltas prograde basinward as abundant coarse detritus was delivered to the Subbasin from the rising Sierra Nevada on the east, the San Emigdio Mountains on the south, and eventually from the Coast Range on the west. Alluvial fan deposition began along the southeast margin of the Subbasin (the Kern River Formation) although there was no comparable event at that time in the northeast. The coarse clastic sediments of the Kern River may, then, be evidence that the accelerating late Cenozoic uplift of the Sierra Nevada began earlier at the southern end of the range.

The final marine regression of the ocean from the Subbasin was greatly accelerated through the Pliocene as progradation of coarse clastic sediments continued from all sides of the Subbasin, leading to the final retreat of the sea by about the end of Pliocene time (Figure 7-9). The stratigraphic sequence in the center of the southern San Joaquin basin records a gradual shallowing from shallow-marine shelf (Etchegoin Formation) through restrictive marine to brackish facies (San Joaquin Formation) and finally to fresh-water fluvial and lacustrine facies (Tulare Formation) in the late Pliocene to middle Pleistocene, even though the basin continued to subside and especially rapidly in the southern Subbasin. The San Joaquin and Tulare are conformable in the center of the Subbasin and both interfinger eastward with Kern River alluvial fan deposits, but an unconformity occurs at the base of the Tulare along the west and south margins of the Subbasin.

A contributing factor in the transition to a nonmarine basin in the late Pliocene was the progressive closing off the western outlet to the ocean due to folding and uplift in the Coast Ranges. The unconformity at the base of the Tulare Formation is due to continuing deformation of the western and southern Subbasin margin in response to San Andreas activity (Davis, 1983, 1986). The rapid subsidence of the southern Subbasin during the Pliocene and early Pleistocene, which was concurrent with the shallowing trend, was probably due to tectonic activity south of the basin margin.

By about the middle of the Pleistocene, the San Joaquin basin drainage outlet was closed or nearly closed, and the impounded drainage created a large lake (Frink and Kues, 1954). Disappearance of the "Corcoran Lake" (Figure 7-9) was likely caused by the establishment of the present Central Valley drainage outlet through the Carquinez Strait (Sarna-Wojcicki and others, 1985).

The Quaternary Period (Pleistocene and Holocene) marked a time when the seas retreated, and continental deposits were deposited (Tulare and Kern River Formations [Page, 1986]). These continental sediments consist of basin-fill fluvial and lake deposits of sand, gravel, and interbedded clays and silts (Williamson et al., 1989). Marine rocks eroded from the Coast Ranges are the primary source sediments for the Tulare Formation on the west, and the granitic rocks from the Sierra Nevada on the east are the source sedimentation for the Kern River Formation.

Page (1986) recognizes the differing depositional environments in the continental deposits. Alluvial fans are present on both sides of the valley, the western side differs significantly from the central and eastern parts of the Subbasin. Western Plio-Pleistocene deposits primarily originate from the weathering and erosion of the Coastal Range, consisting of marine deposits that yield clays, silts, and some sands. In contrast, the eastern side is characterized by quartzose and feldspathic coarser-sized sediments from the Sierra Nevada. On the eastern side of the valley, there are large, migratory stream channels that have created merging fans and broad sheets of inter-fingering, wedge-shaped lenses of sand, gravel, and finer sediment. Conversely, on the western side of the valley, marsh, lake, and floodplain environments are more prevalent, depositing much finer-grained sediment. In addition to structural distinctions, there are differences in the thickness of freshwater-bearing deposits and the sources of groundwater recharge between the western side and the central and eastern parts of the Subbasin. These differences result in more localized and restrictive groundwater systems with poorer water quality on the west side of the Subbasin.

Tectonism has played an important role in the Quaternary history of the San Joaquin basin. Closing of the valley's drainage outlet and continued uplift of the surrounding ranges that supply sediment to the alluvial basin are the consequences of tectonism, but the Quaternary sedimentary record reflects climatic controls more than tectonic. During that time, freshwater lakes formed in the San Joaquin Valley during interglacial periods during the Ice Ages, resulting in thick clay layers found throughout the Tulare Formation. In particular, the E-Clay, including the Corcoran Clay member, and its equivalents have been mapped over much of the San Joaquin Valley, including beneath the Kern and Buena Vista dry lake beds in the southern part of the Subbasin, as well as the Tulare Lake sediments north of the Subbasin (Croft 1972; Page, 1986).

These shallow continental water-bearing deposits make up the regional aquifer system. Paleo-lakes deposited thick beds of clay, which act as impermeable or semipermeable barriers that divide aquifer systems (Croft, 1972). Additionally, the deeper clay layers have been correlated in the western Subbasin which was still the depocenter during deposition of the lower Tulare Formation (Croft, 1972; Page, 1986).

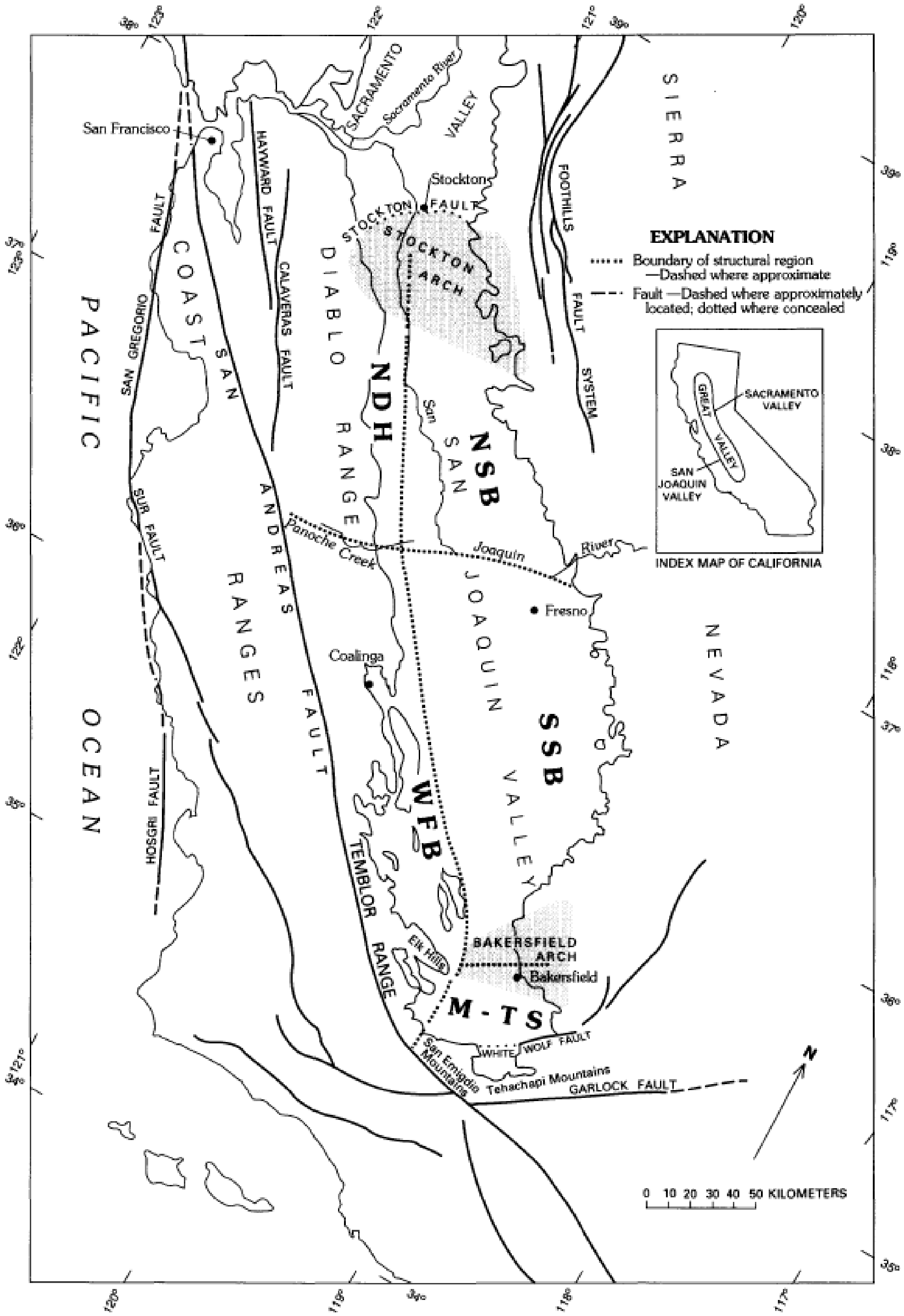
7.2.1.3 Structural Setting

Although the San Joaquin Valley, as the southern part of the Great Valley, constitutes part of a discrete geomorphic and structural province within the western Cordillera of North America, the geology is internally variable in both stratigraphy and style of deformation. To facilitate description of the structural geology, Bartow (1991) subdivided the San Joaquin Valley into five regions on the basis of structural style (Figure 7-10). Each region is structurally distinct in style of deformation and tectonic history. Of these, three are relevant to the Kern County Subbasin and include:

- Southern Sierran block (SSB)
- West-Side Fold Belt (WFB)
- Maricopa-Tejon structural region (M-T S)

The southern Sierran block comprises the southern part of the stable and little-deformed east limb of the San Joaquin Valley Syncline (Bartow, 1991). Its south boundary is the crest of the Bakersfield Arch, a broad southwest-plunging ridge of basement rock. Normal faults along the east side of the valley are concentrated around the Bakersfield Arch. These faults generally trend northwest to north, although a secondary west to west-northwest trend is apparent.

The west-side fold belt extends along the southwest side of the San Joaquin Valley Syncline south to the Elk Hills where the fold trends change from northwest to west (Bartow, 1991). The belt is characterized by a series of folds and faults that generally trend slightly oblique to the San Andreas fault located just outside the Subbasin on the southwest. The intensity of deformation increases southeastward along the fold belt as well as southwestward across the belt toward the San Andreas fault. The increased intensity is evidenced by tighter folds. The stratigraphy of the west-side fold belt is highly variable, as might be expected in a tectonically active area. Stratigraphic columns for three separate areas provide some indication of the variation. Middle Tertiary deposits representing some of the deepest potable water in the San Joaquin Basin are found in the southern Temblor Range (Bartow, 1991).



Kern County Subbasin
Groundwater Sustainability Plan

Source: Bartow_PP1501, Figure 1.

STRUCTURAL REGIONS OF THE SAN JOAQUIN VALLEY

APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\ Figure 7-9 Geologic History Panels.ai

Figure 7-10. Structural Regions of the San Joaquin Valley

The Maricopa-Tejon structural region is bounded by the Bakersfield Arch on the north, the San Emigdio Mountains on the south, the Tehachapi Mountains on the east, and the southeast end of the fold belt on the west. This region is the most deformed part of the Subbasin and has experienced extreme Neogene basin subsidence. The western part of the Maricopa-Tejon structural region is characterized by its great depth to basement. However, the Mesozoic and early Tertiary Great Valley sequence is apparently absent south of the Bakersfield Arch. The Tehachapi-San Emigdio Mountains uplift that bounds the valley on the south may be a transverse structure similar to the Transverse Ranges located southwest of the Subbasin (Bartow, 1991).

7.2.1.4 Regional Faults

The San Andreas Fault is a continental right-lateral strike-slip transform fault that extends roughly 750 miles through the California. It forms the tectonic boundary between the Pacific Plate and the North American Plate. The San Andreas runs generally parallel to the western Subbasin margin within the Coast Ranges. The San Andreas fault system is major part of the tectonic history that has resulted in the formation of the West-side fold belt. Figure 7-11 shows the locations of known faults in the Subbasin and adjacent areas.

The Garlock Fault is a left-lateral strike-slip fault running northeast–southwest along the north margins of the Mojave Desert of Southern California, for much of its length along the southern base of the Tehachapi Mountains for about 160 miles). The northeast-southwest trending White Wolf fault and the smaller Springs fault to the southeast both trend approximately parallel to the Garlock fault, which lies along the southeast side of the Tehachapi Mountains. Both faults, like the Garlock, show some geologic evidence of left-lateral movement. Farther northeast, the northwest-southeast to east-west trending Edison fault is an older Tertiary normal fault with down-to-the north offset of over 1500 ft (Dibblee and Chesterman, 1953; Bartow, 1984). The regional fault systems adjacent to the Subbasin play a crucial role in shaping its geological features. These fault systems, characterized by left-lateral movement and normal faulting, exert influence on the folding and surface structures within the Subbasin, which in turn, influences the direction of groundwater flow. Most of the faulting occurs within the eastern and southern margins of the Kern County Subbasin, associated with the tectonic history of the Sierra Nevada Mountains and Tehachapi and San Emigdio Mountains, respectively. The northeastern area of the Subbasin, covering the northern half of the Bakersfield Arch, has associated normal faulting that is prominent in older sedimentary layers but extends into and is concealed by younger sediments, particularly along the Pond-Poso Creek Fault. These faults exhibit varying orientations, ranging from northwest to northeast, owing to alternating compressional and extensional forces. The California Geological Survey (2010) identified several faults that affect groundwater flow within the Kern County Subbasin. Such faults include the Kern Front Fault, Edison Fault, Pond-

Poso Fault, Pond Fault, White Wolf Fault, Premier Fault, and the New Hope Fault (Figure 7-11).

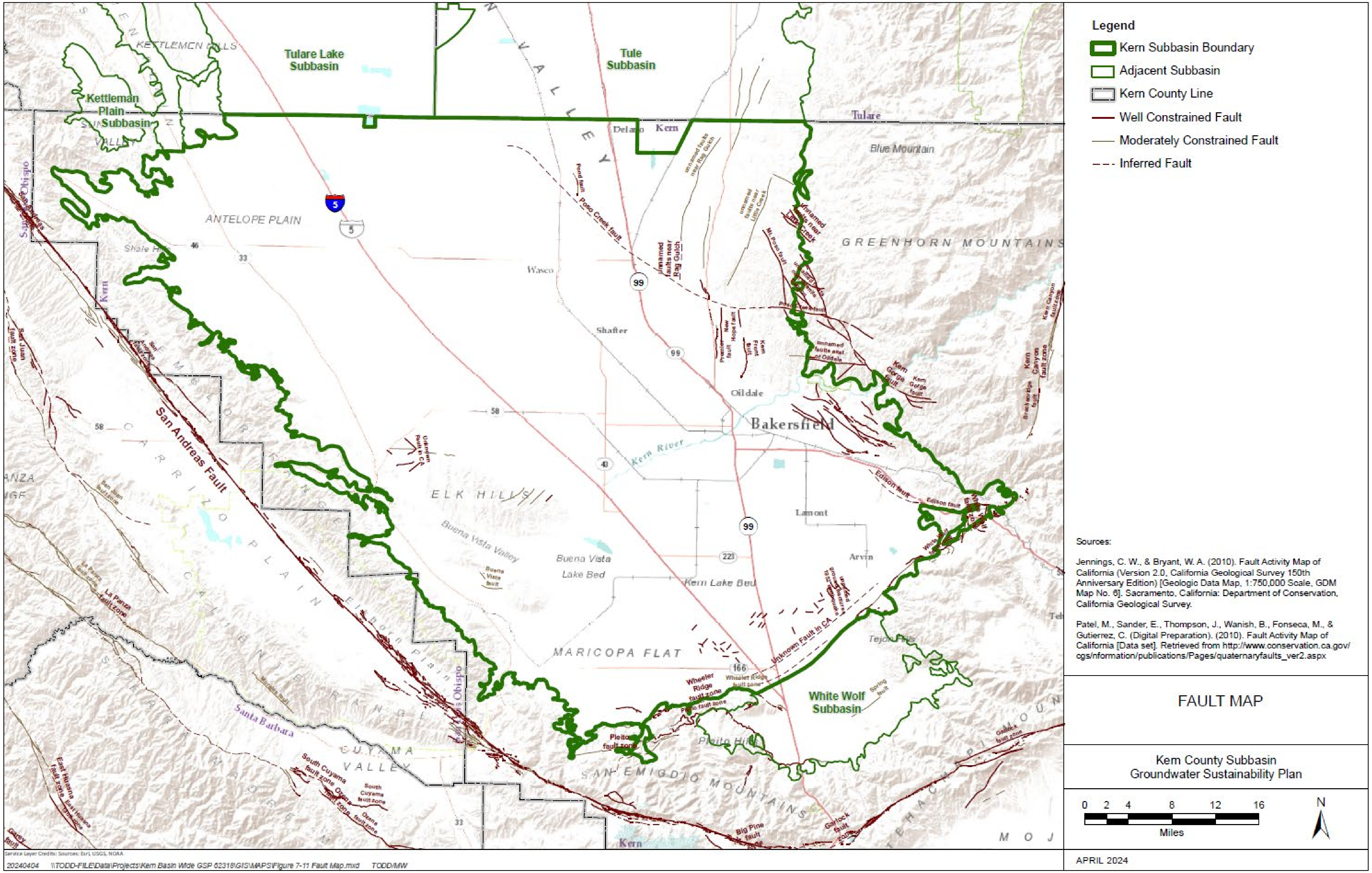


Figure 7-11. Fault Map

This page intentionally left blank.

7.2.1.5 Structural Folds

Figure 7-12 shows the locations of mapped geologic structures in the Subbasin and adjacent areas. The San Joaquin Valley Syncline, an extensive and asymmetric trough, has accumulated sedimentary deposits since the late Mesozoic era, naturally directing water flow in a northwest direction along its trend. The San Joaquin Valley Syncline is several thousands of feet deep. The east limb of the syncline is a little deformed with a generally regular slope across the valley from Sierra Nevada. The west limb of the syncline is very steep because of the deformation associated with the West Side Fold Belt.

In the south, the Maricopa-Tejon structural region (Bartow, 1991) is a highly deformed part of the Subbasin and that created a deep localized depositional basin (Bartow, 1991) during deposition of alluvial sediments. This area is characterized by its great depth to basement of up to 28,000 feet. Together, the San Joaquin Valley Syncline and Maricopa-Tejon structural region (Bartow, 1991) represent the areas with the greatest depth to basement in the Subbasin.

The Bakersfield Arch is a broad structural bowing on the east side of the southern San Joaquin Valley that plunges south-southwest across the Subbasin for about 16 miles where it ends near the Elk Hills. The Bakersfield Arch separates the Maricopa-Tejon structural region from the southern Sierran block. Normal faults along the Eastern Subbasin margin are concentrated primarily along the crest of the Bakersfield Arch which is the site of several major oil fields. The Bakersfield Arch has a low topographic profile but has appreciable structural relief (Bartow, 1991). The Bakersfield Arch is not a barrier to groundwater flow but does represent one part of the upgradient topographic high that allows water to flow from the Kern River. Groundwater recharged by the Kern River flows north and south along the Bakersfield Arch's flanks, moving away from the center of the Subbasin.

The West-Side Fold Belt (Bartow, 1991) features several major anticlines, such as the Lost Hills and Elk Hills (Bartow, 1991; Page, 1986). The Lost Hills structures are oriented toward the northwest, running semi-parallel to the Coast Range and the San Andreas Fault. Page (1986) and DWR (2006) have identified these anticlinal folds in the highlands, particularly the Lost Hills and Elk Hills, as constraints on groundwater flow within the lowlands, which likely applies to other anticlines in the Subbasin.

The Elk Hills Anticline is comprised of a broad, elongate, flat-topped arch with steep dips along its edge. The anticline is approximately 17-miles-long by 6-miles-wide, trending northwest to southeast. The Elk Hills rise to an elevation of over 1,550 feet (Woodring et al, 1932). The Lost Hills Anticline is the southern end member of a 60-mile-long fold of a SE-plunging anticline, which runs parallel to the San Andreas Fault to the west and formed due to related compressional tectonic activity. Specifically, the Lost Hills Anticline is an asymmetric anticline, approximately 20 miles long and 6 miles wide (Medwedeff, 1989).

Structurally, the greatest differences within the Subbasin are between the west-side fold belt and the little-deformed sedimentary cover of the Sierran block on the east-central parts of the valley. The Maricopa-Tejon structural region and west-side fold belt are considered the most highly deformed parts of the San Joaquin Valley with the most complex tectonic history (Bartow, 1991).

7.2.2 Geologic Units and Their Water-Bearing Properties

The Subbasin stratigraphy is described below. The stratigraphy is graphically summarized in Figure 7-13, which shows 6 stratigraphic columns that represent different geographic areas within the Subbasin. In this section, the geologic units are described in order of younger to older to represent their relative importance as groundwater aquifers. In the Subbasin, the younger units generally have the better water-bearing properties that form the more important groundwater aquifers whereas the older units generally have poorer water-bearing properties with limited to no groundwater use.

7.2.2.1 Unconsolidated Nonmarine Deposits (Pliocene to Holocene)

Continental deposits of Pliocene to Holocene age contain most of the freshwater in the Subbasin. The Tulare Formation and the Kern River Formation are moderately to high permeability units that form the most highly productive freshwater aquifer system within the Subbasin (Page, 1986). These deposits consist of the following geologic units:

- Recent Alluvium (Holocene)
- Kern River Formation (Pliocene to Pleistocene)
- Tulare Formation (Pliocene to Pleistocene)

The combined Recent Alluvium, Kern River Formation, and Tulare Formation form the major freshwater aquifer system within the Kern County Subbasin (Page, 1986). Figure 7-13 illustrates the variability of these formations across the Subbasin. The Recent Alluvium covers the underlying formations and can often be indistinguishable between the Kern River and Tulare Formation. The Recent Alluvium consists of alluvial and floodplain gravel, sand, silt, and clay. The floodplain deposits act as localized poorly permeable sand lenses (DWR, 2016). The deposits thicken towards the basin trough and taper to the western and eastern margins (Croft, 1972). The deposits thicken to over 400 feet. The Recent Alluvium has been observed to be loosely consolidated to cemented, which leads to moderate to high permeability (DWR, 2016).

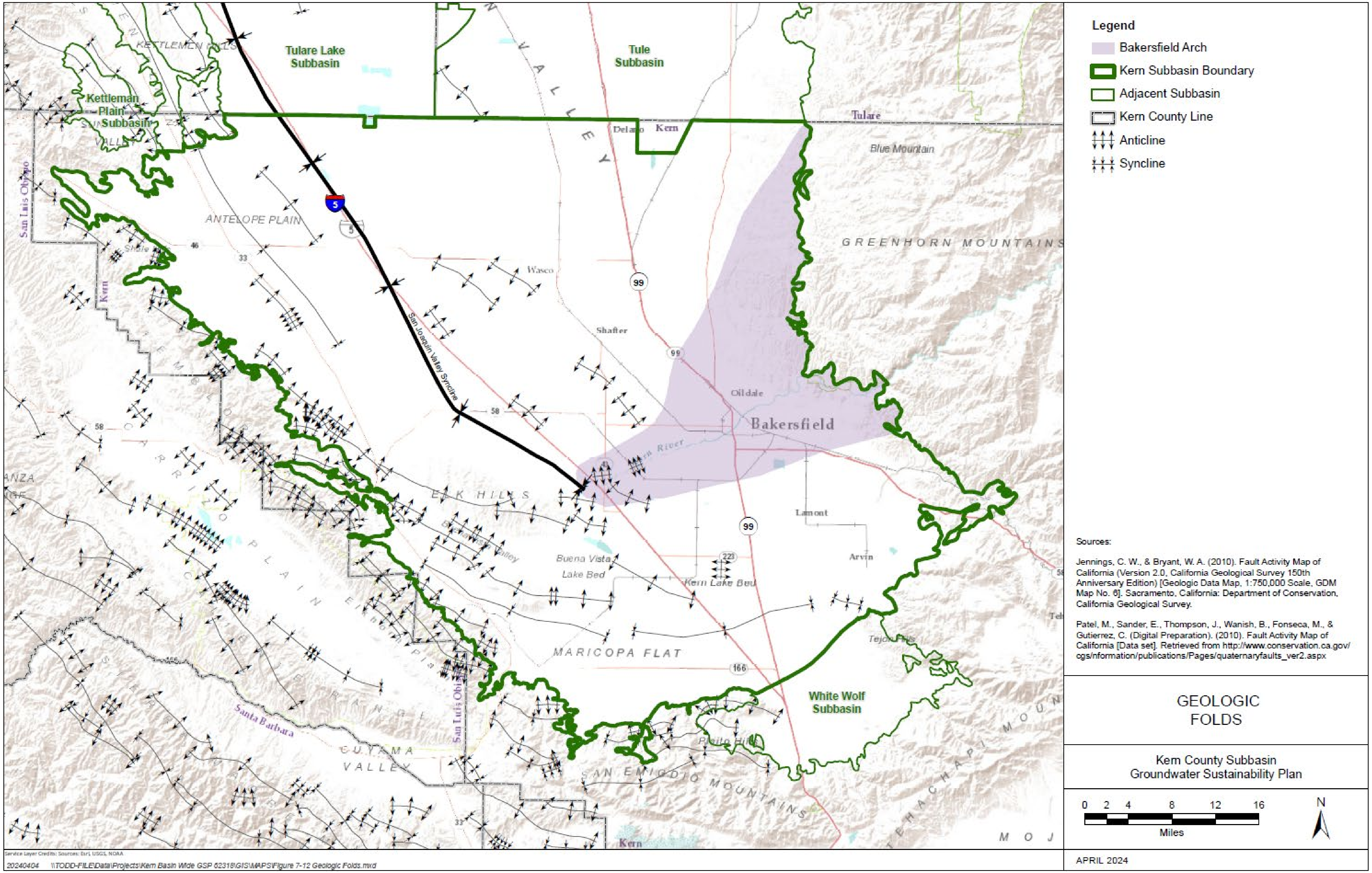


Figure 7-12. Geologic Folds

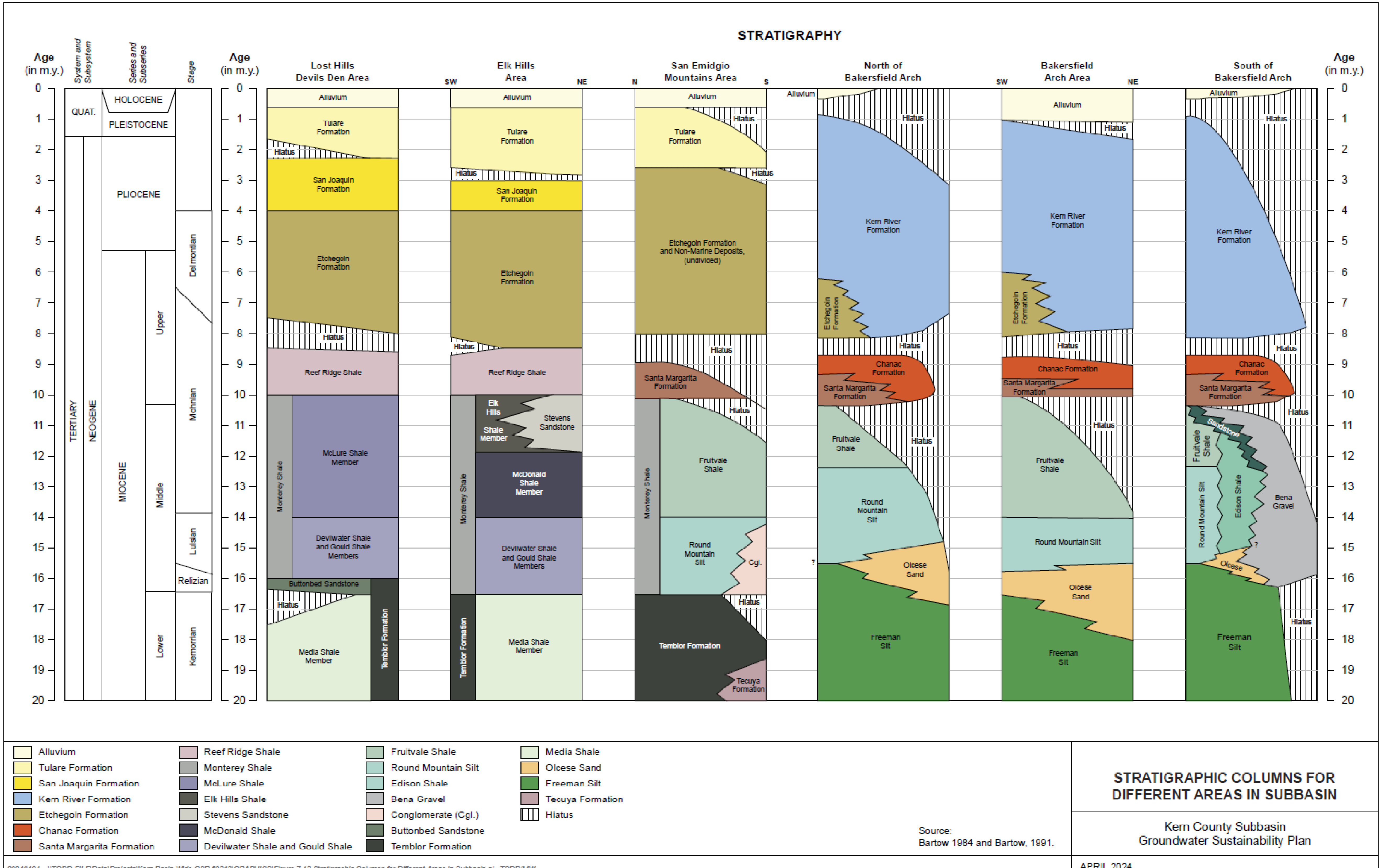


Figure 7-13. Stratigraphic Columns for Different Areas in Subbasin

The Kern River Formation is the youngest of the Tertiary formations and lies unconformably on the Chanac and Santa Margarita Formations in the east (Bartow and McDougall, 1984). The formation has been observed to range from 500 feet to over 2,000 feet below ground surface (Bartow and Pittman, 1983). The formation consists of poorly sorted, fluvial sandstone and conglomerate, with interbeds of mudstone and siltstone, with most of the sedimentation being sourced from the Sierra Nevada Mountain Range (Bartow and Pittman, 1983). The Kern River Formation lies conformably on the Etchegoin Formation. In the center of the Subbasin, the Kern River Formation inter-fingers with or grades into the San Joaquin, Etchegoin and Tulare Formations westward (Scheirer and Magoon, 2008). The Kern River Formation was deposited as an alluvial fan from east to west from the Sierra Nevada. The Etchegoin, San Joaquin, and Tulare Formations are time-equivalent deposits that represent different deposition environments across the Subbasin (Bartow and Pittman, 1983; Bartow, 1991).

The Tulare Formation is comprised of alternating beds of unconsolidated, lacustrine, and fluvial sand and mudstone deposits, with sedimentation sourcing from the Coast Ranges (Dale et al, 1966). The Tulare Formation can be split into Upper and Lower sections. The Upper Tulare Formation is a dominantly sandy alluvial fan and alluvial plain deposits whereas the Lower Tulare Formation is comprised mostly of lacustrine and deltaic deposits (Kiser et al, 1988). The separation between the Upper and Lower Tulare is generally aligned with the Middle Tulare Clay.

There are also lateral changes in the depositional setting changes throughout the Subbasin, with the Tulare Formation being deposited in a fluvial-lacustrine environment in the central Kern County Subbasin. Toward the west of the Subbasin, the Tulare Formation exhibits characteristics of a semi-arid to arid depositional environment, as evidenced by the presence of lacustrine claystone, fan-delta deposits, debris-dominated alluvial fan deposits, and prominently, paleosols (Nilsen and Campbell, 1996). The Tulare Formation has been observed to be over 2,200 feet in thickness.

Fine-grained, low-permeability flood-basin, lacustrine, and marsh deposits are widespread throughout the Kern County Subbasin. In the Western Fold Belt HCM Area, there are several clay layers that represent periods of large lake deposits being formed during interglacial periods during the Pleistocene ice ages (Croft, 1972). The Tulare Formation also features several major clay layers (Everett et al, 2020) that include the following:

- A-Clay
- C-Clay
- E-Clay (including the Corcoran Clay Member)
- Middle Tulare Clay
- Amnicola Clay

A major feature of the Pleistocene paleogeography was the formation of the Corcoran Lake (Figure 7-9) that covered large areas of the San Joaquin Valley for a brief interval near the middle of the Pleistocene (Bartow, 1991). Six clay tongues, representing deposits formed from this lake formed the southwestern San Joaquin Valley area. These are designated in descending order by the letters A through F (Croft, 1972). Of these, the A-, C- and E-clays are found in the Kern County Subbasin.

The Pleistocene Corcoran Lake (Figure 7-9) did not cover the entire Kern County Subbasin, but was primarily located in the areas along and east of the San Joaquin Valley Syncline that, during this time, formed the topographic low area, so more continuous clay deposits formed. To the east, the general upward slope towards the Sierra Nevada limited the distribution of clays due to fluctuating lake levels of the Pleistocene Corcoran Lake (Figure 7-9) during deposition. To the west, the rise of the Westside Fold Belt limited lake deposits to more prominent synclines.

The A-Clay, a blue to dark greenish gray, highly organic clay that is generally less than 60-feet-thick (Croft, 1972) is primarily found associated with the Buena Vista slough and the Tulare, Buena Vista, Kern and Goose Lake beds. The A-Clay is locally discontinuous and primarily acts as a shallow perching horizon. The overlying perched aquifer is comprised of Pleistocene-Holocene fluvial and flood plain silts, clays, and interbedded sands. Croft (1972) mapped the C-Clay to the northwestern corner of the Kern County Subbasin. The unit is described as a silty, calcareous, lacustrine clay deposit. The unit ranges in depths between surface outcrops to 300 feet and is rarely over 50-feet-thick.

The E-Clay (including the Corcoran Clay member) is a major geological horizon that has been mapped over a large area of the southern San Joaquin Basin.fi This report uses the modified E-Clay of Page (1986) which underlies a large portion of the west-central portion of the Subbasin. The Corcoran Clay is a commonly used term; however, it is defined as a distinctive diatomaceous clay bed near Tulare Lake (Frink and Kues, 1954; Davis and others, 1959). Both Croft (1972) and Page (1986) refer to the E-Clay as the extensive lacustrine clay that includes the Corcoran Clay Member of the Tulare Formation. The modified E-Clay (Page, 1986) uses a revised interpretation of the Croft (1974) E-Clay map in the southern part of the Subbasin that places the E-Clay from 100 to 300 feet above the depth that Croft mapped it. The E-Clay has gently folded into an asymmetric NW trending syncline, with a steepening flank to the west (Croft, 1972). Within the western portion of the Subbasin, the E-Clay ranges from 50 to 120 feet in thickness (Foss and Blaisdell, 1968).

Several different interpretations of the extent of the E-clay have been developed by the USGS and others (Croft 1972, Page 1983, 1986; PGA 1991). These generally agree in the areas where the E-Clay is prominent, but vary along the margins. The variability in the distribution of the E-Clay across the Kern County Subbasin has multiple causes.

East of the San Joaquin Valley Syncline, the E-Clay bifurcates into multiple layers that probably represents fluctuating lake levels of the Pleistocene Corcoran Lake (Figure 7-9) during deposition, thus making the margin of the E-Clay difficult to identify in these areas (Croft 1972, Bartow, 1991). In addition, the distribution of the E-Clay is influenced by the geologic structures present during deposition. The Bakersfield Arch formed a low-relief high area where the Kern River Alluvial Fan was being actively deposited. As a result, the E-Clay was either not deposited or was later removed by erosion in these areas. The E-Clay was originally deposited as an essentially flat layer; therefore, subsequent deformation is the result of the ongoing development of the Westside Fold Belt. As a result of this deformation, the E-Clay occurs at varying depths that are higher over the anticlines and lower within the synclines in the Subbasin (Bartow, 1991, Wood and Davis, 1959, Croft, 1972, Page, 1986).

Prior to the formation of the Corcoran Lake, several other regional clay layers were deposited in the western areas of the Subbasin. Gillespie, et al (2017) recognizes a distinct clay layer with a prominent high gamma-ray signature on geophysical logs and is identified as the Middle Tulare Clay (Kiser et al, 1988). Distinctive resistivity log patterns may indicate a transition from lacustrine delta environments in the lower Tulare Formation to a fluvial meander belt setting in the upper Tulare Formation, as suggested by Miller et al. (1990). It is found exclusively along the peripheries of the Elk Hills and Buena Vista anticlines, and exhibits an unusually significant thickness, exceeding several hundred feet beneath the Buena Vista lakebed in the southeast (Gillespie et al, 2022).

The Amnicola Clay is characterized as an olive gray claystone with partial calcareous/dolomitic composition, known to contain the gastropod Amnicola (Croft, 1972). The Amnicola Clay plays a significant role in the Elk Hills region as a local confining layer or aquitard. This unit safeguards fresh groundwater in the upper part of the Tulare Formation from degradation caused by saline oilfield produced waters injected into the lower part of the Tulare Formation, as documented by Crosby and Schymiczek (1990).

7.2.2.2 Plio-Pleistocene Marine Geologic Units

These deposits are primarily considered as confining units. In the eastern Subbasin, these units act as a confining layer that separates the continental deposits from the Santa Margarita Formation aquifer. Elsewhere these units form the base of the continental deposit aquifer. Some wells along the eastern margin of the Subbasin are perforated partially within the Etchegoin Formation unit but the contribution of groundwater is considered to be low (Lofgren and Klausing, 1969). Figure 7-13 shows the variability of these formations across the Subbasin. These units include:

- San Joquin Formation (Late Pliocene)
- Etchegoin Formation (Pliocene)

The San Joaquin Formation is comprised of blue to green, fossiliferous, fine-grained sands, silts and clays (Foss and Blaisdell, 1968). The San Joaquin Formation is only present in the western portion of the Kern County Subbasin, due to the westward retreat of the paleo-marine basin during the Pliocene (Scheirer and Magoon, 2008). The San Joaquin Formation is similar to the Etchegoin Formation and has a similar geometry to the underlying Etchegoin Formation. This similarity continues as the San Joaquin Formation transitions into the Kern River Formation toward the east.

Along the eastern margin of the Subbasin, the Etchegoin Formation is comprised of marine sandstone and micaceous shale (Foss and Blaisdell, 1968). The formation can be divided into two members: basal sandstone or the basal Macoma Claystone, and upper sandstone (Wagoner, 2009). The Etchegoin Formation is broadly distributed throughout the Kern County Subbasin and ranges in thickness from over 15 feet along the Subbasin margin to over 1,200 feet in the center of the Subbasin (Page, 1986; Scheirer and Magoon, 2008). The Etchegoin Formation is interpreted as a minor marine transgression and grades eastward into the Kern River Formation (Bartow and McDougall, 1984).

Miocene and Older Marine Geologic Units in Eastern Subbasin

The Miocene geologic units are primarily marine deposits that reflect the series of marine transgressive and regressive depositional environments that represent changing sea levels over geologic time. As a result, the general geology is a series of sandstone units situated between thick shale and siltstone layers. The sandstones are primarily deposited along the eastern margin of the Subbasin in the vicinity of the Bakersfield Arch. Toward the center of the Subbasin, these sandstones typically interfinger and grade into finer-grained shales and siltstones that are characteristic of a deeper water depositional setting. These units include:

- Chanac Formation (Late Miocene to Early Pliocene)
- Santa Margarita Formation (Late Miocene)
- Fruitvale Shale Formation (Middle to Late Miocene)
- Round Mountain Silt (Middle Miocene)
- Olcese Sand (Early Miocene)
- Freeman-Jewett Formation (Early Miocene)
- Vedder Sand (Oligocene)

Figure 7-13 shows the stratigraphic relationships of these formations across the Subbasin. The Chanac Formation is comprised of fossiliferous, brown nonmarine sandstone, deposited in a coastal plain meandering stream sequence (Link et al, 1990). Lower sections of the Chanac Formation have also been observed to be the lateral equivalent of the Santa Margarita Formation and can be considered different facies of the same depositional cycle. The Chanac Formation ranges in thickness from 100 to

1,000 feet (Bartow and McDougall, 1984) and is confined to the eastern margins of the Kern County Subbasin (Scheirer and Magoon, 2008).

The Santa Margarita Formation consists of an upper bed of a silty, well-sorted, fine-grained sandstone and a lower bed of a fossiliferous, micaceous sandy siltstone, both of which were deposited in a shallow-marine environment. The Santa Margarita Formation ranges in thickness from 200 to 600 feet (DWR, 2016). The Santa Margarita Formation is most prominent in the east of the Subbasin. Towards the center of the Subbasin, the Santa Margarita Formation is faulted, inter-fingers and grades into the Fruitvale Shale (Bartow and McDougall, 1984). The Santa Margarita Formation is highly permeable and can be used as a stratigraphic marker (Croft, 1972).

The upper sandstone bed of the Santa Margarita Formation acts as a source of fresh water in the northeast of the Kern County Subbasin (DWR, 2016). Most of the marine sediments in the Subbasin contain highly saline, connate water. The Santa Margarita Formation and Olcese Sand outcrop along the eastern margin of the Subbasin or the surrounding watershed and so are recharged by freshwater from the surface. This process over time has flushed the original saline connate water with freshwater.

The Fruitvale Shale consists of poorly sorted, marine carbonaceous silt that thins out to the east and west margins of the Subbasin but thickens in the center. Toward the west, the shale unit grades into the Antelope Shale (Bartow and McDougall, 1984). This unit rests conformably on the Round Mountain Silt and underneath the Santa Margarita Formation (Scheirer and Magoon, 2008).

The Round Mountain Silt is a unit comprised of poorly consolidated diatomite, laminated siltstone, and micaceous sandstone and conformably overlies the Olcese Sand and the Freeman-Jewett Formation. The Round Mountain Silt ranges in thickness up to 200 feet (Page, 1986). The formation is present in the east and center of the basin, but inter-fingers with the Monterey Formation to the west (Bartow and McDougall, 1984). The Fruitvale Shale and Round Mountain Silt act as an aquitard, which confines the Olcese Sand, and as a barrier between the Santa Margarita Formation (Reynolds, 1955).

The Olcese Sand is comprised of medium to coarse-grained, poorly cemented, shallow marine shelf sandstone with interbedded siltstone and conglomerate and has been observed to be over 600 feet in thickness (Page, 1986). The Olcese Sand is thickest in the eastern Subbasin margins, where it is near the surface. Toward the west the unit plunges downward and pinches out (Prothero, et al. 2008). Toward the center of the Subbasin, the unit inter-tongues with the underlying Freeman Silt and overlying Round Mountain Silt (Scheirer and Magoon, 2008). The Olcese Sand is a source of fresh water in eastern and northeastern areas of the Subbasin but is utilized primarily in the Kern River Canyon area and northeast Subbasin areas (DWR, 2016).

The Freeman-Jewett Formation consists of two components: the Jewett Sand and the Freeman Silt. The Jewett Sand is a unit of silty sand to sandy shale that unconformably overlies the Vedder Sand or Walker Formation. The Freeman Silt is a siltstone unit that gradationally overlies or inter-tongues the overlying Jewitt Sand. The Silt member acts as an effective groundwater flow barrier (Reynolds, 1955). Toward the east of the Subbasin, the Jewett Sand thickens, however toward the west the Jewett Sand eventually changes into siltstone and thins out, while the Freeman Silt thickens in the west. There are also minor units that lay conformably under the Freeman-Jewett Formation. In the east the Jewett Sand is locally underlain by the Pyramid Hill Sand Member, and in the center of the Subbasin, the Freeman Silt is locally underlain by the Rio Bravo Sand. Toward the center and west of the Subbasin, these two units thin out and are not observed (Bartow and McDougall, 1984).

The Vedder Sand consists of well-sorted, fine to medium-grained sandstone, with localized silica cement. The formation can reach up to 1,000 feet in thickness. The Vedder Sand lies conformably over the Walker Formation and in some areas is laterally equivalent to the upper sections of the Walker Formation (Bartow and McDougall, 1984). Along the eastern and southeast margins of the Subbasin, the Vedder Sand, and the thin, overlying Pyramid Hills Sand Member, may produce fresh groundwater (Page, 1986). The Vedder Sand is unconformably overlain by the Freeman-Jewett Formation north of the Bakersfield Arch. To the south of the Arch, the contact can be observed as conformable (Scheirer and Magoon, 2008).

7.2.2.3 Miocene and Older Nonmarine Units in the Eastern Subbasin

Along the eastern margin of the Subbasin, older nonmarine sedimentary rocks exist. These are generally very coarse grained and are considered to represent rapid erosion during a period of uplift of the Sierra Nevada. These units include:

- Bena Gravel (Miocene)
- Bealville Fanglomerate (late Oligocene and early Miocene)
- Walker Formation (Eocene and early Miocene)

Figure 7-13 illustrates the stratigraphic relationships of these formations across the Subbasin. The Bena Gravel and Bealville Fanglomerate are restricted to a relatively small area in the vicinity of Caliente Creek south of the Kern River (Bartow and McDougall, 1984). The Bealville Fanglomerate is an unsorted granitic rubble that unconformably overlies granitic basement and inter-tongues westward with the Walker Formation. The Bealville Fanglomerate is more than 6,000 feet thick (Dibblee and Chesterman, 1953). It is overlain by the Bena Gravel, which consists of a series of nonmarine gravels that overlie the Walker formation. The Bena Gravel is described as a pebble-cobble conglomerate with interbeds of coarse-grained sandstone that are up to 2,000 feet thick. These two units have greater thicknesses than other units in the area because they are filling the structural basin created by displacement along the Edison

Fault. The Bena Gravel grades laterally into the marine Olcese Sand, Round Mountain Silt, and Edison Shale.

The Walker Formation is the base unit of the Tertiary sequence within the Kern County Subbasin. The Walker Formation is comprised of non-marine clayey sandstone, siltstone, and claystone, which overlie the basement complex along the eastern margin of the Subbasin. The Walker Formation is the nonmarine equivalent of the Vedder Sand, the Freeman-Jewett Formation and the Bealville Fanglomerate. Towards the west, the Walker Formation grades into the lower sections of the Kreyenhagen Formation, which represents a transition from nonmarine to marine depositional setting (Bartow and McDougall, 1984). The Walker Formation is generally poorly permeable and yields small amounts of water, with the quality of the groundwater decreasing with depth and becoming more brackish to mineralized (Hilton et al, 1963).

7.2.2.4 Miocene and Older Marine Geologic Units in Western Subbasin

The older sedimentary layers in the Subbasin reflect marine transgressive and regressive deposition cycles with extensive deposition of fine-grained clay in the deep marine locations (Bandy and Arnal, 1969). Figure 7-8 and Figure 7-13 illustrate the stratigraphic relationships of these formations across the Subbasin. As a result, the general geology is for a series of shale units that may contain localized sand units. The fine-grained geology has generally trapped the original connate water and these units are not considered as usable groundwater aquifers but are part of the sedimentary sequence within the Subbasin. These units include:

- Reef Ridge Formation (Late Miocene to Early Pliocene)
- Monterey Formation (Middle to Late Miocene)
- Temblor Formation (Oligocene to Middle Miocene)
- Tumey Formation (Oligocene)
- Kreyenhagen Formation (Middle to Late Eocene)

The Reef Ridge Formation consists of marine blue shale to brown sandy claystone with thin limestone beds, with occasional sandstone bodies (Foss and Blaisdell, 1968). The formation is thickest in the west of the Subbasin and grading eastward into the Chanac Formation (Scheirer and Magoon, 2008).

The Monterey Formation is comprised of three members of marine origin: Devilwater-Gould Member, McDonald Shale Member and the Antelope Shale Member. The formation is present in the west and grades into the eastern Round Mountain, Fruitvale, and Santa Margarita Formations to the east (Scheirer and Magoon, 2008; Foss and Blaisdell, 1968).

The Temblor Formation is comprised of Cymric Shale, Wygal Shale, Santos Shale, Carneros Sandstone, Media Shale, and Buttonbed Sandstone (Scheirer and Magoon, 2008). This formation is present in the west and is chronologically comparable with the

Vedder, Freeman-Jewett, and Olcese Formations to the east, but the Temblor Formation does not share sediment sources with the eastern equivalents, so it is considered lithologically distinct (Johnson and Graham, 2008).

The Tumey Formation, also locally known as the Wagonwheel Formation, consists of a deep marine, fine grained sandstone, with a massive 500-foot thick basal turbidite sandstone member representing deep water deposition. The unit has been measured to be over 1,200 feet in total thickness and has an unconformable base and top surface (Lillis and Magoon, 2008; Johnson and Graham, 2008).

The Kreyenhagen Formation contains four members: Kreyenhagen Shale (Welcome Shale Member), Canoas Siltstone, Points of Rocks Sandstone, and the Domengine Member (Scheirer and Magoon, 2008). The formation is comprised of dark brown to medium gray fissile, fossiliferous, marine shales, siltstones and some limestones and sandstones (Foss and Blaisdell, 1968). The Kreyenhagen Formation appears in the east but is most prominent in the western margins of the Subbasin and thins toward the Sierra Nevada Mountain Range. In the west, the formation thickens and is highly folded and uplifted (Bartow and McDougall, 1984).

Basement Rocks

The basement complex of pre-Tertiary age exposed throughout the southern Sierra Nevada, Tehachapi, and San Emigdio Mountains and buried beneath deposits of Tertiary and Quaternary age in the San Joaquin Valley. These margins are comprised of igneous and metamorphic rocks, which make up much of the Sierra Nevada, Tehachapi, and Southern Coast Ranges (Lofgren and Klausing, 1969). The basement complex underlies the Subbasin sedimentary rocks and sediments at depths that range to over 20,000 feet in the deepest parts of the Subbasin (Page, 1986).

The basement complex has relatively very low permeability and is generally located outside the valley's agricultural and urban areas, the rocks of the basement complex are a source of groundwater supply that is limited to small-scale domestic and stock uses in areas outside of the Subbasin (Hilton et al, 1963; Croft, 1972). In the surrounding watersheds along the Subbasin margins, fractures and deeply weathered zones in the basement complex may discharge water to streams that flow onto the valley floor (Wood and Dale, 1964).

7.3 Cross Sections

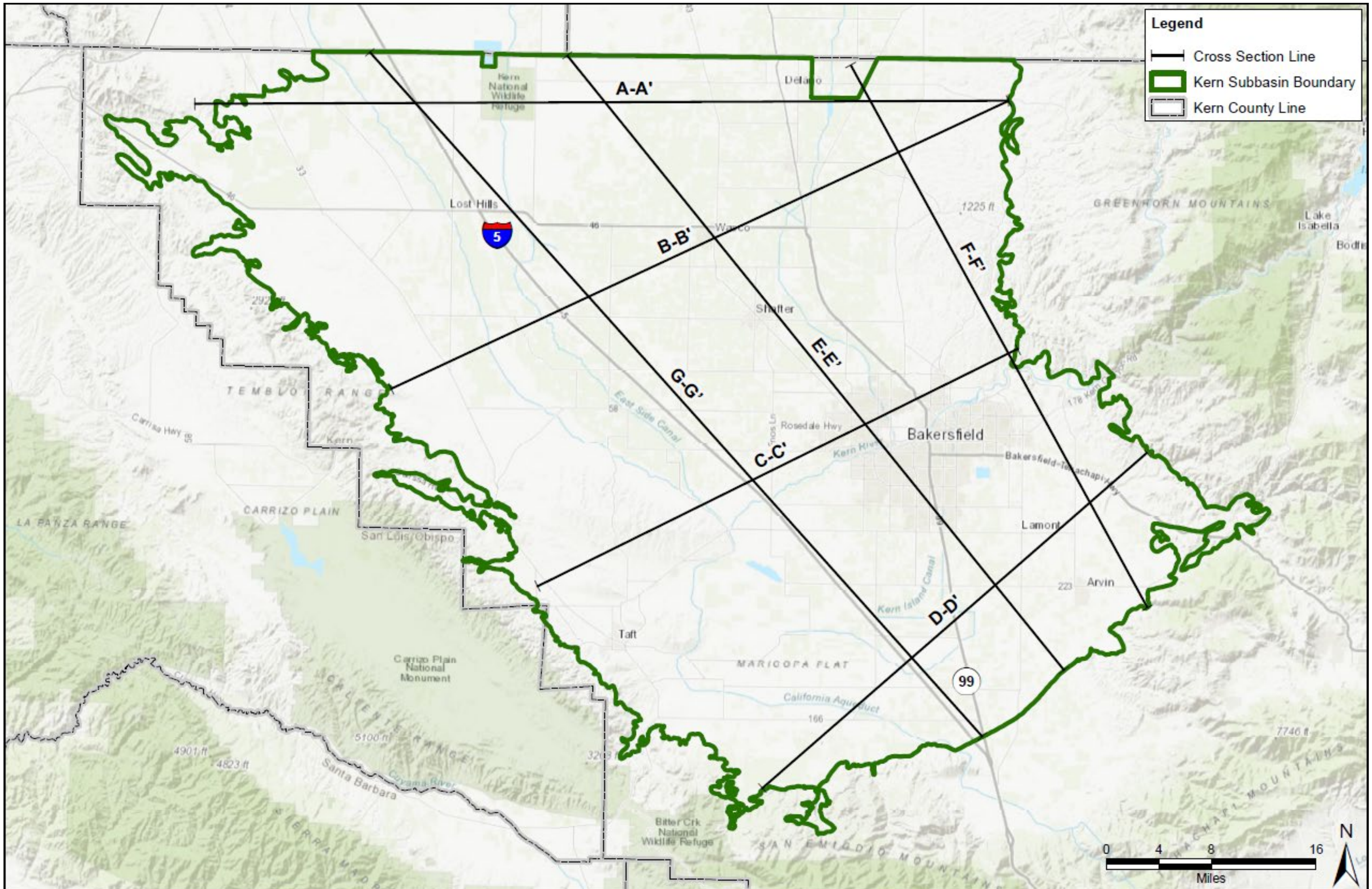
> *§ 354.14. Hydrogeologic Conceptual Model*
> *(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.*

☑ **23 CCR § 354.14(c)**

7.3.1 Regional Cross Sections

A series of seven hydrogeologic cross-sections were developed to illustrate the regional hydrostratigraphy across the Subbasin. A map displaying the orientation of the cross sections is provided in Figure 7-14. The cross sections for the Kern County Subbasin are provided in Figure 7-15 through Figure 7-21. The cross-sections extend laterally across the Subbasin in either a general north-south or east-west orientation and extend vertically down to an elevation of -6,000 feet. As such, the cross-sections include the entire thickness of aquifer materials that are or could reasonably be tapped for groundwater supply purposes.

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	CROSS SECTION LOCATIONS
Sources:	APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GIS\MAPS\ Figure 7-14 Cross Section Locations.mxd - 20240404

Figure 7-14. Cross Section Locations

This page intentionally left blank.

Cross Section Descriptions

Cross section A-A' (Figure 7-15) trends from the west to the east across the northern margin of the Subbasin. The section is comprised at the surface of Recent Alluvium and Tulare/Kern River Formation (shown as Undifferentiated Alluvium) to the top of the E-Clay or its equivalent. Below the E-Clay is a significantly thicker sequence of Tulare/Kern River Formation, ranging from 200 feet to 4,000 feet in thickness. This unit thins in the west, with a steep dip toward the center of the Subbasin. The unit gradually slopes up toward the east and crops out at the surface as the Kern River Formation. The E-Clay, Tulare Clay, and Amnicola Clay are all present and exhibit varying thicknesses ranging from 0 feet to over 50 feet. These clays are thickest in the west and central areas but pinch out toward the eastern and western margins. Below the Tulare/Kern River Formation lie the Plio-Pleistocene Sedimentary units (Etchegoin, Chanac and San Joaquin Formations), which range up to of 800 feet in thickness in the center of the Subbasin but pinch out in the east. The Santa Margarita Formation, Round Mountain Silt and Olcese Sand are shown separately in the east with a relatively steep dip toward the east that eventually outcrop at the surface. To the west, these formations grade into other more fine-grained units (Undifferentiated Miocene and Older Sediments) with thicknesses varying from less than 200 feet, up to 800 feet in thickness.

Cross section B-B' (Figure 7-16) begins in the foothills of the Temblor Range in the west and trends in a northeasterly direction toward the northeast corner of the Kern County Subbasin. The thickness of the Undifferentiated Alluvium is relatively uniform across the section; however, it does pinch out toward the eastern margin. The underlying Tulare and Kern River Formations range in thickness from 0 feet, outcropping to the surface and pinching out in the east, to 2,500 feet, being influenced by a subsurface syncline and anticlinal structure. The E-Clay is present in most of the section but pinches out in the eastern and western flanks. The Tulare Clay and Amnicola Clay exhibit varying thicknesses and both pinch out at the western margin. Both clays are thicker in the center of the section, up to 250 feet. The Amnicola Clay is only present in the west and pinches out eastward whereas the Tulare clay has a larger lateral extent. The underlying Plio-Miocene Sediments are thicker on the western flanks and Subbasin center, but thin and pinch out toward the east. This unit overlies the Santa Margarita Formation, Round Mountain Silt and Olcese Sand, which are only present in the east and dip steeply toward the east. These units range in thicknesses between 200 feet to 1,000 feet, with the Round Mountain Silt having a considerable thickness

Cross section C-C' (Figure 7-17) begins in the west of the Kern County Subbasin and trends in a west to east direction toward the central eastern boundary of the Subbasin. Undifferentiated Alluvium is present over most of the Subbasin where it overlies the Tulare and Kern River Formations but pinches out toward the eastern foothills. In the west, the Tulare Formation is variable in thickness due to the intense folding in the west.

A series of anticline and syncline structures can be observed in the Tulare Formation whereas the Kern River Formation has a gentle dip from east to west across the Subbasin. The Kern River Formation outcrops along the eastern margin. The -Tulare and Amnicola Clay exhibit varying thicknesses in the west due to the folding; however, they pinch out and are not present in the east. The E-Clay is considered to be absent along this section due to influence of the Bakersfield Arch and West Side Fold Belt during deposition (see Section 7.1.7). The Plio--Pleistocene sediments are highly variable, due to intense folding and a large depocenter in the east, with thicknesses ranging from 1,500 to over 4,000 feet. This formation, however, dips towards the eastern flank and pinches out. In the east, the Chanac, Santa Margarita, Round Mountain Silt and Olcese Sand are present. They are steeply dipping and grade into the Miocene and Older Sediments. They range in thickness from 50 to 1,000 feet.

Cross section D-D’ (Figure 7-18) runs parallel to the southern Kern County Subbasin boundary, beginning in the west and terminating in the east, trending in a southwest to southeast direction. The Undifferentiated Alluvium remains a relative constant thickness but pinches out in the east where the Kern River Formation outcrops at the surface. The Tulare and Kern River Formations reach their greatest thicknesses in the south along the section. These formations pinch out in the west and east but reach thicknesses of over 6,000 feet in the center of the section. The E-Clay, Tulare Clay and Amnicola Clay are present within the section. All the clays are thickest in the western portion of the section, on the dipping western flank of the Subbasin axis, while the clays eventually pinch out to the east. The underlying Plio-Pleistocene sediments follow the same trend, and the maximum thickness is over 6,500 feet. The Plio-Pleistocene sediments onlap onto the underlying, easterly dipping Chanac and Santa Margarita Formations, which grade into the underlying Miocene and Older Sediments. In the east, the Chanac and Santa Margarita Formations are upthrown by the Edison Fault. On the eastern side of the fault the Chanac, Santa Margarita, Round Mountain Silt and Olcese Sand are present, which dip steeply toward the east. Most notably, the Olcese Sand thickens to over 2,500 feet.

Cross section E-E’ (Figure 7-19) extends from the northern boundary to the southern boundary, in a northwest to southeast orientation in the center of the Subbasin. The section is comprised of a moderately uniform undifferentiated alluvium layer, which grades into the Tulare and Kern River Formations. The Tulare and Kern River Formations remain at a relatively constant thickness, until reaching the southern end of the section. Here they rise over the Bakersfield Arch and reach their greatest thickness in the Maricopa-Tejon Structural Region (Bartow, 1991) in the south where the thickness varies between 1,800 to 6,000 feet. The Amnicola Clay is only present in the south with a thickness of up to 50 feet whereas the Tulare Clay is present though most of the section with thicknesses of up to 100 feet. The E-Clay is present in the northern and southern areas, where it exhibits a thickness of up to 200 feet, but pinches out in the middle over the Bakersfield Arch. The underlying Plio-Pleistocene sediments follow the structural trend with a thickness of around 3,500 feet.

Cross section F-F’ (Figure 7-20) starts in the northeast corner of the Kern County Subbasin, then trends in a northwest to southeasterly direction to the southeastern corner of the Subbasin. The surficial undifferentiated alluvium is only present in pockets of topographic lows in the eastern and western flanks of the section. The Kern River Formation is the most dominant surficial unit and varies in thickness between 1,000 feet in the north, 200 feet in the center and to 3,000 feet in the east. The E-Clay is generally absent in the east except for a small area below the undifferentiated alluvium at the southern end of the section. The underlying Chanac Formation, Santa Margarita Formation, Round Mountain Silt and Olcese Sand are heavily faulted and folded in this section, the Poso, China Grade and Edison Faults displace these units and create a disjointed lateral continuity. These units exhibit thicknesses of 400 feet, thinning on the crest of a subsurface anticline, and thickens to over 1,000 feet on the eastern margins.

Cross section G-G’ (Figure 7-21) starts in the northwest corner of the Kern County Subbasin, and trends from northwest to southeast across the west central portion of the Subbasin. This area consists of some of the deepest portions of the Subbasin that lies along the San Joaquin Syncline in the north and extends into the Maricopa-Tejon Structural Region (Bartow, 1991) in the south. The underlying Tulare Formation varies in thickness from about 2,000 feet at the Bakersfield Arch to over 6,500 feet in the southern Subbasin. The E-Clay, Tulare Clay and Amnicola Clay are present but are not continuous across this section. The E-Clay varies in thickness but pinches out toward the south. The Tulare Clay is segmented but exhibits considerable thicknesses of up to 150 feet. The Amnicola Clay is also present but thins towards the anticline and pinches out to the east. The Plio--Pleistocene sediments reach thicknesses of over 11,000 feet and thin to 5,000 feet over the Bakersfield Arch.

This page intentionally left blank.

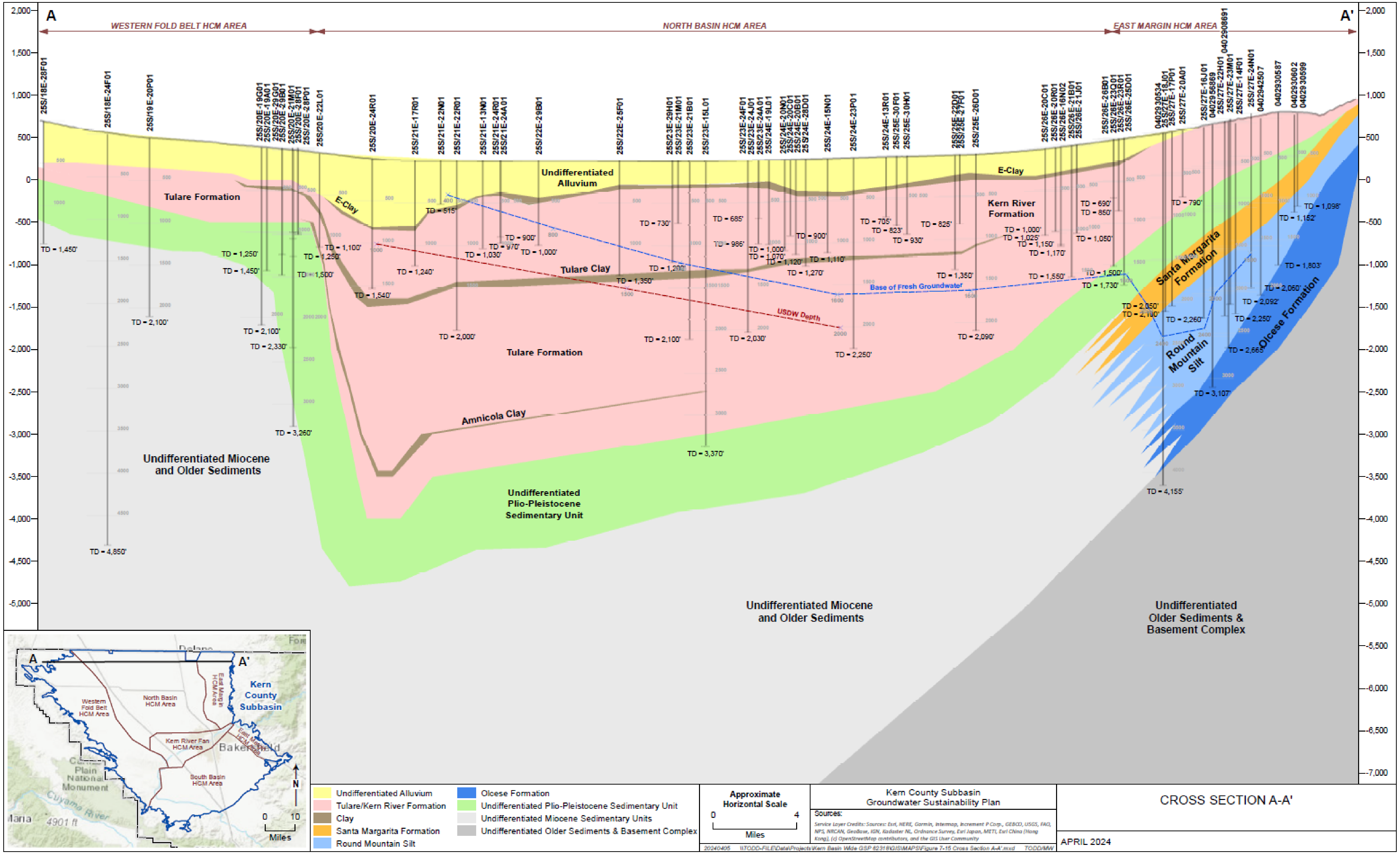


Figure 7-15. Cross Section A-A'

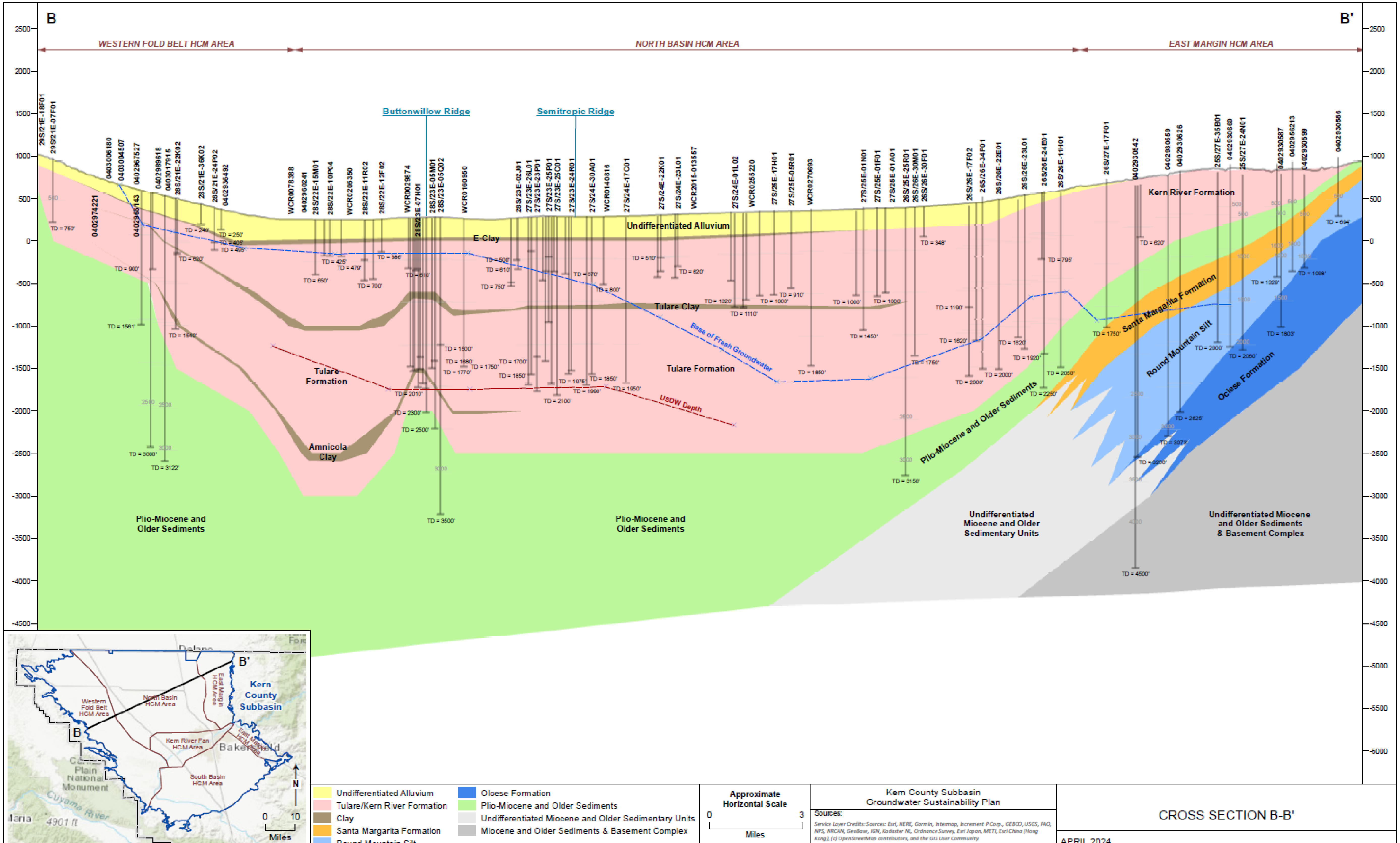


Figure 7-16. Cross Section B-B'

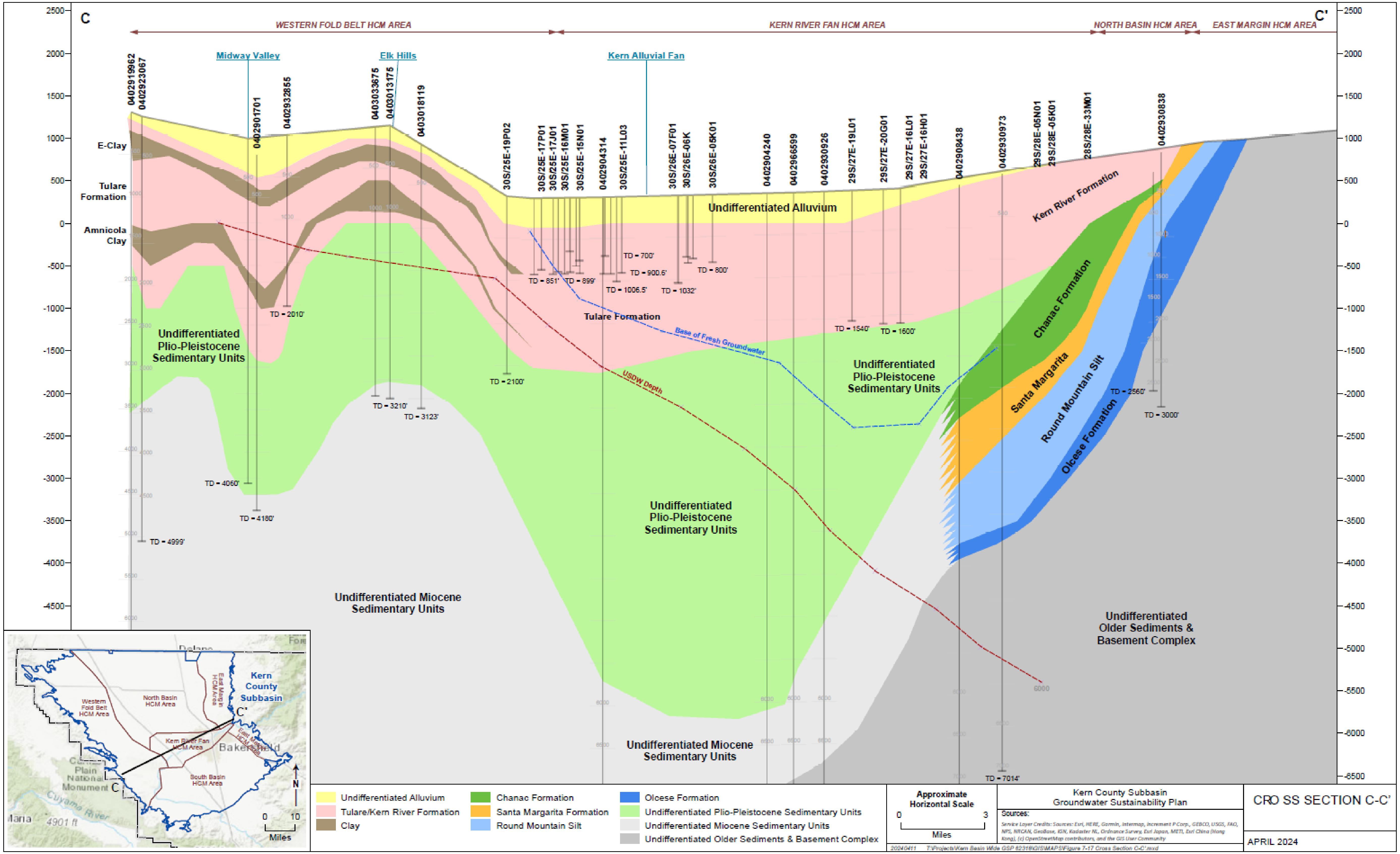


Figure 7-17. Cross Section C-C'

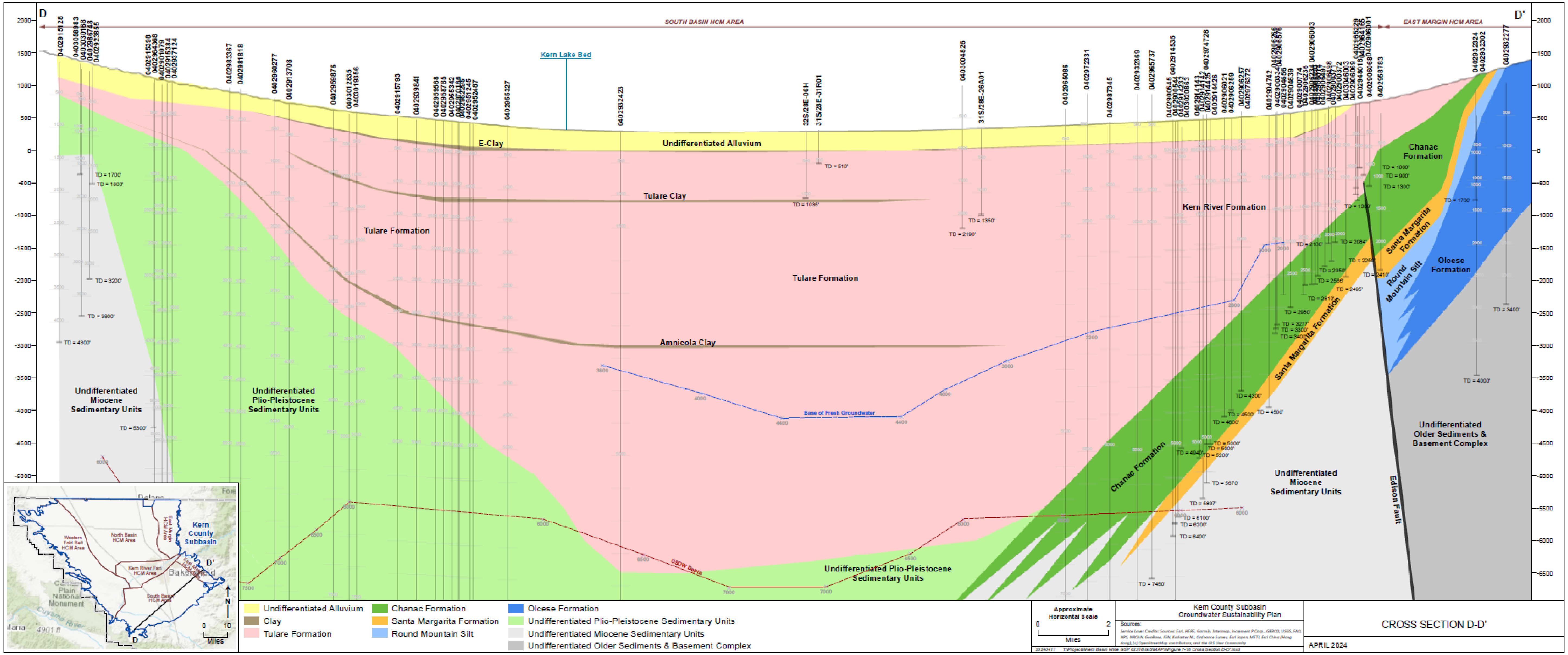


Figure 7-18. Cross Section D-D'

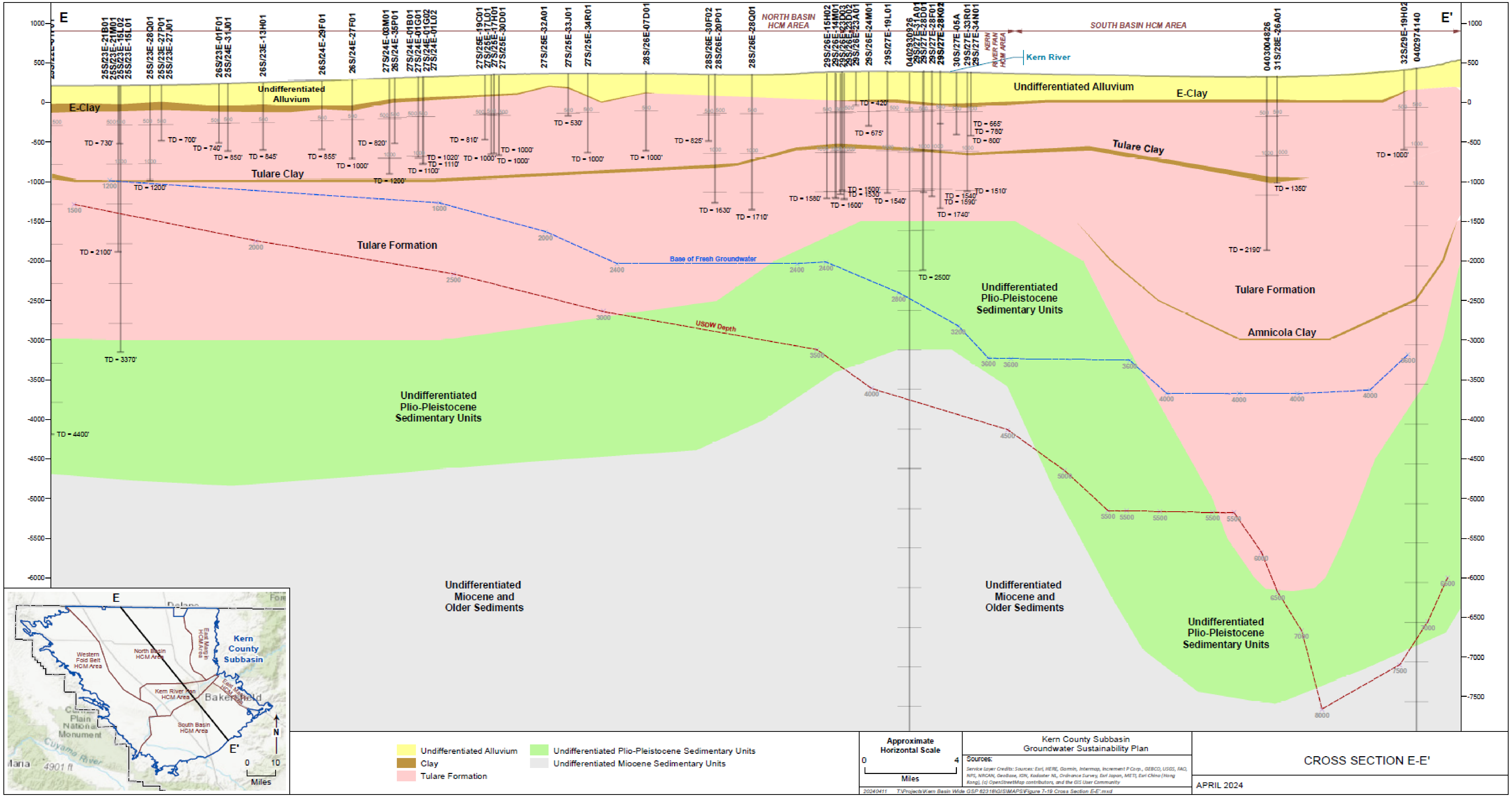


Figure 7-19. Cross Section E-E'

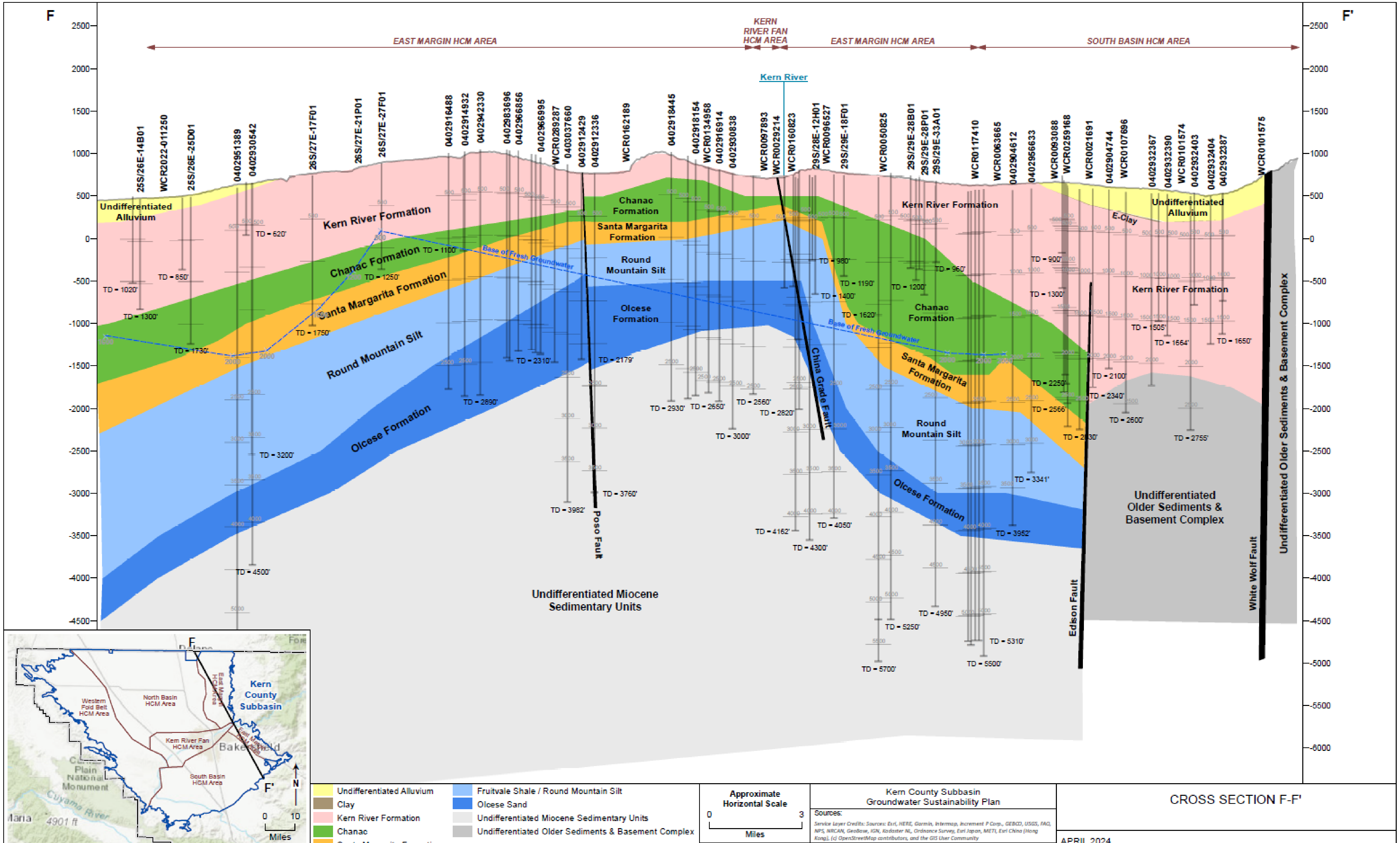


Figure 7-20. Cross Section F-F'

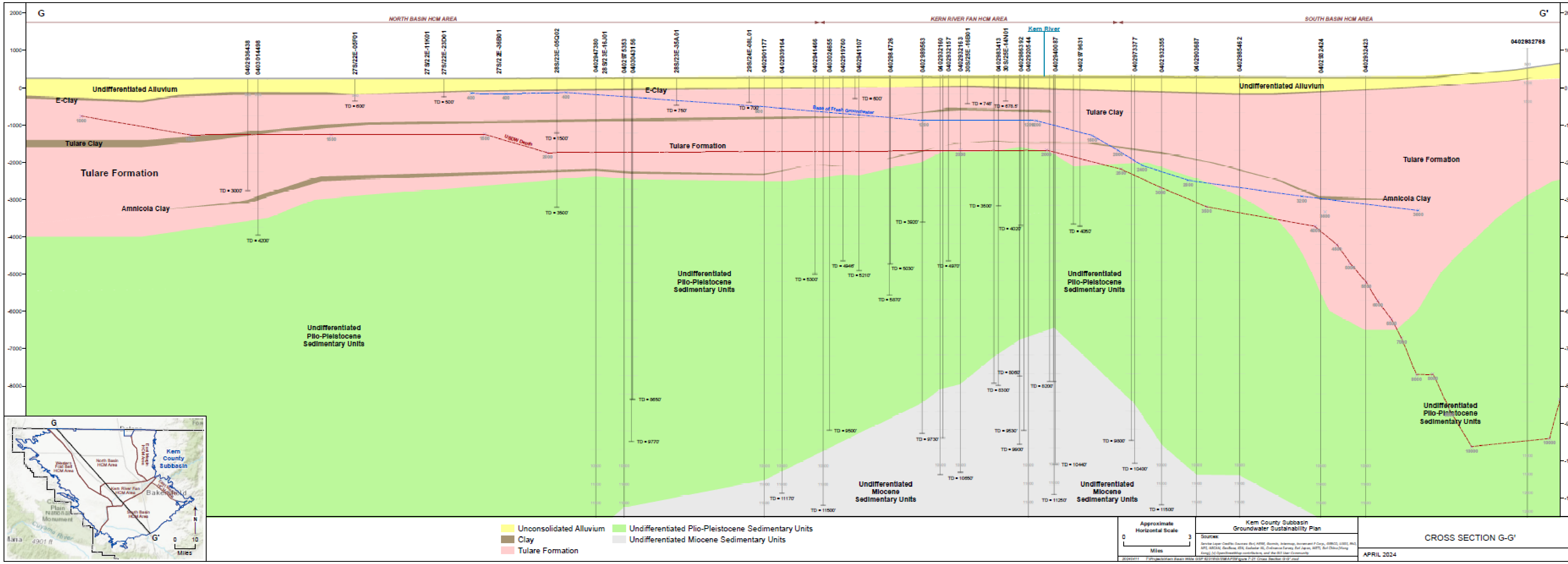


Figure 7-21. Cross Section G-G'

This page intentionally left blank.

7.3.1.1 Geologic Observations

These cross sections illustrate the distribution of the Unconsolidated Nonmarine Deposits, consisting of the Recent Alluvium, Tulare, and Kern River Formations, which form the upper sequence within the Subbasin with varying thicknesses of nonmarine sediments (Page, 1986, Davis and others, 1964, Hilton, 1963). The east-west cross sections (Figure 7-15, Figure 7-16, Figure 7-17, and Figure 7-18) illustrate the general trend of these deposits increasing in thickness from the east margin along a relatively uniform slope westward toward the San Joaquin Valley Syncline. West of this Syncline, these sediments are deformed in varying degrees depending on where they intersect the geologic structures of the West Side Fold Belt. These include:

- Figure 7-15 shows the very steep west limb of the Syncline near the Lost Hills,
- Figure 7-17 shows the highly folded sediments as they cross the Elk Hills.
- Figure 7-16 shows a more gradual increase through an intervening syncline before the slope increases toward the Belridge Hills.
- Figure 7-18 shows the deepest extent of the Unconsolidated Nonmarine Deposits in the southern basin in the Maricopa-Tejon Structural Region (Bartow, 1991).

The presence of the major clay layers within the Tulare Formation are most prominent in the western and central areas of the Subbasin. The older Amincola and Middle Tulare Clays are thickest in areas west of the San Joaquin Valley Syncline, but thin to the east. The more recent E-Clay extends more eastward with limited westward extent relative to the older clay layers. The E-Clay is prominent along the northern Subbasin margin but begins to be less defined toward the center of the Subbasin, likely the result of fewer lake deposits on the Bakersfield Arch and Kern River Alluvial Fan. In the southern Subbasin, the deeper areas of the Maricopa-Tejon structural region also have clays that appear to align with the major clay layers within the Tulare Formation.

The Miocene and older marine sedimentary units on the east side are shown with a transitional edge where they interfinger and eventually pinch out to the west. The more prominent sandstone units (Santa Margarita and Olcese) are predominantly sandstone along the eastern margin but transition to more fine-grained shales and siltstones to the west.

These north south cross sections illustrate the changes in the structural setting from east to west. Figure 7-20 shows the large structural relief of the Bakersfield Arch which brings Miocene and older marine sedimentary units closer to the surface along the eastern margin. The crest of the Bakersfield Arch is more intensely faulted between the Poso and China Grade Faults. These faults form the constraints that create the large oil and gas fields located in this area. Figure 7-21 shows the buried Bakersfield Arch as a deep structure beneath the unconsolidated nonmarine deposits. Figure 7-22 shows the great depth to basement in the areas of the San Joaquin Valley Syncline and western Maricopa-Tejon structural region (Bartow, 1991).

Water Quality Observations

The cross sections show the elevation of the base of fresh-water (Page, 1973) and the depth to the base of an underground source of drinking water (USDW) from Gillespie (2017). Additional maps and descriptions of these two data sets and their role in defining the bottom of the basin are provided in Section 7.6.4.

In the Unconsolidated Nonmarine Deposits, the depth to freshwater indicators is deepest in the east near two major recharge locations, the east margin and the Kern River. Generally, the thickest section of depth to freshwater occurs in the east of the Subbasin and thins to the west. In the western parts of the Subbasin depth to freshwater indicators are relatively shallow and exist high within the Tulare Formation.

The cross sections show that a large portion of the Unconsolidated Nonmarine deposits have groundwater above the base of freshwater. Both depth to freshwater indicators are typically higher than the Miocene and older marine sedimentary units throughout the Subbasin except along the eastern Subbasin Margin. The deeper Miocene and older marine sedimentary units typically contain highly-saline, connate water that is generally not considered a usable source of groundwater supply. The exception is along the eastern margin where the connate waters in the Miocene and older marine sedimentary units has been flushed by freshwater recharge from surface outcrops in the adjacent watersheds. The distribution of freshwater shown on these cross sections is consistent with the three distinct geology-based groundwater occurrences in the Subbasin (Davis and others, 1964, Hilton, 1963, Bertoldi and others 1991) and is an important factor in defining the principal aquifers for the Subbasin.

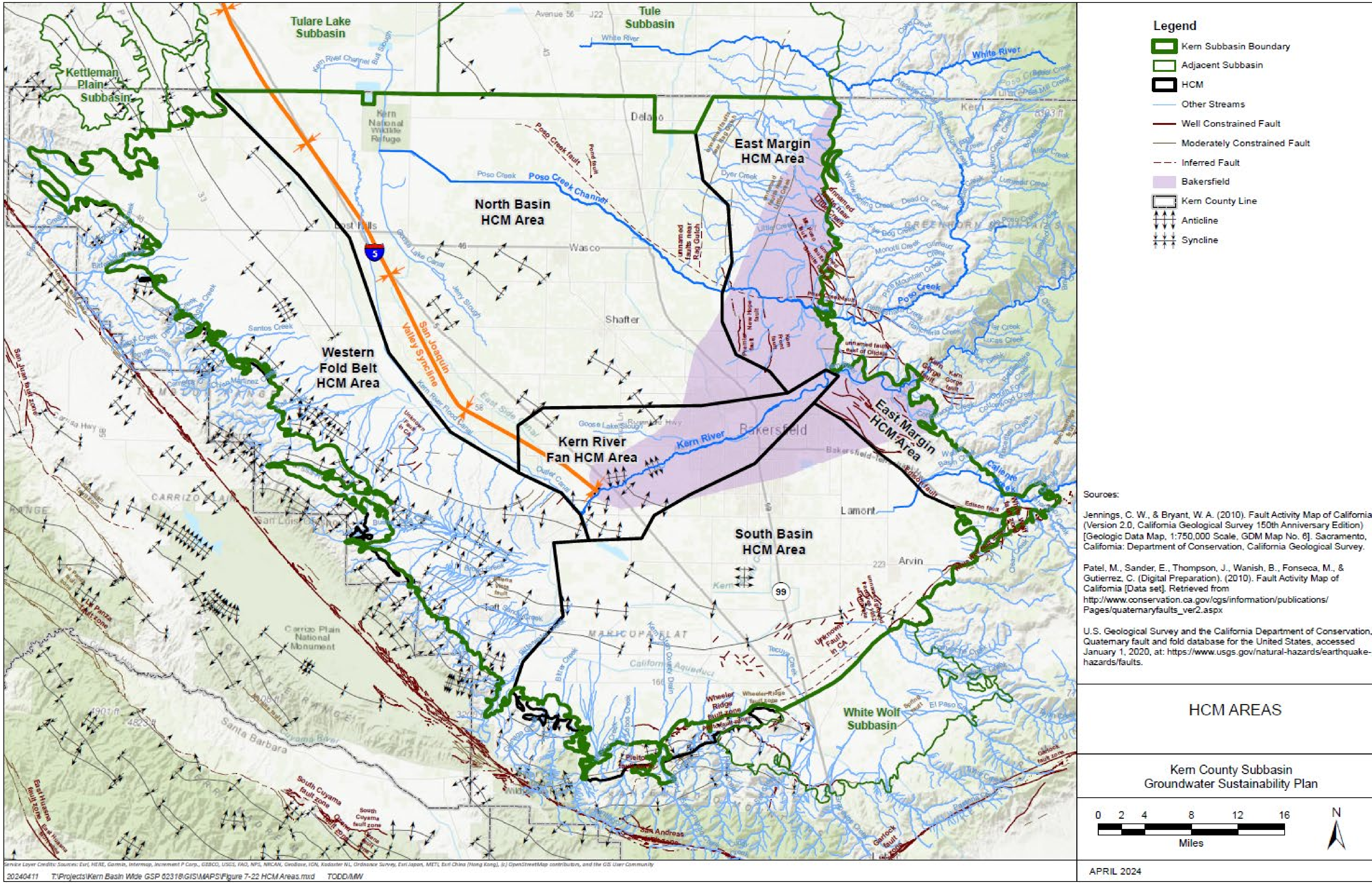


Figure 7-22. HCM Areas

This page intentionally left blank.

7.4 Hydrogeological Conceptual Model (HCM) Subarea Characteristics

*§ **354.14.** Hydrogeologic Conceptual Model*

(d) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.

(2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.

(3) The definable bottom of the basin.

(4) Principal aquifers and aquitards, including the following information:

(A) Formation names, if defined.

(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.

(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.

(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model

☑ 23 CCR § 354.14(b)

The Kern County Subbasin is a large and geologically complex basin with regional faulting, folding and a thick sequence of consolidated and unconsolidated sedimentary deposits. The general distinctive characteristics for each HCM area were summarized in Section 6.2.1.

- **North Subbasin HCM Area** – Area corresponds to the large alluvial basin north of the Kern River Fan area that is a major agricultural area. This area is underlain by a thick sequence of alluvial sediments that form a highly productive aquifer. The presence of clay layers, primarily the E-Clay, influences vertical flow of groundwater to form distinctive aquifer zones in some areas.
- **Kern River Fan HCM Area** – Area corresponds to the Kern River alluvial fan. The Kern River is a large hydrologic feature that provides both a major local surface water supply and source of groundwater recharge. The coarse alluvial sediments with limited clay layers make this the prime area for managed recharge and water banking. These operations generate a distinctive groundwater response seen on hydrographs. Groundwater flow conditions (contours) illustrate the Kern River Fan acts as a natural groundwater divide.
- **South Subbasin HCM Area** – Area corresponds to the large alluvial basin south of the Kern River Fan area that is the other major agricultural area that is underlain by a thick highly productive alluvial aquifer. Kern County Environmental

Health Services water well ordinance requires that wells drilled south of the Kern River Alluvial Fan seal to the E-Clay (Page 1986).

- **Eastern Margin HCM Area** – Area along the eastern Subbasin margin where water supply is derived from older geologic units. In the northeast area, the Santa Margarita and Olcese principal aquifers are the primary source of groundwater supply. This area includes several large fault-bounded oil fields. In the southeast, the Edison Fault forms a groundwater flow barrier.
- **Western Fold Belt HCM Area** – Area along the western Subbasin margin that generally corresponds to the West Side Fold Belt of Bartow (1991). This is the more intensely folded area dominated by large oil fields. Only minimal groundwater pumping occurs in this HCM Area due to the poor water quality. Due to these factors, agricultural and urban water supplies are either imported or derived from other HCM areas.

These five areas are informal designations referring to hydrogeologically similar areas used in the Plan to help organize the HCM discussions. Figure 7-22 shows the location of the HCM areas relative to key components of the geologic and structural setting. The defining characteristics of each HCM area are presented in the following sections. The HCM areas will provide a common framework for describing the hydrogeological variability of the Subbasin for various components of this Plan including support of the definition of undesirable results and sustainability criteria.

The data for the HCM updates were developed from the previously submitted GSPs, an ongoing Basin Study and other supporting references. The HCM section will focus on defining the relevant character of the physical geological structure of aquifer layers including hydrogeologically significant clay layers, geologic structures, groundwater divide, and faults. The section represents the Subbasin wide geologic and hydrogeologic conditions in a consistent Subbasin-wide perspective. The HCM includes Subbasin wide maps, graphs and cross sections required by SGMA regulations.

7.4.1.1 North HCM Area

The North HCM Area (Figure 7-22) corresponds to the large alluvial basin north of the Kern River. The area is characterized as the relatively flat plain in the north-central area of the Subbasin that is a major agricultural area. The North HCM Area includes the communities of Delano, McFarland, Wasco, Shafter, and Buttonwillow that utilize groundwater for water supply. The community of Lost Hills, physically located in the Western Fold Belt HCM area, utilizes groundwater sourced from the North HCM Area for water supply due to naturally occurring poor water quality in the Western Fold Belt HCM Area limiting municipal beneficial use.

The North HCM Area includes a variety of surficial sediments, the predominant being Quaternary Fan Deposits (Qf) in the east and center of the HCM area. Quaternary

Basin Deposits (Qb) are secondary, featuring mostly in the west and northern section of the HCM area. There are also minor Quaternary Lake Deposits in the west and northern boundary of the HCM area. There are also Tulare/Kern River Formations surface outcrops associated with the Semitropic and Buttonwillow Ridges. These sediments create a thick sequence that form a highly productive aquifer that consists of the recent alluvium, and the Tulare and Kern River Formations. The presence of clay layers, primarily the E-Clay, influence vertical flow of groundwater forming distinctive aquifer zones in some areas.

The Primary Alluvial Principal Aquifer is the only significant principal aquifer identified in the North Basin HCM area. The zone beneath and outside the extent of the E-Clay are the key areas that provide the bulk of water production for beneficial use. The primary uses of the Subbasin aquifer system include agricultural, municipal, domestic, and storage for the banking of surface water.

The marine sedimentary units underlying the alluvial sediments are generally composed of thick sequences of shales and siltstones with local sandstone layers. During the deposition of the marine sediments, the North Basin HCM Area was mostly situated in the deeper basin which is predominantly a fine-grained depositional environment. As a result, the marine sedimentary units are hydrogeologically separated from the Primary Alluvial Principal Aquifer. A more detailed discussion of how the marine sedimentary units are assessed for defining the bottom of the basin is provided in Section 7.6.

Geologically, the surficial geology is primarily the recent alluvium, and corresponds to the southern Sierran block structural regional (Figure 7-10) of Bartow (1991) that consists of the little-deformed east limb of the San Joaquin Valley Syncline. The North HCM Area includes the eastern portion of the West Side Fold Belt. This portion, east of the San Joaquin Valley Syncline, is less intensely folded than areas to the west. The North Basin HCM boundaries are defined as follows:

- The northern boundary is the Subbasin boundaries with the adjacent Tulare Lake and Tule subbasins. The Subbasin aquifers and aquitards are correlated with those in the adjacent Subbasins; however, variations are noted that result from differing geologic conditions.
- The western boundary with the Western Fold Belt HCM Area is geologically based and is placed along the western limb of the regional San Joaquin Valley Syncline (Figure 7-12).
- The southern boundary with the Kern River HCM Area is a transition area within the alluvial sediments that is primarily defined by hydrologic influences. The North HCM Area generally lacks the distinctive groundwater response, recognizable on hydrographs, to that of the Kern River and the Kern Fan Banking projects of the Kern River HCM Area.

- The eastern boundary with the Eastern Margin HCM Area is based on physical and geologic differences that represents a transition from the relatively flat plain underlain at the surface by recent alluvium of the North Basin HCM Area to the hillier area (dissected upland) of the Eastern Margin HCM area with the older Kern River Formation at the surface.

Within the North Basin HCM Area, certain anticlines within or adjacent to the Western Fold Belt HCM Area, notably Lost Hills, have been identified as potential constraints to groundwater flow within the lowlands (Page, 1986; DWR, 2006). Other fold structures include the Buttonwillow and Semitropic ridges (anticlines), the Bowerbank Anticline, and the San Joaquin Valley (or Buttonwillow) Syncline (Page, 1986; Bartow, 1991).

7.4.1.2 Kern River Fan HCM Area

The Kern River Fan HCM Area (Figure 7-22) generally corresponds to the thick alluvial fan deposits along the Kern River. The surficial geology consists mostly of Quaternary Fan Deposits (Qf) with a channel of Recent Alluvial (Qal) representing the Kern River. Kern River Formation outcrops can be observed in the east of the HCM area, whilst sections of Quaternary Fan Deposits (Qf) are present in the west. The Kern River Fan HCM area is a relatively level area that extends along the length of the Kern River within the Subbasin. This area consists mostly of the municipal area of the City of Bakersfield and smaller surrounding communities that utilize groundwater and surface waters from the Kern River, CVP and SWP as sources of supply.

The Kern River is a primary hydrologic feature in this HCM Area that provides a major local surface water supply and source of groundwater recharge. The coarse alluvial fan deposits with limited clay layers along the Kern River makes this the prime banking location for the Subbasin. The high-volume recharge from the Kern River and banking projects produces a recognizable pattern on hydrographs that is characteristic of the Kern River HCM Area.

This HCM Area is located along the crest of the Bakersfield Arch that is a broad westward-plunging structural bowing on the east side of the southern San Joaquin Valley (Figure 7-22). The Arch has a low topographic profile but has appreciable structural relief (Bartow, 1991). The Bakersfield Arch separates the Maricopa-Tejon structural region from the southern Sierran block structural regions (Figure 7-10). The Kern River Fan HCM represents the unique characteristics of this structural transition area.

The Primary Alluvial Principal Aquifer is the only principal aquifer identified in the Kern River Fan HCM Area. The Bakersfield Arch formed a low structural rise during the deposition of the Tulare and Kern River Formations. As a result, the large lacustrine, or lake, deposits did not form large continuous clay layers. Therefore, groundwater in this HCM Area is more uniform vertically with only limited vertical zonation.

Geologically, the surficial geology is primarily the recent alluvium and corresponds to the Bakersfield Arch (Bartow, 1991). The Kern River Fan HCM Area boundaries are defined as follows:

- The northern and southern boundaries represent a transitional area within the alluvial sediments that is primarily defined by hydrologic influences of the Kern River and banking operations. Generally speaking, the Kern Fan acts as a groundwater divide between the North and South HCM areas as exhibited by the groundwater contours. The Kern River Fan HCM Area generally lacks the clay layers observed in the adjacent HCM areas.
- The western boundary with the Western Fold Belt HCM Area is geologically based and is placed along the western limb of the regional San Joaquin Valley Syncline at the base of the Elk Hills.
- The eastern boundary with the Eastern Margin HCM Area is based on physical and geologic differences that represents a transition from the relatively flat plain underlain at the surface by recent alluvium of the North Basin HCM Area to the hillier area (dissected upland) of the Eastern Margin HCM Area with the older Kern River Formation at the surface.

The marine sedimentary units underlying the alluvial sediments are generally composed of thick sequences of shales and siltstones with local sandstone layers. As a result, the marine sedimentary units are hydrogeologically separated from the Primary Alluvial Principal Aquifer (see Section 7.5.1.1).

7.4.1.3 South Basin HCM Area

The South Basin HCM Area (Figure 7-22) corresponds to the large alluvial basin south of the Kern River. The area is characterized as the relatively flat plain in the north-central area of the Subbasin that is a major agricultural area. The South Basin HCM Area includes the southern areas of Bakersfield and surrounding communities that utilize groundwater, surface water from the Kern River, and other imported water sources for water supply from the SWP and CVP. In addition, the communities of Arvin, Lamont, Greenfield, and Mettler utilize groundwater for water supply.

The South Basin HCM Area is overlain by mostly Quaternary Alluvium Deposits (Qf), with Quaternary Lake Deposits (Ql) associated with the Buena Vista and Kern Lake Beds. There is also a channel of Quaternary Basin Deposits (Qb), which runs from Bakersfield, the Kern Lake Bed and the Buena Vista Lake Bed. These sediments and subsurface Tulare and Kern River Formations form a highly productive aquifer. The South Basin HCM Area is the deepest part of the Subbasin. The alluvial sediments are over 6,000-feet-thick in this HCM Area. The presence of clay layers, primarily the E-Clay, influences vertical flow of groundwater forming distinctive aquifer zones in some areas. Shallow clay layers are also associated with the Buena Vista and Kern lakes located in the center of this HCM Area.

The Primary Alluvial Principal Aquifer is the only principal aquifer identified in the South Basin HCM area. The zone beneath and outside the extent of the E-Clay are the key areas that provide the bulk of water production for beneficial use. The primary uses of the Subbasin aquifer system include agricultural, municipal, domestic, and storage for the banking of surface water.

Geologically, the surficial geology is primarily the recent alluvium, and corresponds to the Maricopa-Tejon structural region (Figure 7-10) of Bartow (1991) that consists of the little-deformed east limb of the San Joaquin Valley Syncline. The South Basin HCM Area boundaries are defined as follows:

- The northern boundary with the Kern River HCM Area is a transition area within the alluvial sediments that is primarily defined by hydrologic influences. The South Basin HCM Area generally lacks the distinctive groundwater response, recognizable on hydrographs of the of the Kern River and the Kern Fan Banking projects of the Kern River HCM Area.
- The southern boundary is partly the Subbasin boundaries with the adjacent White Wolf Subbasin that is defined by the White Wolf Fault that forms a groundwater flow barrier that significantly limits groundwater flow across the fault. The rest of the southern boundary is defined by the Subbasin boundary with the Tehachapi and San Emigdio Mountains. There is limited groundwater recharge from runoff and subsurface inflow from the Basement Complex and older marine sedimentary units in the adjacent watersheds from the mountain areas.
- The western boundary with the Western Fold Belt HCM Area is geologically based to correspond to the West Side Fold Belt (Figure 7-10).
- The eastern boundary with the Eastern Margin HCM Area is based primarily on the Edison Fault, which has been identified as a groundwater flow barrier.

The marine sedimentary units underlying the alluvial sediments are generally composed of thick sequences of shales and siltstones with local sandstone layers. As a result, the marine sedimentary units are hydrogeologically separated from the Primary Alluvial Principal Aquifer. A more detailed discussion of how the marine sedimentary units are assessed for defining the bottom of the Subbasin is provided in Section Physical Properties.

7.4.1.4 Eastern Margin HCM Area

The Eastern Margin HCM Area of the Kern County Subbasin (Figure 7-22) consists of a narrow area that extends about 6 miles westward from the eastern Subbasin margin. This is an area of dissected uplands that borders the Sierra Nevada. The Eastern Margin HCM Area includes small portions of the City of Bakersfield and surrounding communities that utilize groundwater and surface water from the Kern River for water supply. Agricultural use is concentrated primarily in areas north of Poso Creek or along the Kern River. Other parts of the Eastern Margin HCM Area are lightly populated areas with scattered private wells for agricultural and domestic use.

The Eastern Margin HCM Area is a more structurally complex area than the larger HCMs to the west. The Bakersfield Arch forms a low structural rise that extends across this HCM Area toward the Sierra Nevada. The uplift of the Bakersfield Arch has raised the Kern River Formation so that the Kern River Formation has a much thinner saturated thickness than in other areas of the Subbasin.

The Eastern Margin HCM Area groundwater use is derived from multiple units including the Kern River, Santa Margarita and Olcese Sand Formations. In this HCM, the Santa Margarita and Olcese Sand are the primary source of groundwater supply. Because Kern River Formation thins to the east, it becomes a less prominent source of groundwater supply in this HCM.

The overlying surficial geology in the Eastern Margin HCM Area consists mostly of Kern River outcrop, with Recent Alluvium (Qal) channel deposits trending toward the west. Quaternary Fan Deposits (Qf) are present on the western most boundaries of the HCM area and outcrops of older Miocene and Lower Tertiary marine rocks are observed in the southern section of the HCM area. During deposition of the older marine sedimentary units, this area was more of a shallow marine setting than areas to the west. This led to the deposition of more sandstones in the Eastern Margin HCM Area than in other HCM areas of the Subbasin. In these areas, the Santa Margarita and Olcese formations form prominent sandstone layers; however, these grade laterally to shales and other fine-grained units westward. As a result, much of the water supply for this HCM is derived from the Santa Margarita and Olcese Principal Aquifers.

This HCM area includes several faults, as depicted in Figure 7-22. The most prominent among them are the Kern Gorge, Poso Creek, Mt. Poso and Edison faults, alongside various unnamed, high angle faults which trend to the general contours of the Sierra Nevada foothills. Many of the faults have sufficient vertical offset to act as local groundwater flow barriers making for a more compartmentalized groundwater aquifer in this area (Castle, 1983). The Edison Fault in the southern part of the HCM area forms a strong hydrological barrier that limits groundwater flow. However, the Edison Fault is covered by the younger Kern River Formation which allows groundwater to flow across this area.

This HCM area also contains several large fault-bounded oil fields including several major oil and gas fields. These are primarily concentrated in the area between Poso Creek and the Kern River where the faulting is more intense along the crest of the Bakersfield Arch. A second area of major oil fields occurs south of the Kern River in a second area of intensive faulting.

Geologically, the surficial geology is primarily the Kern River Formation with isolated outcrops of older marine formations found in the incised stream channels. Although this HCM area corresponds to the southern Sierran block structural regional (Figure 7-10) of Bartow (1991), it is more geologically deformed due to faulting than is found in the North Basin HCM Area. The Eastern Margin HCM boundaries are defined as follows:

- The northern boundary is the Subbasin boundary with the adjacent Tule Subbasin. The Subbasin aquifers and aquitards are correlated with those in the adjacent basins; however, variations are noted that result from differing geologic conditions.
- The western boundary with the North Basin, South Basin, and Kern River Fan HCM Areas is based on physical and geologic differences that represent a transition from the hillier terrain (dissected upland) of the Eastern Margin HCM with the relatively flat plain of the HCM Areas to the west. A portion of the western boundary is based primarily on the Edison Fault, which has been identified as a groundwater flow barrier.
- The eastern and southern boundaries are defined by the Subbasin boundary with the Sierra Nevada and Tehachapi Mountains. Groundwater recharges from runoff and subsurface inflow from the adjacent watersheds into the Santa Margarita and Olcese Formations occurs along the Subbasin margin.

One of the distinct geology-based groundwater characteristics of the Subbasin is the occurrence of fresh water in marine sedimentary units where surface recharge from outcrop areas has flushed the original saline connate water from these units and they now contain freshwater (Davis and others, 1964, Hilton, 1963). This condition primarily occurs in the Eastern Margin HCM Area where the Santa Margarita and Olcese Formations form locally important aquifers. A more detailed discussion of how the marine sedimentary units are assessed for defining the bottom of the Subbasin is provided in Section 7.3.3.

7.4.1.5 Western Fold Belt HCM Area

The Western Fold Belt HCM Area of the Kern County Subbasin (Figure 7-22) generally corresponds to the most intensely deformed areas of the West Side Fold Belt of Bartow (1991). The area is characterized by flat alluvial plains that separate linear topographic ridges that correspond to the underlying geologic structures. This HCM Area is largely characterized by large oil fields and poor-quality water. Due to the poor water quality, groundwater is not considered a practical water source in the Western Fold Belt HCM Area. Nearly all water for agricultural, municipal, or industrial use is imported surface water or groundwater from other HCM areas that is conveyed into this HCM area.

The surficial geology is primarily Quaternary Fan Deposits (Qf) that unconformably overlies the Tulare Formation which outcrops along the crest of the linear ridges formed by the underlying structural anticlines, such as the Elk Hills and Buena Vista Hills. The unconformity suggests this was a highland area subject to active erosion. Recent Alluvium (Qal) is present within the Buena Vista Valley. Along the Subbasin's western margin, runoff from several small watersheds in the Coast Ranges recharges an area of recent alluvium that is underlain by older marine shales of the Monterey Formation.

The Lower Tulare Formation represents the thickest alluvial deposits in this HCM Area. By contrast, the Upper Tulare Formation is much thinner or absent. The primary aquitards are the older lake deposits in the Tulare Formation. These are the Middle Tulare and Amincola Clays that are tens to several hundred feet thick in the Western Fold Belt HCM Area, suggesting this area was the lowest part of the Subbasin during the deposition of the Lower Tulare.

Underlying the Tulare Formation is a thick sequence of fine-grained marine sediments that represent deposition in a deep marine environment. As a result, the marine sedimentary unit is hydrogeologically separated from the Tulare Formation.

The most distinctive geologic characteristic of this HCM is the intense folding associated with the West Side Fold Belt structural regional of Bartow (1991). This features several anticlines, which are oriented toward the northwest, running semi-parallel to the Coast Ranges and the San Andreas Fault (Bartow, 1991; Page, 1986). Page (1986) and DWR (2006) note that these anticlinal folds, particularly the Lost Hills and Elk Hills anticlines, act as barriers to groundwater flow. Conversely, the synclines between these anticlines form conduits that collect and direct groundwater flow along their axes. The Western Fold Belt HCM Area boundaries are defined as follows:

- The northern boundary is the Subbasin boundary with the adjacent Tulare Lake and Kettleman Plain Subbasins. The Subbasin aquifers and aquitards are correlated with those in the adjacent Subbasins. However, variations are noted that result from differing geologic conditions.
- The western boundary is defined by the Subbasin Boundary with the Coast Ranges. Runoff and subsurface inflow from adjacent watersheds recharges the Recent Alluvium and Tulare Formation along the Subbasin margin.
- The eastern boundary with the North Basin and Kern River Fan HCM Areas is geologically based and is placed along the western limb of the regional San Joaquin Valley Syncline.
- The southern boundary with the South Basin HCM Area is geologically based at the transition from the highly deformed West Side Fold Belt and the thick sequence of alluvial deposition in the South Basin HCM Area.

The Recent Alluvium and Tulare Formations are considered part of the Primary Alluvial Principal Aquifer; however, only minimal groundwater pumping occurs in this HCM Area due to the poor water quality. Nearly all water for agriculture operations in the northwest portion of the Western Fold Belt HCM Area is imported and supplied by the SWP.

Groundwater pumped for agriculture is blended with higher quality imported water to augment reduced supplies from the SWP.

The Western Fold Belt HCM Area includes disadvantaged communities in the West Kern Water District service area, among others, the cities of Taft and Maricopa. Other towns and communities in the HCM Area include Lost Hills, Blackwells Corner and Belridge that rely on a supply from outside of the HCM Area for drinking water. For example, the West Kern Water District (WKWD) receives SWP water and other surface supplies that are delivered to recharge basins owned by WKWD located in the Kern River Fan HCM Area. The water is then recovered using WKWD wells and distributed to disadvantaged communities in WKWD's service area near southern region of the Western Fold Belt HCM Area. Similarly, the Lost Hills Public Utilities Districts recovers groundwater from wells located in the North Basin HCM Area and distributes this supply to a large northern region of the Western Fold Belt HCM Area.

7.5 Principal Aquifer and Aquitards

☑ 23 CCR § 354.14(b)(4)

A "Principal Aquifer" refers to aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. (DWR, 2016). The Subbasin's groundwater aquifers exhibit geological diversity. The description also includes a discussion of the portions of the formations that bear groundwater that have been utilized historically. In the Subbasin, there are three distinct geology-based groundwater occurrences (Davis and others, 1964; Hilton, 1963) based on the following conditions:

1. Unconfined and semiconfined fresh water in nonmarine alluvial deposits of Recent, Pleistocene, and possibly late Pliocene age. These unconsolidated continental deposits overlie the marine deposits and contain most of the freshwater in the Subbasin.
2. Confined fresh water, contained in marine sediments of Miocene age where surface recharge from outcrop areas has flushed the original saline connate water and the sediments now contain freshwater. This condition occurs in limited areas, primarily along the eastern Subbasin margin, which form locally important aquifers.
3. Saline, connate water contained in marine sediments of middle Pliocene or older age, which underlies the fresh-water body throughout the area. The majority of the marine sediments in the Subbasin contain highly saline, connate water.

Three Principal Aquifers are defined for the Subbasin according to the criteria listed above. These include:

- The Primary Alluvial Principal Aquifer consists of the Unconsolidated Nonmarine Deposits, including the Recent Alluvium, Tulare, and Kern River Formations, from across the Subbasin. These nonmarine deposits provide the most productive freshwater aquifers in the Subbasin and represent the first condition.
- On the eastern side, the Santa Margarita Principal Aquifer and Olcese Principal Aquifer provide local areas of productive freshwater aquifers. These two marine sandstone aquifers represent the second condition where freshwater surface recharge from outcrop areas has flushed the original saline connate water.

Marine units, other than those listed above, are considered as not providing significant or economic quantities of groundwater due to poor water quality consistent with the third condition. These formations are not defined as Principal Aquifers.

The following discussion provides the required information, as defined in the GSP Emergency Regulations (23 CCR § 351(aa)), for describing the three Principal Aquifers in the Subbasin.

7.5.1.1 Primary Alluvial Principal Aquifer

The Subbasin's Primary Alluvial Principal Aquifer essentially extends over the entire Subbasin and consists of the Tulare and Kern River Formations plus the overlying recent alluvium (Figure 7-23). These represent the continental deposits of Pliocene to Holocene age that contain the vast majority of the freshwater in the Subbasin. The Primary Alluvial Principal Aquifer is the source of nearly all of the groundwater used within the Subbasin.

Geologic Formations

The Primary Alluvial Principal Aquifer is comprised of the Unconsolidated Nonmarine Deposits (Pliocene to Holocene) that include the Recent Alluvium, Kern River Formation and Tulare Formation. These are moderately to high permeability units that form the most highly productive freshwater aquifer system within the Kern County Subbasin (Page, 1986).

The Recent Alluvium covers the underlying formations and can often be indistinguishable from the Kern River and Tulare Formations. The Recent Alluvium consists of alluvial and floodplain gravel, sand, silt, and clay up to 400 feet in thickness (DWR, 2016). The Kern River Formation is primarily identified in the eastern half of the Subbasin and was deposited as an alluvial fan from sediments originating from the Sierra Nevada (Page, 1986). The Tulare Formation is comprised of alternating beds of unconsolidated, lacustrine, and fluvial sand and mudstone deposits, with sedimentation sourcing from the Coast Ranges (Dale et al, 1966). The Tulare Formation can be split into the Upper and Lower sections. The Upper Tulare Formation is predominantly sandy alluvial fan and alluvial plain deposits whereas the Lower Tulare Formation is mostly comprised of lacustrine and deltaic deposits (Kiser et al, 1988). The separation between the Upper and Lower Tulare Formations is generally aligned with the Middle Tulare Clay. These formations were deposited together but the sediments were derived from different sources, so these formations essentially merge in the center of the Subbasin.

Within the Tulare Formation several fine-grained, low-permeability flood-basin, lacustrine, and marsh deposits are widespread throughout the Kern County Subbasin. These include several clay layers that represent large lake deposits formed during interglacial periods during the Pleistocene ice ages (Croft, 1972). The E-Clay (including the Corcoran Clay Member), Middle Tulare Clay and Amnicola Clay form these clay layers that extend over large areas of the west-central Subbasin and form regional aquitards within the Primary Alluvial Principal Aquifer. Areas outside of these clay layers lack a regional aquitard allowing for more vertical groundwater flow.

The Primary Alluvial Principal Aquifer exhibits varying groundwater conditions, classified as confined, semiconfined, and unconfined, owing to the presence of clays that act as local aquitards. Because of its distribution and relative shallow depth, compared to the other clay layers, the E-Clay is the most prominent aquitard in the Subbasin. Figure 7-24 shows the distribution of the modified E-Clay of Page (1986) which is a revised interpretation of the Croft (1974) E-Clay map in the southern part of the Subbasin. As shown on Figure 7-24, the E-Clay does not cover the entire Subbasin but is limited to areas in the central parts of the Subbasin.

The character of the E-Clay is more variable across the Kern County Subbasin with areas where the E-Clay is either discontinuous or absent. Figure 7-24 shows the distribution of these areas. These include:

- The Shallow Confining Layer Area where the E-Clay is a thick continuous layer that is characterized by a distinct separation between the groundwater levels above and below the E-Clay.
- The Deep Confining Layer Areas where the E-Clay is a thick continuous layer but there is a less distinct separation because the groundwater levels above and below the E-Clay merge along the margins of these areas creating a hydraulic connection between them. However, county authorities have taken measures to prohibit well construction practices that involve screens across both upper unconfined and lower confined zones in the South Basin HCM.
- The Leaky Aquitard Areas where the E-Clay is a discontinuous layer. Where the groundwater levels rise above the E-Clay, there is still a hydraulic connection vertically across the zone, and where groundwater levels fall below the E-Clay, it becomes unsaturated.
- Outside of these, the E-Clay is either highly discontinuous or absent which results in little to no vertical separation across the interval.

Several different interpretations of the extent of the E-clay have been developed by the USGS and others (Croft 1972, Page 1983, 1986; PGA 1991). These generally agree in the areas where the E-Clay is prominent but vary along the margins. Along the margins of the mapped extent, the E-Clay bifurcates into multiple thin layers that probably represents fluctuating lake levels of the Pleistocene Corcoran Lake (Figure 7-9) during deposition, thus making the margin of the E-Clay difficult to identify in these areas (Croft 1972, Bartow, 1991). As discussed in Section 7.2.2, the E-Clay is generally absent in the Kern River Fan and Western Fold Belt HCM Areas due to the influence of geologic structures. The E-Clay variability is also illustrated on the cross section provided in Figure 7-15 to Figure 7-21.

The variability in the character of the E-Clay across the Kern County Subbasin results in the primary aquifer system behaving as a single principal aquifer. The non-continuous lateral extent of the E-Clay or their lack of lithological consistency, preventing continuous confinement. This separation is most pronounced in the north-central area of the Subbasin adjacent to the Tule and Tulare Lake Subbasins. In the eastern portion of the Subbasin, particularly near the Kern River Alluvial Fan, the aquifer system predominantly comprises an unconfined to semi-confined zone. -Because of the varying character of the E-Clay there is sufficient hydraulic connection so that, at the Subbasin-level, the overall groundwater system acts as a single principal aquifer with varying levels of zonation caused by the E-Clay and other clay layers.

In contrast, the E-Clay is a more continuous well defined clay layer to the north where it covers most Tule Subbasin and all Tulare Lake Subbasin. In these Subbasins, the E-Clay is defined as a vertical boundary between Upper and Lower Principal Aquifers with both the zones above and below the E-Clay providing significant or economic quantities of groundwater. This change in the character of the E-Clay is the basis for these subbasins to the north identify two principal aquifers whereas the Kern County Subbasin defines a single principal aquifer in the alluvial deposits.

The Middle Tulare Clay (Kiser et al, 1988) and Amnicola Clay are found in the Lower Tulare Formation with their thickest locations in more of the western Subbasin. The Middle Tulare Clay and Amincola Clay are several hundred feet thick near the Elk Hills and Buena Vista anticlines (Gillespie et al, 2022). These units form aquitards and locally confined conditions in the Lower Tulare Formation. The distribution and variability of the Middle Tulare Clay and Amincola Clay is shown on the cross sections provided in Figure 7-15 to Figure 7-21. However, due to their location and depth, these deeper clay units form barriers that separate oilfields found in the crest of anticlines in the western Subbasin from the principal aquifer as discussed in the following section on Definable Basin Bottom (see Section 7.2.3).

A persistent area of shallow groundwater has been reported in the Subbasin (KCWA, 2012; DWR, 2009). The extent of this shallow groundwater shown on Figure 7-26 is relatively consistent with Page's (1986) extent of mapped surficial fine-grained flood deposits (Figure 7-6) and shallow clay units related to the A-Clay (Croft, 1972). In the areas shown on Figure 7-26, this shallow groundwater is considered a perched aquifer formed by the A-Clay or its equivalent. The hydrogeological conceptual model the A-Clay intercepts percolating precipitation and agricultural return flows. Groundwater flow is toward the perched aquifer margin or discontinuities where the perched groundwater would then percolate downward through the unsaturated zone to the underlying Primary Alluvial Principal Aquifer. As a perched aquifer, it is hydraulically separate from and not impacted by groundwater pumping in the Primary Alluvial Principal Aquifer.

The Primary Alluvial Principal Aquifer receives the majority of both the natural and managed groundwater recharge in the Subbasin (Figure 7-23). Natural recharge to the Subbasin is derived primarily from precipitation and surface runoff from the surrounding watersheds. Natural recharge is highest on the east side of the Subbasin which receives high precipitation and receives recharge from the Kern River and other smaller streams from the Sierra Nevada. Natural recharge is lowest on the west side which receives less precipitation and lower runoff from the relatively smaller watersheds along the Coast Ranges. Significant managed recharger in the Subbasin occurs through water banking and conjunctive use projects (Figure 7-23). Numerous sources of water are recharged by various projects, including local surface water (Kern River, Poso Creek, and other drainages) and imported water (SWP and CVP).

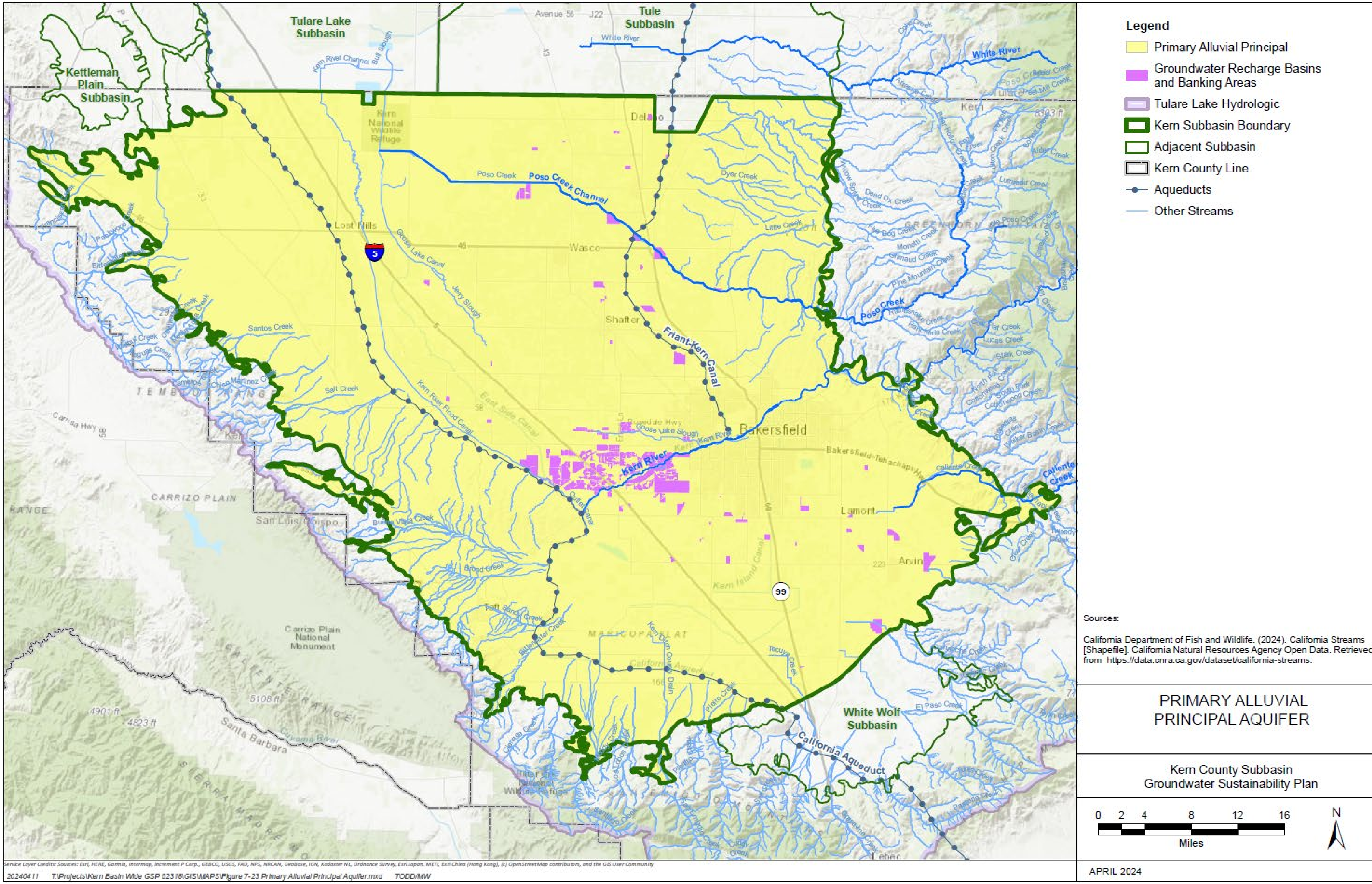


Figure 7-23. Primary Alluvial Principal Aquifer

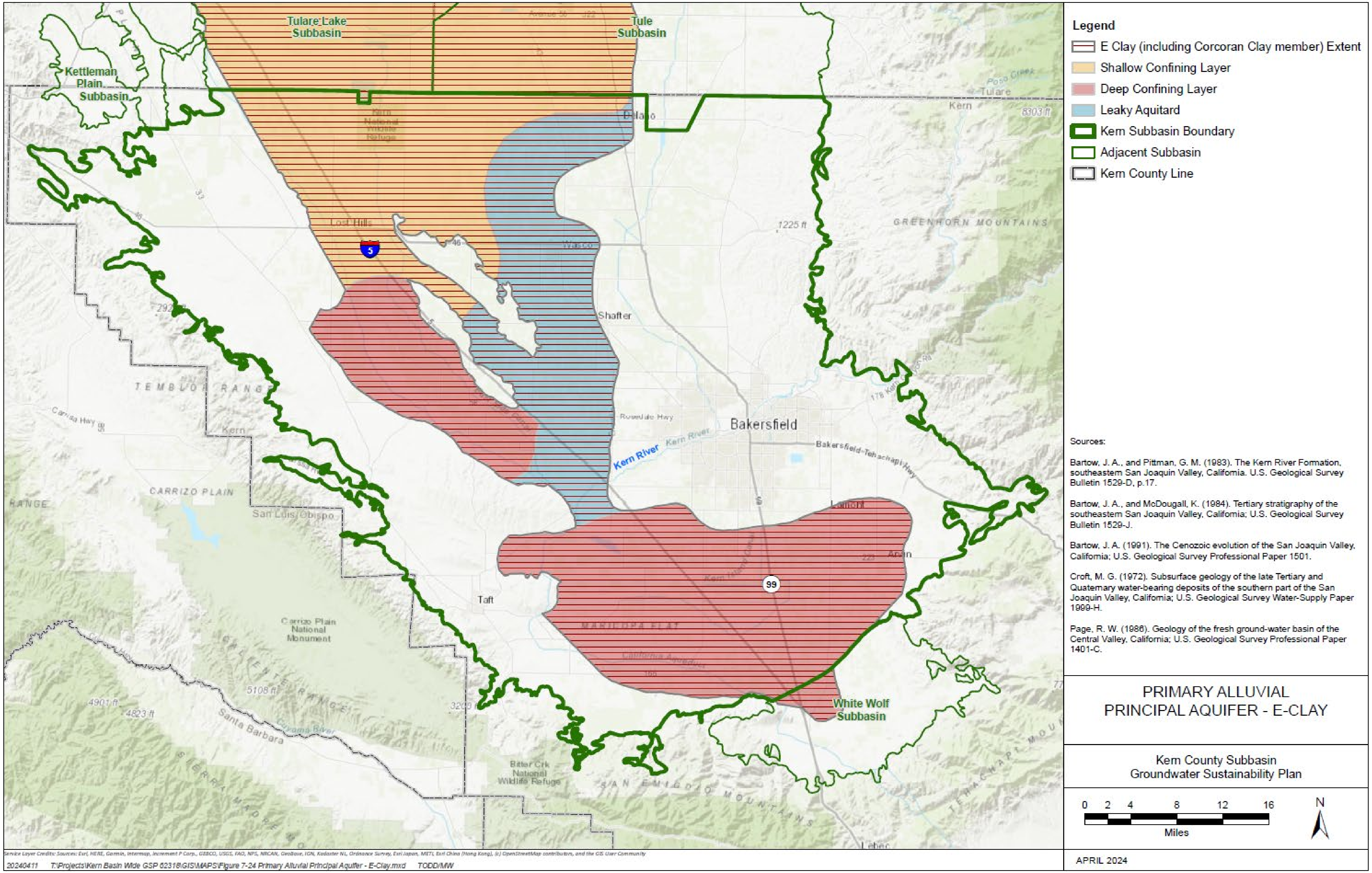
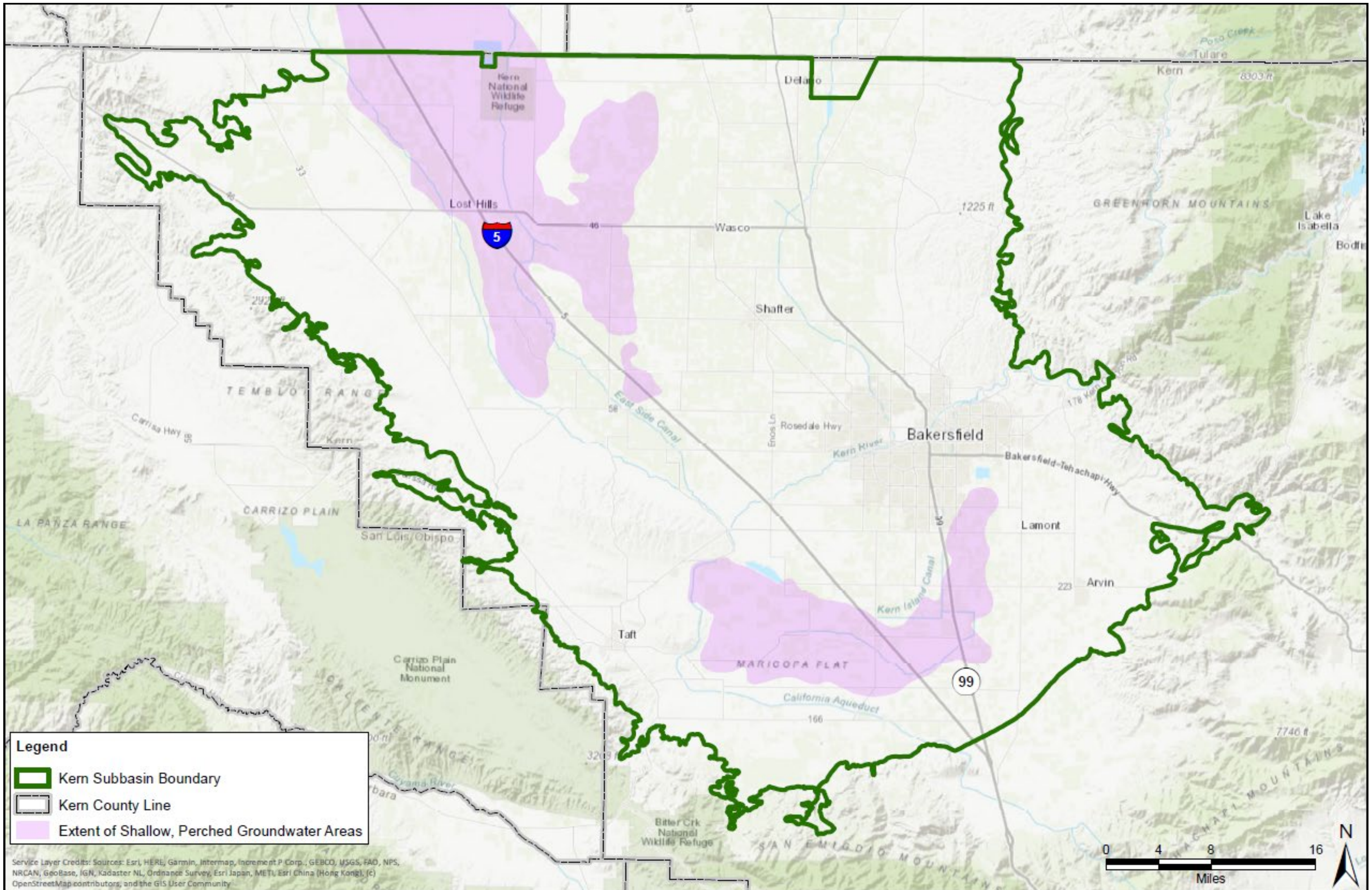


Figure 7-24. Primary Alluvial Principal Aquifer E-Clay



Kern County Subbasin
Groundwater Sustainability Plan

Sources:

EXTENT OF SHALLOW, PERCHED GROUNDWATER AREAS

APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GIS\MAPS\ Figure 8-10 Extent of Shallow, Perched Groundwater Areas.mxd - 20240405

Figure 7-25. Extent of Shallow, Perched Groundwater Areas

This page intentionally left blank.

Physical Aquifer Properties

Aquifer parameters within the Subbasin are available from both well pumping tests and calibrated groundwater models. Aquifer properties include hydraulic conductivity, specific yield (unconfined systems) and storage coefficient (confined systems).

Data regarding the aquifers were obtained from pumping tests conducted by the USGS at irrigation wells during the late 1950s and 1960 (McClelland, 1962). Based on these tests, hydraulic conductivity was estimated as within the range of 3 to 250 ft/d (with a median of 60 ft/d). These values align with published ranges for clean, medium- to coarse-grained sand (Heath, 1983) or for fine sand to coarse gravel (Schwartz and Zhang, 2003). These estimates also coincide with the range of values used in groundwater models (C2VSim, CVHM; Todd, 2018; Todd, 2017).

Pumping test data from McClelland (1962) provided hydraulic parameters based on analysis of data from six supply wells perforated in the Kern River Formation. Multiple-well tests resulted in transmissivity values that ranged from 2,000 to 63,000 ft^2/day, and reported hydraulic conductivity ranged from 2.1 to 160 ft/day. Storage coefficients obtained from the multiple-well tests ranged from 0.0004 to 0.001, indicating semi-confined conditions.

Estimates of specific yield for unconfined zones falls within the range of values published for similar grain sizes and lithology of between 0.02 and 0.4 (Heath, 1983; Morris and Johnson, 1967) and is consistent with estimates through laboratory testing of sample cores, calculations based on lithology type, and calibration of groundwater models (Dale, 1966; Davis et al., 1959; Davis et al., 1964; Faunt et al., 2009; DWR, 2013; Todd, 2017 and 2018).

The E-Clay within the Tulare Formation is commonly known for its fine-grained beds, though its lithology varies from fine (clay and silt) to coarse (sand) textures (Page, 1986; Faunt et al., 2009). Faunt et al., (2009) compiled and estimated horizontal hydraulic conductivities for the E-Clay within the Tulare Formation within the range of 0.0024 to 33 ft/d. Vertical hydraulic conductivity was estimated to range from 6.6×10^{-6} to 1.5×10^{-3} ft/d, representing a potential range of vertical anisotropy from 360:1 to 22,000:1. This anisotropy range indicates that, in areas where the E-Clay is continuous, the E-Clay forms a significant regional aquitard.

Structural Properties

The Kern County Subbasin is significantly shaped by geological features. The San Joaquin Valley Syncline is an extensive and asymmetric trough that has accumulated thick sedimentary deposits (Figure 7-26). It can also be noted that due to asymmetric loading by the Sierra Nevada and Coast Ranges the San Joaquin Valley has undergone late Miocene subsidence (Levandowski and Jones 2015).

Another structural feature of the Subbasin is the Bakersfield Arch (Figure 7-26) that forms a low-relief structural high in the center of the Subbasin that developed starting in Miocene and continuing to recent times. The alluvial sediments dip to the north and south off the flanks of the arch, which create deep basins for infill of sediments (Bartow, 1991). The arch is not a barrier to groundwater flow but does represent one part of the upgradient topographic high that allows water to flow outward from the river.

Numerous geological structures, including faults and folds, are distributed throughout the Subbasin, as observed in local geological maps (Figure 7-11 and Figure 7-12). Normal faulting along the eastern Subbasin margin is prominent in older sedimentary layers but extends into and is concealed by younger sediments, particularly along the Pond-Poso Fault (Poso Creek Fault) in the north and the Edison Fault in the south. Normal faults along the eastern margin exhibit varying orientations, ranging from northwest to northeast, owing to alternating compressional and extensional forces. Delineation occurs at the southern boundary of the Subbasin, where the northeast-trending White Wolf Fault actively displaces the Kern County Subbasin from the southern White Wolf Subbasin.

Structurally, the western Subbasin geology differs significantly from the central and eastern parts of the Subbasin. Western Plio-Pleistocene deposits primarily originate from the weathering and erosion of the Coastal Range, consisting of marine deposits that yield clays, silts, and some sands. In contrast, the eastern side is characterized by quartzose and feldspathic coarser-sized sediments from the Sierra Nevada.

The West Side Fold Belt features several anticlines, including Lost Hills and Elk Hills (Bartow, 1991; Page, 1986). These structures are oriented toward the northwest, running semi-parallel to the Coast Range and the San Andreas Fault (Figure 7-26). Page (1986) and DWR (2006) have identified these anticlinal folds in the West Side Fold Belt, particularly the Elk Hills and Lost Hills, as constraints on groundwater flow within the lowlands, which likely applies to other anticlines in the Subbasin. The Elk Hills Anticline is comprised of a broad, elongate, flat-topped arch with steep dips along its edge. The anticline is approximately 17-miles-long by 6-miles-wide, trending northwest to southeast. The Elk Hills rise to an altitude of over 1,550 feet (Woodring et al, 1932). The Lost Hills Anticline is the southern end member of a 60-mile-long fold of a Southeast-plunging anticline, which runs parallel to the San Andreas Fault to the west and formed due to related compressional tectonic activity. Specifically, the Lost Hills Anticline is an asymmetric anticline, approximately 20-miles-long and 6-miles-wide (Medwedeff, 1989).

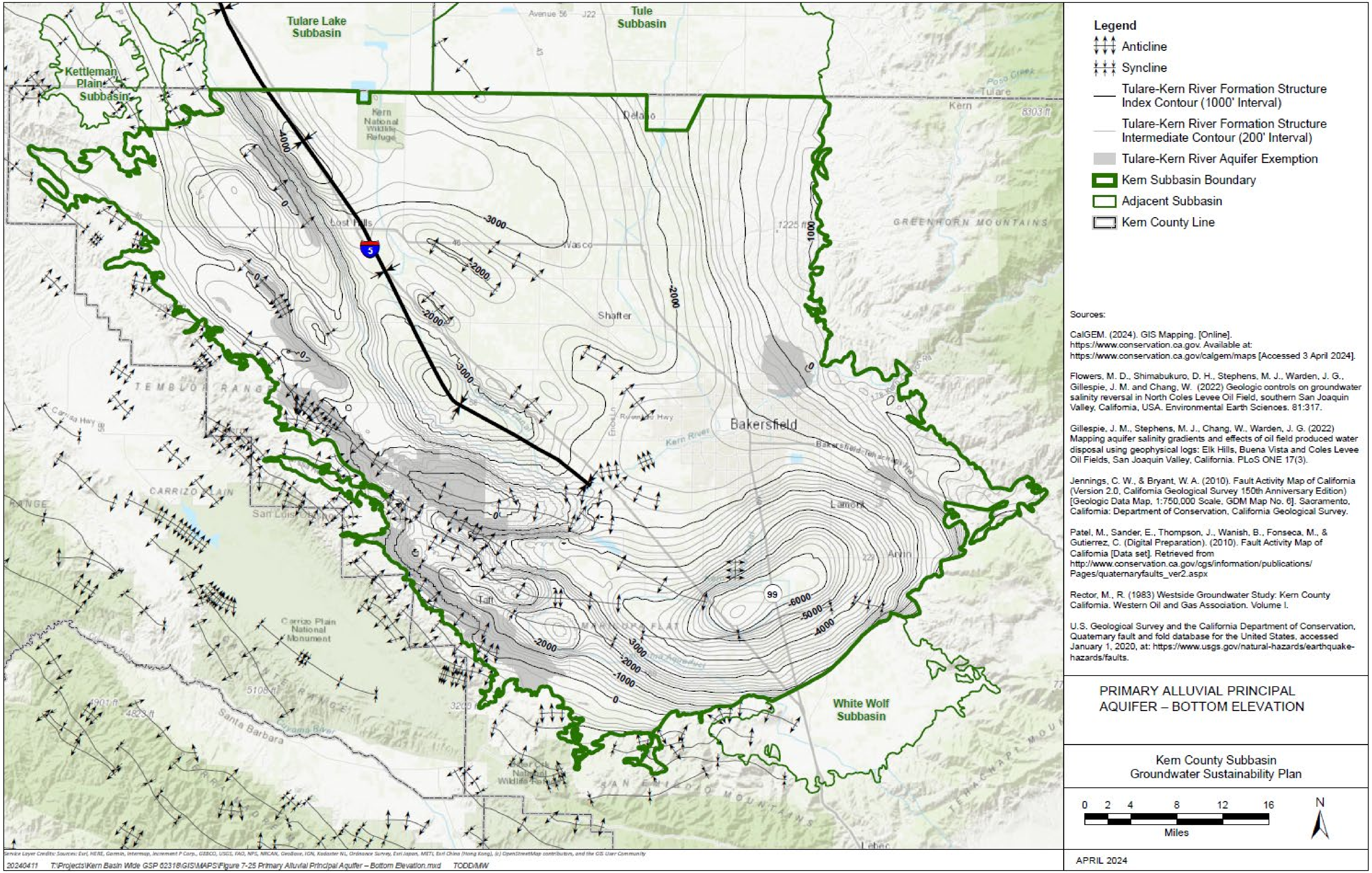


Figure 7-26. Primary Alluvial Principal Aquifer Bottom Elevation

This page intentionally left blank.

General Water Quality

This section is a general summary of water quality in the Primary Alluvial Principal Aquifer. A more detailed discussion of water quality is provided in Section 8. Groundwater quality in the Primary Alluvial Principal Aquifer is generally of good quality for agricultural and municipal uses. The highest quality groundwater is typically associated with Kern River recharge. TDS concentration in the Western Fold Belt HCM Area typically ranges from 1,000 to 4,000 mg/L (KCWA, 2011) which limits the availability of usable groundwater in this HCM area. Elsewhere, TDS concentrations in this principal aquifer range 200 to 1,500 mg/L (KCWA, 2011).

This difference is generally attributed to the source of recharge of the groundwater and the influence of connate waters from older marine formations. Lower TDS concentrations and greatest depths USDW occur along the eastern margin of the Subbasin due to the influx of low TDS recharge from the Sierra Nevada. Higher TDS concentrations on the west side are attributed to runoff from older marine formations in the Coast Ranges, with stream names such as Salt Creek and Bitterwater Creek. Two properties exist to increase the TDS concentrations: remnant high-salinity connate water from the Tulare Formation and salt-bearing sediments in underlying older marine formations. (Metzger and Landon, 2018, Sierra Scientific Services, 2013, KCDEH, 1980; KCDEH and KCWA, 1982, Wood & Dale, 1964).

Elevated nitrate and other solute concentrations are typically present in shallow perched zones and in the unconfined zone above the Corcoran Clay. Groundwater is progressively fresher and lower in TDS below the Corcoran Clay, toward the center of the basin, and in the eastern half of the Subbasin. In contrast, arsenic concentrations increase with depth and in close proximity to portions of the Corcoran Clay. See Section 8 for additional information on these water quality constituents.

Primary and Designated Beneficial Uses

Production from the Primary Alluvial Principal Aquifer provides the bulk of water production in the Subbasin for beneficial use. The primary uses of the Subbasin aquifer system include agricultural, municipal, domestic, and storage for the banking of surface water. The designated beneficial uses for the Subbasin in the Tulare Lake Basin Water Quality Control Plan (CVRWQCB, 2018) include:

- Municipal and Domestic Supply (MUN) - Uses of water for community or individual water supply systems, including, but not limited to, drinking water supply.
- Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching.
- Industrial Service Supply (IND) and Process Supply (PRO) - Water use for industrial activities that either are not dependent on water quality (IND) or those that are dependent upon water quality (PRO).

The predominant use of groundwater from the principal aquifer in the Subbasin is for irrigated agriculture. Municipal, small-water systems and private wells are the other significant use of groundwater. Groundwater is also used by several communities in the Subbasin as a source of municipal water supply, by a small number of private commercial entities for industrial use (i.e., food processing), and to supply an unknown number of private domestic wells.

Data Gaps

The data gaps associated with the hydrogeologic conceptual model for the Primary Alluvial Principal Aquifer include:

- Physical properties of the Westside aquifers and Eastside aquifers.
- Physical properties of the upper zone of the primary aquifer system.
- Groundwater characterization on the eastern and western flanks of the Subbasin and in the upper and shallow zones.
- Groundwater quality of the primary aquifer zones and confined zones on the eastern and western flanks of the Subbasin, from wells screened solely in a single aquifer zone.
- As improvements to monitoring networks are made, data can be used to fill data gaps in the Subbasin.

7.5.1.2 Santa Margarita Principal Aquifer

The Santa Margarita Principal Aquifer is comprised of both the Santa Margarita Formation and Olcese Sand within a limited area in the northeastern Subbasin (Figure 7-27). This principal aquifer is so named because the Santa Margarita Formation is considered the primary producing horizon in this area of the northeastern Subbasin, but many wells are screened in both the Santa Margarita and Olcese Sand. This aquifer is the source of a significant volume of groundwater used, primarily for agricultural supply, within the Santa Margarita Principal Aquifer area shown on Figure 7-27 and Figure 7-28.

This principal aquifer extends from the Pond-Poso Fault (Poso Creek Fault) to the south and extends northward into Tule Basin; and extends from the Subbasin margin on the east to either the extent of the sandstone formation or the base of fresh water in the west as shown on Figure 7-15, Figure 7-16, and Figure 7-20. South of the Pond-Poso Fault, the Santa Margarita and Olcese Sand are highly faulted with multiple oil fields with aquifer exemptions in these areas (Figure 7-27 and Figure 7-28). The Santa Margarita Principal Aquifer is separated from the overlying Primary Alluvial Principal Aquifer by a thick regional aquitard.

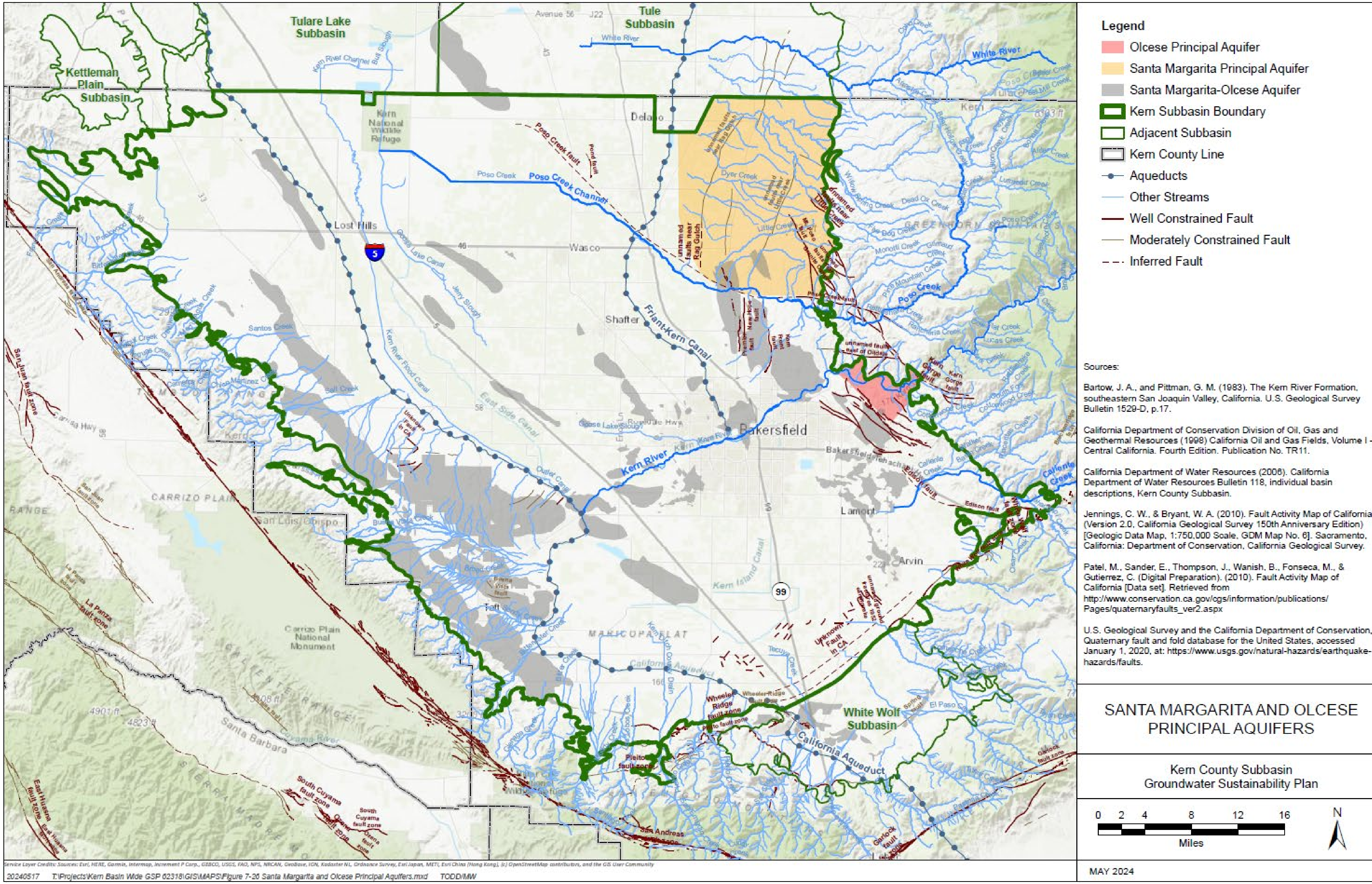


Figure 7-27. Santa Margarita and Olcese Principal Aquifer (Subbasin View)

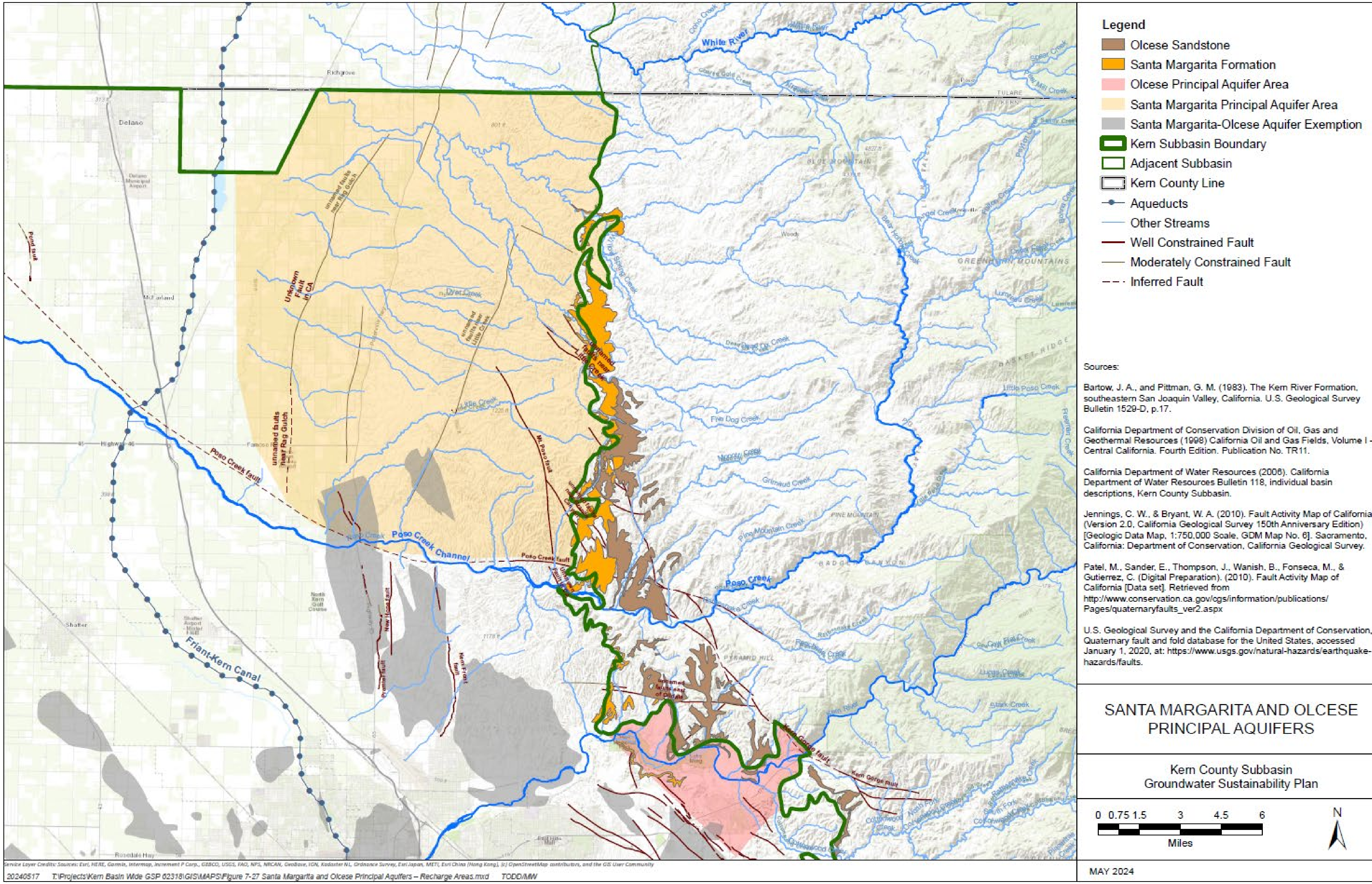


Figure 7-28. Santa Margarita and Olcese Principal Aquifers

Geologic Formations

The Santa Margarita Formation consists of an upper bed of a silty, well-sorted, fine-grained sandstone and a lower bed of a fossiliferous, micaceous sandy siltstone, both of which were deposited in a shallow-marine environment. The Santa Margarita Formation is a permeable sandstone unit with an average thickness of 200 feet (Bartow, 1984). The Santa Margarita Formation is most prominent in the east of the Subbasin (Figure 7-15, Figure 7-16, and Figure 7-20). Toward the center of the basin, the Santa Margarita Formation inter-fingers and grades into the Fruitvale Shale Formation (Bartow and McDougall, 1984). The Olcese Sand is a fine- to coarse-grained marine sandstone with silty sandstone and sandy siltstone interbeds.

Originally deposited in a nearshore marine environment with saltwater, the Santa Margarita Formation now contains freshwater due to groundwater recharge. The Santa Margarita and Olcese outcrop in the watershed areas adjacent to the Subbasin where they are recharged by rainfall and stream seepage. The recharge has, over time, flushed the original saline connate water and now contain freshwater (Davis and others, 1964; Hilton, 1963). The aquifers deepen toward the west, underlying fine-grained deposits that limit natural recharge.

Both the Santa Margarita and Olcese Sand Formations are confined above and below silt and shale layers (Figure 7-15, Figure 7-16, and Figure 7-20) that form competent aquitards that separate this principal aquifer from others. The Etchegoin Formation and Macoma Claystone (Bartow, 1984) act as confining layers between the Santa Margarita and the Primary Alluvial Principal Aquifers. The Round Mountain Silt below the Santa Margarita Formation serves as an aquitard, restricting vertical flow between the Santa Margarita Formation and the underlying Olcese Sand (Bartow, 1984). The Freeman Silt, a marine siltstone that, due to its comparatively finer/siltier texture, is understood to effectively serve as the bottom of the groundwater basin underlying the Olcese Sand.

Physical Aquifer Properties

A series of single-well pumping tests and step-drawdown tests conducted in wells in the Northeast Kern County Subbasin produced estimates of transmissivity ranging from 3,600 to 6,300 ft^2/day and an estimate of the range of hydraulic conductivities of 5.1 ft/day to 8.6 ft/day (Schmidt, 2016). Based on the data collected, a storativity estimate of 6×10^{-4} also was obtained. Analysis of the recovery data provides an estimated transmissivity of 2,800 ft^2/day and hydraulic conductivity of 4.8 ft/day. Reported specific capacities averaged about 12.5 gpm/ft (McClelland, 1962). Hydraulic properties of the Santa Margarita and the Olcese Sand Formations can be estimated as ranging from approximately 2.1 ft/day to 8.6 ft/day, with a midpoint of the range of approximately 5 ft/day.

Structural Properties

Bartow's (1984) mapping highlights various normal faults within the Northeast Kern County Subbasin, including the East-West striking Mt. Poso Fault and the North-South striking Kern Front Fault (Figure 7-27 and Figure 7-28). These faults exhibit minimal vertical offset, approximately 100 feet or less, within the primary aquifer units of interest. The impact of some faults on the hydraulic conductivity of these aquifer units remains uncertain at present.

General Water Quality

Groundwater in the Santa Margarita Formation is the sodium bicarbonate type with TDS concentrations ranging between 360 to 500 mg/L. Groundwater in the Olcese Sand is the calcium-sodium bicarbonate type with concentrations ranging between 360 to 410 mg/L. Groundwater in the unconsolidated nonmarine sediments in this area are of the calcium-sodium bicarbonate type with TDS concentrations ranging between 290 to 680 mg/L. A more detailed discussion of water quality is provided in Section 8.

Groundwater quality becomes brackish toward the west in the Santa Margarita Principal Aquifer. Recharge from outcrops of the Santa Margarita and Olcese Sand in the watersheds adjacent to the Subbasin provide a source of freshwater to this principal aquifer. This recharge has moved westward down-structure displacing the original saline waters into the deeper parts of the Subbasin (Reynolds, 1955). The transition of freshwater to saline water marks the western extent of the Santa Margarita Principal Aquifer, with estimated TDS values of over 2,000 mg/l (Gillespie, 2016).

Primary and Designated Beneficial Uses

Production from the Santa Margarita Principal Aquifer provides water supply to a limited area in the northeastern part of the Subbasin and also extends into the southeastern portions of the adjacent Tule Subbasin. The p sole use of the Santa Margarita Formation is agricultural. The primary use within this area is to support irrigated agriculture, with a focus on citrus, pistachios, and other permanent tree crops.

Data Gaps

The primary data gaps and uncertainty in the hydrogeologic conceptual model include:

- Hydraulic properties of the aquifers, including hydraulic conductivity and storativity.
- Aquifer-specific groundwater levels. Data for groundwater levels and quality have been obtained from wells screened in multiple aquifer zones.
- Underflow recharge from the Sierra Nevada Mountains.
- Well construction and pumping proportion between the shallow and deep aquifers.

The data gaps listed above create uncertainty on the impacts of different aquifer zones on the sustainability indicators. Additional monitoring points and dedicated monitoring wells perforated in the principal aquifers in the future would help reduce the uncertainty associated with these data gaps.

7.5.1.3 Olcese Principal Aquifer

The Olcese Sand Formation was formed in a nearshore marine environment that was present along the eastern Subbasin margin as shown on cross section B-B' (Figure 7-16) and F-F' (Figure 7-20). The formation is a fine- to coarse-grained marine sandstone with silty sandstone and sandy siltstone interbeds. The formation dips to the southwest and is encountered at depths of approximately 200 to 800 feet bgs under the Olcese GSA Area (approximately 600 to -300 feet msl) and reaches depths of approximately 2,000 feet bgs (-1,400 feet msl). The average thickness of the Olcese Sand Principal Aquifer in the Olcese GSA Area is roughly 1,000 feet. Available aquifer testing data indicates transmissivity of the Olcese Sand Formation is on the order of 6,300 feet squared per day and hydraulic conductivity is on the order of 0.55 to 6 feet per day.

As the formation dips to the southwest, the depth to the top of the Olcese Sand Formation increases to greater than 2,300 feet bgs near the Ant Hill Oil Field and further to greater than 3,500 feet bgs before pinching out northeast of Bakersfield. This depth is substantially below the overlying Kern River, Chanac, and Santa Margarita Formations, which serve as the primary sources for groundwater production in the eastern portion of the Kern County Subbasin.

Overlying the Olcese Sand Formation is the Round Mountain Silt a marine siltstone and claystone that serves as an aquitard, restricting vertical flow between the Santa Margarita Formation and the Olcese Sand. The Round Mountain Silt is up to 800 feet thick within the Olcese GSA Area that separates the Olcese Sand Principal Aquifer from the Shallow Alluvium. Local outcroppings of the Round Mountain Silt are observed along the margins of the Kern River, laterally constraining the extent of the Shallow Alluvium (Figure 7-16 and Figure 7-20).

Below the Olcese Sand is the Freeman Silt, a marine siltstone that typically acts as a lower bounding aquitard (Bartow, 1984) and which, due to its comparatively finer/siltier texture, is understood to effectively serve as the bottom of the groundwater basin underlying the Olcese GSA. Older formations (i.e., the Jewett Silt, Rio Bravo Sand and Vedder Sand and the Walker Formation) underly the Freeman Silt and are included within the "undifferentiated older sediments" shown in the cross-sections prepared for this HCM.

The Olcese Sand is recharged by rainfall directly on outcrops within and outside of the Subbasin, by streamflow in the watersheds adjacent to the Subbasin, and likely by the

Kern River in the vicinity of the Kern Gorge Fault at the eastern Subbasin margin (Figure 7-28). The Olcese Sand, like the Santa Margarita Formation, originally contained saltwater at the time of its deposition. Over time, recharge from rainfall and freshwater sources displaced the saltwater westward, resulting in a usable fresh groundwater resource suitable.

Physical Aquifer Properties

Measurements taken by Birkholzer, et al. (2011) state the average porosity is 33 percent and the permeability ranges from 9 to 40 ft/d. Single-well pumping tests produced transmissivity estimates ranging from 3,600 to 6,000 ft^2/day, estimated hydraulic conductivities of 5 to 9 ft/day, and a storativity estimate of 6×10^{-4}. Reported specific capacities ranged from 10 to 12.5 gpm/ft (McClelland, 1962). The Round Mountain Silt provides a confining layer where it overlies the permeable Olcese Sand and has an average permeability of 3×10^{-4} ft/d (Birkholzer, et al. 2011).

Structural Properties

The Kern Gorge Fault constrains subsurface inflows to the groundwater system, creating a lateral boundary between granodiorite bedrock of the Sierra Nevada and the alluvial and marine sedimentary deposits of the Kern County Subbasin. The Round Mountain Silt, where present, further hinders vertical flow between the overlying Shallow Alluvium and the underlying Olcese Sand. The Olcese Sand progressively thins and pinches out into the Round Mountain Silt to the southwest (Bartow, 1984) and also thins to the southeast of the Olcese GSA Area, eventually pinching out and/or interbedding with the overlying Edison Shale.

Several northwest/southeast-oriented faults (Bartow, 1984) offset the Olcese Sand, likely diminishing lateral transmissivity. Additional faults to the north of the Olcese GSA Area likely constrain hydraulic connection to the north. The progressive thinning, dipping, and fault-induced displacement of the Olcese Sand bound usable groundwater resources to localized areas, limiting connectivity to the other principal aquifers of the Kern County Subbasin.

General Water Quality

Groundwater quality data based on samples collected from Olcese Water District wells within the Olcese Principal Aquifer (Wells #2 and #3) shows a sodium-potassium sulfate type, with TDS concentrations ranging from 860 to 1,100 mg/L, sulfate ranging between 320 and 550 mg/L (above the secondary Maximum Contaminant Level (MCL) of 250 mg/L), and iron concentrations exceeding the secondary MCL of 0.03 mg/L in some cases. Recent groundwater quality data indicate no significant trends in the concentrations of these constituents. In contrast, groundwater from the Canyon View Ranch well on the far eastern edge of the Subbasin tends to be of a calcium/bicarbonate type, with an average TDS concentration of 230 mg/L.

Stable isotope data reveal that groundwater within the Olcese Sand Principal Aquifer exhibits a "heavier" composition than the waters of the Kern River yet remain somewhat lighter than stable isotope ratios characteristic of local precipitation in the area (Visser et al., 2016). The isotopic signature suggests that recharge sources for the Olcese Sand Principal Aquifer are predominantly from local rainfall, likely falling onto exposed outcrops of the Olcese Sand east and north of the Olcese GSA. Additionally, a portion of the recharge comes from lighter waters sourced from the Kern River, either via seepage through the Kern Gorge Fault or through areas of hydraulically connected Shallow Alluvium near the eastern margin of the basin.

Groundwater from Olcese Water District Well #4 located further west is of a sodium bicarbonate type with slightly lower concentrations of TDS (710 to 840 mg/L), sulfate (130 to 240 mg/L), and iron (0.066 mg/L) compared to Wells #2 and #3. Groundwater in this well also has a higher pH (8.8), compared to the 7.7 to 8.5 observed in Wells #2 and #3.

Primary and Designated Beneficial Uses

The primary use of groundwater within the Olcese GSA is as a supply source for irrigated agriculture, primarily citrus and other permanent tree crops. Groundwater is pumped from this principal aquifer to meet excess demands for irrigation that are not met by the Olcese Water District and its primary landowner's riparian and non-riparian rights to Kern River surface water. Groundwater is used by the Anne Sippi Clinic as the raw water source for their domestic water supply; this is the only known potable consumption of groundwater in the Olcese GSA Area. Additionally, a small but unquantified amount of water is used by local ranchers for stock water. These uses are consistent with the beneficial use designations in the Tulare Lake Basin Water Quality Control Plan (CVRWQCB, 2018).

Data Gaps

The primary data gaps and uncertainties in the hydrogeologic conceptual model include:

- Uncertainty regarding the aquifer properties of the Olcese Principal Aquifer.
- Uncertainty about the source and rate of recharge of the Olcese Principal Aquifer.
- Uncertainty about the location and extent of the Olcese Principal Aquifer outcrops.
- Lack of consistent long-term historical water level data from the Olcese Principal Aquifer, and resultant uncertainty about groundwater gradients.

While the uncertainties listed above contribute to some uncertainty about the overall hydrogeologic conceptual model, they do not significantly impede the ability of the Olcese GSA to sustainably manage the groundwater resources of the Olcese Principal

Aquifer. Additional monitoring data and investigations could help reduce these uncertainties in the future.

7.6 Basin Boundaries and Basin Bottom

Basin boundaries and basin bottom provide a description of the geologically controlled lateral and vertical limits that define the margins of the groundwater aquifer system, and therefore represent barriers to groundwater flow (DWR, 2016).

7.6.1 Lateral Boundaries

☑ 23 CCR § 354.14(b)(2)

The boundaries of the Kern County Subbasin have been defined by DWR (DWR, 2006 and 2016c). As described in DWR's Bulletin 118, the Subbasin is "bounded on the west, southwest, and east by the bedrock formations of the Coast Range, San Emigdio Mountains, and Sierra Nevada, respectively. It is separated by the White Wolf Subbasin on the southeast by the White Wolf Fault. The northern boundary is generally coincident with the County line." (DWR, 2016c). The Subbasin's lateral boundaries on the east, west and south sides are geologically based, whereas the northern boundary is jurisdictionally based.

The geologically-based Subbasin boundaries are generally defined as the lateral extent of the Pliocene or younger (Quaternary) units based on the surficial geologic map published by the California Division of Mines and Geology (Figure 7-6). The east and southeastern boundary borders the Sierra Nevada range that is composed of igneous and metamorphic Basement Complex rocks, primarily granite. However, outcrops of Miocene or older sedimentary units, including the Santa Margarita Formation and Olcese Sand, occur just outside of the Subbasin boundary. The east and southeast have multiple large watersheds that provide a source of recharge as either stream recharge or subsurface inflows to the Subbasin.

A portion of the south Subbasin boundary is defined by the White Wolf Fault which separates the Subbasin from the adjacent White Wolf Subbasin. The White Wolf Fault is considered to be a hydrogeologic flow barrier that restricts groundwater flow between the White Wolf and Kern County Subbasins.

The southwest and west boundaries are outcrops of Miocene or older sedimentary units in the Coast Ranges. A 2018 basin boundary modification modified the boundary for certain segments on the western side based on the contact between the Quaternary alluvium and Pliocene or older rocks, as mapped by Jennings (2010). None of the Principal Aquifer units outcrop in the Coast Ranges, and the majority of these units in the Coast Ranges are fine-grained shales and siltstones that limit subsurface inflow into the Subbasin from the west. The watersheds along the western boundary are much smaller than other areas which limits the potential for stream recharge in this area.

On the northwest edge of the Basin the boundary with the Kettleman Plain Subbasin is based on the jurisdictional extent of the Devils Den Water District. Little to no groundwater flow is considered to occur across this boundary, and groundwater flow in the Kettleman Plain Subbasin flows north to the Tulare Lake Subbasin (Wood and Davis, 1959).

On the north side, the Subbasin boundary is defined primarily by the Kern County line, with the exception of two jurisdictionally based cutouts where portions of certain Groundwater Sustainability Agencies' (GSA) in the basins north of the county line (i.e., a portion of the Delano-Earlimart Irrigation District GSA and El Rico GSA) extend southward into Kern County. The Primary Alluvial Principal Aquifer correlates to the Upper and Lower Principal Aquifers defined in the Tule and Tulare Lake Subbasins. The Santa Margarita Principal Aquifer correlates to the Santa Margarita Formation and OlceseSand of the Southeastern Subbasin of the Tule Subbasin. The Pliocene Marine Deposits aquitard of the Tule Subbasin is consistent with the Kern County Subbasin definition of these units.

7.6.2 Definable Basin Bottom

☑ 23 CCR § 354.14(b)(3)

The bottom of the Subbasin varies significantly across the Subbasin based on changes in geometry, structural features at depth, groundwater quality, oilfield locations and aquifer exemptions. Previous Central Valley studies have observed saline groundwater in various areas and depths and have used water quality as the effective bottom of the Subbasin groundwater. In accordance with DWR BMP guidance (DWR, 2016), the Subbasin bottom is defined using the following criteria:

- physical properties define the vertical limit below which little to no significant groundwater movement occurs.
- geochemical properties that define the vertical extent of usable groundwater. These may include:
  - Base of freshwater maps in the Central Valley published by the DWR and USGS.
  - The USEPA definition for Underground Source of Drinking Water (USDW).
- Administrative and geologic boundaries of exempted aquifers.

In basins where produced water from underlying oil and gas operations is beneficially used within the basin, or injected into the basin's USDW, the HCM can further characterize the geologic boundaries that separate the USDW from the oil and gas aquifers and identify the basin bottom.

7.6.3 Physical Properties

☑ **23 CCR § 354.14(b)(4)(B)**

The geologic boundary shown on Figure 7-29 is the composite bottom thickness of the three defined principal aquifers. The principal aquifers represent the portion of the Subbasin that currently provides the primary sources of groundwater in the Subbasin for beneficial uses of drinking water supply, agricultural irrigation, industrial supply and other uses.

The base of the Primary Alluvial Principal Aquifer is defined as the base of the continental deposits which is consistent with how Bertoldi and others (1991) and Williamson and others (1989) defined it for the regional aquifer system. The thickness of the Primary Principal Aquifer ranges between 2,000 to 3,000 feet across much of the Subbasin, with a maximum thickness of over 6,000 feet south of Bakersfield. However, the contact between continental and the underlying marine deposits is not always certain because the deposits interfinger in some places. However, this uncertainty is not considered to affect the analysis of groundwater flow because (1) the total probable volume affected a very low percentage of the total volume of the aquifer system and (2) these very deep deposits are generally considered as below the practical pumping limits so that an error in estimating their thickness has little to no effect on the flow-system analysis (Bertoldi and others, 1991; Williamson and others (1989).

Along the eastern margin, the Santa Margarita and Olcese Sand Formations are marine sandstone units underlying the continental deposits that contain freshwater; however, these marine formations are hydraulically separated from the overlying continental deposits of the Kern River Formation by marine shale units. The total thickness of the Subbasin is considered as the combined thickness of the continental deposits and the freshwater marine sandstones as shown in Figure 7-29.

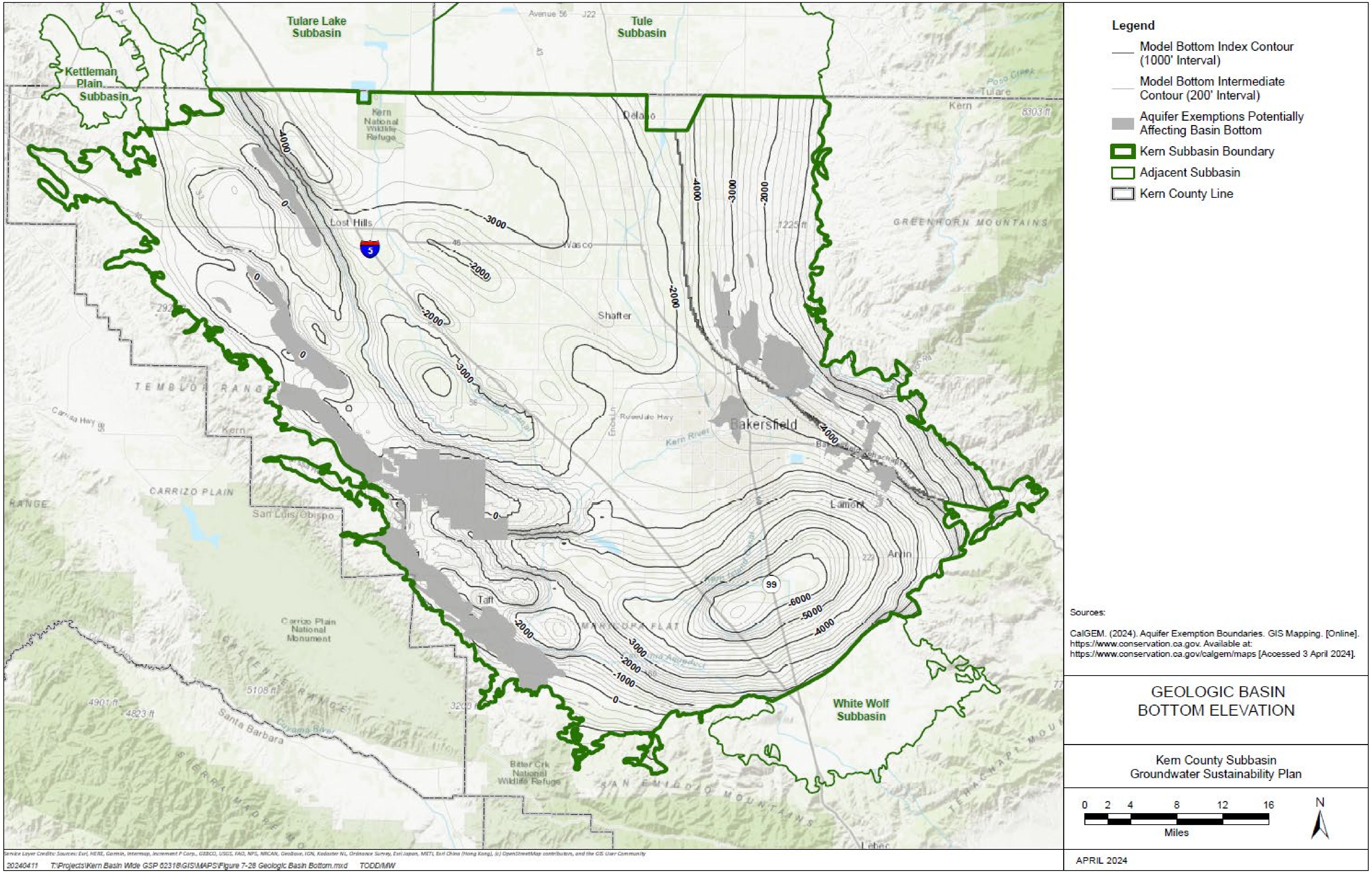


Figure 7-29. Geologic Basin Bottom Elevation

This page intentionally left blank.

The maximum thickness of both consolidated and unconsolidated sediments in the Subbasin may reach over 18,000 feet (Davis et al., 1959). The deeper portions of the Subbasin contain mostly Miocene and older marine sedimentary units. These deeper marine sandstones have not been flushed of their original, highly saline connate waters. This indicates that these units have little to no significant groundwater movement in these deeper units and do not receive recharge from the surface or other sources of freshwater. Therefore, these deeper units do not contain usable groundwater supplies and are considered to be below the definable basin bottom following DWR BMP guidance (DWR, 2016).

7.6.4 Geochemical Properties

The section describes the geochemical properties evaluated including the Central Valley Base of freshwater maps develop by the USGS (Page, 1986) and the Subbasin depth to USDW map (Gillespie et al, 2017).

Base of Fresh Water

SWRCB resolution 88-63 (as amended by 2006-0008) provides policy on sources of drinking water. According to that guidance, groundwater with a TDS of less than 3,000 mg/L may reasonably be expected to supply a public water system, if aquifer yield is sufficient (more than 200 gallons/day), the supply is not contaminated or beyond reasonable treatment, and the groundwater is not exempted by 40 CFR §146.4 (SWRCB, 2006).

In general, this definition indicates that any formation containing groundwater with a TDS of less than 3,000 mg/L outside of an exempted aquifer (including oil-producing zones) would qualify as a USDW if it contains a sufficient quantity of groundwater.

Fresh groundwater is underlain by more saline groundwater in many basins of the Central Valley; therefore, the base of this fresh water can be used to define the basin bottom. In 1973, a USGS investigator (Page, 1973) mapped the base of fresh water in the Central Valley using a specific conductance value of 3,000 micromhos per centimeter (µmho/cm), which is equivalent to a TDS range of about 2,000 to 2,880 mg/L varying with temperature and differences in water chemistry.

This mapping of the base of fresh water by Page (1973) is generally consistent with SWRCB resolution 88-63 (as amended by 2006-0008) that provides policy on sources of drinking water. According to that guidance, groundwater with a TDS of less than 3,000 mg/L may reasonably be expected to supply a public water system, if aquifer yield is sufficient (more than 200 gallons/day), is not contaminated beyond reasonable treatment, and the groundwater is not exempted by 40 CFR §146.4 (SWRCB, 2006).

Page’s (1973) base of freshwater elevation contours are shown on Figure 7-29. The base of fresh water is typically shallowest along the western edge of the southern San

Joaquin Valley and deepens towards the center of the Valley. In the Subbasin, depths exceed 4,400 feet below msl south of Bakersfield. The shallowest elevation of the base of freshwater reaches is 0 to 400 feet below msl in the western areas of the Subbasin. In the Santa Margarita Principal Aquifer, the base of fresh water occurs at about 2,600 feet below msl in the area east of Delano.

Underground Source of Drinking Water (USDW)

The depth of USDW has recently been defined in the southern San Joaquin Valley by a team of researchers from California State University, Bakersfield (Gillespie et al., 2017). The group used geophysical log analyses to estimate the depth where water salinity increased above the 10,000 mg/L threshold included in the USDW definition. This map, showing the depth to a water salinity of 10,000 mg/L, was designated as the base of the USDW by the investigators; the map is shown as Figure 7-31.

As shown on Figure 7-31, the contours defined by water salinity vary greatly in the Kern County Subbasin, where the depth to 10,000 mg/L TDS is shallow in the center and the northern and western margins, ranging from <500 to 2,000 feet. At the eastern margins of the Subbasin, depths range in from 2,000 to 6,000 feet. The steepest change in depth is in the south of the Subbasin, as depths change from 2,500 to over 10,000 feet. There is a noticeable depression north of the Wheeler Ridge foothills, where USDW may exceed 10,000 feet (Gillespie et al., 2017). While it seems highly unlikely that groundwater would be extracted from such depths, there is no basis for assuming that USDW could not extend that deep. Along the eastern margin of the Subbasin, formation waters are below the USDW standard of 10,000 mg/L from the surface to the basement rocks.

As shown on Figure 7-31, the contours defined by water salinity are shallow in the West Margin HCM Area, compared to the rest of the Kern County Subbasin. The depth of USDW ranges from less than 1,000 feet to 2,500 feet below msl. The deepest section occurs between the Buttonwillow Ridge and Elk Hills area and the Buena Vista Lakebed. Although waters in many sands in the western valley are more saline than 3,000 mg/L TDS, numerous wells contain waters between 3,000 and 10,000 mg/L, particularly in the nonmarine Tulare Formation. Along the western margin of the Subbasin, the formation waters are within oil reservoirs and are not 100 percent water saturated (Gillespie and others, 2017).

7.6.4.1 Oil Fields Aquifer Exemptions

An aquifer exemption removes an aquifer or portion of an aquifer from protection as an USDW under the Safe Drinking Water Act (SDWA). Federal Underground Injection Control (UIC) regulations allow USEPA to exempt aquifers that do not currently serve as a source of drinking water and will not serve as a source of drinking water in the future, based on specific criteria (USEPA, 2019).

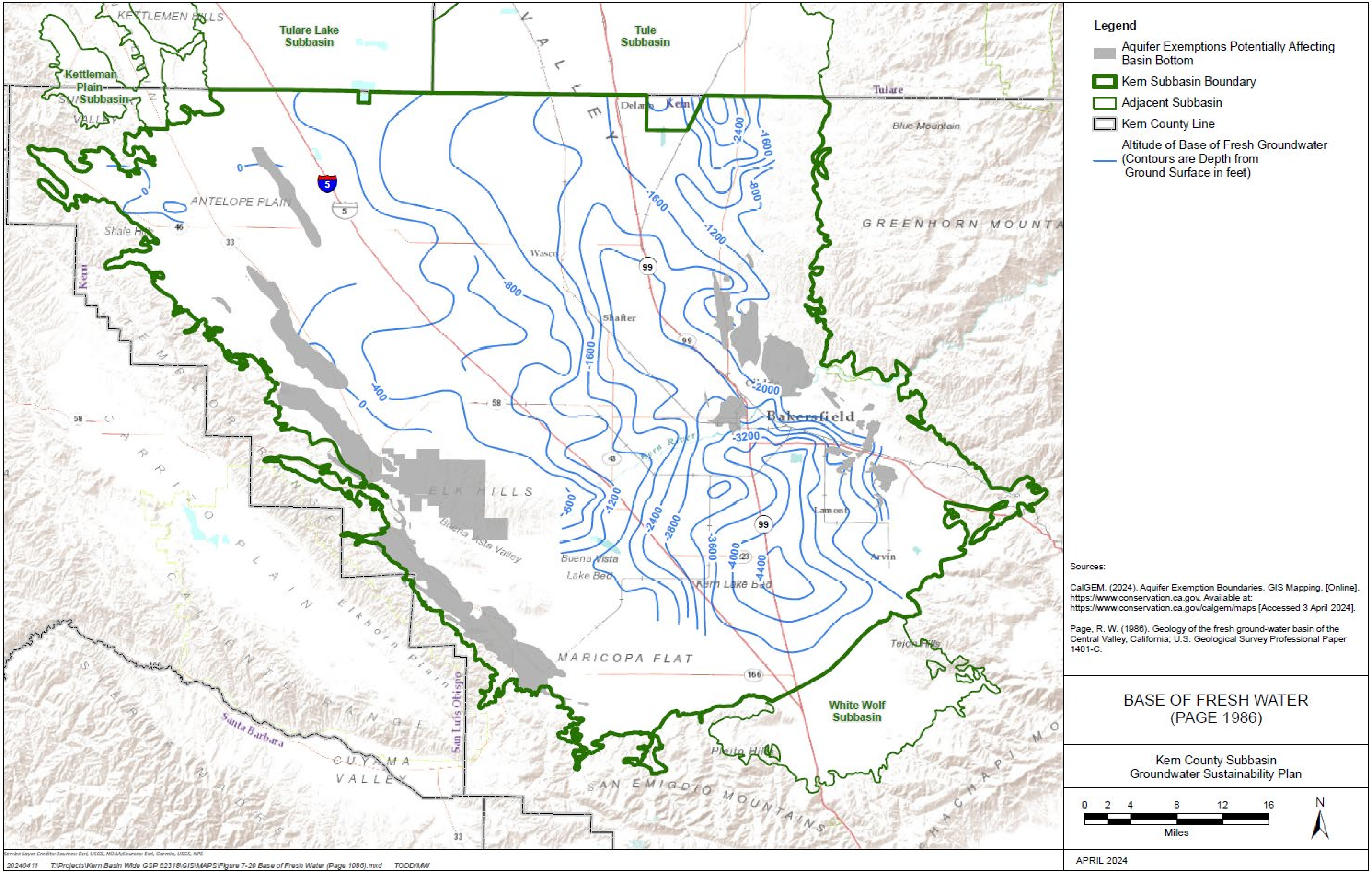


Figure 7-30. Base of Fresh Water (Page 1986)

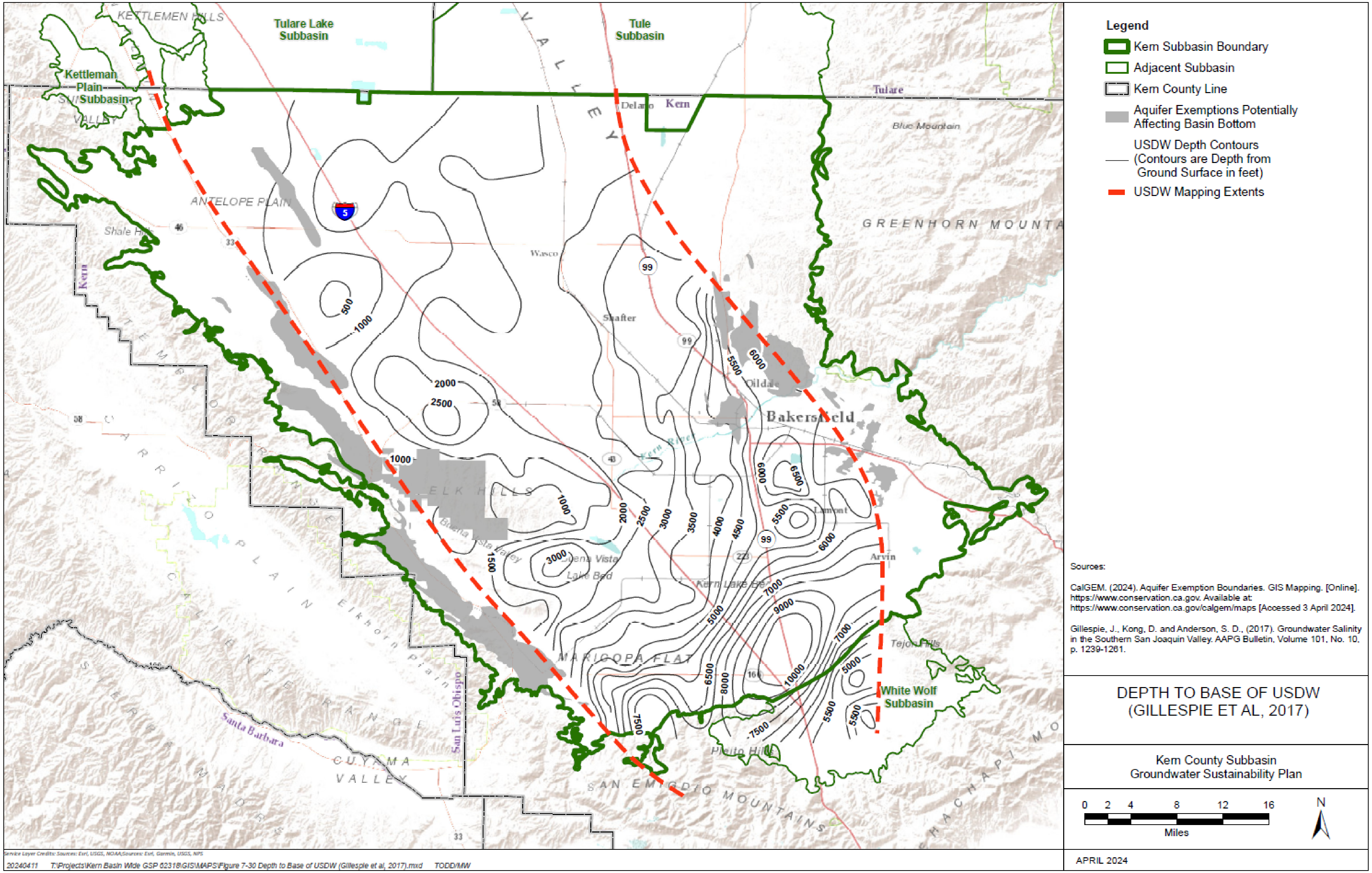


Figure 7-31. Depth to Base of USDW

7.6.4.2 Approach for Mapping Aquifer Exemption for Basin Bottom

As noted in the DWR's BMP Guidance (DWR, 2016), in basins with underlying oil and gas operations, the geologic boundaries that separate the USDW from the oil and gas aquifers, the identify "exempted aquifer" portion of the groundwater basin that has been permitted for underground injection control by California Geologic Energy Management Division (CalGEM) or the SWRCB Oil and Gas Monitoring Program.

Our approach, based on the maps and analysis described above, is to define the bottom elevation as the portion of the Subbasin outside of the vertical and lateral extent of the exempted aquifer zone. This approach to modifying the base of fresh water and USDW and defining the bottom of the groundwater Subbasin is illustrated by the conceptual diagram on Figure 7-32. Specifically, the bottom of the groundwater Subbasin, based on the maps and analysis described above, will be modified by the top of oil fields and exempt aquifers where shallower. It is further assumed that the Subbasin would be a continuous unit from the surface down to the basin bottom; no formations below the shallowest oil producing zone or shallowest exempt aquifer would be included. Not all oilfields are exempted aquifers, and not all exempted aquifers are oilfields, but the shallowest depth of either should define the basin bottom.

The purpose of this Plan is not to exempt aquifers, nor is it to define the maximum depth or water quality concentration at which groundwater is economically recoverable or treatable now or in the future. However, by applying the criteria of 40 CFR §144.3 and 40 CFR §146.4, active oil and gas aquifers and exempted aquifers are not a part of the groundwater basin for beneficial use. Rather than re-contouring the maps around these shallower exempt aquifers, the areas of the aquifer exemptions are shown on the maps (Figure 7-29, Figure 7-30, and Figure 7-31), and the depth ranges for these aquifer exemption areas are summarized on Table 7-1.

Table 7-1. US EPA Oilfield Aquifer Exemptions used to modify the Definable Bottom of the Subbasin.

Active Oil and Gas Fields in Area	HCM Area	Uppermost Exempt Aquifer Geologic Formation	Aquifer Exemption Average Depth (feet)	Base of Fresh Water (feet msl) (Page, 1986)	Base of USDW (feet) (Gillespie, 2017)
Primacy Aquifer Exemptions					
Ant Hill	Eastern Margin HCM	Olcese Formation	2,000	-1800 to -1600	USDW to Basement
Antelope Hills (Williams Area)	Western Fold Belt HCM	Upper Tulare Formation	850	>0	Oil reservoir not water saturated
Belridge, North	Western Fold Belt HCM	Tulare - Etchegoin Formation	600	>0	Oil reservoir not water saturated

Active Oil and Gas Fields in Area	HCM Area	Uppermost Exempt Aquifer Geologic Formation	Aquifer Exemption Average Depth (feet)	Base of Fresh Water (feet msl) (Page, 1986)	Base of USDW (feet) (Gillespie, 2017)
Primacy Aquifer Exemptions					
Belridge, South	Western Fold Belt HCM	Tulare Formation	400	-100 to 0	Oil reservoir not water saturated
Cymric (McKittrick Front Area)	Western Fold Belt HCM	Tulare Formation (below Amincola Clay)	1,200	>0	Oil reservoir not water saturated
Cymric (Welport Area)	Western Fold Belt HCM	Tulare Formation (below Amincola Clay)	1,000	>0	Oil reservoir not water saturated
Kern River	Eastern Margin HCM	Kern River Formation	900	-2000 to -1600	6000 ft to Basement
Lost Hills	Western Fold Belt HCM	Tulare Formation	200	>0	500 to 1000 ft
McKittrick (Main Area)	Western Fold Belt HCM	Tulare Formation	500	>0	Oil reservoir not water saturated
McKittrick (Northeast Area)	Western Fold Belt HCM	Tulare Formation	400	>0	Oil reservoir not water saturated
Midway-Sunset	Western Fold Belt HCM	Tulare - San Joaquin Formation	200	>0	Oil reservoir not water saturated
Railroad Gap	Western Fold Belt HCM	Tulare Formation (below Amincola Clay)	1,100	>0	Oil reservoir not water saturated
Edison (Edison Groves Area)	Eastern Margin HCM	Chanac - Olcese Formation	1,130	-2400 to -2000	USDW to Basement
Edison (Jeppi Area)	Eastern Margin HCM	Chanac - Santa Margarita Formation	3,300	-2800 to -2400	6000 ft to Basement
Edison (Main Area	Eastern Margin HCM	Chanac - Santa Margarita Formation	750	-2800 to -2000	6000 ft to Basement
Edison (Northeast Area)	Eastern Margin HCM	Chanac Formation	350	>-2000	USDW to Basement
Edison (Race Track Hill Area)	Eastern Margin HCM	Chanac - Santa Margarita Formation	1,070	-2400 to -2000	USDW to Basement
Edison (West Area)	Eastern Margin HCM	Chanac Formation	3,200	>-2000	USDW to Basement
Fruitvale (Calloway Area)	North Basin HCM	Chanac Formation	4,050	-3200 to -2800	4500 ft
Fruitvale (Greenacres Area)	North Basin HCM	Etchegoin - Chanac Formation	4,300	-2800 to -2400	4500 ft
Fruitvale (Main Area)	North Basin HCM	Etchegoin - Chanac Formation	3,000	-3200 to -2400	4500 to 5000 ft
Kern Bluff	Eastern Margin HCM	Transition Zone - Santa Margarita Formation	740	-2000 to -1600	USDW to Basement
Kern Front	Eastern Margin HCM	Etchegoin - Chanac Formation	2,200	-2400 to -1600	6000 ft to Basement
Poso Creek (Enas Area)	Eastern Margin HCM	Etchegoin Formation	1,800	-2000 to -1200	USDW to Basement

Active Oil and Gas Fields in Area	HCM Area	Uppermost Exempt Aquifer Geologic Formation	Aquifer Exemption Average Depth (feet)	Base of Fresh Water (feet msl) (Page, 1986)	Base of USDW (feet) (Gillespie, 2017)
Primacy Aquifer Exemptions					
Poso Creek (McVan Area)	Eastern Margin HCM	Etchegoin Formation	1,150	-1600 to -1200	USDW to Basement
Poso Creek (Premier Area)	Eastern Margin HCM	Etchegoin Formation	2,350	-1600 to -1200	5000 to 6000ft/Basement
Edison Transition Sand Exempt Area	Eastern Margin HCM	Santa Margarita Formation	800	>-2000	USDW to Basement
Kern Front Chanac Oil Sand Exempt Area	Eastern Margin HCM	Upper Chanac Oil Sand	1,400	-2400 to -1600	6000 ft to Basement
Poso Creek McVan Basal Etchegoin Exempt Area	Eastern Margin HCM	Basal Etchegoin	1,000	-1600 to -1200	USDW to Basement
Poso Creek Primier Basal Etchegoin Exempt Area Area	Eastern Margin HCM	Basal Etchegoin	1,800	-2000 to -1200	USDW to Basement
Asphalto Upper Tulare Exempt Area	Western Fold Belt HCM	Upper Tulare Formation	200	>0	Oil reservoir not water saturated
Belridge-North Tulare Exempt Area	Western Fold Belt HCM	Tulare Formation	640	>0	Oil reservoir not water saturated
Belridge-South Tulare Exempt Area	Western Fold Belt HCM	Tulare Formation	300	-100 to 0	Oil reservoir not water saturated
Cymric Tulare Exempt Area	Western Fold Belt HCM	Tulare Formation	624	>0	Oil reservoir not water saturated
Elk Hills Lower Tulare Phase 1 Exempt Area	Western Fold Belt HCM	Tulare Formation	950	-300 to 0	<1000 to 2000 ft
Elk Hills Lower Tulare Phase 2 Exempt Area	Western Fold Belt HCM	Tulare Formation	980	-300 to 0	<1000 to 2000 ft
Lost Hills Tulare Exempt Area	Western Fold Belt HCM	Tulare Formation	50	>0	500 to 1000 ft
McKittrick Tulare Exempt Area	Western Fold Belt HCM	Tulare Formation	189	>0	Oil reservoir not water saturated

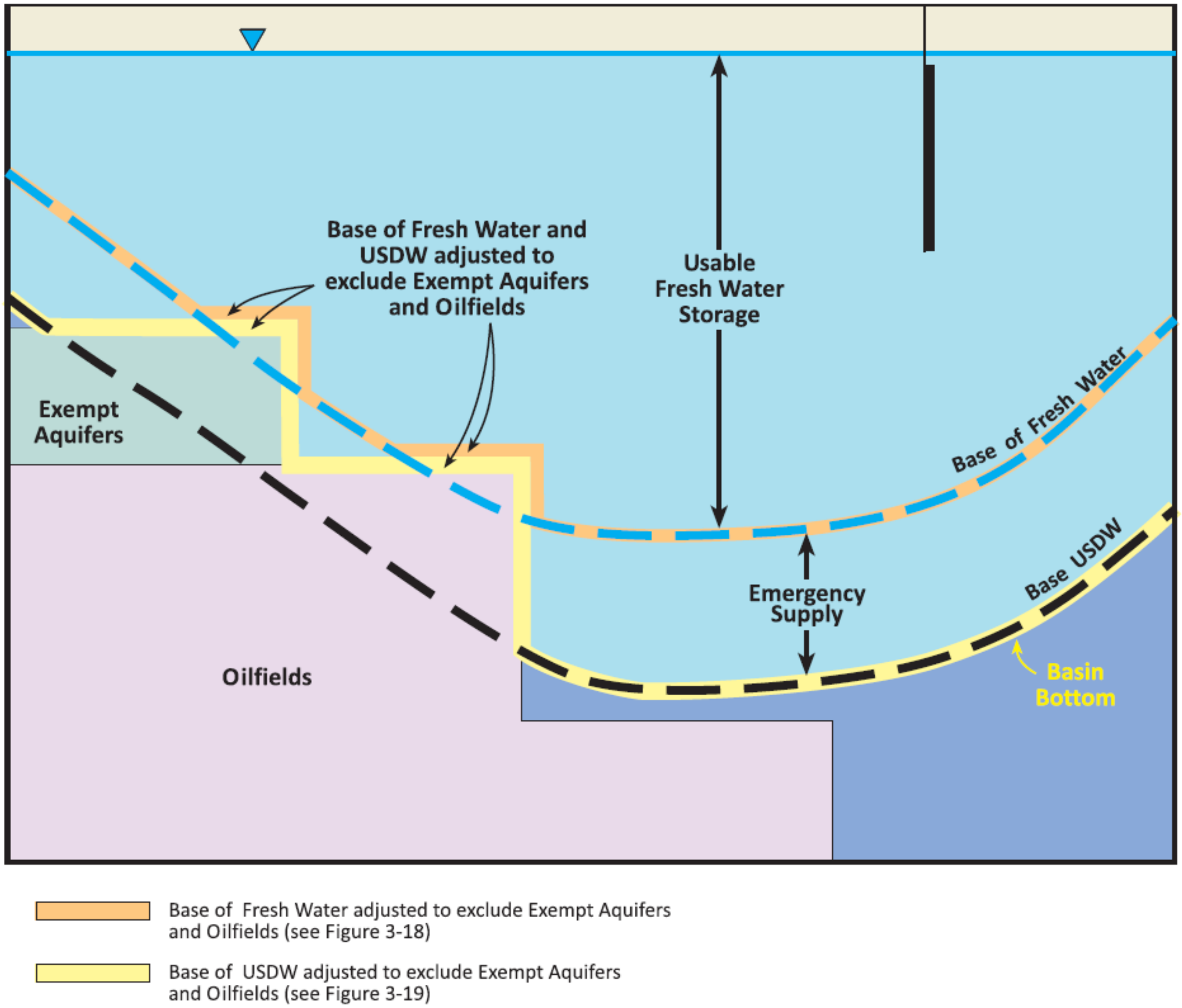
Regulatory Framework

An aquifer exemption is an action by USEPA to remove an aquifer or portion of an aquifer from protection as an USDW under the SDWA. UIC regulations allow USEPA to exempt aquifers that meet the following criteria:

- 40 CFR § 146.4 (a) “It does not currently serve as a source of drinking water.”
- 40 CFR § 146.4 (b)(1) “It cannot now and will not in the future serve as a source of drinking water because it is mineral, hydrocarbon, or geothermal energy

producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible."

- 40 CFR § 146.4(c) "The total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/L and it is not reasonably expected to supply a public water system."



Kern County Subbasin
Groundwater Sustainability Plan

CONCEPTUAL APPROACH BOTTOM OF THE SUBBASIN IN THE PLAN AREA

Sources: Modified from Page, 1986 and DOGGR, 1988.

APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\ Figure 7-31 Conceptual Approach Bottom of the Subbasin in the Plan Area.ai

Figure 7-32. Conceptual Approach Bottom of the Subbasin in the Plan Area

This page intentionally left blank.

In order to submit a proposal by the State to the USEPA, CalGEM shall consult with the appropriate Regional Water Quality Control Board and the SWRCB to ensure that the subject proposal meets California Public Resources Code (PRC) 3131(a), which states that the State must “ensure the appropriateness of [the] proposal” concerning the conformity with all of the following:

- Criteria set forth in 40 CFR § 146.4 (listed above).
- The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.
- The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.

The California Division of Oil, Gas and Geothermal Resources (DOGGR; now called CalGEM) was granted primacy to implement the Class II injection UIC program by the US Environmental Protection Agency (USEPA, 1982). The primacy aquifer exemption boundaries are based on the 1973-1974 production limits as hydrocarbon producing reservoirs shown in Volumes I and II of California Oil and Gas Fields, published by the California Division of Oil and Gas (DOGGR, 1973 and 1974, respectively).

A post-primacy aquifer exemption is an action by USEPA to remove an aquifer or portion of an aquifer from protection as an USDW under the SDWA. Applications prepared by the field operator are reviewed by CalGEM and the State Board. If, following public comment, both concur that an aquifer or portion of an aquifer may merit consideration for exemption, the application is submitted to the USEPA. The USEPA may exempt an aquifer as a potential USDW if it satisfies 40 CFR §146.4. Thus, if future aquifer exemptions are approved by USEPA, corresponding changes will be made to adjust the bottom of the basin.

Areas de-designated for a specific beneficial use under the Central Valley Regional Water Quality Control Board (CVRWQCB) Basin Plan (CVRWQCB, 2018) are still considered part of the Subbasin unless the de-designated area is already defined as outside the Subbasin based on physical, geochemical, or aquifer exemption criteria discussed above.

Kern County Subbasin Oil and Gas Fields

Kern County has been a major producer of oil and gas since the 1890s, marked by the initial discovery of oil on the county's west side. As of 2019, it ranked seventh among U.S. oil-producing counties. U.S. Energy Information Administration data (Kern Economic Development Foundation (KEDF), 2021) indicates an annual production of approximately 119 million barrels of oil and 129 billion cubic feet of gas. These quantities represent 71 percent of California's and 3 percent of total U.S. oil production, and accounts for 78 percent of California's total natural gas production (KEDF, 2021).

Figure 7-33 shows the administrative boundaries of the Subbasin Oil and Gas Field from CalGEM along with the locations of currently active wells (CalGEM, 2023).

Because of the extensive folding and faulting along with the geologic history of deposition of marine shales in a deep basin, the Kern County Subbasin has the geological conditions that are conducive to the development of oil and gas fields. The exempt aquifers are those formations described and depicted as the shaded portions on the maps and cross sections of the report. The location and extent of the existing approved aquifer exemptions in the Subbasin are shown in Figures 7-34 and 7-35, which show the primary and post-primacy aquifer exemption, respectively.

Oil and gas field operations are required to comply with an array of federal, state and local regulatory requirements. The USEPA must review and approve aquifer exemption requests in accordance with the regulatory criteria in 40 CFR 146.4. CalGEM regulates production of oil, gas, and geothermal resources, including standards for well design and construction standards, surface production equipment and pipeline requirements, and well abandonment procedures and guidelines (California Code of Regulations, Title 14, Division 2, Chapter 4). USEPA has also granted CalGEM primacy over the Underground Injection Control program for Class II wells.

Oil Field Geology Overview

The presence of an oil and gas field typically indicates that all or a portion of a geologic formation is hydraulically isolated from the rest of the formation or adjacent formations (a condition required to trap the hydrocarbons). Therefore, an understanding of oil field geology is important to understanding its relationship to the groundwater aquifer. The following is a brief overview of oil and gas field characteristics summarized from the following references (King, 2023, Selley, 2022, North, 1985 and Boggs, 2011) to provide background on the geological controls that isolate an oil and gas field exempt aquifer from other areas of the aquifer.

There are four geological requirements for the formation of a conventional hydrocarbon reservoir 1) Source Rock, 2) Migration Path, 3) Reservoir Rock and 4) Trapping Mechanism. The source rock is typically a fine-grained sedimentary rock such as organic-rich shales, siltstones, or coals from marine or deltaic deposits. The source rock needs to achieve sufficiently elevated pressures and temperatures to transform organic materials in the shale into commercial quantities of oil and gas. The source rock must also have a sufficiently low permeability to keep the organic material in place over a long period of geologic time for this transformation process to occur.

As pressures increase, the oil and gas are eventually forced out of the source rock. The main driving mechanism in oil and gas migration is buoyancy since hydrocarbons are less dense (lighter) than the resident water. In order to prevent this upward buoyant flow from reaching the surface, a vertical flow barrier is required along the migration path.

The Reservoir is a sedimentary rock with sufficient porosity and permeability to allow for the accumulation of oil and gas. The Trap is the geologic features that keep the oil and gas in place, so it does not migrate further. Traps require a relatively impermeable geologic feature that stops upward migration and provides sufficient lateral confinement to keep the oil and gas contained in the Reservoir Rock over geologic time.

Traps can be categorized as stratigraphic or structural. As the names imply, stratigraphic traps are related to the layering of the rock strata, while structural traps are related to the structural deformations of the rock formations. Examples of the different trapping mechanisms are shown in Figure 7-36. Stratigraphic traps include pinch-outs and unconformities where the reservoir is encased in low permeability unit as the result of the original deposition of the sediments. Structural traps are related to the deformation after deposition due to tectonic forces that create geologic folds (anticlines) or faults. All these types of traps are present in the Subbasin oil and gas fields.

This page intentionally left blank.

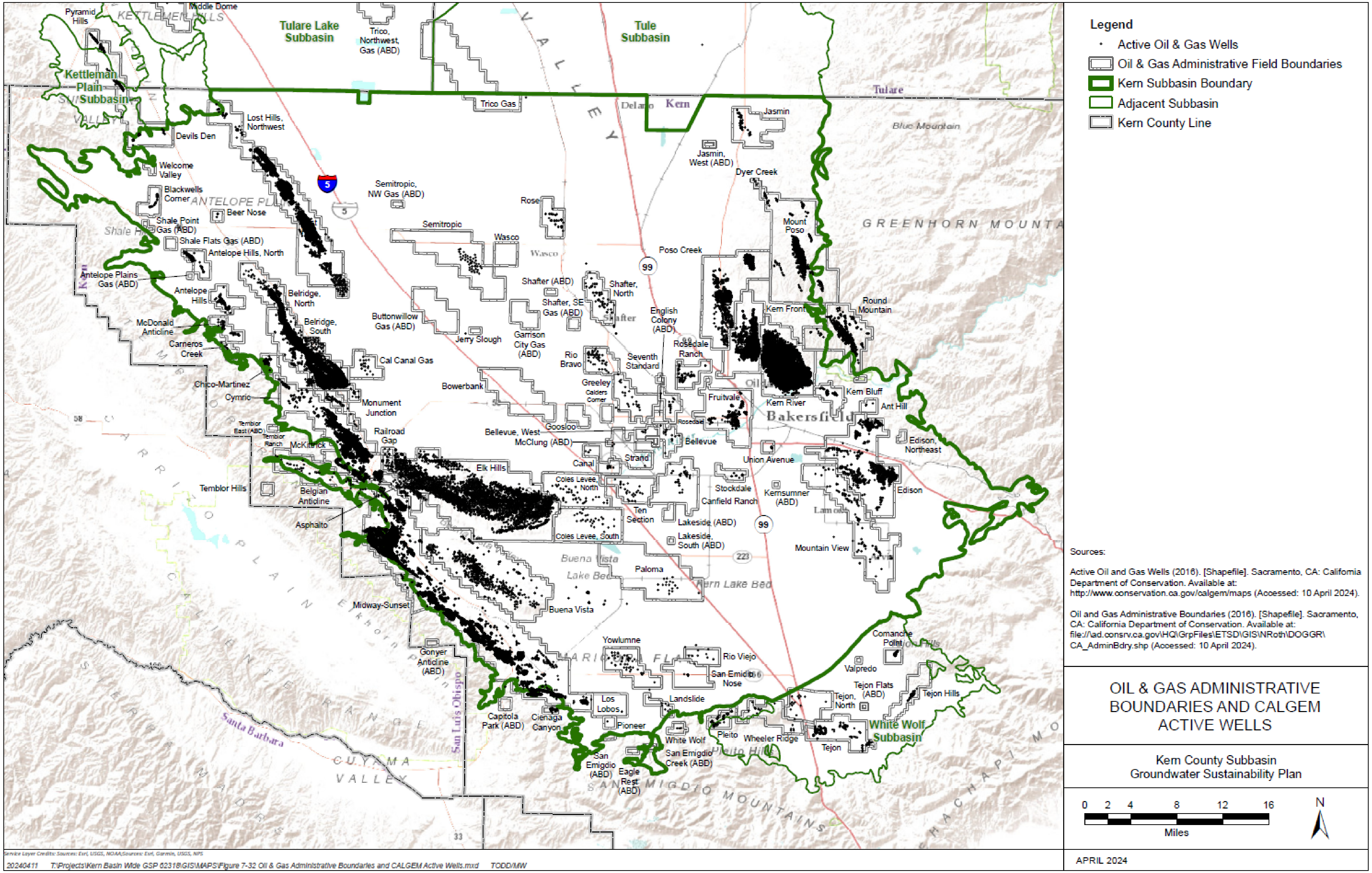


Figure 7-33. Oil & Gas Administrative Boundaries and CALGEM Active Wells

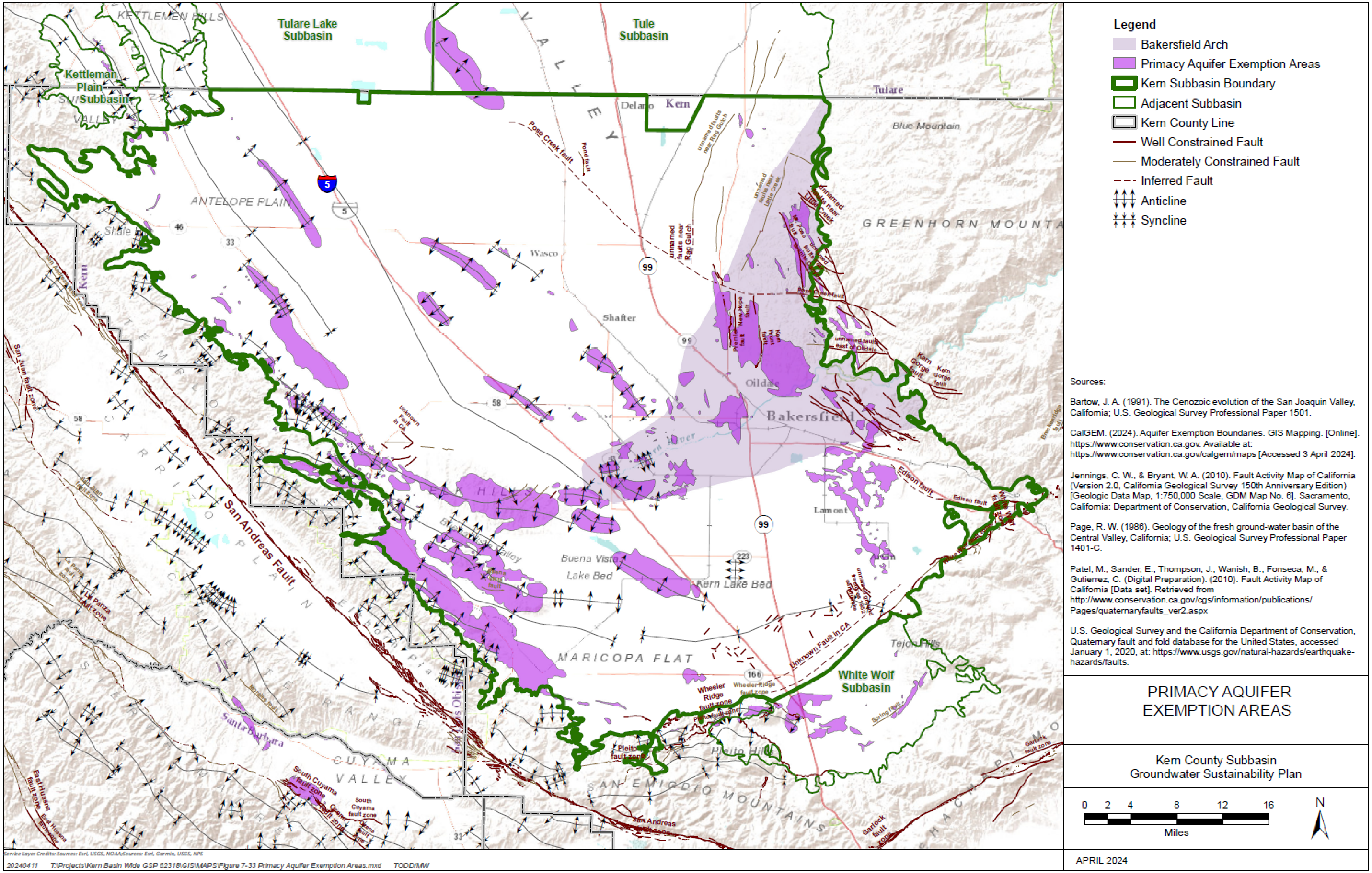


Figure 7-34. Primacy Aquifer Exemption Areas

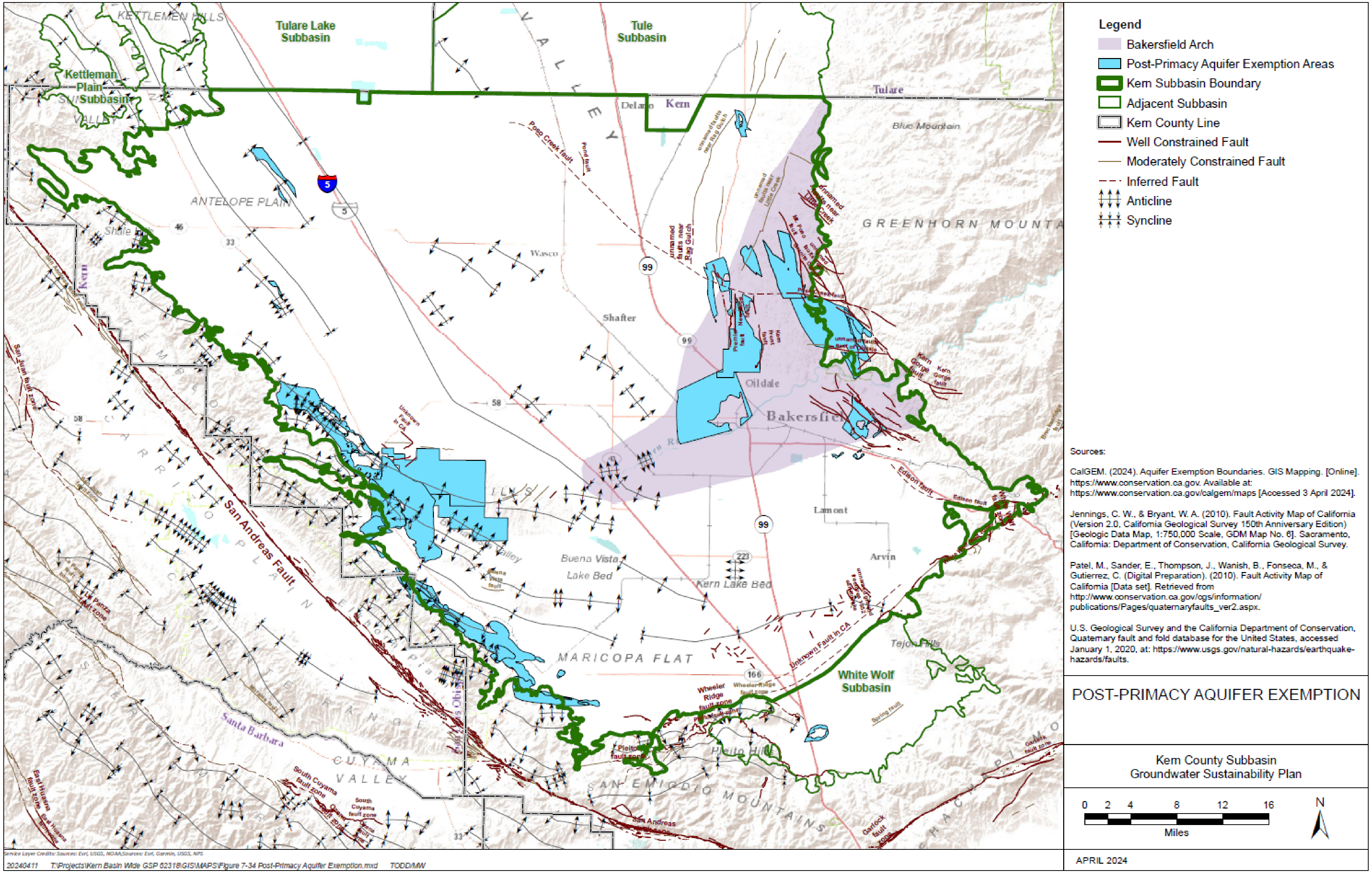
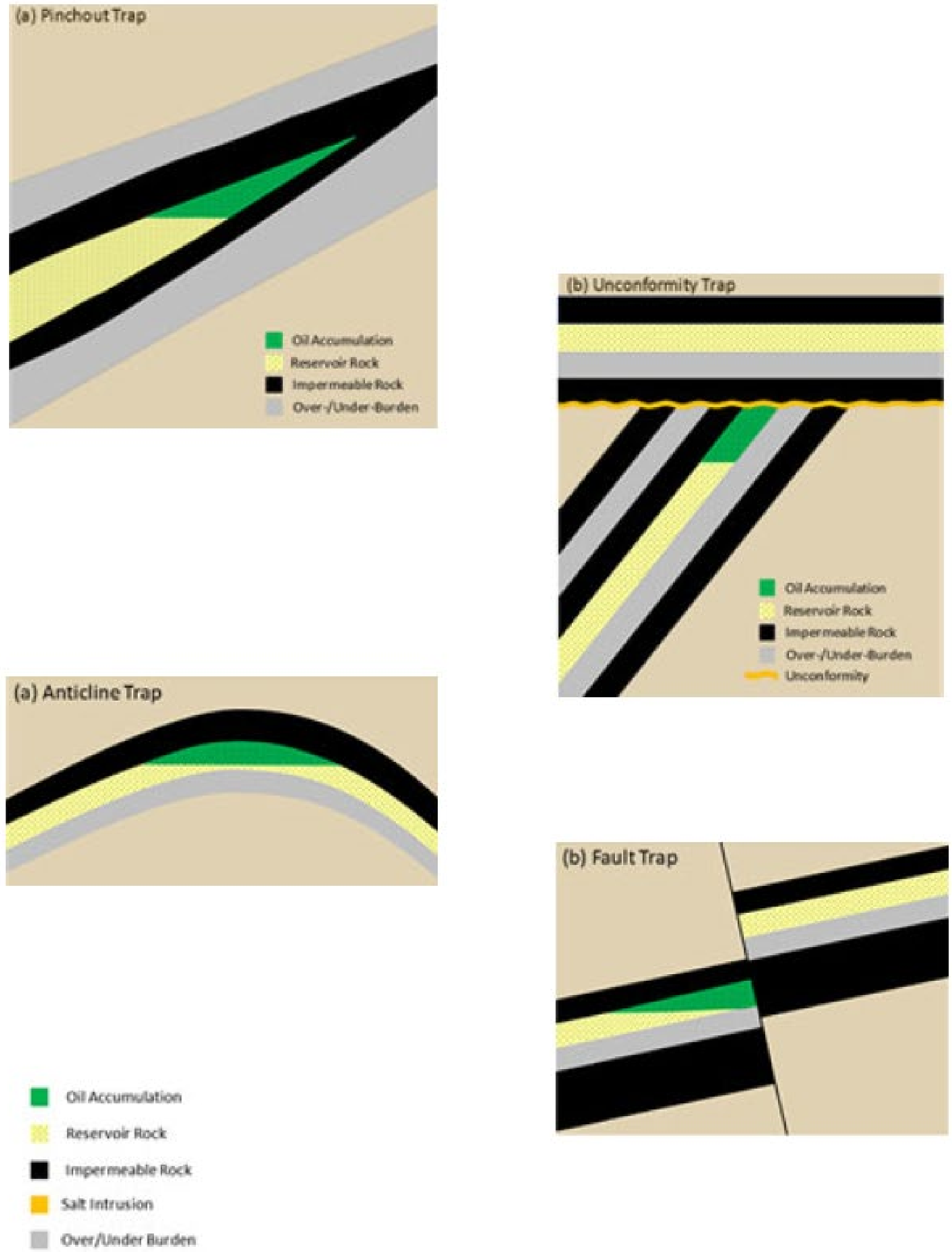


Figure 7-35. Post-Primacy Aquifer Exemption

This page intentionally left blank.



Kern County Subbasin
Groundwater Sustainability Plan

Source: Petroleum Geology, Figures 2.07a, 2.07b, 2.08a, 2.08b.

OIL FIELD TYPE SCHEMATIC

APRIL 2024

TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\ Figure 7-35 Oil Field Type Schematic.ai

Figure 7-36. Oil Field Type Schematic

7.6.5 Subbasin Bottom Definition

Based on the evaluation of the physical properties, geochemical properties and aquifer exemptions, the Subbasin bottom is defined as the base of the principal aquifers as shown in Figure 7-29. The aquifer exemption areas that occur within the stratigraphic intervals for the principal aquifers are defined as localized areas below the Subbasin bottom due to their physical and geological properties that isolate them from the rest of the principal aquifer. These exempt aquifer areas, shown as shaded areas on Figure 7-29, are defined as being located outside of the Subbasin, following DWR's BMP Guidance (DWR, 2016) and as shown in Figure 7-32. In the western Subbasin, these aquifers are primarily located along the western rim of the Subbasin or along the crest of anticlines. In the eastern Subbasin, these aquifer exemption areas generally lie in the areas outside of the Santa Margarita and Olcese Principal Aquifer areas.

From review of the geology in relation to the base of freshwater and USDW shown on the maps (Figure 7-30 and Figure 7-31) and cross sections (Figure 7-15 through Figure 7-21), the geochemical property indicators are generally occurring at or above the physical, or geological, base of the three principal aquifers (Figure 7-28). The base of the USDW (Figure 7-31) generally becomes shallower from east to west across the Subbasin. In the western Subbasin (Western Fold Belt HCM Area), these data indicate that there are areas where most, if not all, of the saturated thickness is below either the base of freshwater or the base of the USDW. This is consistent with general lack of groundwater usage in the Western Fold Belt HCM Area due to high TDS concentrations. Additional discussion of TDS concentrations is provided in Section 8.

The geochemical property indicators for the base of freshwater (Page, 1973) and depth to USDW (Gillespie, 2017) are not used to define the Subbasin bottom but are guides to further assess the potential beneficial use. The two above-referenced maps were developed based on contouring of scattered water quality data in the Subbasin without consideration of the geologic boundaries. Therefore, these data, in their current form, provide a good general reference but lack the local specificity to be part of the Subbasin bottom definition. Further evaluation of the base of freshwater and the depth USDW used to integrate these geochemical indicators as part of the Subbasin bottom elevation may be evaluated for future Plan updates in addition to those developed for the aquifer exemptions.

8. CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

§ 354.16. *Groundwater Conditions*
Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information.

☑ 23 CCR § 354.16

This section presents information on historical and current groundwater conditions within the Subbasin to provide context and a basis from which to analyze Sustainability Indicators, develop Sustainable Management Criteria (SMCs), and identify Projects and Management Actions (P/MAs) to achieve and maintain sustainable groundwater management. Information below is presented for the entire Subbasin, with specific reference to the Hydrogeologic Conceptual Model (HCM) areas described previously (Sections 6.2.1 and 7.2.2) and the principal aquifers (Section 7.2.3).

8.1 Groundwater Elevations, Flow Directions, and Long-Term Trends for Each Principal Aquifer

§ 354.16. *Groundwater Conditions*
Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information.
(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:
(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

☑ 23 CCR § 354.16(a)(1)
☑ 23 CCR § 354.16(a)(2)

Groundwater conditions describe the groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

- Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
- Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

- Groundwater elevation data have been recorded in the Subbasin by the USGS, DWR and local agencies since at least the 1920s, but data prior to the 1950s is sparse. Groundwater elevation data are currently collected in the Subbasin by the GSAs and reported to and stored in a Data Management System (DMS) for the Subbasin.

Current and historical groundwater conditions are described by principal aquifer in this section. The Subbasin principal aquifers, as defined in Section 7.2.3, include the following:

- Primary Alluvial Principal Aquifer.
- Santa Margarita Principal Aquifer
- Olcese Sand Principal Aquifer.

The Primary Alluvial Principal Aquifer essentially extends over the entire Subbasin (Figure 7-23) forming the largest and most productive aquifer in the Subbasin. Two other local principal aquifers, the Santa Margarita and Olcese Sand Principal Aquifers, have been defined in the Eastern Margin HCM area. These two principal aquifers are of a more limited areal extent as shown on Figure 7-26 and Figure 7-27.

8.1.1 Primary Alluvial Principal Aquifer

The Primary Alluvial Principal Aquifer consists of the full vertical extent of the Unconsolidated Nonmarine Deposits that includes the Recent Alluvium, Tulare, and Kern River Formations (Figure 7-35) that contains the vast majority of the freshwater in the Subbasin. Aquifer conditions generally range between unconfined to confined depending on location, local geology, and depth.

8.1.1.1 Groundwater Flow Directions

☑ 23 CCR § 354.16(a)

A generalized diagram depicting groundwater flow directions within the Subbasin is provided in Figure 8-1 that is based on the groundwater elevation contour maps provided below. This diagram provides a conceptual understanding of groundwater flow within the Subbasin to provide context in reviewing the groundwater elevation data and contour maps provided in this section. In general, groundwater flows from areas of recharge with higher groundwater elevations to areas of discharge with lower groundwater elevations. However, groundwater flow is also influenced by geologic structures, such as anticlines and faults. The following describes the overall groundwater flow within the Subbasin by HCM area.

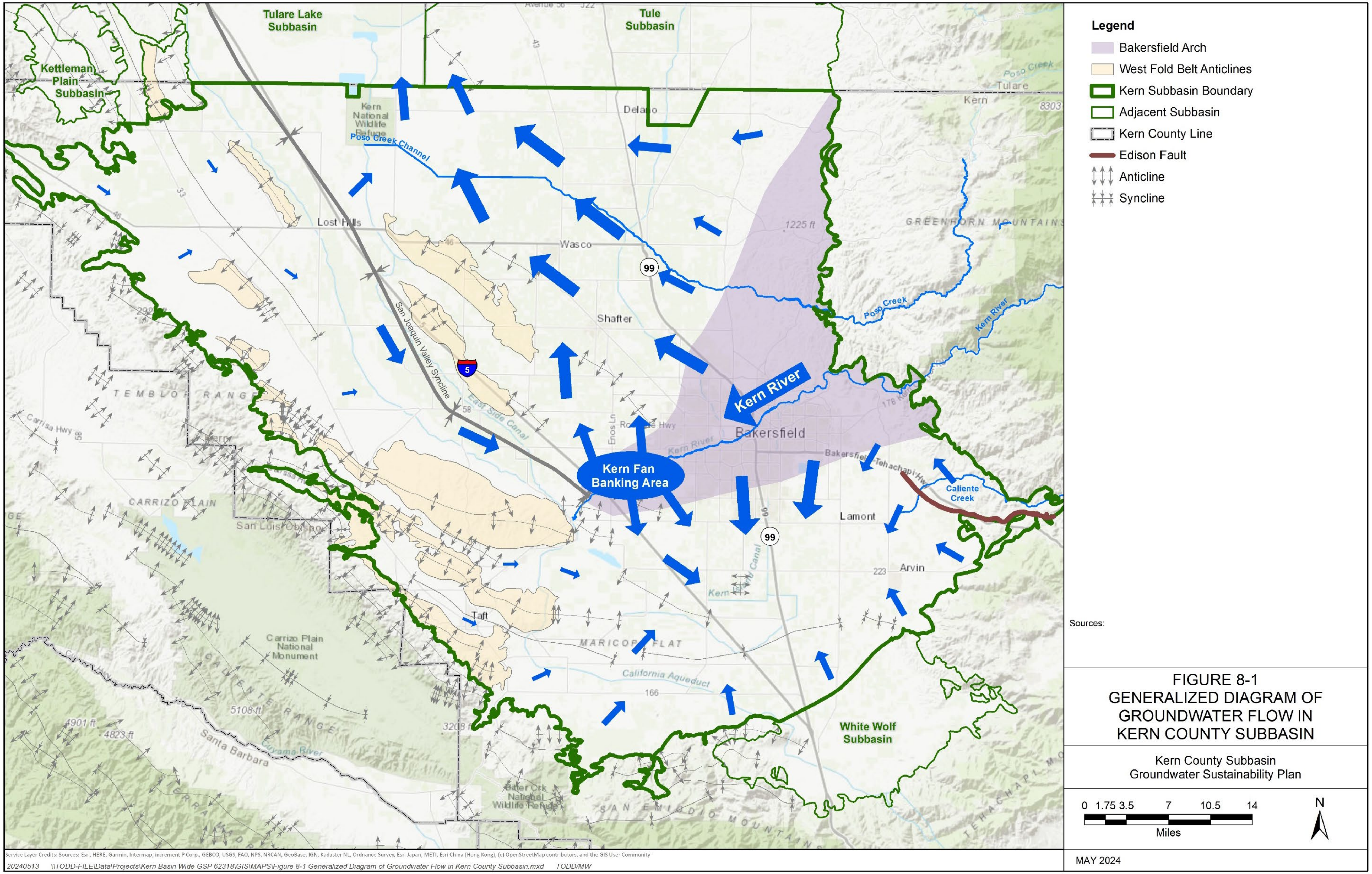


Figure 8-1. Generalized Diagram of Groundwater Flow in Kern County Subbasin

This page intentionally left blank.

The Primary Alluvial Principal Aquifer receives both natural and managed groundwater recharge across the Subbasin. Natural recharge to the Subbasin is derived primarily from precipitation and surface runoff from the surrounding watersheds. Natural recharge is highest on the east side of the Subbasin which receives high precipitation and receives recharge from the Kern River and other smaller streams from the Sierra Nevada. Natural recharge is lowest on the west side which receives less precipitation and lower runoff from the relatively smaller watersheds along the Coast Ranges. Significant managed groundwater recharge in the Subbasin occurs through the numerous conjunctive use projects that are located across the Subbasin (Figure 8-1). Water banking programs also store significant volumes of surface water in the Subbasin. These water banking programs and conjunctive use operations recharge and store water from multiple sources including imported water (SWP and CVP) and local surface water (Kern River, Poso Creek, and other drainages).

Groundwater elevations in the Subbasin are typically highest in the Kern River Fan HCM Area due to recharge along the Kern River and the Kern Fan Banking Area in wet years (Figure 8-1). The Kern River has a large watershed in the Sierra Nevada with highly variable flows ranging from 140 thousand acre-feet (TAF) to over 2.5 million acre-feet (MAF). The Kern River HCM Area is generally underlain by coarse-grained, relatively high permeability alluvial fan deposits (Section 7.2.2.2). The Kern River flows roughly along the axis of the Bakersfield Arch, which forms a broad topographical rise that gradually dips to the north and south, effectively splitting the Subbasin into northern and southern groundwater flow regimes. Within the Kern Fan Banking Area, groundwater flow is more variable due the storage of large volumes of surface water in the aquifer that is later recovered by pumping. As a result of the Kern River and banking operations, groundwater flow in this HCM Area generally radiates both north and south from the Kern River to other parts of the Subbasin (i.e., there is an effective groundwater flow divide in the vicinity of the Kern River).

Groundwater flow in the Eastern Margin HCM Area is generally from the Subbasin margin toward the center of the Subbasin. However, groundwater flow is affected by geologic structures, primarily faulting, within this area. In the southern part of the Eastern Margin HCM Area, the aquifer is recharged from runoff from Caliente Creek and surrounding watersheds. The Edison Fault forms a flow barrier (Figure 8-1) where groundwater flow east of the fault is northward. Southeast of Bakersfield, the effects of the Edison Fault diminish and groundwater flow shifts to the west toward the center of the Subbasin.

In the Eastern Margin HCM Area north of the Kern River, the aquifer is recharged from runoff from Poso Creek and smaller streams from surrounding watersheds that percolates into the alluvial sediments. Groundwater flow is generally westward; however, faulting locally impedes groundwater flow especially along the crest of the Bakersfield Arch. As a result, groundwater flow may be locally interrupted or compartmentalized due to faulting resulting in a longer, more complex flow path across this area.

North of the Kern River in the North Basin HCM Area, the general pattern of groundwater flow includes inflows primarily from the south and east. Groundwater flow within the HCM Area is generally toward agricultural and urban groundwater pumping areas. Local water banking and conjunctive use projects create variable groundwater flow patterns near these facilities in response to recharge and recovery operations. Groundwater flow also exits the Subbasin across the northern Subbasin boundary (Figure 8-1). Along the eastern half of the northern Subbasin boundary, groundwater flow tends to be parallel to the boundary. Along the western half of the northern Subbasin boundary, groundwater flow is typically northward into the Tulare Lake and Tule Subbasins.

South of the Kern River in the South Basin HCM Area, the general pattern of groundwater flow is from the Subbasin margins toward the center of the HCM Area (Figure 8-1). Runoff in streams, sourced from surrounding watersheds, percolates to groundwater along the Subbasin margin. Groundwater flow within the HCM Area is generally toward agricultural and urban groundwater pumping areas. Along the southern Subbasin Boundary, groundwater flow is typically northward indicating a consistent inflow from the White Wolf Subbasin that is restricted somewhat by the bounding White Wolf Fault.

Groundwater flow in the Western Fold Belt HCM Area is highly influenced by geologic structures of the West Side Fold Belt (Bartow, 1991). The boundary between the Western Fold Belt and North Basin HCM Areas is a geologically complex structural area where groundwater flow is directly affected by the anticlines and synclines of the Westside Fold Belt. The Lost Hills, Elk Hills and Buttonwillow Anticlines restrict the west to east groundwater flow toward the axis of the Subbasin in this area. As a result, any groundwater flow from the Western Fold Belt HCM Area takes a circuitous route and trends southeastward along the structural low formed by the San Joaquin Valley Syncline (Figure 8-1). Flow continues to the southeast around the Buttonwillow Anticline, which creates a long groundwater flowpath from the Western Fold Belt HCM Area to other parts of the Subbasin. As a result of the influence of these geologic structures, there is limited hydraulic connection between the Western Fold Belt HCM Area and other HCM areas.

In the Western Fold Belt HCM Area, the aquifer is recharged from runoff from the surrounding watersheds. This area principally relies on imported surface water via the Aqueduct since the preponderance of naturally poor groundwater quality due to the presence sediments of marine origin. Precipitation along the western margin of the Subbasin is typically lower than elsewhere in the Subbasin. The Elk Hills Anticline effectively separates this HCM into northern and southern groundwater flow regimes

(Figure 8-1). North of the Elk Hills, groundwater flow along the margin is generally eastward; however, it shifts to a more southeasterly direction due to the influence of the geologic structures previously described. South of the Elk Hills, groundwater flow is generally southeasterly between the anticlines where it ultimately flows into the South Basin HCM. Little groundwater pumping occurs in the Western Fold Belt HCM Area due to poor groundwater quality that limits the ability to utilize groundwater and the expanse of open range land where no groundwater pumping occurs. Water users in this HCM area rely on imported water and/or groundwater conveyed by the California Aqueduct and from other parts of the Subbasin for agricultural and municipal uses.

8.1.1.2 Current Groundwater Elevation Contour Maps and Lateral Gradients

☑ **23 CCR § 354.16(a)**
☑ **23 CCR § 354.16(a)(1)**

Groundwater elevation contour maps were prepared for Spring 2023 (Figure 8-2) and Fall 2023 (Figure 8-3) for the Primary Alluvial Principal Aquifer. Groundwater elevations range from a high of over 600 feet mean sea level (msl) along the southeastern boundary of the Subbasin in the Sierra Nevada foothills to the lowest elevations of -150 feet msl along the northern Subbasin boundary. The Spring and Fall 2023 groundwater elevations (Figure 8-2 and Figure 8-3) generally represent seasonal high and seasonal low based on current groundwater conditions.

As described in the preceding subsection, groundwater flow is influenced by geologic structures in the Subbasin. The Edison Fault and the West Side Fold Belt, shown on Figure 8-2 and Figure 8-3, represent geologic structures that influence groundwater flow as evidenced by significant changes in the magnitude and direction of flows across those areas. A brief description of the groundwater elevation contour maps and regional pumping patterns is provided for each HCM.

The upstream stretch of the Kern River is a major recharge area in the Subbasin. Groundwater elevations along the upper Kern River range from 400 to 200 feet msl from east to west and remain relatively stable in both the Spring and Fall 2023 maps (Figure 8-2 and Figure 8-3). Within several miles of the river channel, water levels are lower compared to areas along the river channel. In the Kern Fan Banking Area, groundwater levels in Spring 2023 ranged between 50 to 100 feet msl; however, in the Fall 2023 groundwater elevations rose to 100 to 200 feet msl in response to natural and active recharge during the wet hydrologic year of WY2023. The lateral gradients are variable ranging from 0.002 and to 0.015 feet/foot.

In the North Basin HCM Area (Figure 8-2 and Figure 8-3), the highest groundwater elevations occur adjacent to the Kern River Fan HCM Area with elevations above 300 feet msl. The lowest elevations of -150 feet msl occur along the northern Subbasin boundary. The eastern side of the North Basin HCM Area has more variable groundwater elevations ranging from 150 feet msl to -50 feet msl. This variability is generally associated with water banking and conjunctive use project operations in this area. In the rest of the North Basin HCM Area, groundwater elevations range from 50 feet msl to -150 feet msl. Groundwater gradients shift to a more northerly direction with outflow to the Tule and Tulare Lake Subbasins. The lateral gradient in this area is generally from east to west at a gradient of 0.002 feet/foot.

In the South Basin HCM Area, the highest groundwater elevations are adjacent to the Kern River Fan and Eastern Margin HCM Areas with elevations above 350 feet msl. A second area of higher groundwater elevations occurs along the western margin of the South Basin HCM with groundwater elevations about 300 feet msl. The lowest elevations of 0 to 50 feet msl are generally associated with data from an active pumping well and may not represent static conditions (Figure 8-2 and Figure 8-3). The South Basin HCM Area may receive subsurface inflows from the southern White Wolf Subbasin and does not have a subsurface outflow to an adjacent area; therefore, groundwater flow is generally from the margins to the center of the HCM Area. The lateral gradient in this area ranges from about 0.002 to 0.007 feet per foot.

Groundwater elevations along the western margin of the North Basin HCM show local variability because of the geologic structure of the Westside Fold Belt (Lost Hills, Buttonwillow and Bowerbank Anticlines) that influences groundwater flow (Figure 8-2 and Figure 8-3). West of these anticlines, groundwater elevations range from 250 to 100 feet msl with a southeasterly lateral gradient of about 0.006 feet/foot. East of the anticlines, groundwater elevations range from 0 to -50 feet msl with a north to northeasterly lateral gradient of ranging from 0.004 to 0.006 feet/foot.

It is important to note that limited data in the Western Fold Belt and Eastern Margin HCM areas, where few wells are located, restrict the ability to develop detailed groundwater elevation contour and gradient maps in these areas (Figure 8-2 and Figure 8-3). These areas represent remote areas of the Subbasin with little to no groundwater pumping and wells. As such, the areas covered by the groundwater elevation contours generally represent the regional pumping distribution patterns for agricultural and urban use.

In the Eastern Margin HCM Area south of the Kern River, Figure 8-2 and Figure 8-3 further illustrate the effects of the Edison Fault as a groundwater flow barrier in the southeastern corner of the Subbasin. The highest groundwater elevations east of the Edison Fault range from 350 to over 600 feet msl, whereas west of the Edison Fault, groundwater elevations range from 150 to less than 100 feet msl (Figure 8-2 and Figure 8-3). The lateral gradient in this HCM shifts from a northerly direction and then shifts to a more westerly direction with a general gradient of 0.01 to 0.015 feet per foot. This is interpreted to represent the northern extent of the effect of the Edison Fault.

In the Eastern Margin HCM Area north of the Kern River, groundwater elevations range from 100 to 250 feet msl (Figure 8-2 and Figure 8-3). In this area, the bottom of the Primary Alluvial Principal Aquifer rises toward the Sierra Nevada and Bakersfield Arch resulting in reduced saturated thickness. As a result, groundwater pumping from the Primary Alluvial Principal Aquifer along the Eastern Margin is limited with most wells instead extracting from the deeper Santa Margarita Principal Aquifer.

This page is blank intentionally.

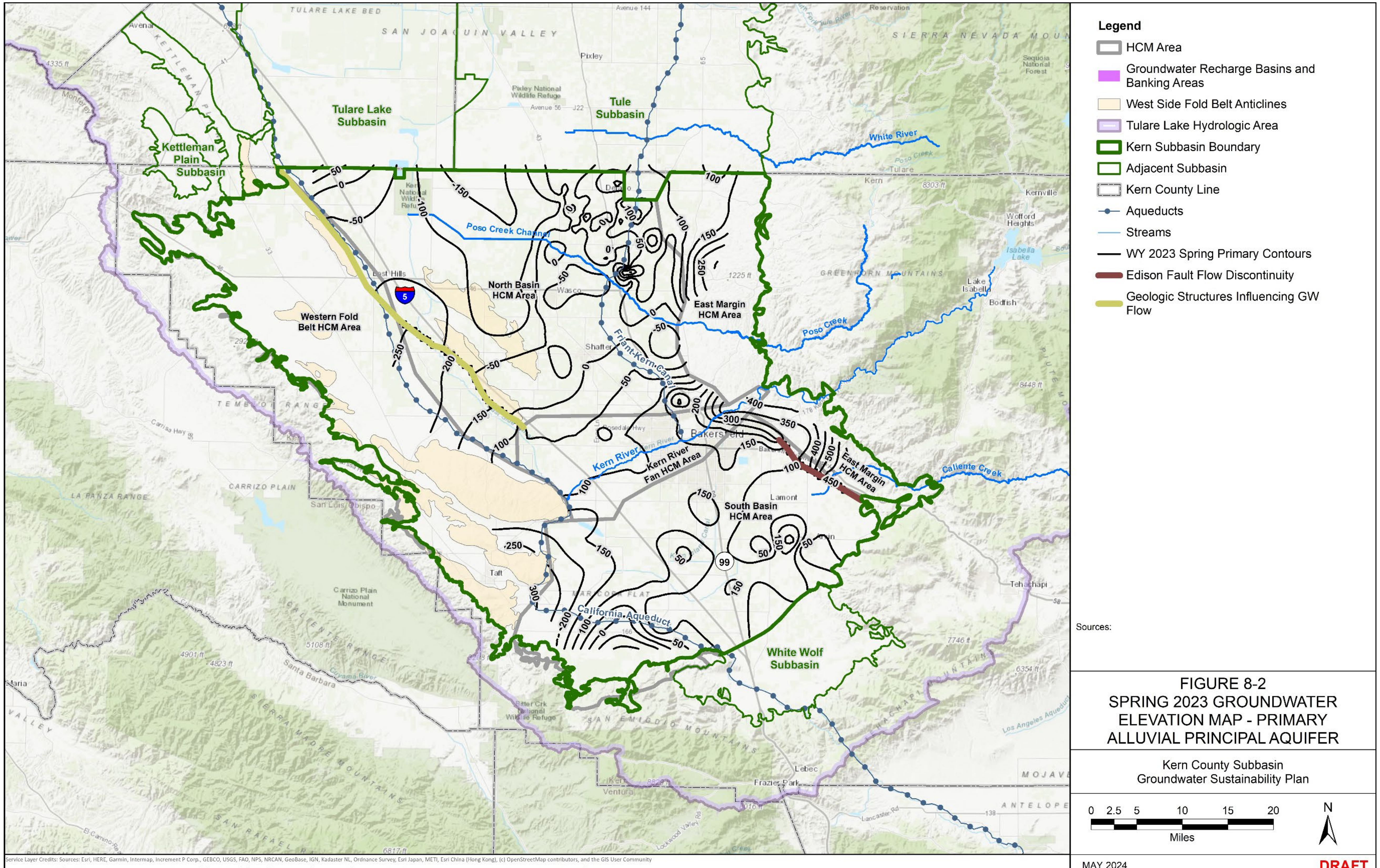


Figure 8-2. Spring 2023 Groundwater Elevation Map – Primary Alluvial Principal Aquifer

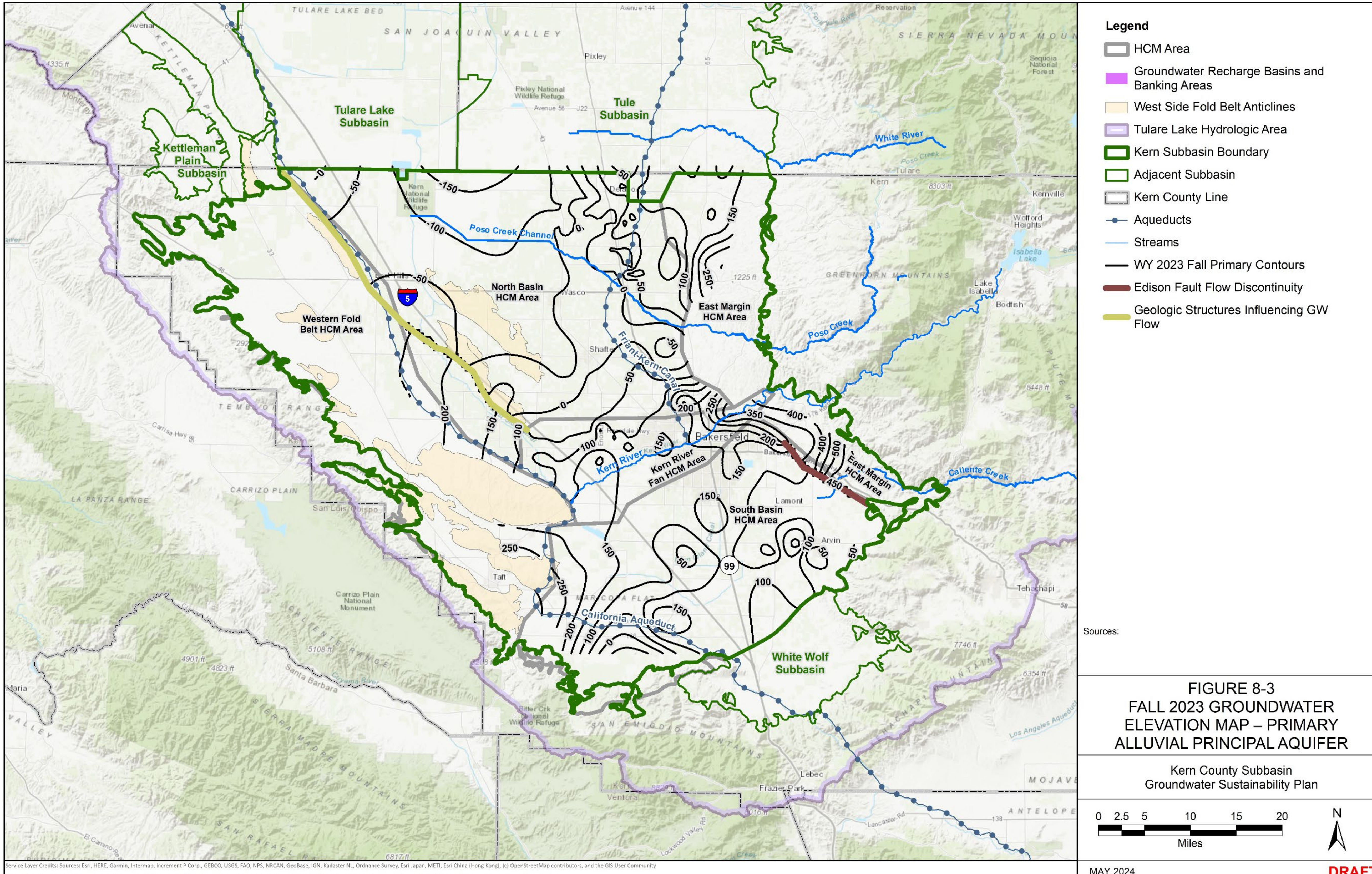


Figure 8-3. Fall 2023 Groundwater Elevation Map – Primary Alluvial Principal Aquifer

Groundwater contours are not shown for the Western Fold Belt HCM Area because this area contains few active wells. Conceptually, groundwater flow is oriented parallel to the geologic structures in a general southeasterly direction. Due to the low recharge rates in the western Subbasin, groundwater flow into the other subbasins is considered to be minor.

8.1.1.3 Historical Groundwater Elevation Contour Maps

☑ **23 CCR § 354.16(a)**
☑ **23 CCR § 354.16(a)(1)**

GSP regulations require GSPs to include presentation of historical groundwater conditions "*including data from January 1, 2015, to current reporting year*" 23 CCR § 354.16. Figure 8-4 provides groundwater elevation maps for the Primary Alluvial Principal Aquifer covering the following four periods that represent different hydrologic conditions in the Subbasin:

- Fall 2011 – represents annual and seasonal high groundwater elevations during the relatively wet conditions in WYs 2010 to 2011.
- Fall 2015 – representing annual and seasonal low groundwater elevations during the WYs 2012 to 2015 drought.
- Fall 2019 – representing annual and seasonal high elevations during the relatively wet conditions in WYs 2017 to 2019.
- Fall 2022 – representing annual and seasonal low groundwater elevations during the WYs 2020 to 2022 drought.

These four maps represent groundwater conditions during wet and dry hydrologic years during similar seasons to illustrate the range in seasonal high and low conditions within the Subbasin. During most hydrologic water year types, the seasonal high groundwater condition occurs in the spring and the seasonal low occurs in the fall. However, in wet years such as 2011 and 2019, groundwater elevations in the Fall are more variable with higher groundwater elevations occurring in the fall in the vicinity of the water banking and conjunctive use projects because recharge operations extend into the late spring and summer months.

In general, groundwater elevations are consistent with historical trends (Figure 8-4). Groundwater elevations range from a high of 600 feet msl along the southeastern boundary of the Subbasin in the Sierra Nevada foothills to the lowest elevations of -50 to -200 feet msl along the northern Subbasin boundary. Groundwater gradients tend to diverge from the Kern River toward the north and south (i.e., evidence of a groundwater divide). During the drought periods, this divergence is less notable due to the drought conditions which result in greater groundwater use with very little recharge.

Figure 8-5 provides the change in groundwater elevation maps for the Primary Alluvial Principal Aquifer covering the following four periods:

- Fall 2011 to Fall 2015.
- Fall 2015 to Fall 2019.
- Fall 2019 to Fall 2022.
- Fall 2022 to Fall 2023.

These periods represent the effects of multi-year droughts and wet periods on groundwater conditions in the Subbasin.

The period from Fall 2011 to Fall 2015 represents the cumulative four-year change over the multi-year drought period from relatively high groundwater levels following a wet period of WYs 2010 and 2011 to the relatively low groundwater levels during the drought of WYs 2012 to 2016. Over this period, declines of 50 to 150 feet were experienced over large areas of the Subbasin, which is consistent with the high groundwater use and the recovery of previously banked surface water in these areas. Toward the Subbasin margins, the change in groundwater elevations was generally minimal, which is consistent with the lower groundwater use and proximity to natural recharge in these areas.

The period from Fall 2015 to Fall 2019 represents the cumulative four-year change in groundwater levels following the multi-year drought ending in WY 2016 followed by wet years in WY 2017 and WY 2019. Groundwater elevations in the Kern Fan Banking Area increased by 100 to 200 feet in response to the large volumes of surface water storage that occurred during this time. Elsewhere, groundwater elevations generally rose by 50 to 150 feet with some localized areas of declining groundwater levels.

The period from Fall 2019 to Fall 2022 represents the cumulative three-year change in groundwater elevations following the return to a multi-year drought period. Similar to the Fall 2011 to Fall 2015 period, groundwater levels generally declined over the entire Subbasin. Declines of 25 to 125 feet occurred over large areas of the Subbasin, consistent with groundwater use and recovery of previously banked surface water. The change in groundwater elevations near the Subbasin margins was generally minimal, consistent groundwater use and proximity to natural recharge in these areas.

The period from Fall 2022 to Fall 2023 represents the one-year change in groundwater levels following the extremely wet WY 2023. Groundwater elevations in the Kern Fan Banking Area increased by 100 to 200 feet in response to the large volumes of surface water storage that occurred during this time. Elsewhere groundwater levels ranged from near zero to 50 feet with some localized areas of declining groundwater levels.

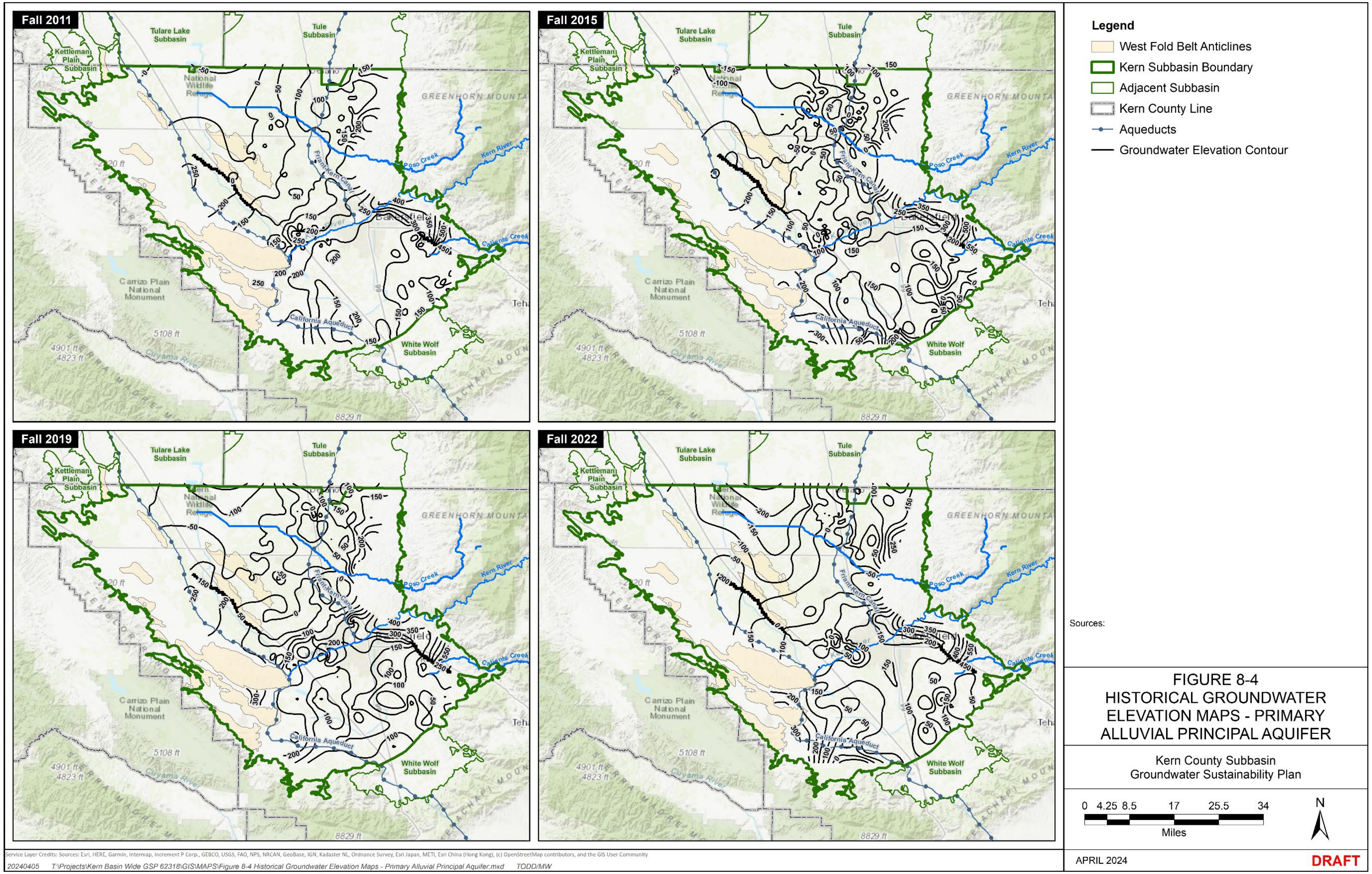


Figure 8-4. Historical Groundwater Elevation Maps – Primary Alluvial Principal Aquifer

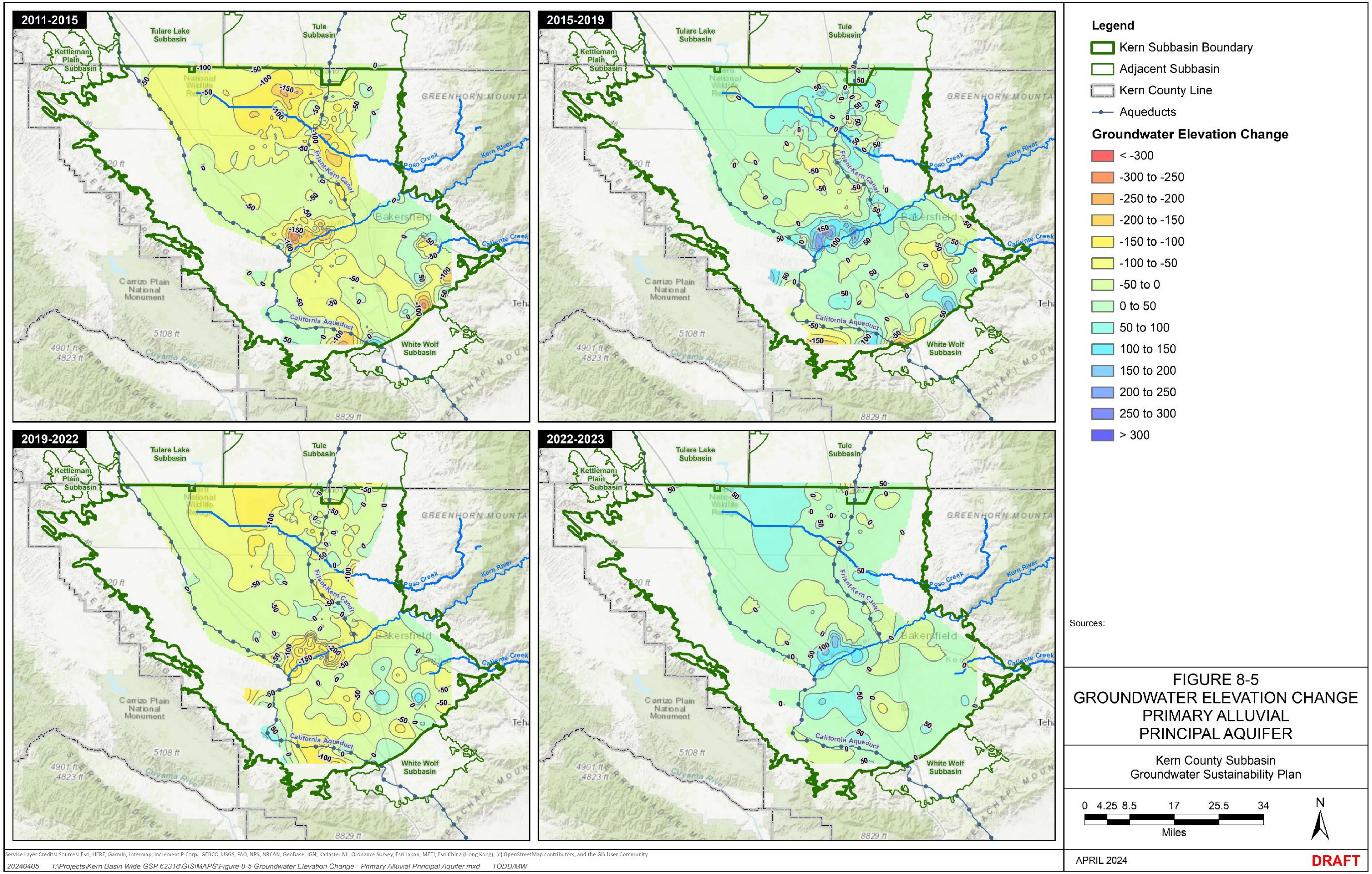


Figure 8-5. Historical Groundwater Elevation Change - Primary Alluvial Principal Aquifer

8.1.1.4 Regional Groundwater Elevation Contour Map with Adjacent Basins

GSP regulations include several references to evaluation of Plan implementation with respect to adjacent basins (23 CCR § 355.4(b)(7)). This includes an understanding of the regional nature of groundwater conditions. To evaluate this, regional groundwater data, Figure 8-6 presents a regional groundwater elevation map based on data provided in the recent SGMA Annual Reports from the Kern County (Todd Groundwater, 2022), Tulare Lake (Geosyntec, 2022) and Tule Subbasins (Thomas Harder & Co., 2022). A compilation of the regional groundwater elevation data provided in these reports shows that the groundwater water depression in the north-central areas of the Kern County Subbasin is a continuation of a larger regional groundwater depression that is centered in the Tule and Tulare Lake Subbasins to the north.

The lowest groundwater elevations occur in the Tulare Lake Subbasin but also appear to extend further north toward the Westside, Kings and Kaweah Subbasins. Because groundwater elevations in the Kern County Subbasin are generally higher than those to the north, this large depression is further inducing northward groundwater flow out of the Kern County Subbasin and could potentially impact the Kern Subbasin's ability to reach sustainability.

8.1.1.5 Hydrographs Depicting Long-Term Groundwater Elevations

☑ 23 CCR § 354.16(a)(2)

Per GSP regulations, hydrographs include "*historical data to the greatest extent available, including from January 1, 2015, to current reporting year*" (§356.2(b)(1)(B)). Figure 8-7 shows hydrographs representing different areas of the Subbasin for the Primary Alluvial Principal Aquifer over the period from WY 1955 through WY 2023. The wells shown on Figure 8-7**,** were selected based on having a long historical record for that area and are labeled by well name, GSA, and HCM Area.

Historically, groundwater elevation trends in the Subbasin generally show an increase during wet periods and a decrease during dry periods. During the wetter periods of WYs 1995-1998, WYs 2005-2006, WYs 2010-2011, WYs 2017-2019 and WY 2023, there was an increase in both natural and managed recharge from conjunctive use projects and storage of surface water for banking projects accompanied with a rise in groundwater elevations. This increase in groundwater elevations was more pronounced in the areas with water banking and conjunctive use projects. Conversely, dry periods have decreased natural recharge and deliveries of surface water and increased recovery of stored surface water by pumping. As expected, groundwater elevations generally declined across the Subbasin during these intervening dry years. During the extended drought periods (WYs 2012 to 2016 and WYs 2020 to 2022), several areas in the Subbasin experienced historic low groundwater elevations. However, some areas show that the historic low groundwater elevations occurred during the drought in the early 1990s and prior to the importation of SWP and CVP water in the 1960s.

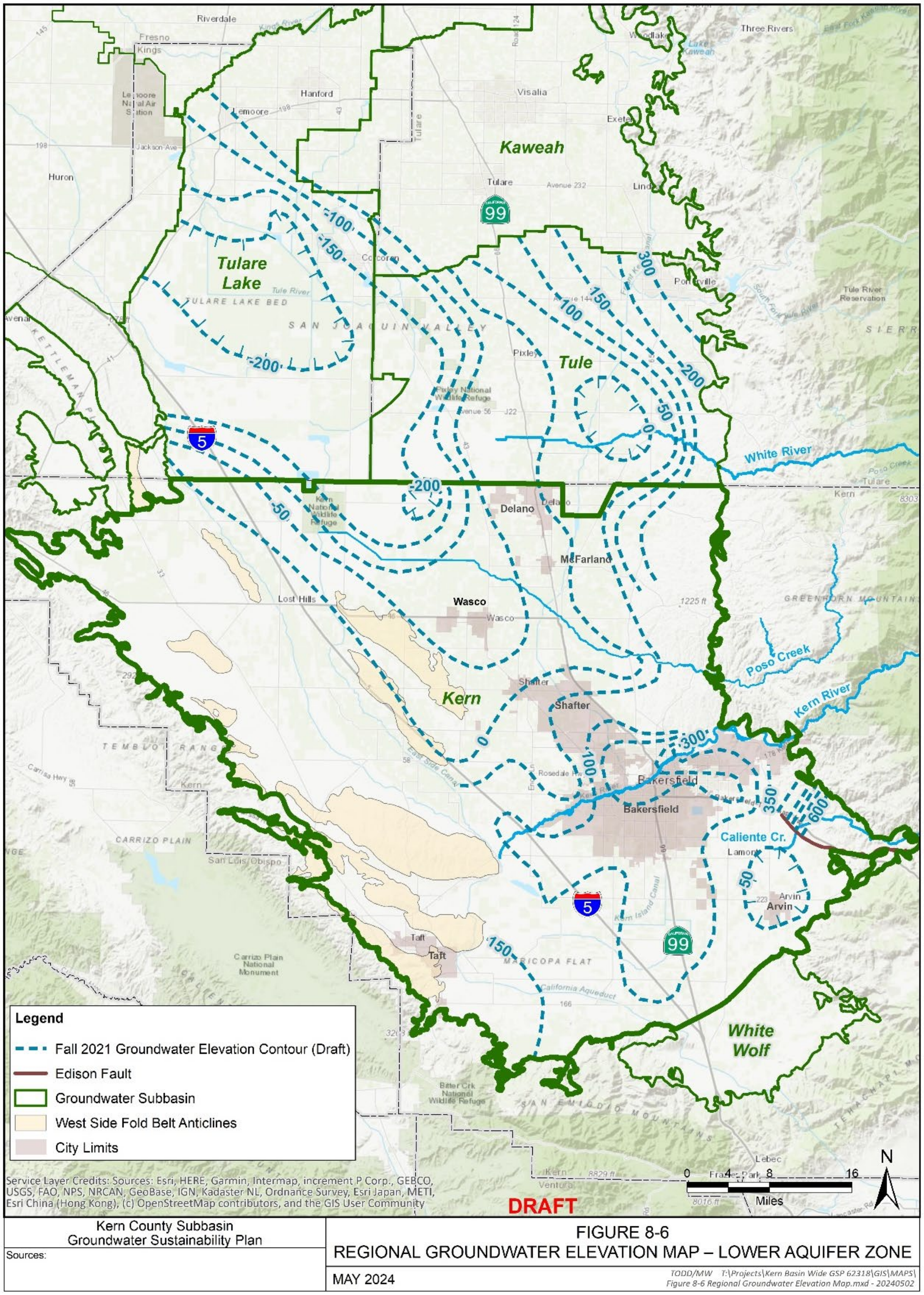


Figure 8-6. Regional Groundwater Elevation Map

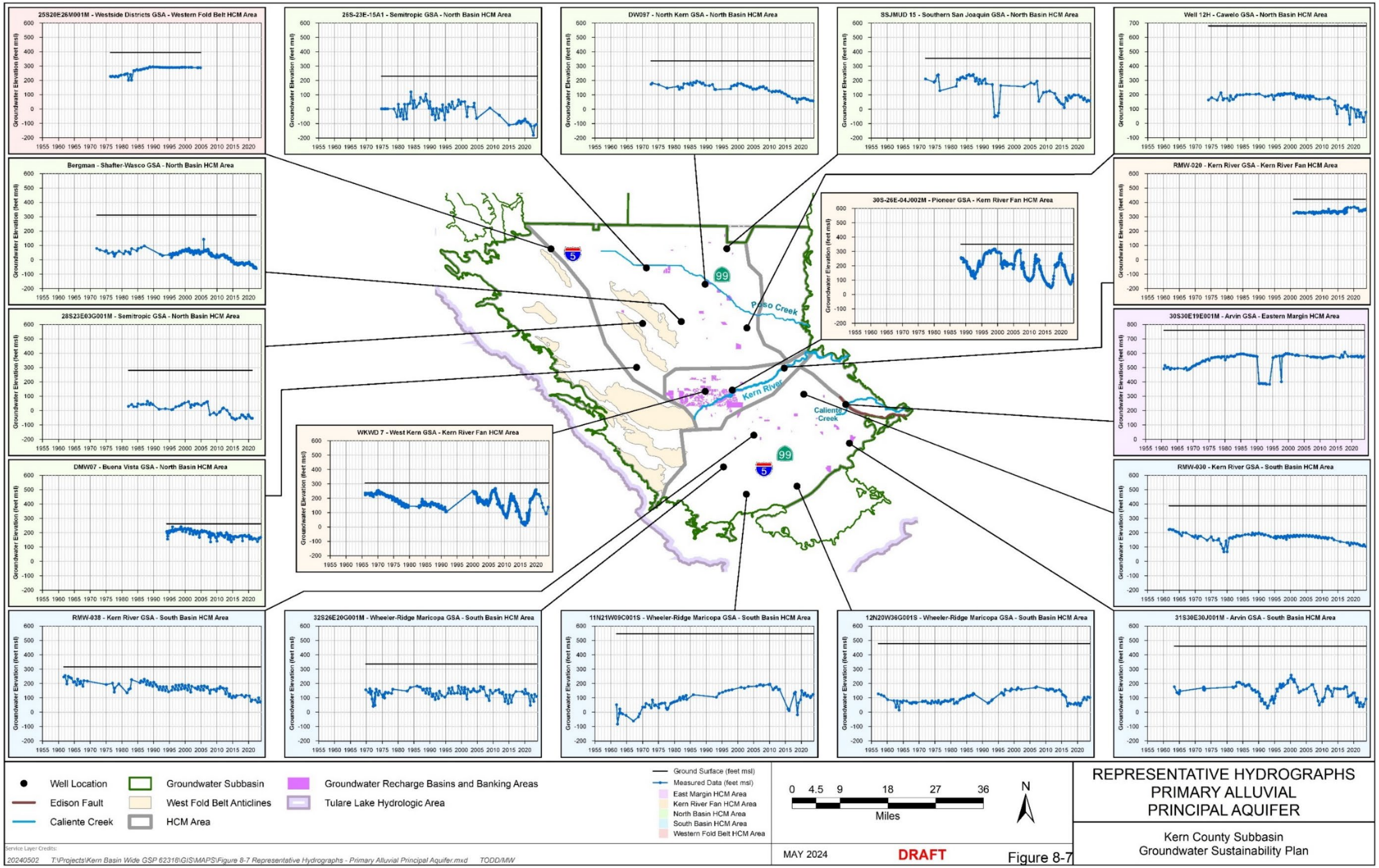


Figure 8-7. Representative Hydrographs Primary Alluvial Principal Aquifer

This page intentionally left blank.

In the Kern River Fan HCM Area, groundwater elevations are higher along the Kern River but exhibit significant fluctuations in the banking areas. Upstream of the banking areas, groundwater elevations along the Kern River are higher and remain more stable (Figure 8-7, hydrograph RMW-020) with groundwater elevations between 300 to 400 feet msl. In the banking areas, groundwater elevations have fluctuated more than 200 feet from wet to dry years due to influence of varying recharge and recovery operations (Figure 8-7, hydrographs 30S-26E04J002M and WKWD 7). Groundwater elevations near the water banking operations are more highly variable than- those experienced elsewhere in the Subbasin with groundwater levels varying by 200 feet or more during the period of intensive banking operations starting around WY 1993.

In the North Basin HCM Area, seven hydrographs are shown on Figure 8-7. In general, groundwater elevations have generally declined since WY 2012 due to the extended period of drought that led to a severe reduction in imported water supplies. The lowest groundwater elevations since WY 2012, between -100 and -200 feet msl, occur along the northern Subbasin boundary. Groundwater elevations generally are higher toward the Kern River to the south and the Subbasin margin to the east. Several wells in this HCM Area experienced historic lows during the recent drought periods.

In the South Basin HCM Area, six hydrographs (RMW-030, RMW-038, 31S30E30J001M, 12N20W36G001S, 11N21W09C001S, 32S26E20G001M) are shown on Figure 8-7. As shown, groundwater in some areas declined from WY 2012-2016 due to the effects of the extended drought and limitation on imported water supplies during this time. However, since WY 2016, water levels have recovered to pre-drought levels and remain relatively stable. The lowest groundwater elevations since WY 2012 have ranged between 200 to -50 feet msl. However, historic lows for most of the wells in this HCM Area generally occurred prior to WY 2012. Groundwater elevations generally are higher toward the Kern River to the north and to the west along the margin with the Western Fold Belt HCM Area. Groundwater elevations show a seasonal pumping patterns response.

In the Eastern Margin HCM Area, hydrograph 30S30E19E001M has groundwater elevations generally ranging from 500 to 600 feet msl (Figure 8-7) that shows the effects of the Edison Fault as a groundwater flow barrier in the southeastern corner of the Subbasin. Groundwater elevations in this well have remained relatively stable during the recent drought periods and are higher than groundwater elevations from the 1960s and 1970s.In the areas north of the Kern River, the Primary Alluvial Principal Aquifer has only limited saturated thickness, so most wells in this area pump groundwater from the Santa Margarita Principal Aquifer (see Section 7.2.3.2).

In the Western Fold Belt HCM Area, hydrograph 35S20E26M001M shows groundwater elevations generally ranging from 200 to 300 feet msl (Figure 8-7). Groundwater elevations in this well have remained relatively stable, even during the recent drought periods which demonstrates the lack of groundwater pumping in the Western Fold Belt HCM Area. Stable groundwater elevations also show the effects of the Lost Hills Anticline as a groundwater flow barrier that limits groundwater interaction with the North Basin HCM Area. There are no known groundwater wells in the southern portion (south of Elk Hills) of the Western Fold Belt HCM Area; therefore, there are no representative monitoring wells or available trends.

8.1.1.6 Vertical Hydraulic Gradients

☑ **23 CCR § 354.16(a)(2)**

Evaluation of vertical gradients can be accomplished by examination of water levels in multiple wells sites or well clusters that consist of wells completed at different depth intervals. Figure 8-8 provides hydrographs from multiple well sites or well clusters that are completed at different depth intervals from four separate areas within the Subbasin. Two locations are in the Kern River Fan HCM Area near the Kern Fan Water Banking Area.

- The 30S24E-13D well cluster consists of three wells located at the western end of the Kern River Fan HCM Area. Vertical head differences range from about 10 to 32 feet with an average downward vertical gradient 0.042 feet per foot.
- The 32N Triple well cluster consists of three wells located at the central Kern River Fan HCM Area. Vertical head differences range from 6 to 16 feet with an average upward vertical gradient 0.030 feet per foot.
- The S-10 well cluster consists of three wells located in the North Basin HCM Area near the northern Subbasin boundary. Vertical head differences range from 11 to 22 feet; however, in this case the vertical gradients converge to the middle interval. From the shallow well there is an average downward vertical gradient 0.010 feet/foot whereas for the deep well there is an average upward vertical gradient 0.050 feet per foot
- The S-9 well cluster consists of two wells located in the southern portion of the North Basin HCM Area. Vertical head differences range from +4 to -4 feet with an average upward vertical gradient 0.004 feet per foot.

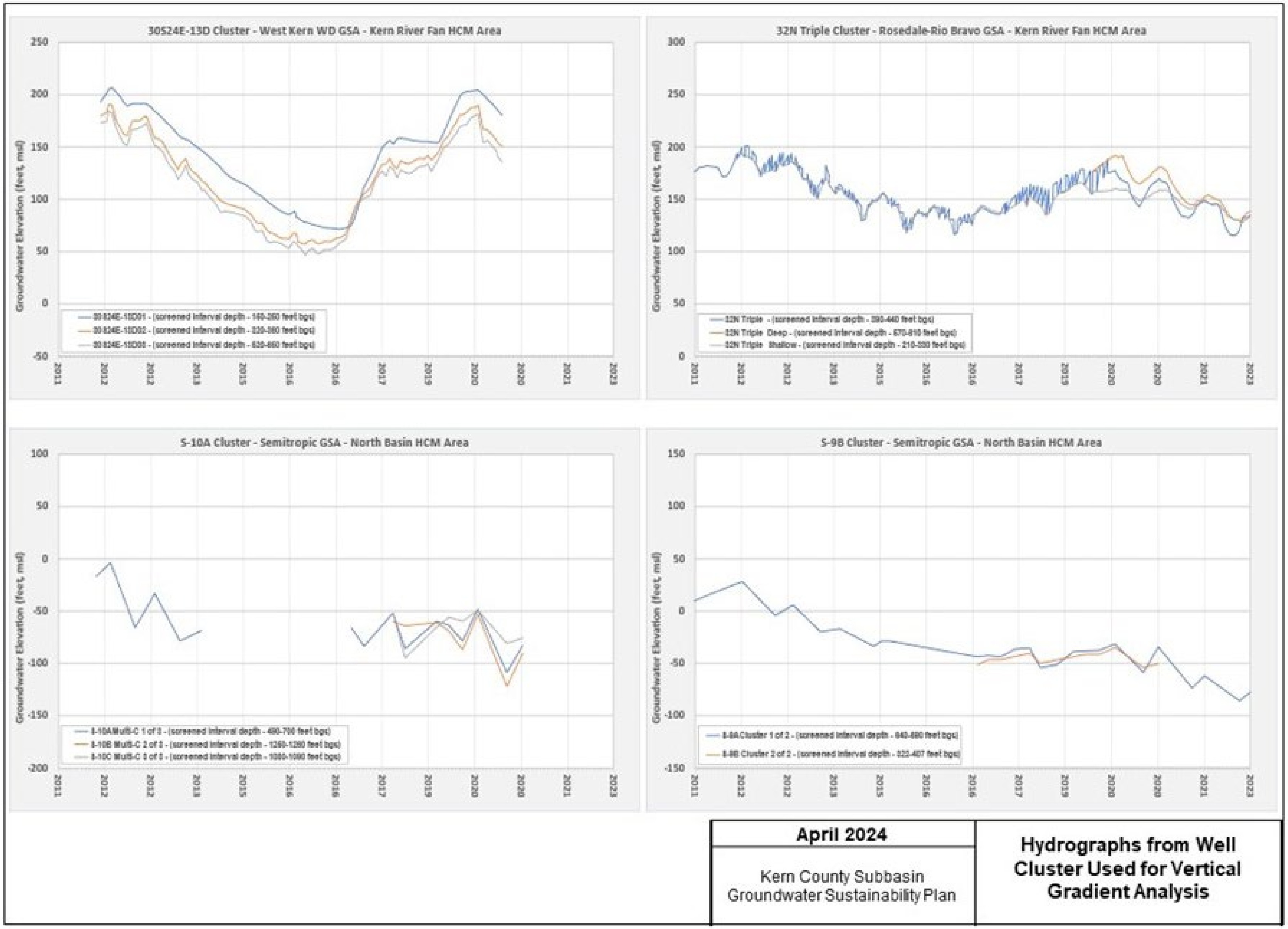


Figure 8-8. Hydrographs from Well Clusters Used for Vertical Gradient Analysis

This page intentionally left blank.

These vertical gradients are considered reasonable for a single, large heterogeneous alluvial aquifer. Vertical gradients between the different zones within the principal aquifer may develop due to geologic heterogeneity such as clay layers, variability in proximity to recharge sources and the intensity of groundwater pumping. Vertical gradients may also vary in time as the factors affecting water levels are also temporally variable.

8.1.1.7 Hydraulic Gradients Between Principal Aquifers

☑ **23 CCR § 354.16(a)(2)**

The Primary Alluvial Principal Aquifer is the largest principal aquifer that essentially covers the entire Subbasin. The other principal aquifers are related to older marine sandstone layers along the Subbasin margin. These are limited to only the Eastern Margin HCM Area. The discussion of the hydraulic gradients between principal aquifers is discussed in the following section for the Santa Margarita Principal Aquifer.

In the North Basin, Kern River Fan, South Basin and Western Fold Belt HCM Areas, the Primary Alluvial Principal Aquifer is underlain by older marine sedimentary rocks that do not meet the DWR (2016) criteria for a principal aquifer (Section 7.2.3). In addition, mapping by California State University, Bakersfield (Gillespie et al., 2017) indicates that units below the Primary Alluvial Principal Aquifer have total dissolved solids (TDS) concentrations in excess of the underground source of drinking water (USDW) limit of 10,000 mg/L (Section 7.3.2). Therefore, an analysis for hydraulic gradients between principal aquifers is not applicable to these HCM areas.

8.1.2 Santa Margarita Principal Aquifer

§ 354.16. *Groundwater Conditions*

(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.

(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

☑ **23 CCR § 354.16(a)(1)**
☑ **23 CCR § 354.16(a)(2)**

The Santa Margarita Principal Aquifer is located mainly in the Eastern Margin HCM Area in the northeastern corner of the Subbasin (Figure 7-26 and Figure 7-27). The principal aquifer area is bounded by the Poso Creek (or Pond-Poso) Fault to the south, the Subbasin margin to the east, a stratigraphic pinch-out of the Santa Margarita to the north in the Tule Subbasin, and highly saline connate waters in the deep basin to the west. In this area, wells are drilled deeper (typically ranging from 1,000 to 2,000 feet bgs.) in order to extract fresh groundwater from the Santa Margarita Formation and Olcese Sand.

As described in Section 7.2.3.2, this principal aquifer is a confined freshwater aquifer formed within marine sandstones of Miocene age. Surface recharge from outcrop areas in the watershed areas along the eastern Subbasin margin has replaced the original saline connate water. This condition occurs in a limited area along the eastern Subbasin margin that forms a locally important groundwater source.

8.1.2.1 Groundwater Flow Directions

Based on the HCM (Section 7.2.2.4), groundwater recharge occurs in formation outcrops located in the watersheds bordering the Subbasin and outflow is considered as almost exclusively from groundwater pumping. Therefore, groundwater is inferred to flow from the Subbasin margins westward toward the groundwater pumping areas.

8.1.2.2 Groundwater Elevation Maps

Groundwater elevations for the local Santa Margarita Principal Aquifer are variable geographically and not readily conducive to water level contouring. This is also due to many of these wells being screened across multiple aquifers. Therefore, Figure 8-9 provides maps of groundwater elevation data that are posted on maps for Fall 2019, Spring 2020, Fall 2021 and Spring 2022 on Figure 8-9**,** As shown, groundwater levels rebounded significantly in Spring 2022 compared to Fall 2021. Increases in groundwater elevations for Spring 2022 averaged about 100 feet for the five southern monitoring wells. Even though the increase in groundwater elevations between the two posted measurements for Fall 2021 and Spring 2022 is less in Well 8L1 than in the southern wells (only about 9 feet), the overall seasonal fluctuations for that well are similar to the remaining wells.

8.1.2.3 Long-Term Hydrograph Trends

Figure 8-10 is a hydrograph of groundwater levels for six wells identified in Figure 8-9 that penetrate the Santa Margarita Formation. As shown in Figure 8-10, groundwater levels in the Santa Margarita Formation are generally consistent across the area. All hydrographs show that prior to 1977 groundwater levels in the Santa Margarita Formation were falling at a rate of approximately 10 feet per year. Beginning in 1977, Kern-Tulare Water District began importing water and, as a result, groundwater pumping decreased, and groundwater levels significantly increased. From 1983 through 2011 groundwater levels remained stable, varying seasonally from elevations of 60 to 120 feet msl. During the 2013 through 2016 drought, groundwater pumping increased, resulting in spring groundwater levels declining by over 50 feet and fall levels declining by 100 feet to historic lows. Since then, groundwater levels have recovered by over 50 feet indicating the recharge capability of this aquifer.

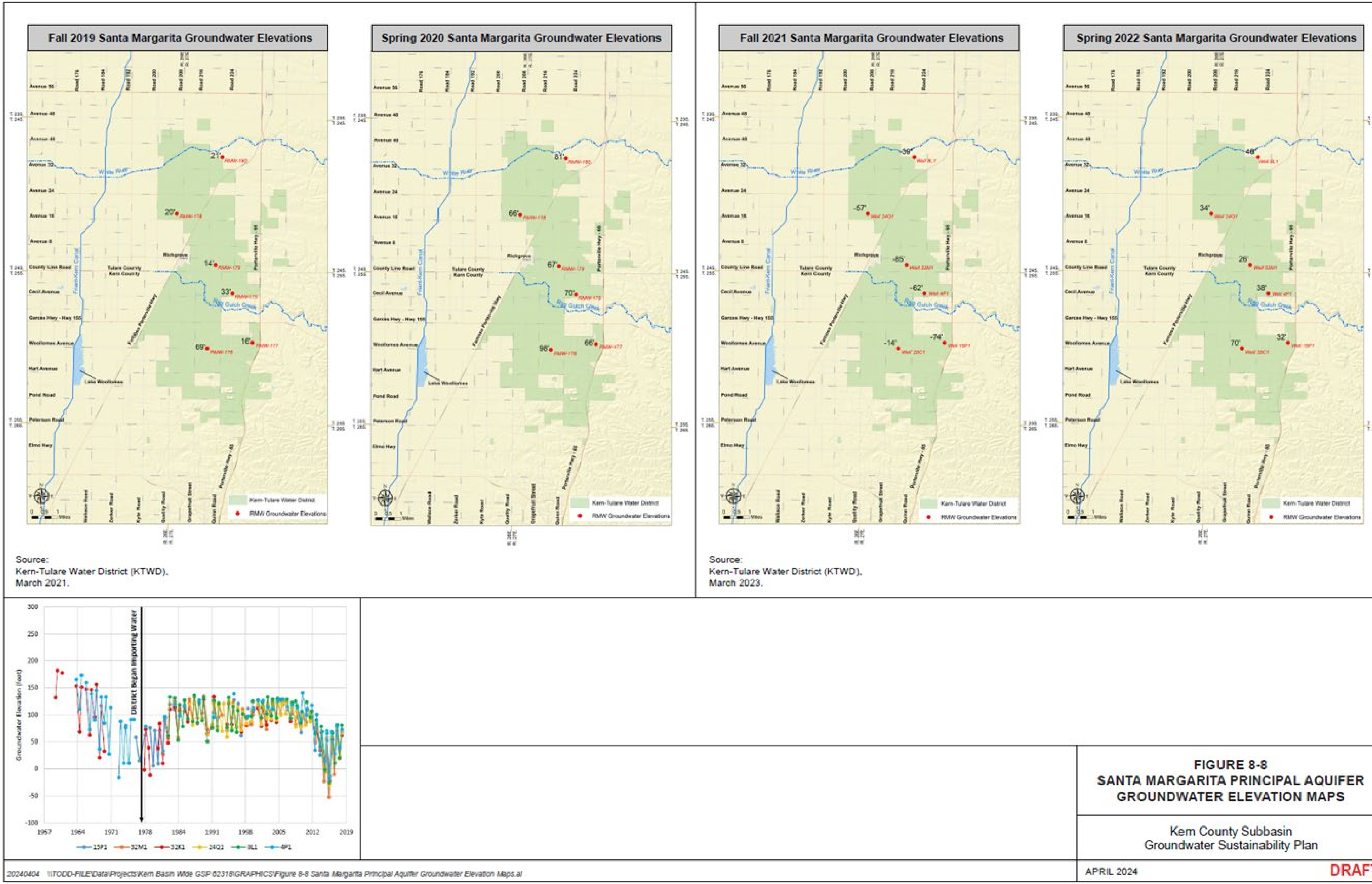


Figure 8-9. Santa Margarita Principal Aquifer Groundwater Elevation Maps

This page intentionally left blank.

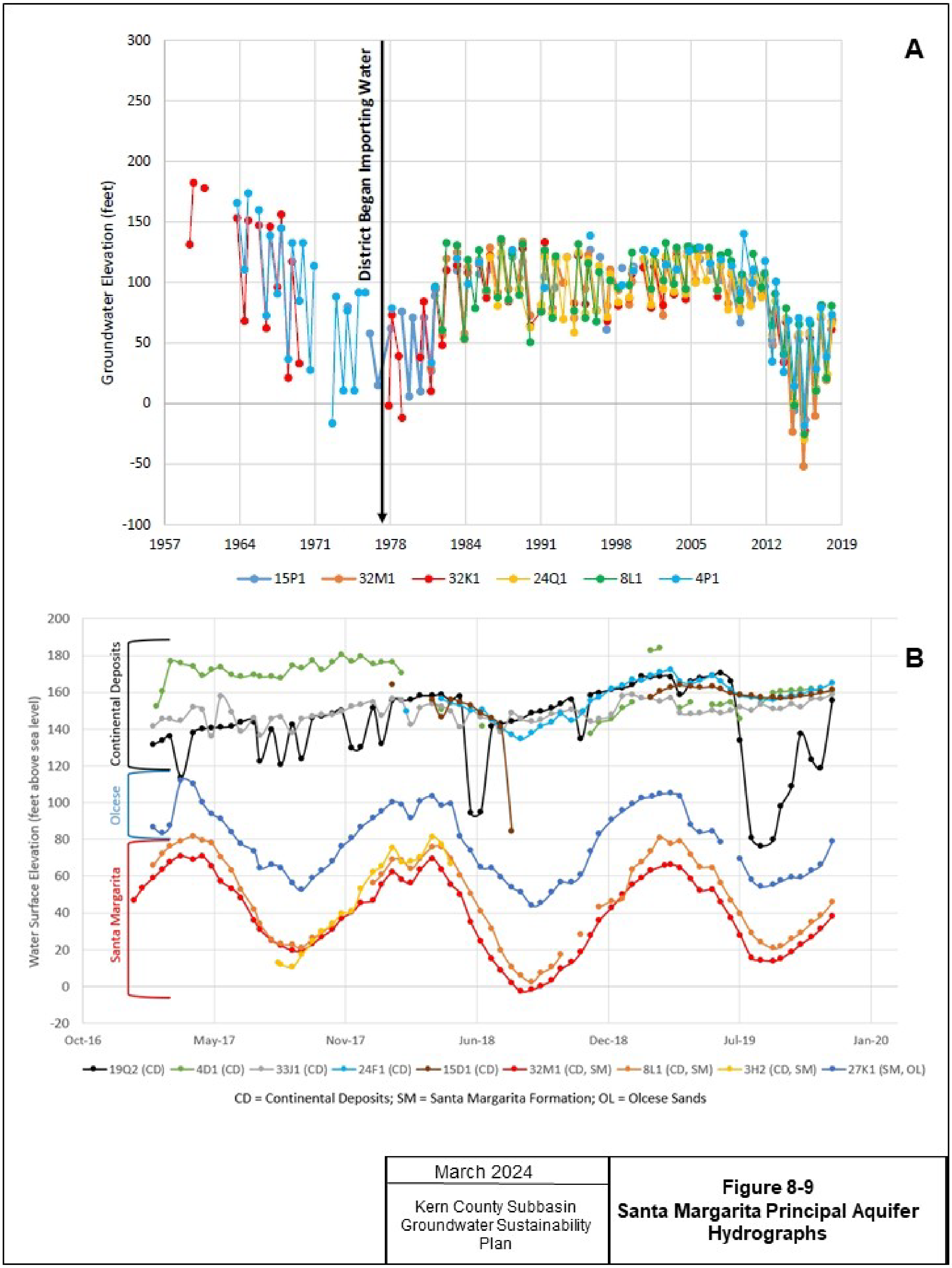


Figure 8-10.Santa Margarita Principal Aquifer Hydrographs

8.1.2.4 Lateral and Vertical Groundwater Gradients

The Santa Margarita Principal Aquifer is hydraulically separated from the overlying Primary Alluvial Principal Aquifer system by aquitard layers in the intervening Plio-Miocene Marine Deposits (Section 7.2.3.2). However, some wells are also screened across both the principal aquifers. Based on the data provided on Figure 8-9, lateral gradients vary from 0.003 to 0.008 feet per foot toward the groundwater pumping areas in the center of the area.

Figure 8-10 is a hydrograph comparing groundwater elevation trends for wells completed across both the Santa Margarita Formation and Olcese Sand. Well numbers 24F1, 4D1, 15D1, 33J1, and 19Q2 are completed only within the Primary Alluvial Principal Aquifer. Wells 8L1, 32M1, 27K1 and 3H2 are completed across the Primary Alluvial Principal Aquifer and the Santa Margarita Principal Aquifer. However, well 27K1 is completed across both the Santa Margarita Formation and Olcese Sand whereas the others are completed across only the Santa Margarita Formation. The following observations can be made from Figure 8-10:

- Wells that penetrate the Olcese Principal Aquifer have water levels that are about 40 feet higher than those that only penetrate the Santa Margarita Formation.
- Wells penetrating the Santa Margarita and/or Olcese Principal Aquifers reflect seasonal fluctuations of about 60 feet.
- Wells that are screened across the Primary Alluvial Principal Aquifer and Santa Margarita have water levels that are representative of the deeper Santa Margarita Formation. This has been verified by data collected in a dedicated monitoring well that is solely completed in the Santa Margarita Formation being consistent with the data collected in the Santa Margarita Formation wells screened across the two aquifers.
- The 40-foot difference in groundwater elevation can be used to calculate a vertical hydraulic gradient of about 0.1 feet per foot; however, these two units are separated by 300 to 400 feet of the Round Mountain Silt which is considered to form a confining layer separating these two aquifers; therefore, little to no groundwater exchange is considered to occur between these two principal aquifer units.

8.1.2.5 Hydraulic Gradients Between Principal Aquifers

The differences in groundwater level elevations and fluctuations between three principal aquifers are shown in Figure 8-10. These wells represent groundwater levels from the Primary Alluvial and Santa Margarita Principal Aquifers. The following observations can be made from Figure 8-10:

- Groundwater levels in the Primary Alluvial Principal Aquifer are 60 to 140 feet higher than those in the Santa Margarita Principal Aquifer and do not show the large seasonal fluctuations evidenced in the Santa Margarita Principal Aquifer and Olcese Principal Aquifer.

- Wells that penetrate the Santa Margarita Principal Aquifer show a lower groundwater elevation than wells completed only in the Continental Deposits.
- The 60- to140-foot difference in groundwater elevation can be used to calculate a vertical hydraulic gradient of about 0.04 to 0.11 feet per foot. The Primary Alluvial Principal Aquifer and Santa Margarita Principal Aquifer are separated by about 1,500 feet of the San Joaquin and Etchegoin Pliocene marine deposits. These units are considered to form a confining layer separating these two aquifers; therefore, little to no groundwater exchange is considered to occur between these two principal aquifer units.

8.1.3 Olcese Sand Principal Aquifer

__§ 354.16.__ Groundwater Conditions
Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information
(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:
(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

☑ 23 CCR § 354.16(a)(1)
☑ 23 CCR § 354.16(a)(2)

The Olcese Principal Aquifer is located mainly in the Eastern Margin HCM area in the vicinity of where the Kern River enters the Subbasin (Figure 7-26 and Figure 7-27). This principal aquifer is so named because the Olcese Sand is the primary producing horizon in this area, which generally coincides with the Olcese GSA. The formation is encountered at depths of approximately 200 to 800 feet bgs under the Olcese GSA Area (approximately 600 to -300 feet msl). The Olcese Sand dips to the southwest and reaches depths of greater than 2,000 feet bgs (-1,400 feet msl). The Round Mountain Silt above the Olcese Sand serves as an aquitard, restricting vertical flow between the Santa Margarita Principal Aquifer and the Olcese Principal Aquifer. Below the Olcese Sand, the Freeman Silt typically acts as a lower bounding aquitard (Bartow, 1984).

8.1.3.1 Groundwater Flow Directions

The Olcese Principal Aquifer is recharged locally at surface outcrops in the surrounding watersheds and directly by rainfall and stream seepage, including recharge from the Kern River, within the principal aquifer area. The aquifer deepens toward the west where it is overlain by fine-grained Round Mountain Silt that limits natural recharge in these areas. This principal aquifer provides the source of nearly all the groundwater used within the Olcese Principal Aquifer area (Figure 7-27).

8.1.3.2 Groundwater Elevation Maps

Groundwater elevation contour maps for the Olcese Principal Aquifer for Fall 2019, Spring 2020, Fall 2021 and Spring 2022 are presented on Figure 8-11. As indicated on Figure 8-11, Fall 2021 groundwater elevations are about 320 feet higher in the Canyon View Ranch Well in the eastern portion of the Olcese GSA than in wells to the west. A steep hydraulic gradient is evident between the Canyon View Ranch well and the deeper downgradient wells. The seasonal difference for groundwater elevations in Wells #2, #3, and #4 varies from 2 to 15 feet indicating a less steep gradient in this area. In Spring 2022 (Figure 8-11), groundwater elevations were relatively stable in the Canyon View Ranch Well while water levels rose an average of about 62 feet in other wells. Given the location of the recharge areas to the north and northeast, it is inferred that groundwater flows generally from the northeast to southwest across the Olcese GSA Area.

8.1.3.3 Long-Term Hydrograph Trends

Historical groundwater elevation data extends back to 1966 for Well #1 and 1977 for Well #2. Based on the Well #1 and Well #2, groundwater levels between 1966 and 1983 ranged between approximately 471 and 543 feet msl. During this period there was little to no groundwater pumping. Once groundwater pumping began in the late 1980s in Wells #1 and #2, groundwater levels adjusted to a new equilibrium state in the range of approximately 350 to 400 feet msl. Reduced pumping in the mid-1990s (Well #2) and late 1990s/early 2000s (Well #1) corresponded to a rise in groundwater levels back to a range of approximately 430 to 490 feet msl. Resumption of pumping in Well #2 and the start of pumping in Well #3 (a replacement for Well #1) in the late 2000s corresponded to a return, by late 2014, to the levels observed in the early 1990s. It should also be noted that in 2014 the Olcese Water District pumped approximately 1,000 acre-feet of additional groundwater to support a water sale to another entity within the Kern Subbasin (previous smaller volume sales occurred in 2004, 2005 and 2009). Data from Spring 2016 indicates a recovery of water levels in Wells #2 and #3 to elevations around 410 feet msl.

An inverse correlation exists between annual pumping volumes and observed groundwater levels. This correlation likely also relates to climate since increased groundwater pumping appears to generally correspond with periods of drought. The relationship between groundwater levels, pumping rates, and climate is further born out on a seasonal timeframe. Higher frequency water level data collected in 2015 to 2023 illustrates that groundwater lows occur in the summer or fall and highs in the winter or spring (see Figure 8-12). The relative degree to which water level fluctuations within the principal aquifer are dependent on pumping rates versus precipitation/recharge patterns is not certain at this time (i.e., no water level data exist for a period when either of the two potential causative factors are isolated or held constant). However, what is clear is that, the above fluctuations notwithstanding, groundwater levels have been relatively stable since the late 1980s/early 1990s when the current regime of land use and pumping began within the Olcese GSA Area, and there is no indication of a chronic long-term decline in water levels.

8.1.3.4 Lateral and Vertical Groundwater Gradients

A comparison of contemporaneous multiple groundwater level measurements between February 2015 and July 2017 show that the lateral groundwater gradient is, on average, toward the southwest with the magnitude ranging from 0.005 to 0.0095 feet per foot. No multi-well locations occur in this area to define vertical gradients.

8.1.3.5 Hydraulic Gradients Between Principal Aquifers

In the localized area, wells are completed only in the Olcese Principal Aquifer. The Olcese Sand is bound above by the Round Mountain Silt and below by the Freeman Silt that act as aquitards that hydraulically separate the Olcese Sand from overlying and underlying geologic units.

This page intentionally left blank.

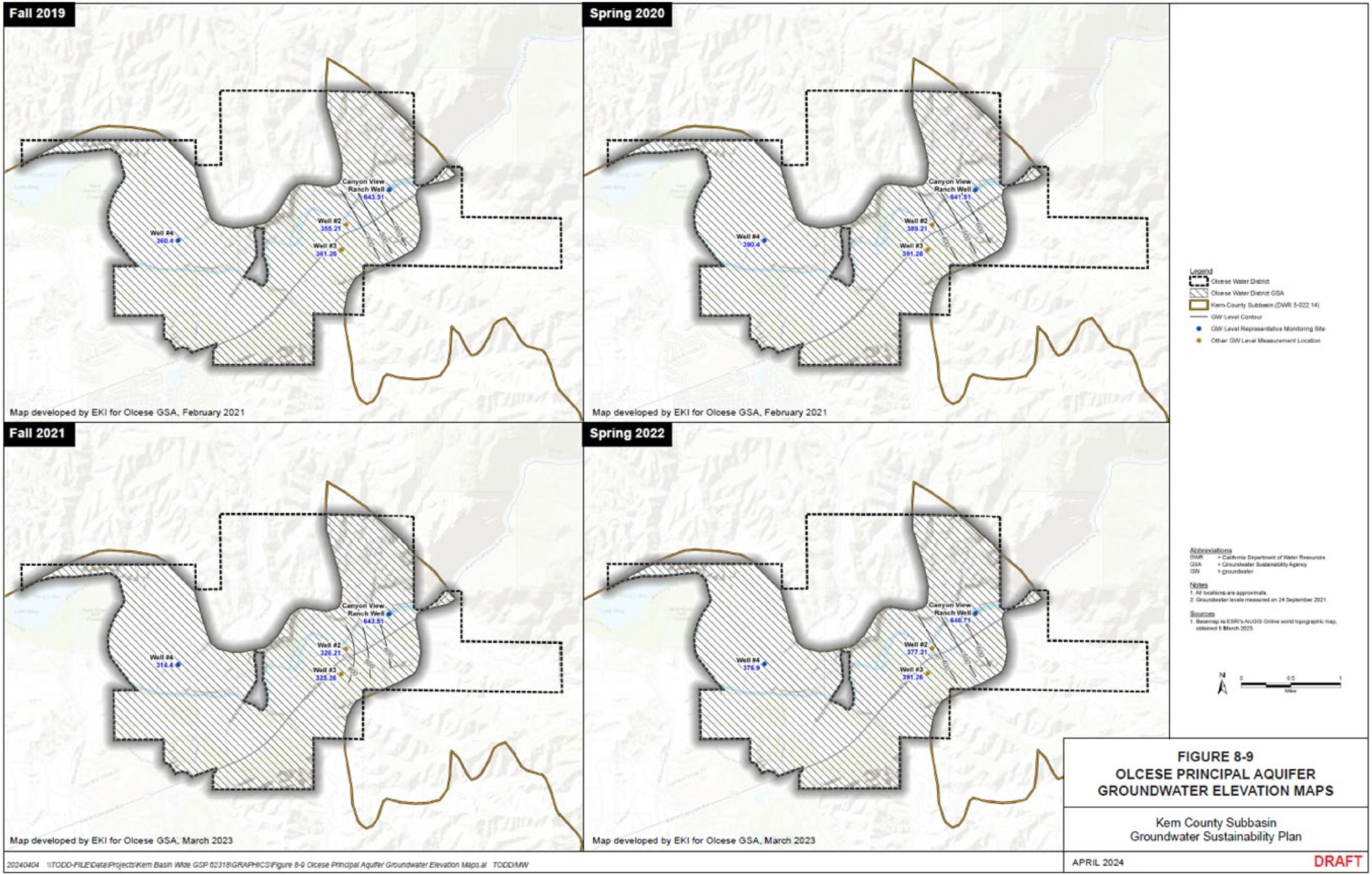


Figure 8-11.Olcese Sand Principal Aquifer Groundwater Elevation Maps

This page intentionally left blank.

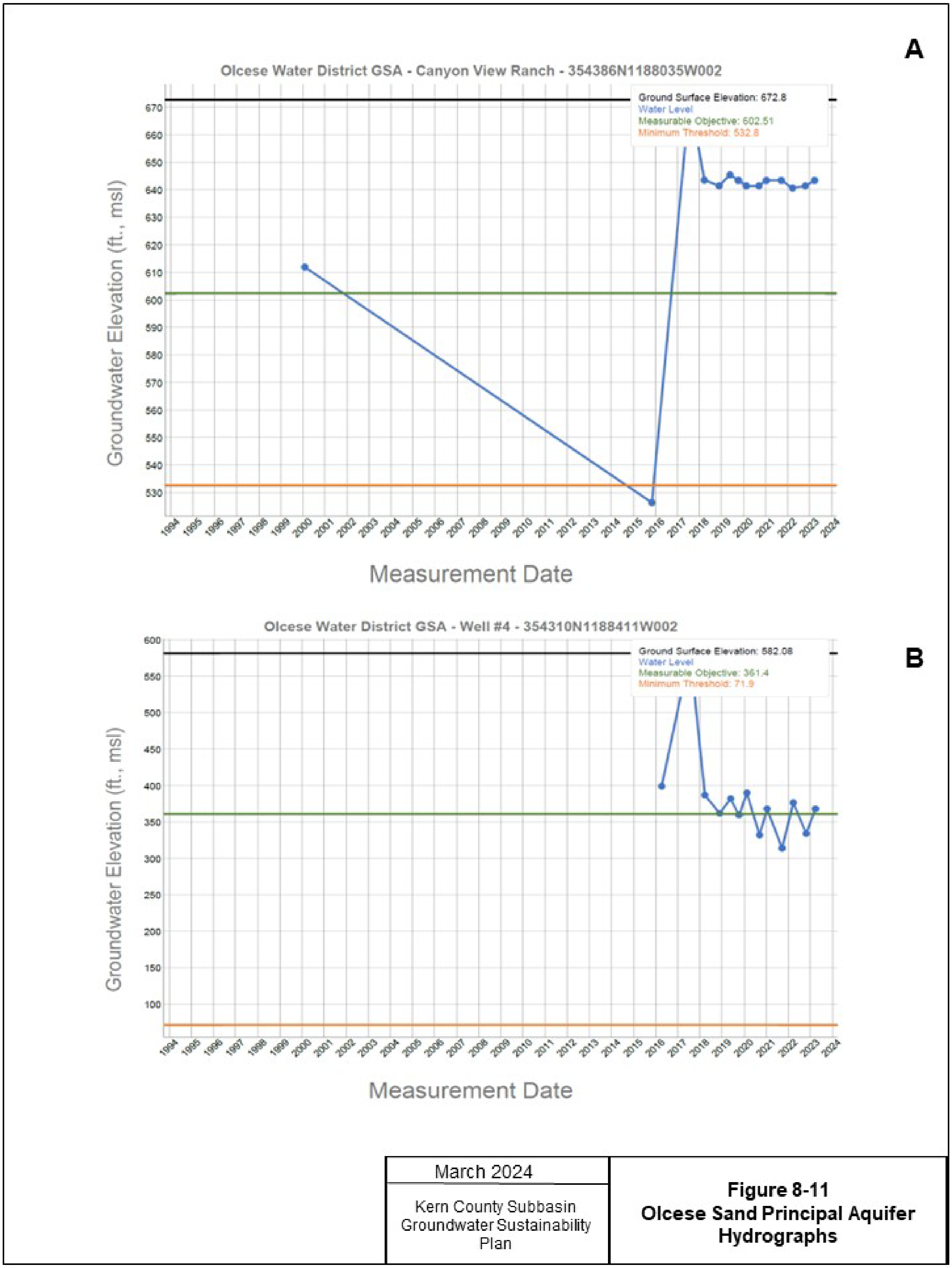


Figure 8-12. Olcese Sand Principal Aquifer Hydrographs

8.2 Change in Groundwater in Storage

> ***§ 354.16.*** *Groundwater Conditions*
> *Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information.*

☑ 23 CCR § 354.16(b)

The change in groundwater storage is a volumetric water budget summation of the total groundwater inflows and outflows within the Subbasin. This change is physically represented by the change in groundwater levels over time. The magnitude of change in groundwater elevation is a function of the storage capacity within the pore spaces of the aquifer including groundwater under confined and unconfined conditions.

8.2.1 Subbasin Change in Groundwater in Storage

> ***§ 354.16.*** *Groundwater Conditions*
> *(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.*

☑ 23 CCR § 354.16(b)

The local groundwater-surface water model (C2VSimFG-Kern) is the agreed upon method for generating coordinated Subbasin-wide water budgets for the Subbasin. C2VSimFG-Kern is based on the C2VSim Fine Grid Public Beta model (C2VSimFG-Beta) that was released by DWR for SGMA support in May 2018 (GSP Regulation §354.18(f)). For this Subbasin Plan, the C2VSimFG-Beta input files have been revised to incorporate locally derived managed water supply and demand data to better represent the local water budgets for the Subbasin. A more detailed discussion of the C2VSimFG-Kern model is provided in Section 9.

8.2.1.1 Annual and Cumulative Change in Groundwater in Storage Graphs

The C2VSimFG-Kern model is routinely updated with new input data following the same methodology to maintain consistency in generating coordinated water budgets through WY 2022. Section 9 includes additional information on the development and application of C2VSimFG-Kern for these purposes. Figure 8-13 shows the simulated change in groundwater storage for the Subbasin over the 28-year period from WY 1995 through WY 2022. Note that these values include surface water stored by the water banking projects. The storage and recovery of this surface water does not result in a change in groundwater storage as the projects can only recover previously stored water. The updated C2VSimFG-Kern results for change in groundwater in storage for the Subbasin and the water year type based on the San Joaquin Valley Index (CDEC, 2023) are summarized on Figure 8-13.

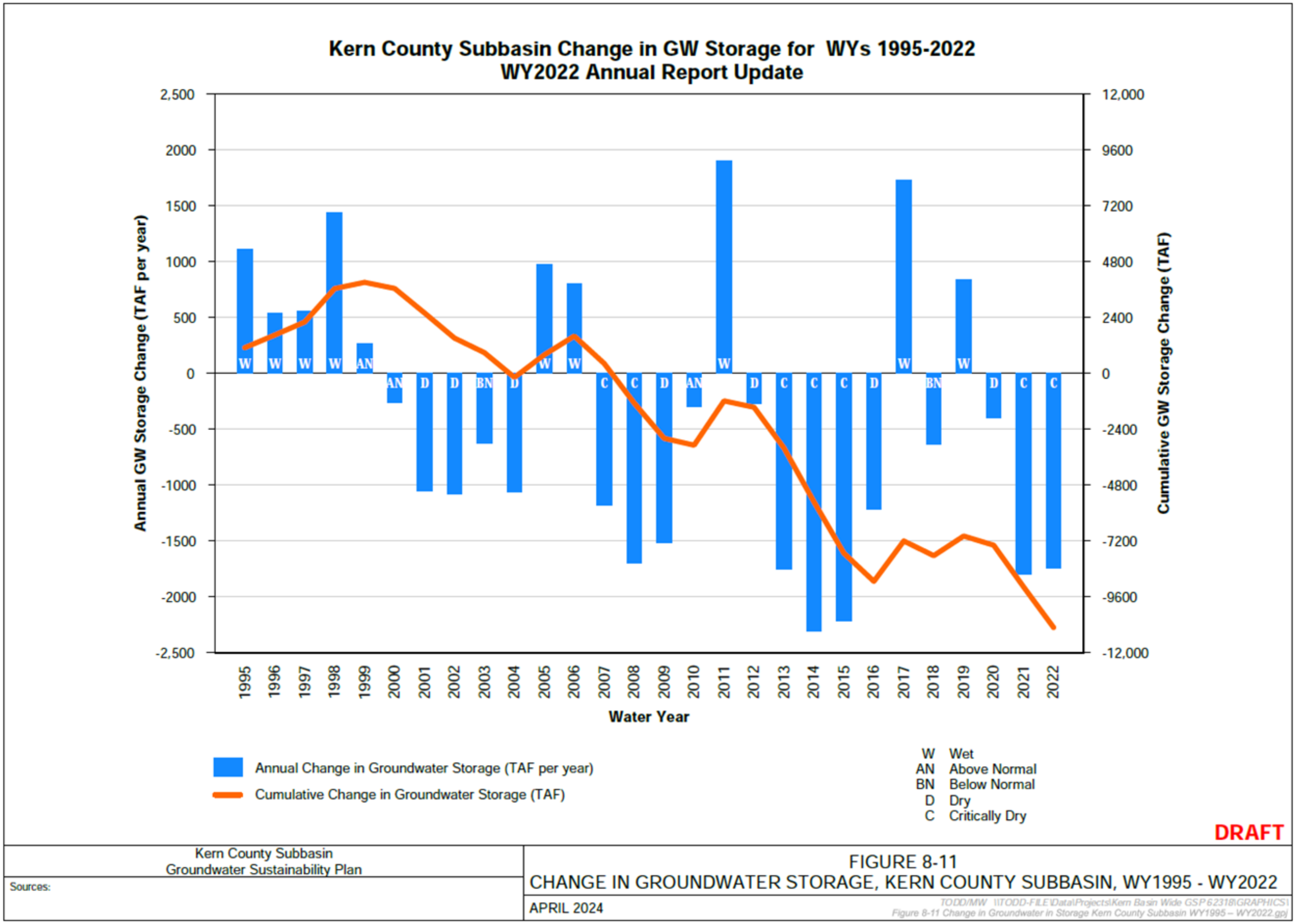


Figure 8-13.Annual Change in Storage

This page intentionally left blank.

The variation in the simulated change in groundwater in storage over the historical period generally corresponds with the variation in climatic conditions and surface water supply availability (Figure 8-14). During the periods WY 1995 to WY 1999, WY 2005 to WY 2006 and WY 2011, the groundwater in storage volume was stable to increasing, which correlates to above average rainfall and surface water availability during these periods. During WY 2000 to WY 2004, WY 2007 to WY 2010 and WY 2012 to WY 2015, groundwater storage volume decreased, correlated to periods of drought and low surface water availability.

During below normal to critically dry water years (WYs 2016, 2018, 2020 and 2021 under the San Joaquin Valley Index; CDEC, 2023), the largest change in groundwater in storage and stored surface water is concentrated in the center of the Subbasin in the vicinity of the large Kern Fan Banking Area along the Kern River. Other areas of concentrated groundwater recovery are noted to the north and southeast near those large water banking and conjunctive use projects. Widespread, but lesser, declines in groundwater storage are observed over most other areas of the Subbasin. Some limited areas of slight increases are present south of the Kern River along the southeastern corner of the Subbasin.

During the wet water years for WYs 2017 and 2019, the highest magnitude change in groundwater storage and stored surface water is again concentrated in the center of the Subbasin in large Kern Fan Banking Area. In WY 2017, this area experienced a significant increase in storage due to the high volume of recharge in the Kern Fan Banking Area. Other areas of large-scale managed aquifer recharge are noted to the north and southeast parts of the Subbasin as areas of high change in storage. Over the remainder of the Subbasin, the change in groundwater in storage varies from areas with increases to areas with decreases; however, these areas of decreases are less than those noted in the WY 2016 maps. Areas of significant recharge also occur along the Kern River, Poso Creek and along the southeastern Margin of the Subbasin.

8.2.1.2 Change in Groundwater in Storage Maps

The change in groundwater in storage maps based on C2VSimFG-Kern output have been reported in each of the Annual Reports provided to DWR. The C2VSimFG-Kern binary output files were accessed to extract the change in groundwater storage for each element and model layer. C2VSimFG-Kern output provides the total volume of storage change within a model element for all four model layers. To compensate for the fact that model elements vary in size, the data were normalized to the rate of acre-feet- per square mile. The normalized rates were then interpolated onto a uniform one-square mile grid superimposed over the Subbasin. Using the C2VSimFG-Kern groundwater model provides a consistent methodology for depicting generalized changes is storage across the Subbasin, however, the version of the C2VSimFG-Kern available for this exercise does, not in all cases, represent accurate locations of groundwater extractions or overlying demands. The map on Figure 8-14 shows a generalize representation of total changes in groundwater and surface water in storage generated by the C2VSimFG-Kern model for the entire Subbasin.

The Subbasin is currently conducting a Basin Study to update the model and improve accuracy for extractions and demands.

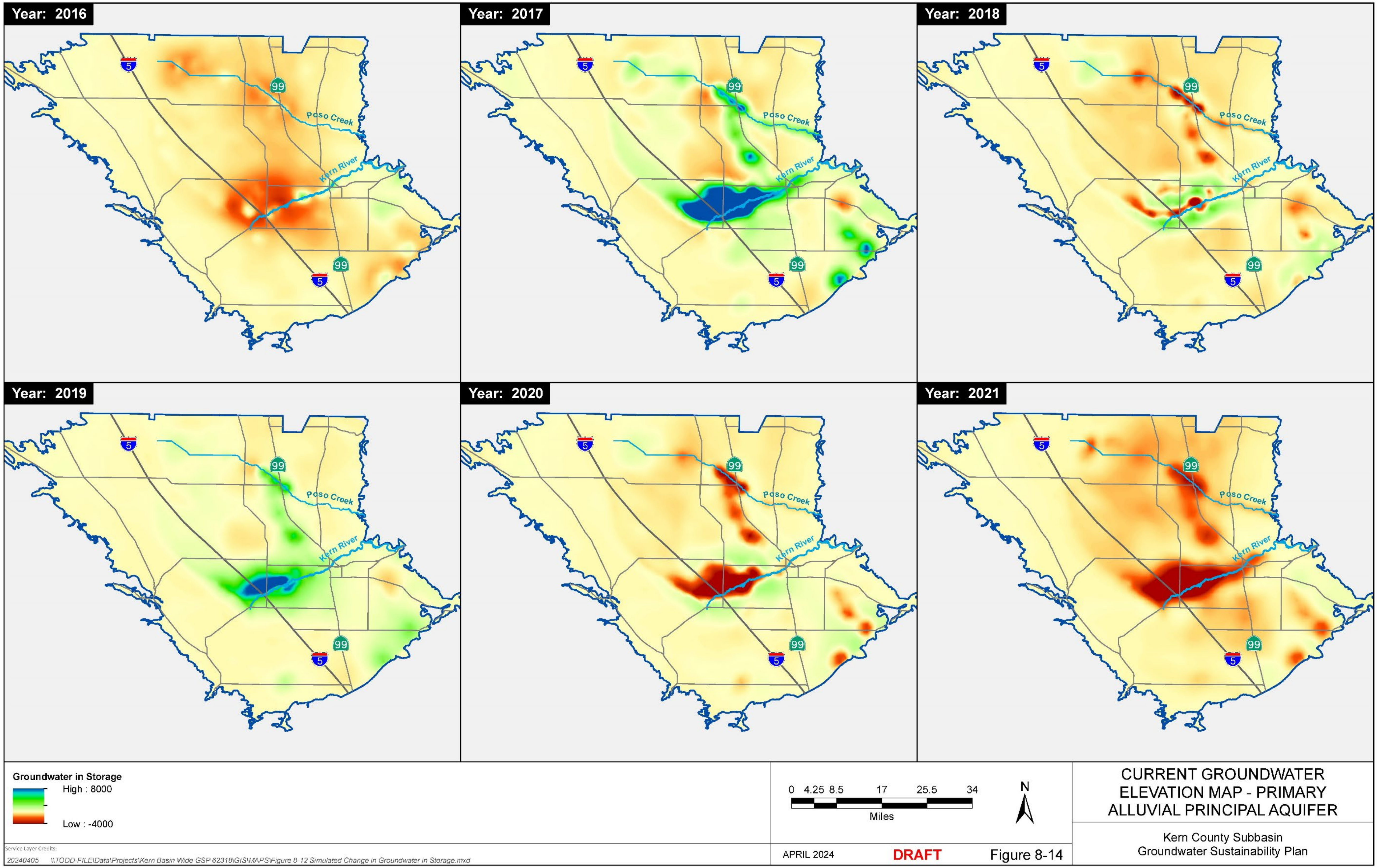


Figure 8-14. Simulated Change in Groundwater Storage 2016-2021

This page intentionally left blank.

The effect of the water banking and conjunctive use projects is reflected in the areal distribution and magnitude of the change in groundwater storage and stored surface water. Figure 8-14 presents the six annual Subbasin-wide change in groundwater storage maps (which include changes in stored surface water) for WYs 2016 to 2021. The change represents the sum of the total inflow components plus the total outflow components. A positive value represents an increase in the volume of water stored in the aquifer, which is physically represented as a rise in groundwater levels whereas a negative represents a decrease in water in storage typified by a decline in groundwater levels.

Figure 8-14 illustrates how water banking and conjunctive use projects produce the most significant localized changes in water in storage due to the magnitude and concentration of such activities. For the critically dry year of WY 2022, these activities are dominated by large volumes of recovery pumping to provide a critical water supply when other surface water supplies are scarce. However, it should be noted that the decline in water in storage associated with the recovery pumping occurs only after similar or larger volumes of surface water have been stored in the Subbasin, which has contributed to the overall amount of available water in storage in previous years. Agricultural and urban areas, in contrast, show lower magnitude annual changes on Figure 8-14, but these are more widespread over the Subbasin. Localized recharge along the major streams and from runoff from the surrounding watersheds is significant in wet years but is diminished during the dry years.

8.2.2 Groundwater in Storage Estimated from Groundwater Elevation Maps

An estimate of the total groundwater in storage is not required by GSP Regulations; however, it is provided here as a useful context to put into perspective the relative scale of the change in annual and cumulative change in groundwater in storage with respect to the large size of the Subbasin.

For this assessment, a uniform set of well locations was used to interpolate a set of contoured time-series of groundwater elevation maps that can be consistently compared with one another. Approximately 2,500 wells representing the WYs 1993 to 2022 were extracted from the Subbasin DMS and supplemented with data from the California Natural Resources Agency web portal (CNRA, 2023) to provide continuity with surrounding Subbasins. From this large data set from a large number of wells, the locations were screened for spatial and temporal coverage to develop the uniform set of well locations used in the analysis.

8.2.2.1 Estimated Annual Storage Volume Change

A calculated annual change in storage was developed to compare the groundwater elevation change with the simulated change in water in storage. This provides a method to calculate available storage within other mapped surfaces. Interpolated groundwater surfaces were developed for the Subbasin for March 30 and September 30 of each year between 1985 and 2022.

The change in groundwater elevation was the difference between the average of a spring and fall groundwater measurement compared to a similar value from the previous year. Changes in the interpolated groundwater elevation surfaces (via numerical integration by subtracting head differences, by grid cell, and then summing), can be used to infer net changes in groundwater in storage, dV, by:

$$\mathrm{d}V = SA\sum_{i=1}^{N} \Delta h_i$$

where:

- Δh = head difference in cell i,
- A = grid cell area (uniform),
- N = number of grid cells, and
- S = Storage Coefficient
- S = specific yield (Sy) for unconfined conditions with Sy = 0.075, or
- S = specific storage (Ss) x aquifer thickness (b) for semi-confined conditions where Ss =$4.3\text{x}10^{-5}$ feet^{-1}

This thickness is based on the Subbasin bottom from Section 7.3.2 and 7.3.5. The aquifer thickness (b) was variable based on geology with the average unconfined (b) = 250 feet. The maximum semi-confined thickness (b) = 2,500 feet to be consistent with maximum wells depths in the deeper portions of the basin. The storage coefficients for the Basin are discussed in Section 7.

The resultant change in storage is summed for both the unconfined and semi-confined aquifer depth zones and compared to changes in storage output from modeled water budgets for 1995-2022. Figure 8-15 shows the annual comparison of the calculated and simulated storage from WYs 1995 to 2022. The Correlation Coefficient (R) for this comparison is 91 percent with the average difference between the two methods ranging from 9 percent to 14 percent over the periods WYs 1995 to 2014 and WYs 1995 to 2022, respectively. These results indicate good agreement, considering the nature of the groundwater dataset and associated processing, as described above, and the separate uncertainties associated with the modeled water budgets.

8.2.2.2 Estimated Subbasin Storage Volume

The above method can also be used to develop estimates of the total groundwater in storage within the Subbasin. These methods provide a means to evaluate the changes of groundwater in storage in context with the overall size of the Subbasin. The methodology is applied using the hydrogeological conceptual model for defining the storage within the Primary Alluvial Principal Aquifer presented in Chapter 7 and shown on Figure 7-25 and the groundwater conditions from Section 8 and shown on Figure 8-2 and Figure 8-3. Based on these data, variable depths of the saturated thicknesses of the upper unconfined and lower semiconfined aquifer zones were developed.

To calculate the usable storage, a specific yield was applied to the upper unconfined aquifer zones and a specific storage was applied to the lower semiconfined aquifer zones. A maximum depth was applied to limit the vertical saturated thickness in the deeper portions of the Subbasin used for this calculation. The available usable storage also includes a strict limitation of available useable storage from the Western HCM in consideration of the near absence of pumping in this area due to natural water quality issues (see Section 8.4).

A sensitivity analysis was used to evaluate uncertainty in determining the available usable storage from the deeper portions of the Subbasin. The storage coefficient is the product of the thickness of the lower semiconfined aquifer zone times the specific storage. Therefore, the sensitivity analysis varied the maximum depth, which was varied from 1,000 to 3,000 feet of total depth. The thickness of the upper unconfined aquifer zone was not varied; therefore, the change in thickness affected the available vertical saturated thickness of the lower semiconfined aquifer zone.

The results of this analysis are summarized in Table 8-1. Since the maximum well depths in the deeper portions of the Subbasin commonly range up to 2,500 feet, the estimated usable storage in the Subbasin is considered to range between 190,000,000 to 230,000,000 acre feet. The sensitivity analysis provides a range of potential usable storage volumes for comparison.

Table 8-1. Sensitivity analysis results of available usable storage volume in the Subbasin

Maximum Depth (feet bgs)	Estimated Usable Storage	
	Minimum Volume (acre-feet)	Maximum Volume (acre-feet)
3,000	220,000,000	260,000,000
2,500	190,000,000	230,000,000
2,000	150,000,000	190,000,000
1,500	110,000,000	150,000,000
1,000	90,000,000	130,000,000

This page intentionally left blank.

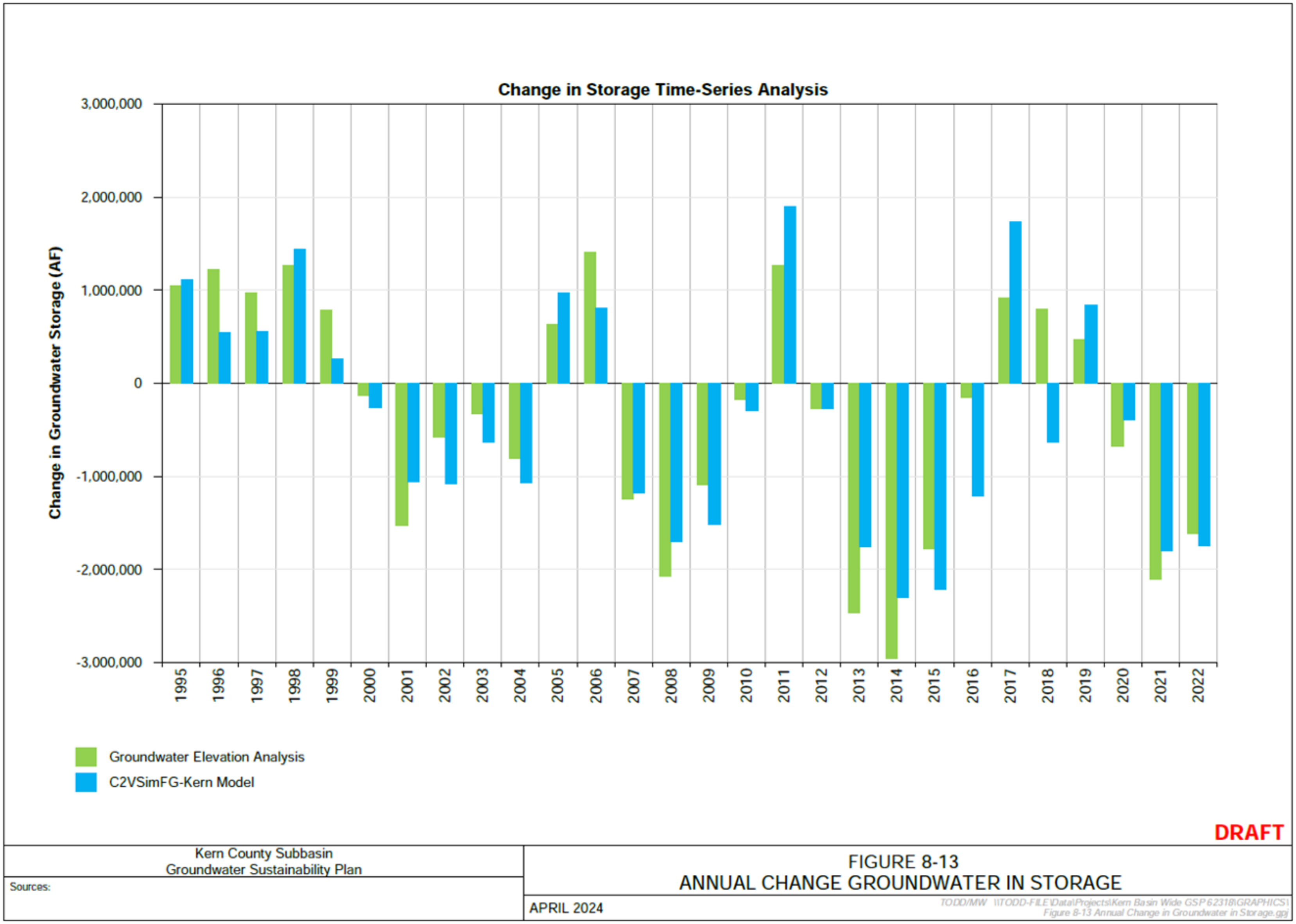


Figure 8-15. Annual Change in Groundwater Storage (Elevation vs. Model Analysis)

This page intentionally left blank.

8.3 Seawater Intrusion

§ 354.16. *Groundwater Conditions*
(b) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.

☑ **23 CCR § 354.16(c)**

Because the Subbasin is located more than 60 miles from coastal areas, seawater intrusion is not considered to be an issue and therefore is not applicable.

8.4 Groundwater Quality

§ 354.16. *Groundwater Conditions*
(c) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

☑ **23 CCR § 354.16(d)**

Groundwater quality is characterized using a combination of groundwater quality data sets available from SWRCB's GAMA and GeoTracker database, DTSC's EnviroStor database, GSAs, and literature review. Groundwater constituents of concern (COCs) discussed in this section are based on SWRCB's Groundwater Quality Considerations for High and Medium Priority Groundwater Basins letter to the DWR (**Appendix L**), dated November 22, 2022. Point-Source contamination sites are identified using SWRCB GeoTracker and DTSC EnviroStor databases. Oilfield Injection Wells and Produced Water Pond sites are extracted from GeoTracker. In addition to using GeoTracker, a literature review of oilfield injection wells studies in the Subbasin are used to understand the extent to which there is contamination from oil and gas developments which impact groundwater quality.

8.4.1 Groundwater Quality Constituents of Concern

The SWRCB's methodology for identifying COCs includes evaluation of numerous datasets from State and Regional Water Board regulatory programs. SWRCB developed a list of constituents of concern to be included in the Plan by evaluating data from the following datasets:

- Division of Drinking Water
- Department of Pesticides Regulation
- Irrigated Lands Regulatory Program
- GAMA Local Groundwater Projects
- USGS National Water Information System
- Water Board Clean Up and Permitted Sites

The methodology includes the following steps:

- Screening the data to represent domestic, irrigation/industrial, municipal, and other water supply well types.
- Excluding constituents not related to human health, not generally impacted by groundwater management activities, or not exceeding screening criteria in three or more wells basin wide.

Table 8-2 summarizes the prevalence of exceedances for constituents identified in SWRCB's methodology using 2015 to 2023 data from GAMA, along with each constituent's associated drinking water health-based standard. As agricultural use is the primary use throughout the Subbasin, agricultural thresholds are included in the table, where applicable. Agricultural thresholds were published by the Food and Agriculture Organization of the United Nations in 1985 (SWRCB Water Quality Goals). The criteria are protective of various agricultural uses, including irrigation of various types of crops and stock watering. At or below these thresholds, agricultural uses of water should not be limited. Agricultural thresholds are specifically a concern for TDS because the drinking water standards are too high to be protective of salt sensitive crops.

Each constituent is further evaluated by HCM, including the range, median, exceedances based on pre--2015 and 2015 to 2023 conditions to better characterize the constituents of concern. GAMA data from 2010 to 2023 have been used for pre--2015 and 2015 to 2023 evaluations. Figure 8-16 shows the distribution of wells used for groundwater quality evaluation. Section 5.6.1 and 5.6.2 shows well inventory and well density per HCM, showing minimum wells along the western part of the Subbasin and lower density of wells in the eastern part of the Subbasin. As described in Section 5.2, the Western Fold Belt and Eastern Margin HCMs are primarily served by surface water therefore, it is expected that there are less wells and groundwater quality data for these HCMs.

As discussed in Section 7.3.4.1 and shown in Figures 7-33 and 7-34, the Western Fold Belt and the Eastern Margin HCM areas contain various primary and post-primacy aquifer exemptions. Areas de-designated for a specific beneficial use are under the 2018 CVRWQCB Basin Plan. In addition, in 2023, CVRWQCB proposed an oilfield de-designation Basin Plan Amendment for the Lost Hills, located in the Western Fold Belt HCM. Determination of additional proposed de-designations are still under development by CVRWQCB at the time of this Plan development.

Minimal to no pumping is observed in the Western Fold Belt HCM area. This is consistent with degraded water quality and Basin Plan de-designations in this HCM Area, limiting the ability to beneficially use groundwater. Rather than extract groundwater, users within this HCM import surface water and/or recovered banked surface water supplies to meet demand.

The constituents of concern discussed are for characterization purposes. SWRCB's Groundwater Quality Considerations for High and Medium Priority Groundwater Basins letter to the Department of Water Resources states:

> *While it may not be appropriate for a GSP to set minimum thresholds and measurable objectives for all constituents identified for the basin, most or all of the constituents should be discussed in the basin setting since these constituents are present in the basin at concentrations that can impact beneficial users of groundwater.*

Table 8-2. Constituent Prevalence in Kern Subbasin (2015 to 2023)

Constituent	Drinking Water Standard	# of Wells Exceeded	# of Wells Sampled	% of Wells Exceeded
1,2,3-Trichloropropane (1,2,3-TCP)	5 ppt	220	494	44.5%
Arsenic	10 ppb 100 ppb[1]	113	495	22.8%
Benzene	1 ppb	2	454	0.4%
Dibromochloropropane (DBCP)	200 ppt	9	476	1.9%
Ethylene Dibromide (EDB)	20 ppt	3	472	0.6%
Gross Alpha	15 pCi/L	19	388	4.9%
Nitrate (as N)	10 ppm	112	740	15.1%
Nitrate + Nitrite (as N)	10 ppm	53	213	24.9%
Nitrite (as N)	1 ppm	11	623	1.8%
Perfluorooctane sulfonate (PFOS)	4 ppt	30	203	14.8%
Perfluorooctanoic acid (PFOA)	4 ppt	14	203	6.9%
Selenium	50 ppb	4	482	0.8%
Total Dissolved Solids	1,000 ppm[2] 450 ppm[1]	65	541	12.0%
Uranium	20 pCi/L	20	284	7.0%

[1]Agricultural goals from Water Quality Goals for Agriculture, Food and Agriculture Organization of the United Nations, 1985
[21]Upper Maximum Contaminant Level.

This page intentionally left blank.

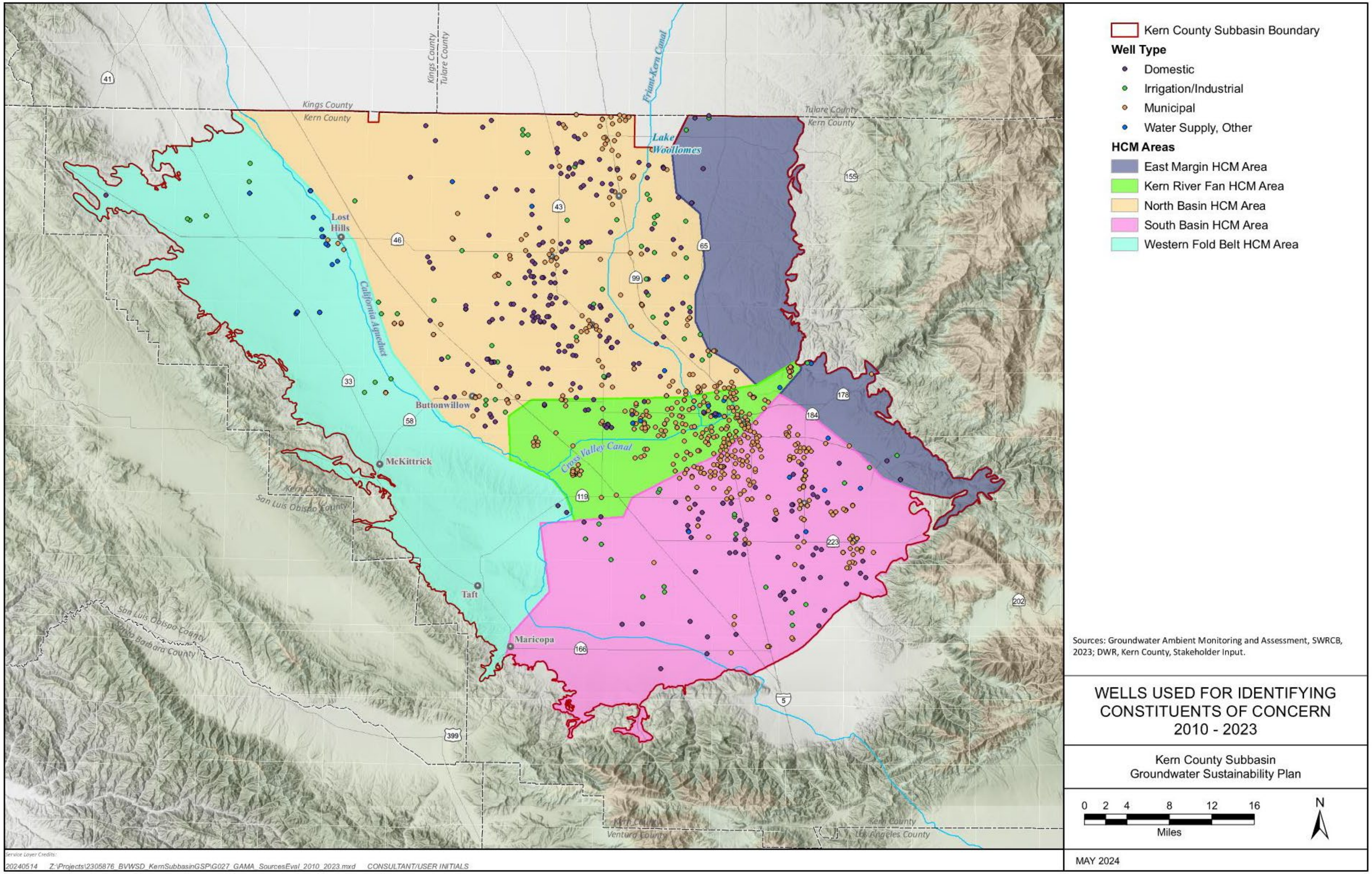


Figure 8-16. Wells Used for Groundwater Characterization

This page intentionally left blank.

8.4.1.1 1,2,3-Trichloropropane (1,2,3-TCP)

1,2,3-TCP is a synthetic organic chemical with a primary MCL of 5 parts per trillion (ppt) and no agricultural goal. 1,2,3-TCP contamination is widespread throughout the Subbasin. Throughout the Central Valley, most of the 1,2,3-TCP found in groundwater was introduced through application of soil fumigants sold under the trade names of D-D, Telone, and Telone II. These fumigants were applied by land application from 1950 through 1984. Telone II remains on the market today but no longer contains 1,2,3-TCP. The active ingredients of these soil fumigants were reported to be highly effective and decomposed in the soil; 1,2,3-TCP was an inert ingredient that bonds to water and sinks in the aquifer. 1,2,3-TCP is a highly stable compound, meaning that it is resistant to degradation and has a half-life of hundreds of years (Samin et. al. 2012). Fumigants containing 1,2,3-TCP as an inert ingredient were discontinued in 1984.

Figure 8-17 displays the 1,2,3-TCP median concentration per well, along with wells that had an exceedance. 1,2,3-TCP contamination is primarily seen in the Kern River Fan, North Basin and South Basin HCMs where urban development has moved into historically agricultural areas. Table 8-3 summarizes pre-2015 and 2015 to 2023 1,2,3-TCP median and range for each HCM. The 1,2,3-TCP median concentration for each HCM is non-detect; however, the range shows there are sources with 1,2,3-TCP concentrations above the MCL in the North Basin, Kern River Fan and South Basin HCM's. The upper range of 1,2,3-TCP concentration is higher in 2015 to 2023 conditions in the Kern River Fan and the South Basin HCM's and lower in the North Basin HCM.

Table 8-4 summarizes pre-2015 and 2015 to 2023 1,2,3-TCP exceedances for each HCM. While the number of wells with 1,2,3-TCP exceedances is greater from the pre-2015 to the 2015 to 2023 conditions, these increases do not indicate increasing concentrations, or degradation of groundwater quality. Rather, it reflects a more comprehensive understanding of 1,2,3-TCP distribution as the number of wells sampled increased when the drinking water MCL became effective in January 2018.

This page intentionally left blank.

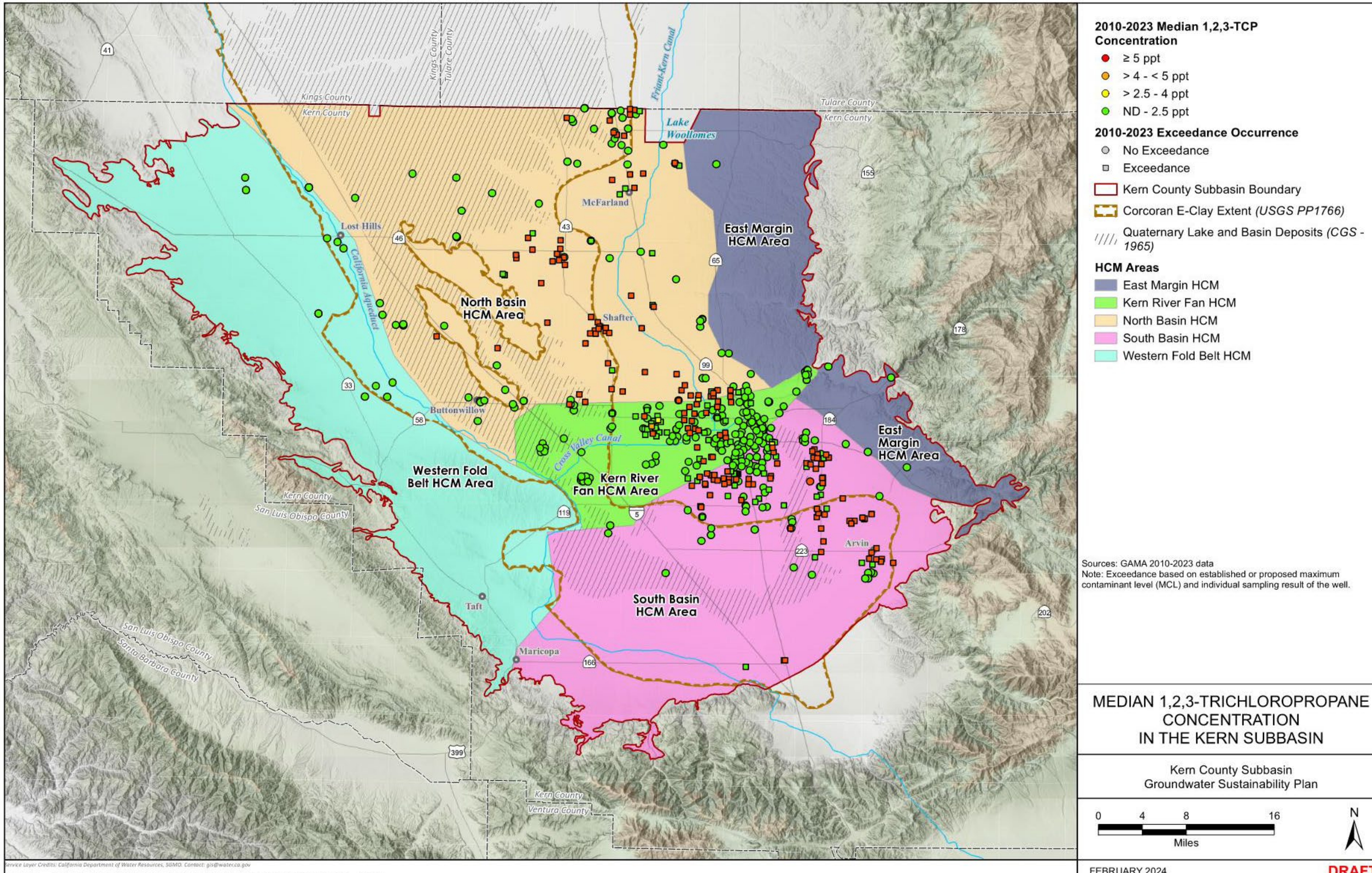


Figure 8-17. Median 1,2,3-TCP Concentration

This page intentionally left blank.

Table 8-3. Range and Median Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (ppt)	Median (ppt)	# of Wells Sampled	Range (ppt)	Median (ppt)	# of Wells Sampled
Western Fold Belt	ND	ND	1	ND	ND	17
North Basin	ND – 800	ND	78	ND – 536	ND	139
Kern River Fan	ND – 370	ND	131	ND – 550	ND	163
South Basin	ND – 450	ND	118	ND – 570	ND	169
Eastern Margin	ND	ND	1	ND	ND	6

Table 8-4. 1,2,3-TCP Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Western Fold Belt	0	1	0.0%	0	17	0.0%
North Basin	32	78	41.0%	76	139	54.7%
Kern River Fan	21	131	16.0%	49	163	30.1%
South Basin	45	118	38.1%	95	169	56.2%
Eastern Margin	0	1	0.0%	0	6	0.0%
Total	98	329	29.8%	220	494	44.5%

For consistency with other constituents, 1,2,3-TCP median concentrations for wells within and outside the boundaries of E-c-lay and the lake deposits are summarized in Table 8-5. However, the only relationship between 1,2,3-TCP prevalence and clay deposits is lower occurrence where the clay is serving as a physical barrier that impedes 1,2,3-TCP migration into the deeper aquifer. Additionally, the soil fumigants that contained 1,2,3-TCP were typically applied to row crops (potatoes, carrots, sugar beets) which are mostly grown in sandy soils, not where dense clays are present. Consequently, the greatest prevalence of 1,2,3-TCP is within areas where urban sprawl was converted from previous agricultural areas.

Table 8-5. Median 1,2,3-TCP Summary for Wells within E-c-lay or Lake Deposits Boundaries

HCM	Geology	2010-2023 Median (ppt)	2010-2023 # of Wells Sampled
Western Fold Belt	E-c-lay	ND	9
	Neither	ND	8
North Basin	E-c-lay and Lake Deposits	ND	28
	E-c-lay	7	52

HCM	Geology	2010-2023 Median (ppt)	2010-2023 # of Wells Sampled
	Neither	ND	69
Kern River Fan	E-c-lay and Lake Deposits	ND	12
	E-c-lay	ND	13
	Neither	ND	144
South Basin	E-c-lay and Lake Deposits	ND	10
	E-c-lay	10.5	46
	Lake Deposits	5	3
	Neither	ND	119
Eastern Margin	Neither	ND	6

Of the 494 wells sampled for 1,2,3-TCP in the Subbasin, 220 wells have concentrations above the MCL. Data trending was performed in the three HCMs where 1,2,3-TCP is detected above drinking water standards. Figure 8-18 shows the drastic fluctuation between sample results from each well with no relevant correlation to changes in groundwater elevations or any other groundwater management action. Similarly, Figure 8-19 provides a traditional chemograph with a representative example of a well with fluctuating 1,2,3-TCP concentrations that have no correlation with groundwater elevations.

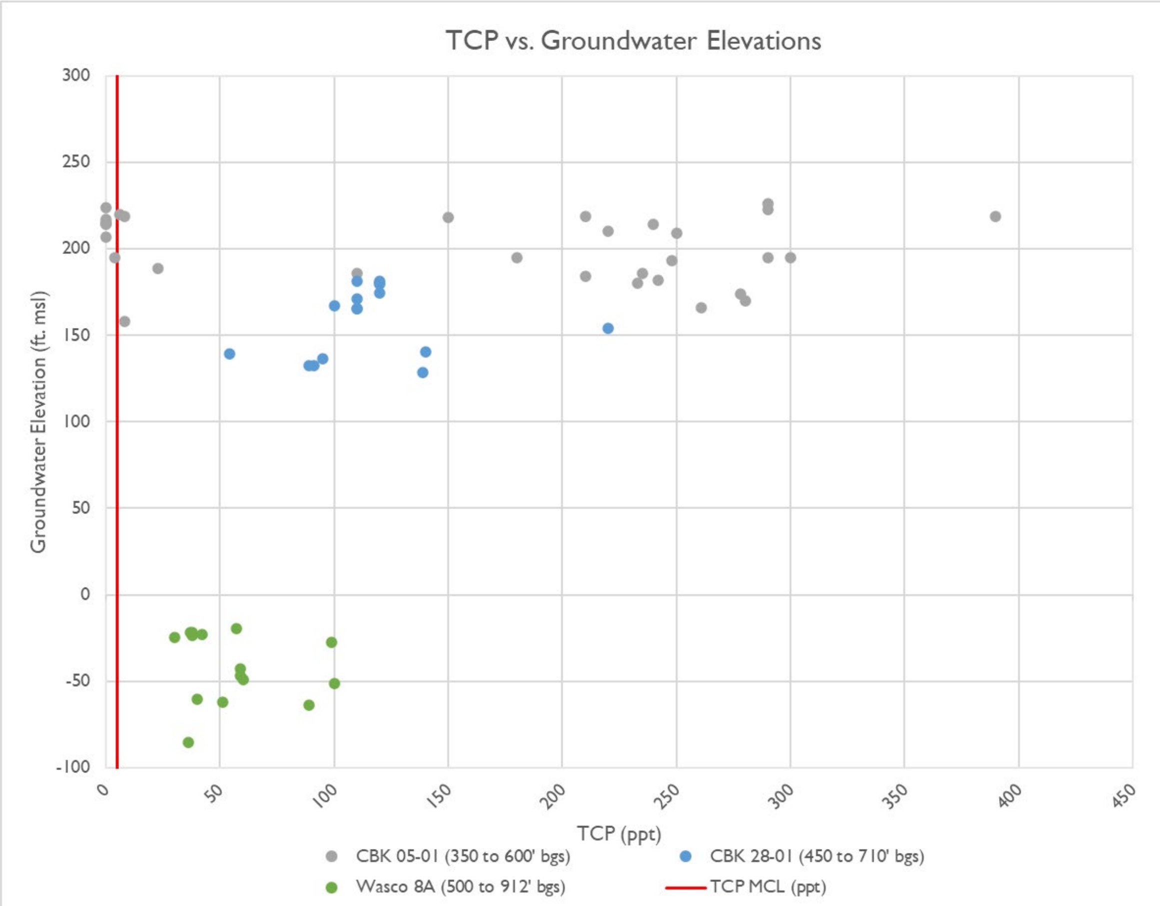


Figure 8-18. 1,2,3-TCP vs. Groundwater Elevations

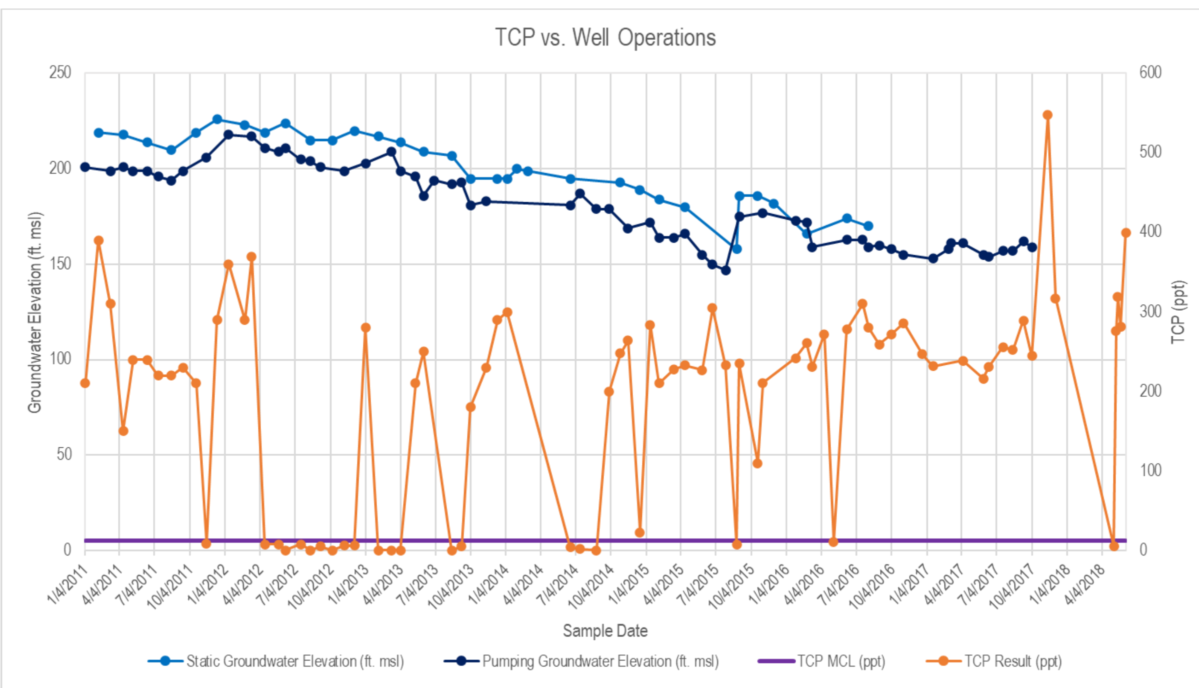


Figure 8-19. 1,2,3-TCP vs. Groundwater Elevations

Evaluating data based on groundwater elevation changes, proximity to surface water bodies (river, unlined canal, spreading grounds) and pumping patterns indicates that the variation in 1,2,3-TCP concentrations can be correlated in some areas with well operation (hours of active pumping or length of time the well is pumped before a sample is collected). To further demonstrate a stronger correlation between well operation and 1,2,3-TCP concentration, Figure 8-20 and Figure 8-21 shows one well, located in Kern River Fan HCM, plotted with static and pumping groundwater elevations then plotted with monthly production data. This well is a representative example of extreme fluctuations where 1,2,3-TCP ranges from non-detect to more than 100 ppt.

Monthly production volumes (million gallons) are shown with the 1,2,3-TCP concentrations in Figure 8-20. Initially this data was plotted to evaluate a potential correlation between well operation and 1,2,3-TCP concentration. Since production data is monthly, and grab samples represent a single point in time, the trends are not directly aligned. However, there are periods, such as spring through late summer 2015, and summer 2016 through fall 2017, which show consistency. After this well was seasonally taken offline (December 1, 2017 through April 30, 2018), a 1,2,3-TCP sample was collected after approximately two hours of flushing; the result was 5.6 ppt. After the well started operating normally, routine samples were collected and showed an increasing trend as operational hours increased (refer to Figure 8-21).

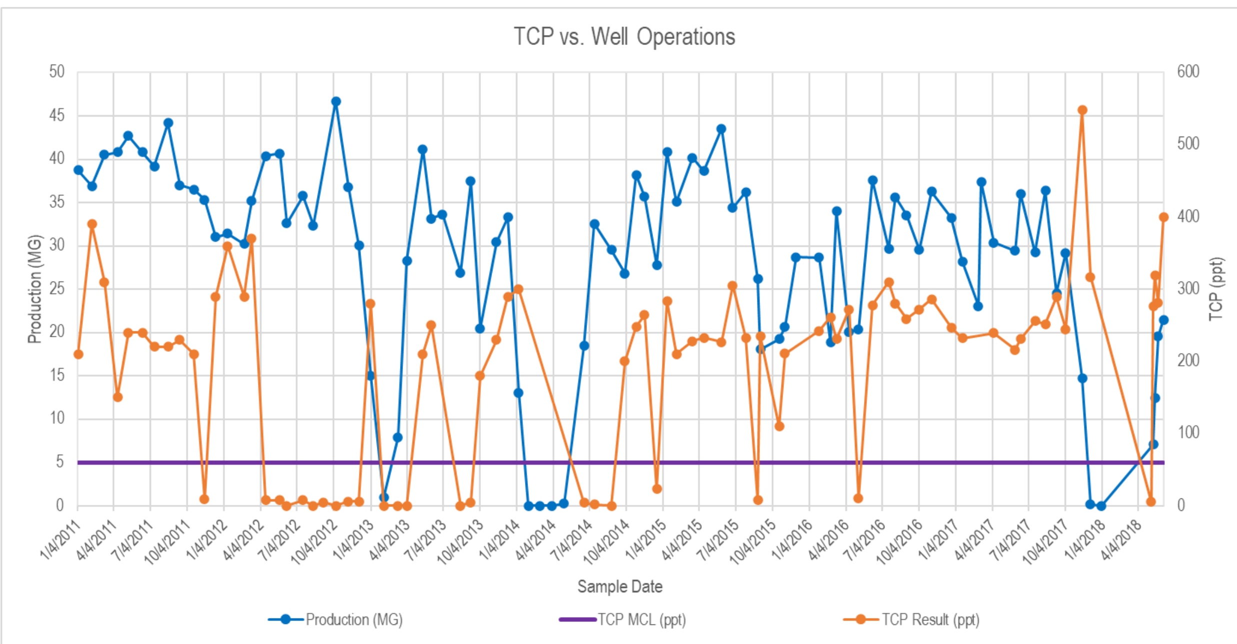


Figure 8-20. 1,2,3-TCP vs. Well Operation

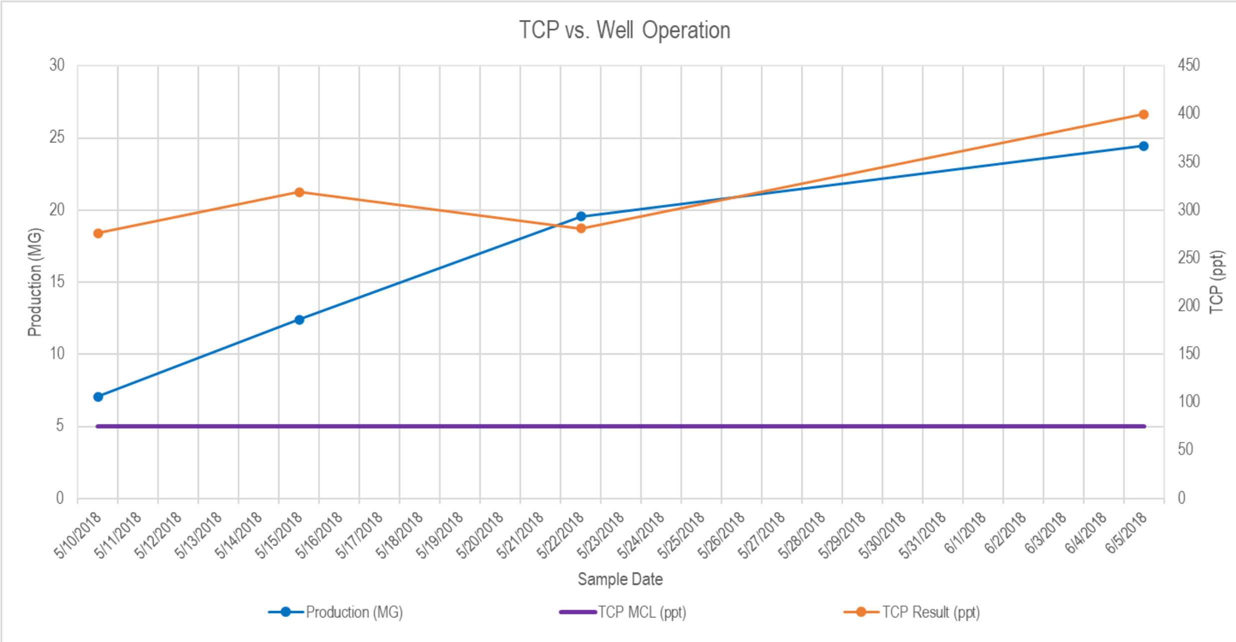


Figure 8-21. 1,2,3-TCP vs. Well Operation

8.4.1.2 Arsenic

Arsenic is a naturally occurring trace element with a primary drinking water MCL of 10 parts per billion (ppb) and an agricultural goal of 100 ppb. In aquifers, arsenic is commonly adsorbed onto clay surfaces and to iron (Fe-III) and manganese (Mn-IV) oxyhydroxide coatings on mineral grains or included in sulfide minerals (pyrite, FeS2) by substitution for sulfur in the mineral structure (Brannon and Patrick, 1987; Raven et al., 1998; Lin and Puls, 2000; Graft al., 2002; Goldberg, 2002; Farquharetal.,2002; Tufano et al., 2008). Arsenic can be released from aquifer sediments into groundwater by several geochemical processes which include desorption when surfaces pH increases from values less than 8 to greater than 8.5 under oxic conditions, reductive dissolution of iron and manganese oxyhydroxides under geochemically reduced or anoxic conditions, oxidation and dissolution of sulfide minerals, and, competitive desorption by increased concentrations of competing anions such as phosphate (Welch et al., 2000; Smedley and Kinniburgh, 2002; Welch and Stollenwerk, 2003; Barringer and Reilly, 2013; Lin and Puls, 2000; Neil et al., 2012).

In the southern San Joaquin Valley, arsenic-rich minerals such as arsenopyrite (FeAsS), a common constituent of shales and apatite, and phosphorites are the most common sources of arsenic leaching sediments in the aquifer (Burton et al, 2012). These minerals are bound in the E-Clay deposits and in the valley trough where thick lakebed clay deposits such as the Tulare Lake, Kern Lake, and Buena Vista Lake beds are present (Bulletin 118, DWR). In the Subbasin, it’s important to understand that arsenic-rich minerals in the E-Clay are typically present in the upper aquifer (approximately 300-feet below ground surface). Whereas arsenic concentrations increase with depth when arsenic is bound in the lakebed deposits, which typically occur near the base of fresh water. USGS studies report finding arsenic concentrations increase across the valley trough where aquifer sediments are finer and reducing conditions favor arsenic mobilization into groundwater. Additionally, higher arsenic concentrations have been observed during periods of declining groundwater elevations which is believed to be a result of less dilution of shallow water with older groundwater, which contains higher arsenic concentrations. Figure 8-22 present median arsenic concentrations as well as areas with E-clay and lakebed deposits.

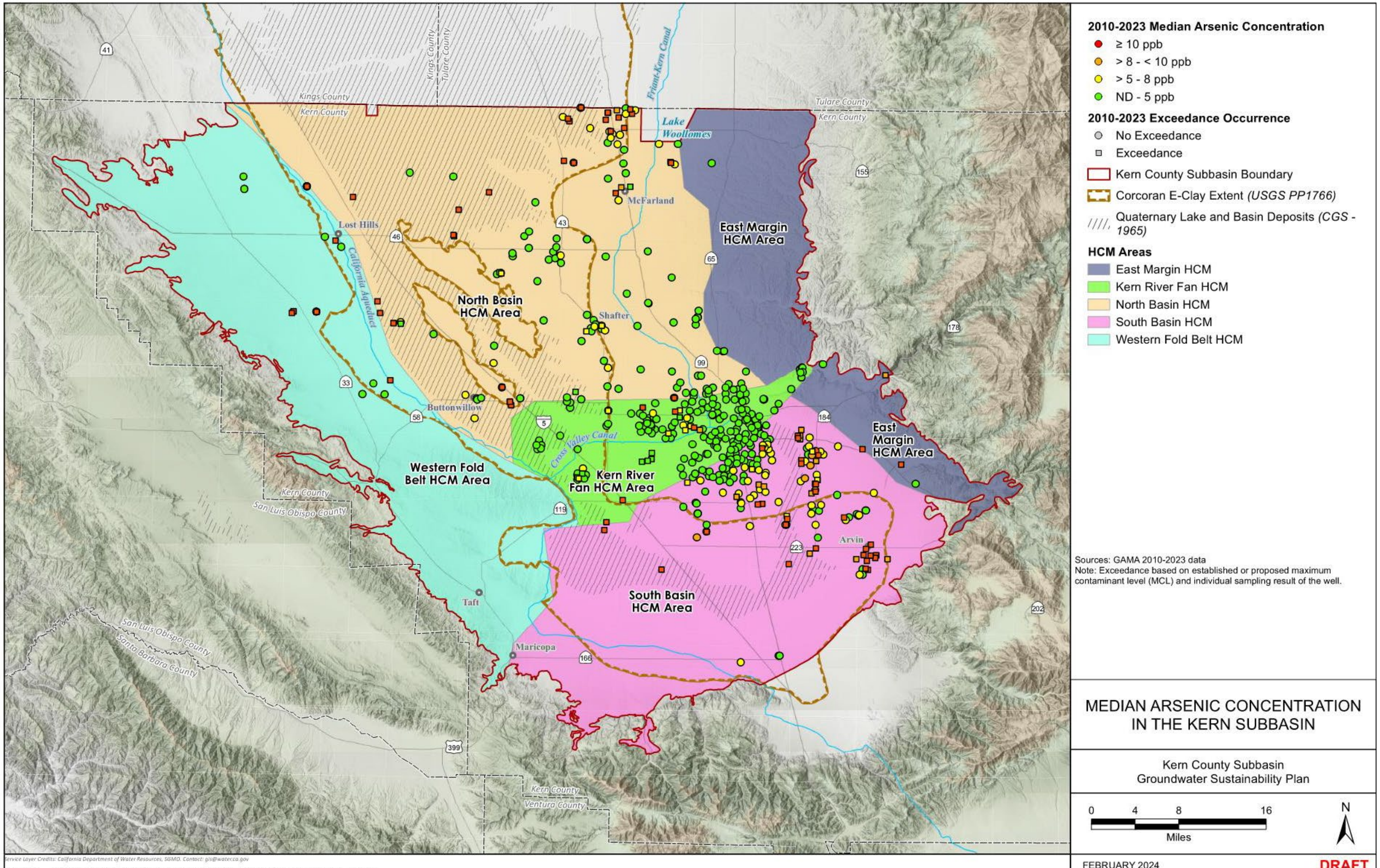


Figure 8-22. Median Arsenic Concentration in the Kern Subbasin

This page intentionally left blank.

As illustrated in Figure 8-22, higher arsenic concentrations are primarily seen in the North and South Basin HCMs, where the wells are within or near the E-clay or lake deposit boundaries. Table 8-6 summarizes pre-2015 and 2015 to 2023 arsenic median concentration and range for each HCM. The arsenic median concentration for each HCM is below the MCL; however, the range shows there are sources with arsenic concentration above the MCL in each HCM. It is noted that the upper range of arsenic concentration is higher in 2015 to 2023 conditions, but the median concentration for each HCM remained relatively the same, except for the South Basin which increased from 3.2 to 5.2 ppb.

Table 8-7 summarizes pre-2015 and 2015 to 2023 arsenic exceedances for each HCM. While the number of wells with arsenic MCL exceedances for each HCM is greater from the pre-2015 to the 2015 to 2023 conditions, these increases do not necessarily indicate degradation of groundwater quality. Rather, it may reflect a more comprehensive understanding of arsenic distribution as the number of wells sampled increased in all HCM's from the pre-2015 to the 2015 to 2023 conditions.

Table 8-6. Arsenic Range and Median Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (ppb)	Median (ppb)	# of Wells Sampled	Range (ppb)	Median (ppb)	# of Wells Sampled
Western Fold Belt	ND	ND	1	ND - 156	4.1	20
North Basin	ND - 45	3.4	104	ND - 300	2.7	138
Kern River Fan	ND - 25	ND	148	ND - 210	ND	161
South Basin	ND - 140	5.1	137	ND - 220	5.7	170
Eastern Margin	ND - 13	4.6	3	ND - 36.4	6.2	6

Table 8-7. Arsenic Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Western Fold Belt	0	1	0.0%	8	20	40.0%
North Basin	22	104	21.2%	33	138	23.9%
Kern River Fan	11	148	7.4%	19	161	11.8%
South Basin	34	137	24.8%	50	170	29.4%
Eastern Margin	1	3	33.3%	3	6	50.0%
Total	68	393	17.3%	113	495	22.8%

Since E-Clay and lake deposits have arsenic-rich minerals that can mobilize arsenic into groundwater, higher median arsenic concentrations are typically present within and near the outside the boundaries of E-Clay and the lake deposits, as summarized in

Table 8-8. In the South Basin HCM, wells that exceed the arsenic MCL are mostly within the boundary of lakebed deposits. It is important to note well construction, which can significantly influence water quality, was not taken into consideration for this analysis. Rather, this is a broad interpretation of contaminant prevalence and hydrogeologic conditions.

In the Western Fold Belt HCM, arsenic exceedances from 2015 to 2023 occurred in eight wells which were all USGS wells. As mentioned in Section 8.4.1, a majority of the Western Fold Belt HCM's agricultural and urban water supplies are either imported or derived from other HCM areas due to the poor water quality. Western Fold Belt HCM groundwater quality will be further discussed in the TDS section. In the Eastern Margin HCM, arsenic exceedances from 2015 to 2023 occurred in two wells, a municipal non-transient non-community well and a USGS well.

Wells in the North Basin, Kern River Fan and South Basin HCMs representing locations of the aquifer above and below these deposits and where E-Clay and deposits are not present were trended to assess the influence of location and well construction on arsenic concentration. The following sections further discuss the arsenic trends in the North Basin, Kern River Fan and South Basin HCMs based on available well data and previous literature studies conducted.

Table 8-8. Median Arsenic Summary for Wells within E-Clay or Lake Deposits Boundaries

HCM	Geology	2010-2023 Median (ppb)	2010-2023 # of wells sampled
Western Fold Belt	E--clay	ND	9
	Neither	5.6	11
North Basin	E-c-lay and Lake Deposits	5.2	29
	E-Clay	4.1	54
	Neither	2	71
Kern River Fan	E-c-lay and Lake Deposits	ND	11
	E-c-lay	ND	15
	Neither	ND	141
South Basin	E-c-lay and Lake Deposits	11	9
	E-c-lay	6.4	48
	Lake Deposits	8.7	4
	Neither	5.2	118
Eastern Margin	Neither	4.4	8

As shown in Figure 8-22, wells with higher arsenic concentration are in the Delano-McFarland area of the North HCM, primarily where the E-Clay is present. Schmidt and Associates, 2007, conducted a study of arsenic concentrations in the Delano-McFarland area. Vertical distribution of arsenic in groundwater from pilot hole isolation zone sampling, public supply wells, and the color of subsurface deposits for six wells were evaluated to determine groundwater conditions. Based on this study, arsenic concentrations increased with depth and are generally higher below depths ranging from 900 to 1000 feet bgs where blue-green deposits are present, indicative of reduced groundwater conditions. The study concluded that in the Delano-McFarland area, groundwater above a depth of 900 feet bgs have oxidized conditions and usually contains concentrations below 10 ppb.

North Basin HCM well trending of four wells shows elevated arsenic concentrations present at similar screen intervals depths, except Shafter well 15 (Figure 8-23). At groundwater elevations 151 to 0 feet msl and 122 to -5 feet msl, Delano 25 and 26 have consistent arsenic concentrations of 4 to 6 and 13 to 17 ppm, respectively. Both wells have similar screen interval depths, however, Delano 25 is within the boundary of the E-c-lay while Delano 26 is right outside the boundary (~0.3 miles), outside of the confining layer. Unlike Delano 25, Delano 26's arsenic concentrations consistently exceed the MCL. Limited data for Wasco 8A and Shafter 15 tentatively correlates increasing arsenic concentrations at increasing groundwater elevations approaching the E-c-lay. Shafter 15's arsenic concentration is generally above the MCL, fluctuating between 9 to 15 ppb with minimal groundwater elevation changes. The highest arsenic concentrations for all the wells screened below the E-c-lay (Shafter 15, Wasco 8A, and Delano 25) are at groundwater elevations of approximately 25 to 0 feet msl.

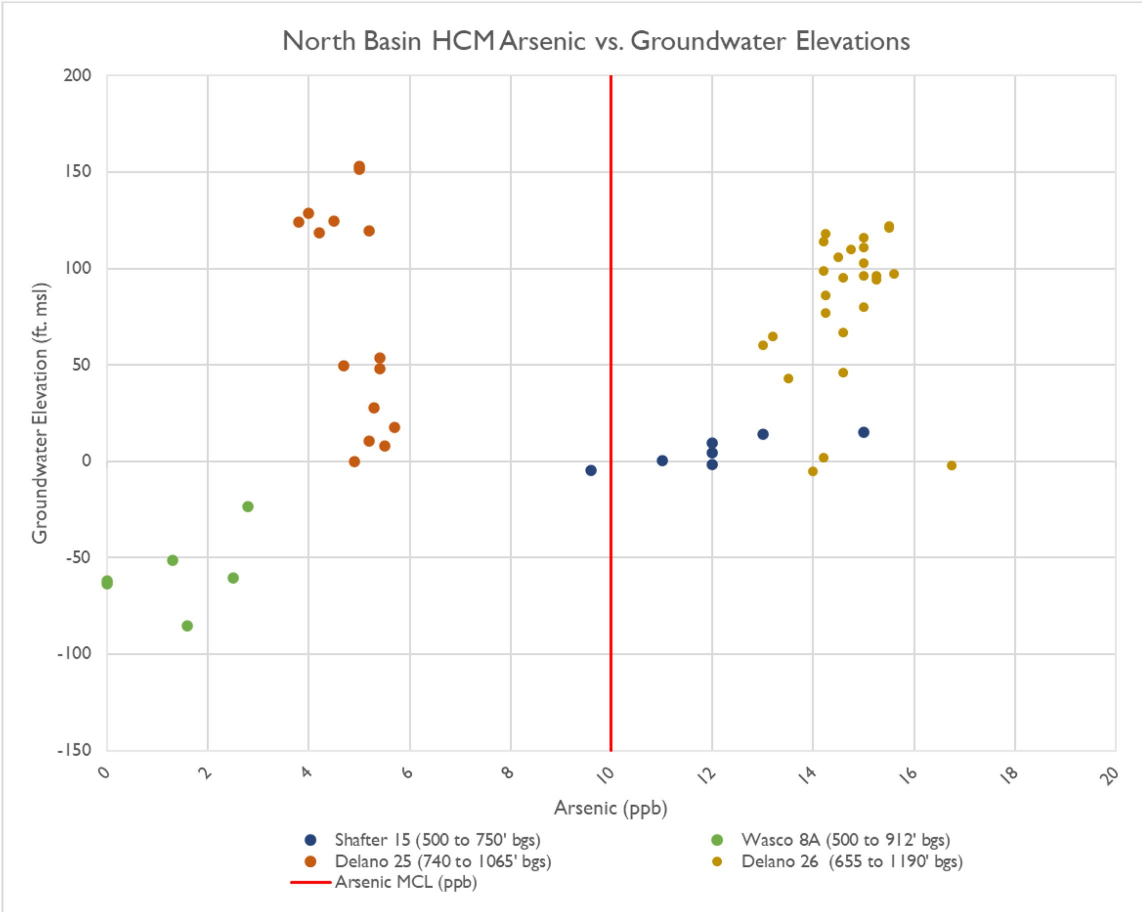


Figure 8-23. North Basin HCM Arsenic vs. Groundwater Elevations

The Kern River Fan HCM area serves as the major source of groundwater recharge and surface water storage for the Subbasin. Banking operations in this HCM show a distinct groundwater elevation response, ranging from 25 to 300 feet msl. Figure 8-24 shows arsenic trends for three wells, Enos, RRBWSD Shop and WKWD Well 6-06, which are situated within recharge basin areas. For each well, arsenic concentrations remain consistently below half the MCL, irrespective of groundwater elevation fluctuation and well screening depths of 260 to 750 feet bgs,

Figure 8-25 shows wells situated one to four miles from a recharge basin. Contrary to the less variable arsenic concentration of wells within a recharge basin area, arsenic concentration for wells situated outside showed greater fluctuations and response to groundwater elevation change. Most notable are wells CBK 32 and Greenley, showing opposing responses to groundwater elevation changes. Well CBK 32, screened at 400 to 710 feet bgs, demonstrates arsenic concentration increasing in response to declining groundwater elevation. Higher arsenic associated with wells constructed deeper than 650 feet bgs could be related to the local clay deposits in the Kern River Fan HCM. Greenley, screened at 310 to 410 feet bgs, demonstrates arsenic levels increasing with groundwater elevation increase.

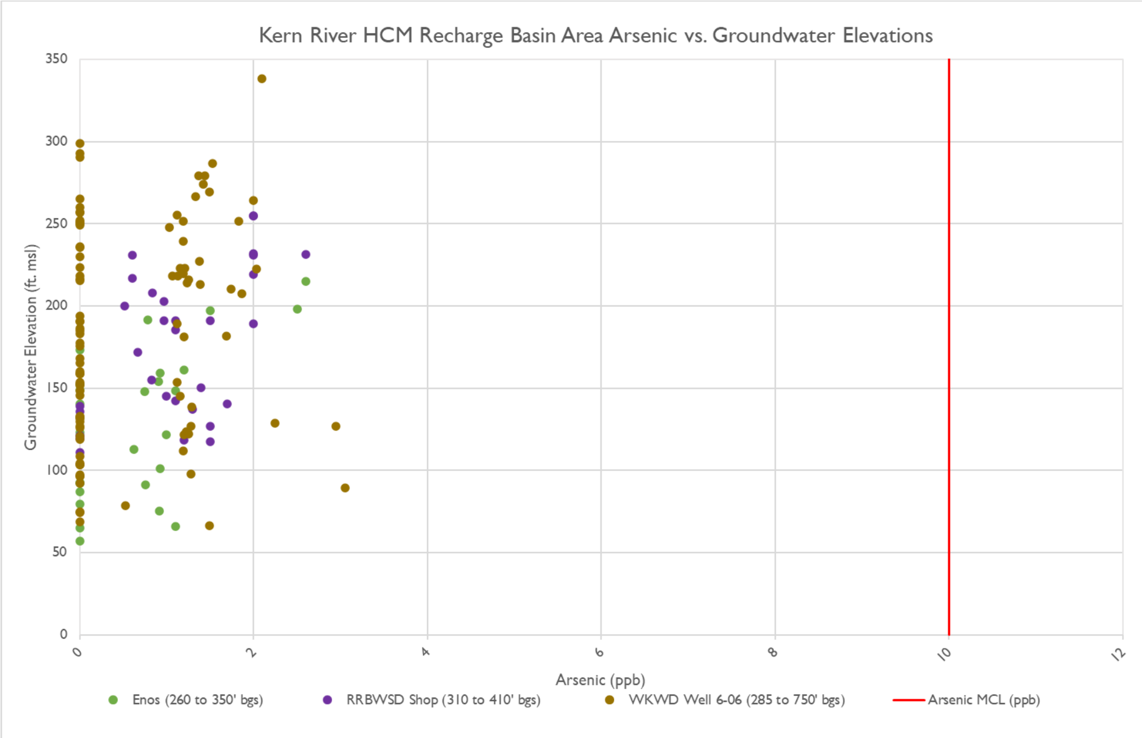


Figure 8-24. Kern River Fan HCM Recharge Basin Area Arsenic vs. Groundwater Elevations

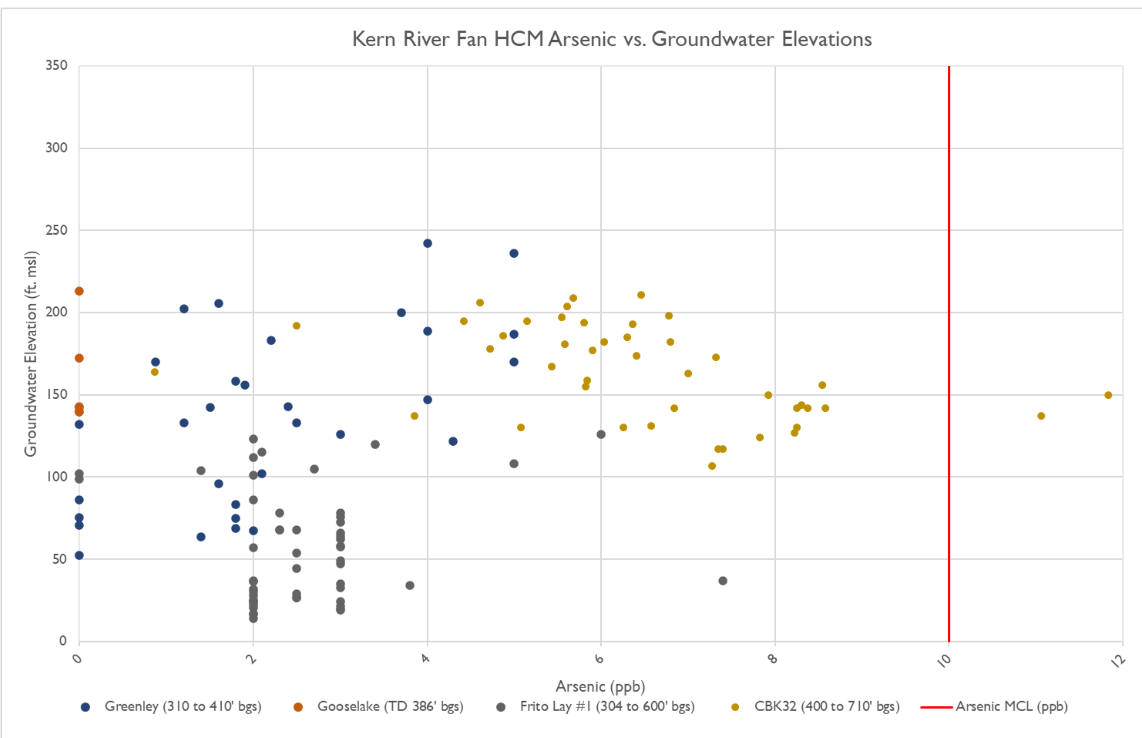


Figure 8-25. Kern River Fan HCM Arsenic vs. Groundwater Elevations

In the South Basin HCM, high arsenic concentration clusters are located south of the City of Bakersfield along the lakebed deposits and in the City of Arvin within the E-c-lay boundary.

OPOA Well 03, screened at 360 to 600 feet bgs, Arvin 14, screened at 600 to 900 feet bgs, and LPUD Well 17, screened at 400 to 705 feet bgs, are located in a cluster of high arsenic wells and were trended to represent wells with deeper construction. EL ADOBE POA Well 01, screened at 0 to 75 feet bgs, and EWRWC Well 01, screened at 270 to 470 feet bgs, represents wells with more shallow construction.

The trended wells also represent well location in relation to E-c-lay and lake deposit boundary. OPOA Well 03 is located slightly outside the E-c-lay and lake deposits boundary among the well cluster south of the city of Bakersfield. Arvin 14 is in the city of Arvin cluster within the E-Clay boundary. LPUD Well 17 is located within the E-c-lay boundary. EL ADOBE POA Well 01 is located within the E-Clay and lake deposits boundary and EWRWC Well 01 is located within only lake deposits boundary.

Trending of wells in the South HCM showed arsenic concentrations tend to fluctuate regardless of screen intervals depths and groundwater elevation, except LPUD Well 17, which showed consistent arsenic concentration regardless of groundwater elevation changes. OPOA Well 03 arsenic concentrations showed slightly increasing trend as groundwater elevations increase while Arvin 14, EL ADOBE POA Well 01, and EWRWC Well 01 concentrations seem to be more variable with groundwater elevation changes.

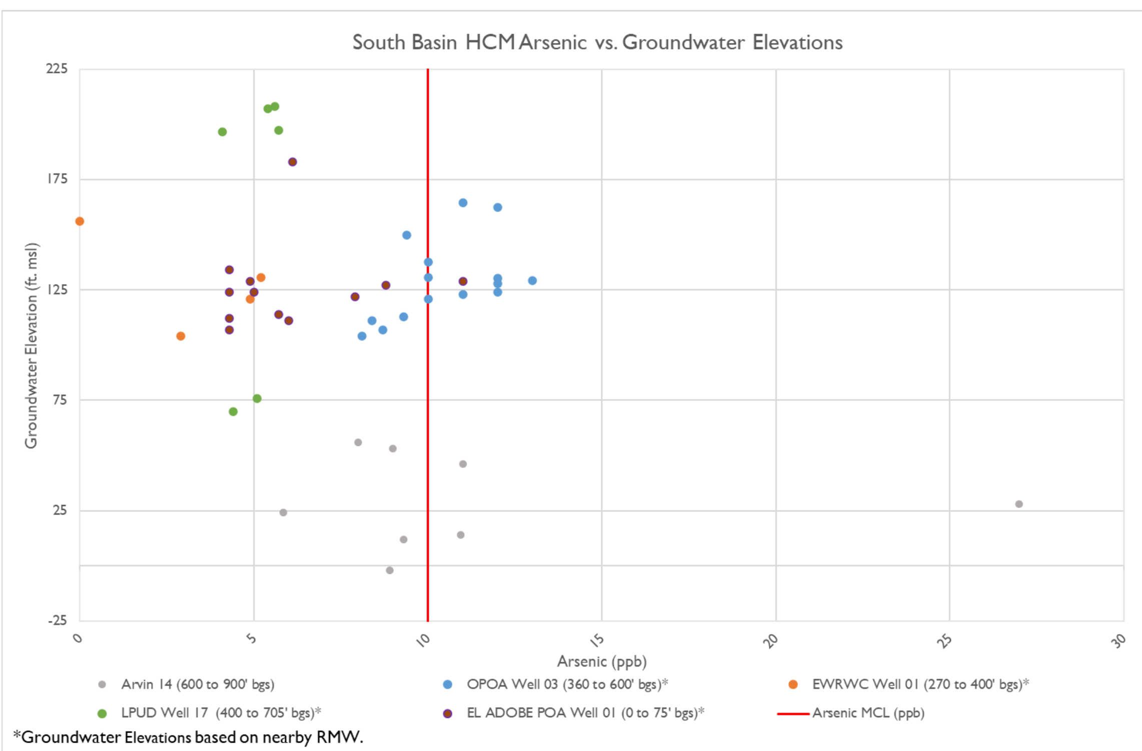


Figure 8-26. South Basin HCM Arsenic vs. Groundwater Elevations

While wells within the E-Clay or lakebed deposit boundary tend to have higher arsenic concentrations, trending demonstrated well construction, proximity to recharge basins and groundwater elevation may also impact arsenic concentration. Wells where an arsenic concentration trend is identified and consistent, whether the trend is arsenic levels are stable or the trend is arsenic levels can be correlated to groundwater elevation, can provide insight arsenic levels of the Subbasin.

8.4.1.3 Benzene

Benzene has a primary MCL of 1 ppb and does not have an agricultural goal. Sources of contamination are crude oil and gasoline, but also naturally in volcanic gases and smoke resulting from forest fires. Benzene may be released to groundwater from leaking underground fuel storage tanks and piping, fuel spills during transportation, and leaks at refineries. Figure 8-27 displays the median concentration of benzene per well, along with if the well had an exceedance.

This page intentionally left blank.

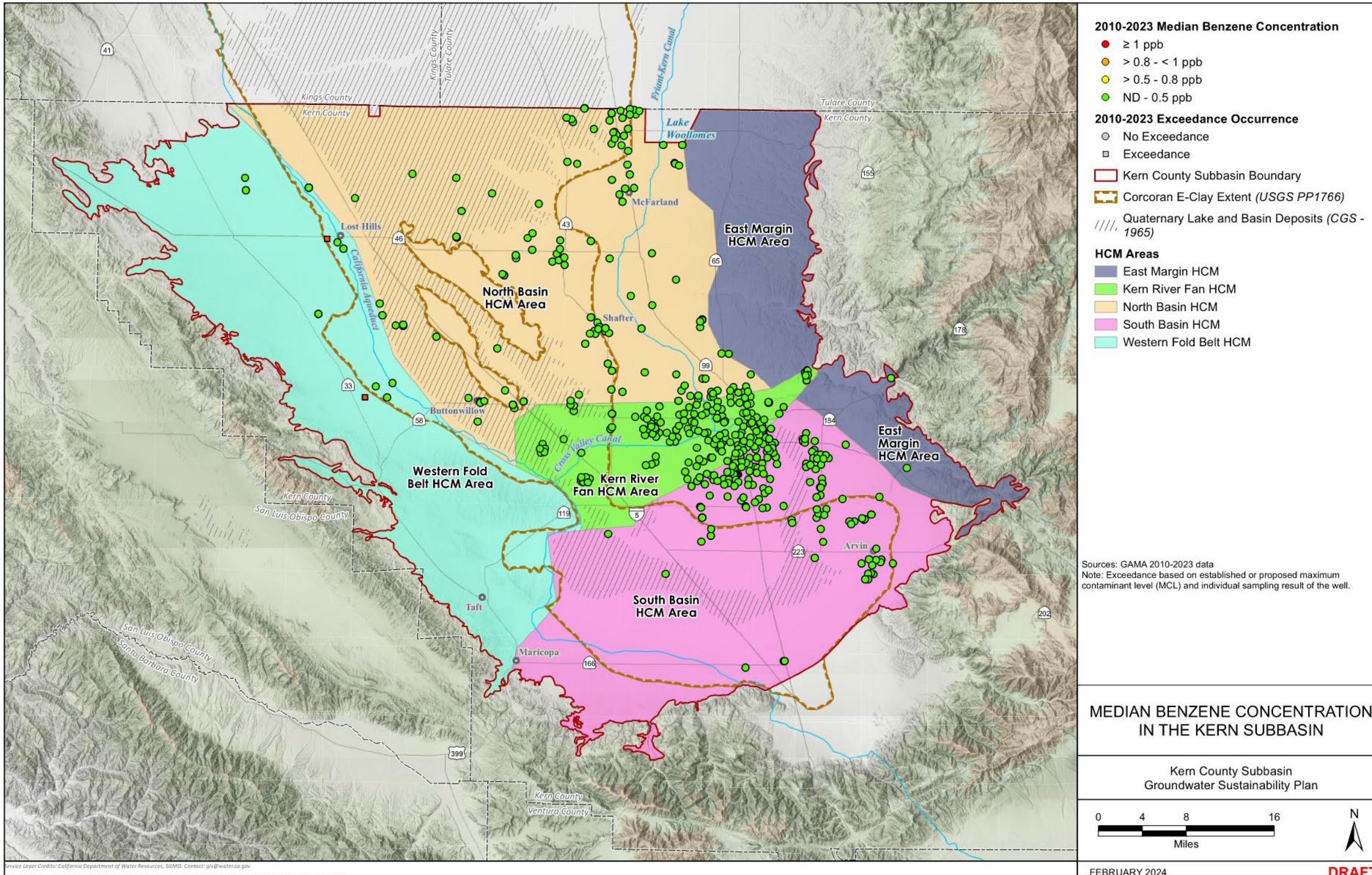


Figure 8-27. Median Benzene Concentration in the Kern Subbasin

This page intentionally left blank.

Based on the range of concentration, median and number of sources exceeding the MCL, benzene is not prevalent in the Subbasin. Table 8-9 summarizes pre-2015 and 2015 to 2023 benzene median and range for each HCM. The benzene median concentration in each HCM is non-detect. The range of detections in the North Basin, Kern River Fan, and Eastern Margin HCMs are also non-detect, indicating benzene is not a COC for three HCMs. In the South Basin, benzene is detected in one municipal well below the MCL. In the Western Fold Belt HCM, data where benzene was detected is from the USGS NWIS dataset from GAMA. Well categories include one industrial/irrigation, one municipal and one other water supply. Of the three wells with detections, two wells have detections above the MCL, one industrial/irrigation, one municipal. The municipal well detection is not confirmed and not seen in the DDW dataset from GAMA. Table 8-9 and Table 8-10 summarizes benzene exceedances for each HCM.

GeoTracker and EnviroStor databases were searched for open contamination cleanup sites the Subbasin. Five leaking underground storage tanks (LUST) sites were identified in the Subbasin. Details regarding the location of the sites are discussed in Section 8.4.2.

Table 8-9. Range and Median Benzene Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (ppb)	Median (ppb)	# of Wells Sampled	Range (ppb)	Median (ppb)	# of Wells Sampled
Western Fold Belt	6.71	6.71	1	ND - 16.5	ND	17
North Basin	ND	ND	91	ND	ND	121
Kern River Fan	ND	ND	142	ND	ND	156
South Basin	ND - 0.65	ND	128	ND - 0.66	ND	157
Eastern Margin	ND	ND	1	ND	ND	3

Table 8-10. Benzene Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Western Fold Belt	1	1	100.0%	2	17	11.8%
North Basin	0	91	0.0%	0	121	0.0%
Kern River Fan	0	142	0.0%	0	156	0.0%
South Basin	0	128	0.0%	0	157	0.0%
Eastern Margin	0	1	0.0%	0	3	0.0%
Total	1	363	0.3%	2	454	0.4%

8.4.1.4 Dibromochloropropane (DBCP), Ethylene Dibromide (EDB)

DBCP has a primary MCL of 0.2 ppb and does not have an agricultural goal. Sources of contamination are a banned nematicide that is still present in soils and groundwater due to runoff or leaching from former use on soybeans, cotton, vineyards, tomatoes, and tree fruit. Since its use was banned in 1977, groundwater contaminant concentrations in municipal wells have shown either steady or decreasing trends. In 2008 the Department of Public Health (transferred to State Water Board as DDW in July 2014) estimated the median half-life of DBCP in the Central Valley is 20 years. Figure 8-28 displays the median DBCP concentration per well, along with if the well had an exceedance.

EDB has a primary MCL of 0.05 ppb and does not have an agricultural goal. Sources of contamination are a banned pesticide and ingredient of soil and grain fumigant formulations, which use was banned in 1984. EDB was also used as a lead scavenger in antiknock gasoline mixtures ended with the phase-out of leaded gasoline in the US by 1996. EDB's half-life estimates vary from 2 to 15 years (Pignatello and Cohen, 1990). Currently there is no use of EDB in California. Figure 8-29 displays the median EDB concentration per well, along with if the well had an exceedance.

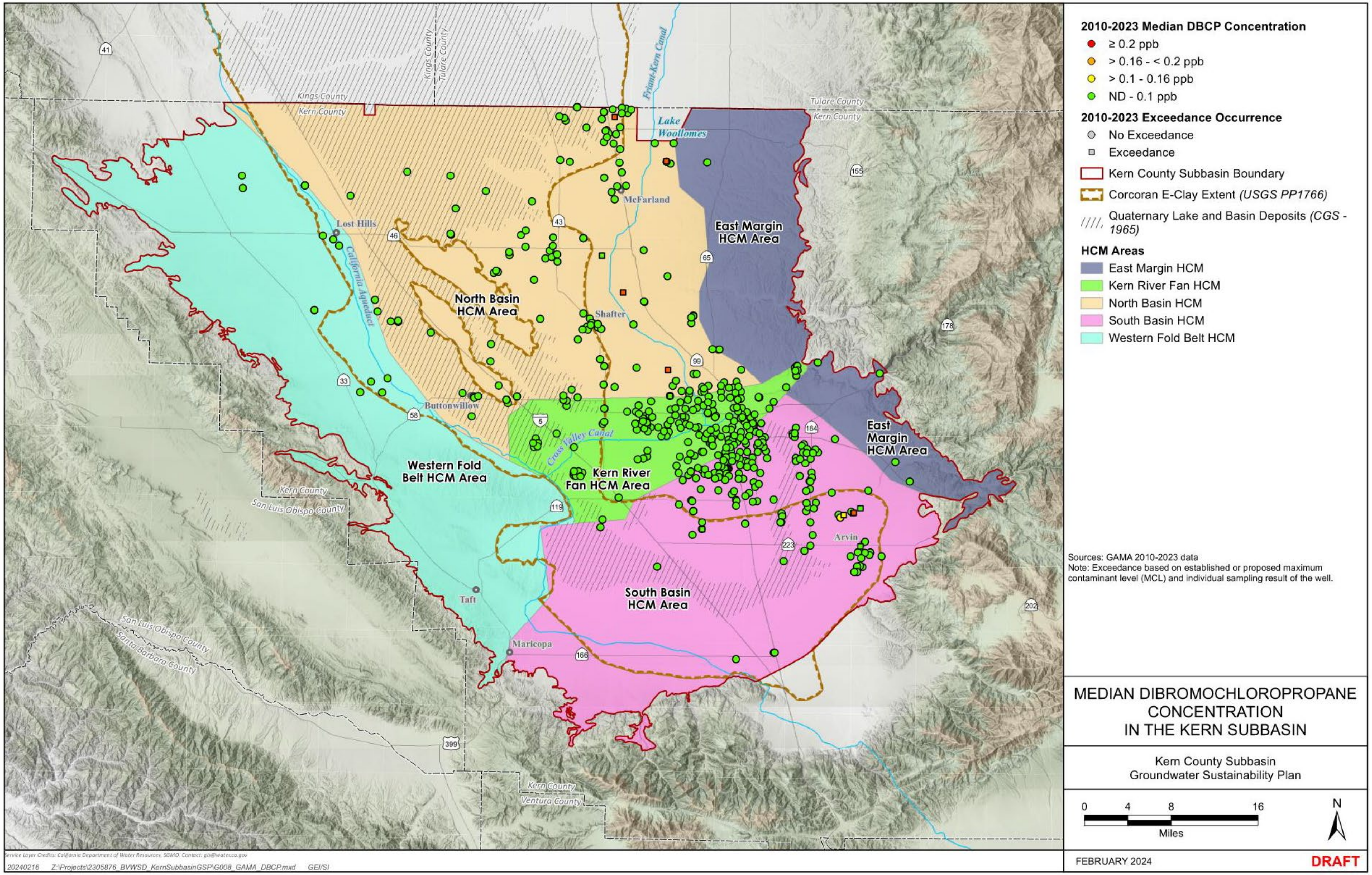


Figure 8-28. Median Dibromochloropropane (DBCP) Concentration in the Kern Subbasin

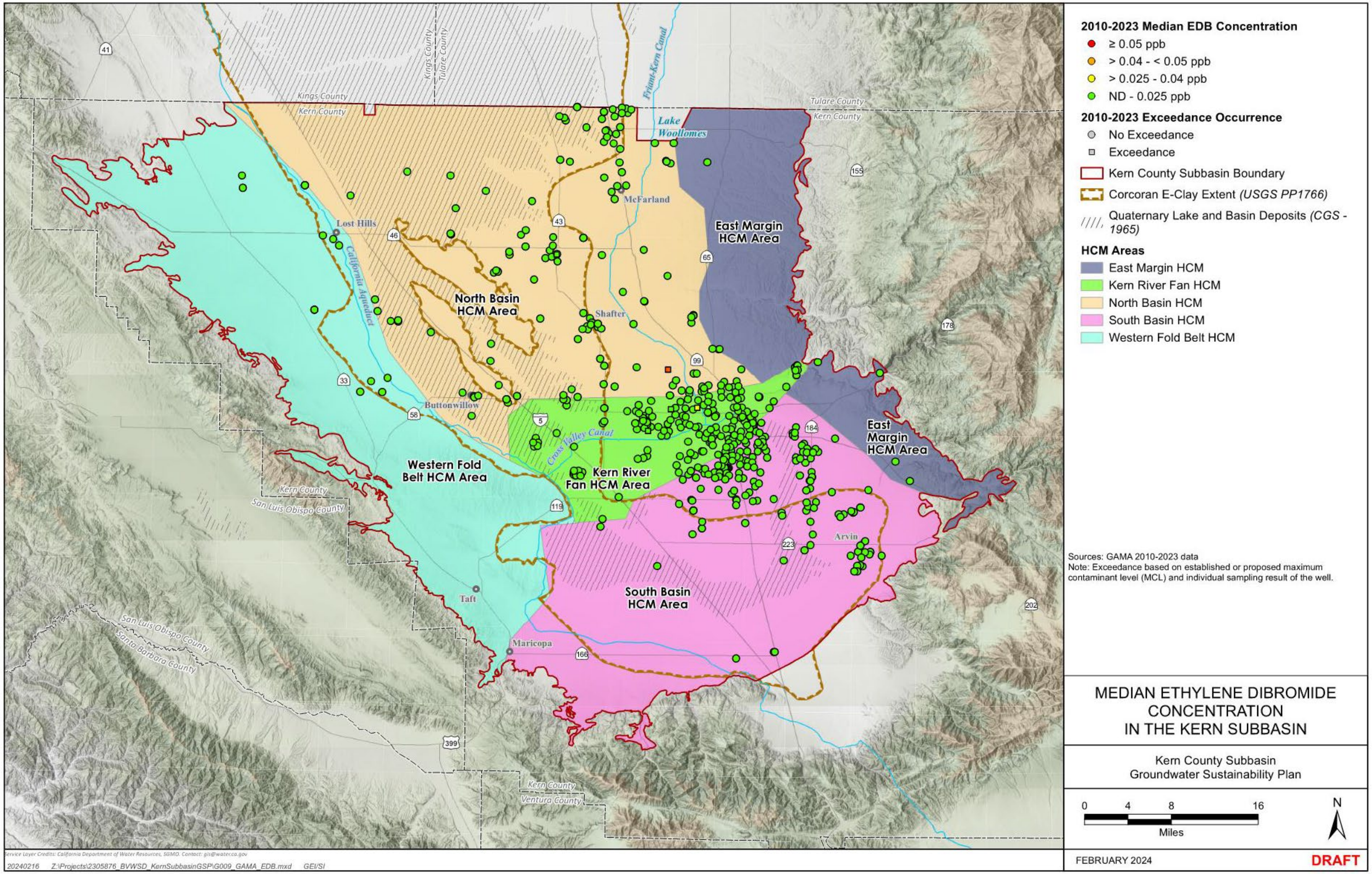


Figure 8-29. Median Ethylene Dibromide (EDB) Concentration in the Kern Subbasin

Evaluation of the range of concentration, median and number of sources exceeding the MCL demonstrates that DBCP and EDB are not prevalent in the Subbasin. Table 8-11 summarizes pre-2015 and 2015 to 2023 median and range for both constituents for each HCM. The median DBCP and EDB concentrations are non-detect for all HCMs. Table 8-12 summarizes DBCP and EDB exceedances for each HCM. DBCP shows a decrease in the number of sources exceeding the MCL between pre--2015 and 2015 to 2023. Evaluation of eight of the nine sources with DBCP detections over the MCL confirmed DBCP concentrations were declining or below the MCL for these sources. The remaining source which exceeds the DBCP MCL was a USGS other water supply well which only had one sample result. In the 2015 to 2023, three sources showed EDB concentrations above the MCL. Further evaluation of each source showed EDB concentrations declined to below the MCL or the source had a one-time detection and follow up samples were non-detect for EDB.

Table 8-11. DBCP and EDB Range and Median Summary by HCM

HCM	2010 to 2014[1]			2015 to 2023[2]		
	Range (ppb)	Median (ppb)	# of Wells Sampled	Range (ppb)	Median (ppb)	# of Wells Sampled
Dibromochloropropane (DBCP)						
Western Fold Belt	ND	ND	1	ND	ND	17
North Basin	ND - 1.2	ND	101	ND- 1.9	ND	133
Kern River Fan	ND - 0.28	ND	144	ND- 0.26	ND	158
South Basin	ND - 0.85	ND	132	ND- 0.56	ND	163
Eastern Margin	ND	ND	2	ND	ND	5
Ethylene Dibromide (EDB)						
Western Fold Belt	ND	ND	1	ND	ND	17
North Basin	ND - 0.41	ND	100	ND - 0.052	ND	133
Kern River Fan	ND - 0.19	ND	144	ND - 0.39	ND	158
South Basin	ND	ND	132	ND - 0.006	ND	159
Eastern Margin	ND	ND	2	ND	ND	5

Table 8-12. DBCP and EDB Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Dibromochloropropane (DBCP)						
Western Fold Belt	0	1	0.0%	0	17	0.0%
North Basin	4	101	4.0%	4	133	3.0%
Kern River Fan	1	144	0.7%	0	158	0.0%
South Basin	6	132	4.5%	5	163	3.1%
Eastern Margin	0	2	0.0%	0	5	0.0%

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Total	11	380	2.9%	9	476	1.9%
Ethylene Dibromide (EDB)						
Western Fold Belt	0	1	0.0%	0	17	0.0%
North Basin	1	100	1.0%	1	133	0.8%
Kern River Fan	1	144	0.7%	2	158	1.3%
South Basin	0	132	0.0%	0	159	0.0%
Eastern Margin	0	2	0.0%	0	5	0.0%
Total	2	379	0.5%	3	472	0.6%

8.4.1.5 Gross Alpha, Uranium

Gross alpha has a primary MCL of 15 pCi/L and uranium has a primary MCL of 20 pCi/L. Alpha particles (α-particles) are a type of radiation emitted by some radionuclides. Alpha emitters are used to treat cancer, as a static eliminator in paper mills and other industries, and in smoke detectors. Gross alpha may be comprised of radium-226, uranium-235 and radon-222 as the source of the alpha particles. Uranium is a naturally occurring radioactive element in rocks, soil, water, plants, animals, and humans.

Uranium is common in specific types of igneous, metamorphic, and sedimentary rocks. Research indicates that increased concentrations of uranium in groundwater caused by mobilization of uranium present in soil with irrigation waters containing bicarbonates (Jurgens et al 2010). Also, nitrate can mobilize uranium through a series of bacterial and chemical reactions (Nolan and Weber 2015). Figure 8-30 displays the median concentration of gross alpha and uranium per well, along with if the well had an exceedance. As seen, the distribution and concentration of gross alpha and uranium for sources with detections above the MCL are closely related.

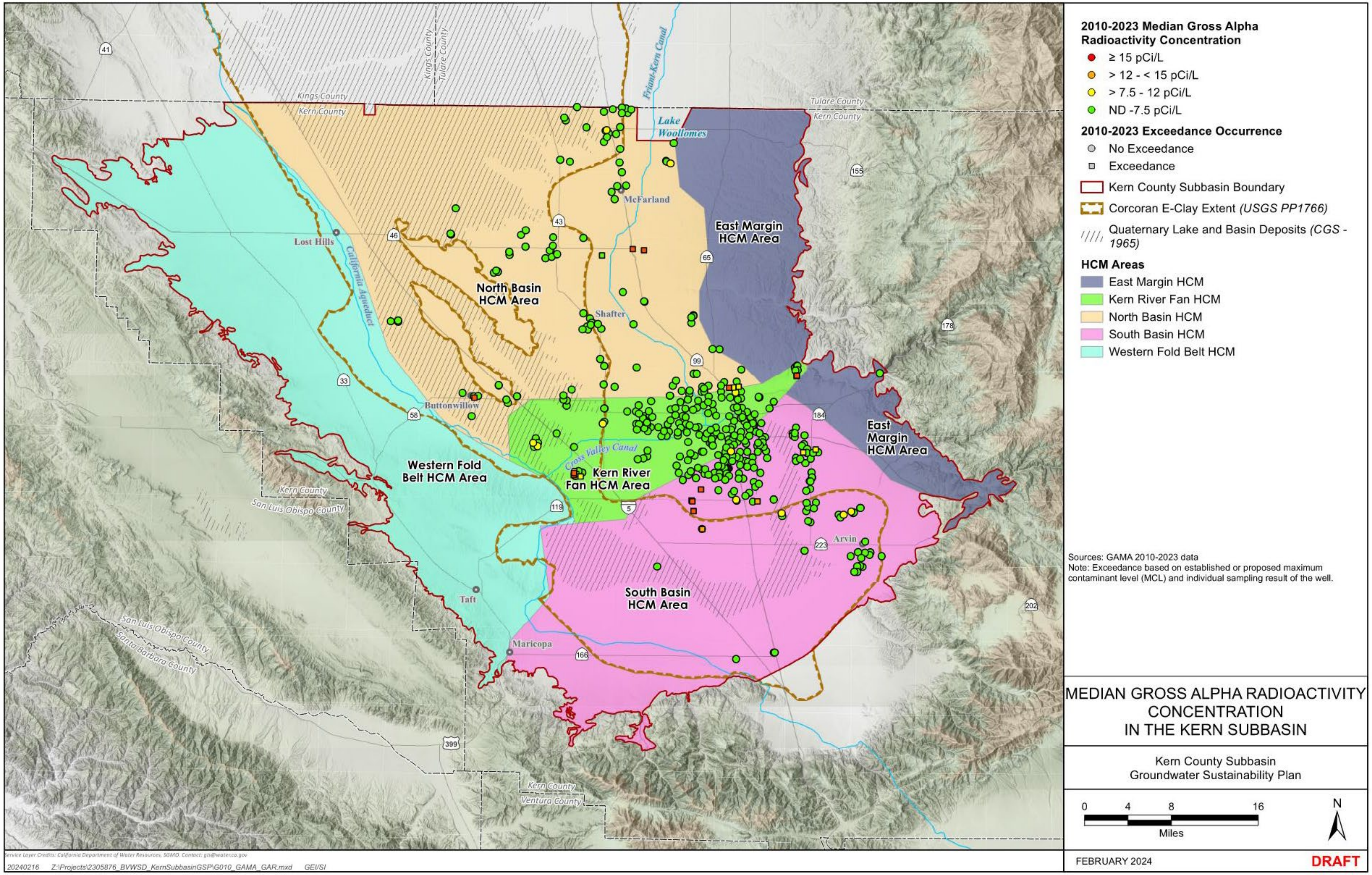


Figure 8-30. Median Gross Alpha Concentration in the Kern Subbasin

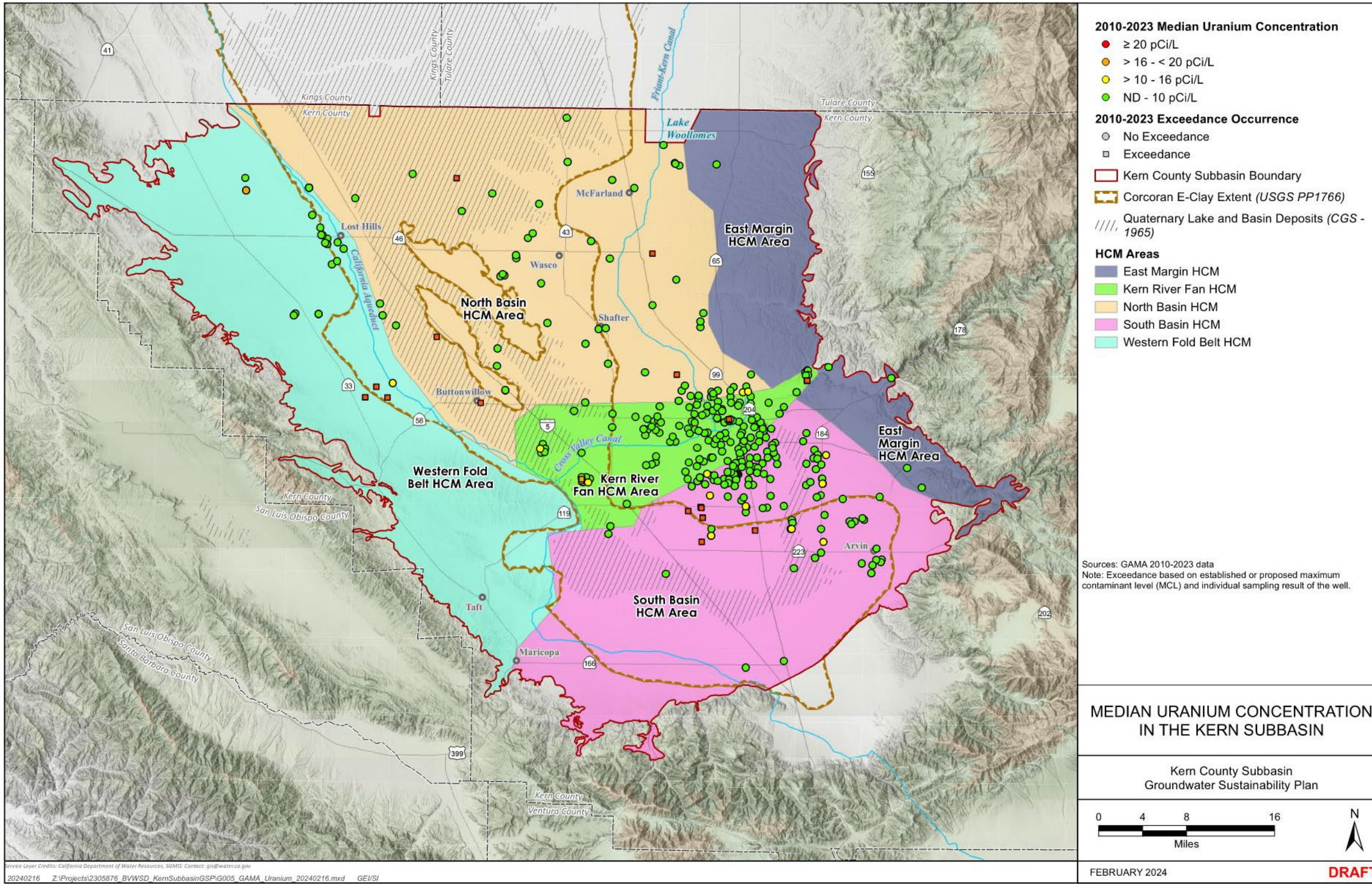


Figure 8-31. Median Uranium Concentration in the Kern Subbasin

Table 8-13 summarizes pre-2015 and 2015 to 2023 gross alpha and uranium median and range for each HCM. The 2015 to 2023 median gross alpha concentration is non-detect in each HCM, and the median uranium concentration is non-detect in the Western Fold Belt, North Basin and Eastern Margin HCMs and less than 3 pCi/L in the Kern River Fan and South Basin HCM. Table 8-14 summarizes each HCM's pre-2015 and 2015 to 2023 arsenic exceedances. The number of wells with gross alpha and uranium MCL exceedances for each HCM is greater from the pre-2015 to the 2015 to 2023 conditions. These increases do not necessarily indicate degradation of groundwater quality. Rather, it may reflect a more comprehensive understanding of gross alpha and uranium distribution as the number of wells sampled increased in all HCM's from the pre-2015 to the 2015 to 2023 conditions. Additionally, the number of wells exceeding the respective MCL indicate that gross alpha and uranium are not wide-spread contaminant of concern for the Subbasin.

While radium-226, uranium-235 and radon-222 are all sources for gross alpha, evaluation of the wells with exceedances demonstrate that gross alpha and uranium concentrations are closely related. It is important to note that Table 8-14 represents the count of wells where gross alpha or uranium is detected above the MCL and does not represent the count of wells out of compliance with the MCL, as compliance is based on a quarterly average and not a single detection.

For 2015 through 2023, there are 19 municipal wells with detections exceeding the gross alpha MCL. Evaluation of the 19 municipal wells confirmed that uranium concentration, where available, closely aligned with gross alpha concentration. Ten of the 19 wells also have uranium detections exceeding the uranium MCL and is discussed in the uranium summary. Of the 9 wells with only gross alpha exceedance, one is treated by blending and the remaining 8 have average gross alpha concentration below the MCL, or the gross alpha exceedance was a one-time detection and not confirmed.

Of the 20 wells with detections over the uranium MCL, 12 are municipal wells, three are domestic wells, three are other water supply wells and two are irrigation/industrial wells. Four of the municipal wells are in the Kern River Fan HCM and each have treatment installed. In the North Basin HCM, there are three municipal wells which have detection exceeding the MCL, one has treatment, one's uranium detection is not confirmed, and one is a standby well. In the South Basin HCM, one well has treatment, one well is an inactive well and two wells are currently out of compliance for uranium. In the Western Fold Belt HCM, the one municipal well with detections above the MCL is an inactive well.

Table 8-13. Gross Alpha and Uranium Range and Median Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (pCi/L)	Median (pCi/L)	# of Wells Sampled	Range (pCi/L)	Median (pCi/L)	# of Wells Sampled
Gross Alpha						
Western Fold Belt	-	-	-	-	-	-
North Basin	ND - 19.3	ND	75	ND - 113	ND	104
Kern River Fan	ND - 33.2	ND	133	ND - 45.6	ND	142
South Basin	ND - 76.7	ND	123	ND - 76.3	ND	140
Eastern Margin	ND - 7.8	3.9	1	ND - 4.5	ND	2
Uranium						
Western Fold Belt	ND	ND	1	ND - 345	ND	28
North Basin	ND - 18	ND	25	ND - 42.9	ND	56
Kern River Fan	ND - 64.7	1.7	104	ND - 45	1.7	101
South Basin	ND - 87	2.3	87	ND - 81	2.9	94
Eastern Margin	ND - 1.3	ND	2	ND - 3.3	1	5

Table 8-14. Gross Alpha and Uranium Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Gross Alpha						
Western Fold Belt	-	-	-	-	-	-
North Basin	3	75	4.0%	6	104	5.8%
Kern River Fan	5	133	3.8%	5	142	3.5%
South Basin	5	123	4.1%	8	140	5.7%
Eastern Margin	0	1	0.0%	0	2	0.0%
Total	13	332	3.9%	19	388	4.9%
Uranium						
Western Fold Belt	0	1	0.0%	3	28	10.7%
North Basin	0	25	0.0%	5	56	8.9%
Kern River Fan	2	104	1.9%	5	101	5.0%
South Basin	2	87	2.3%	7	94	7.4%
Eastern Margin	0	2	0.0%	0	5	0.0%
Total	4	219	1.8%	20	284	7.0%

As uranium is naturally occurring in soils and sediments, and can mobilize into groundwater, median uranium concentrations for wells within and outside the boundaries of E-Clay and the lake deposits were evaluated and summarized in Table 8-15. In each HCM where uranium is detected, median uranium concentration is highest for wells within the E-Clay only boundary, followed by wells in E-Clay and lake deposits boundary.

Table 8-15. Median Uranium Summary for Wells Overlying E-c-lay or Lake Deposits

HCM	Geology	2010-2023 Median (pCi/L)	2010-2023 # of Wells Sampled
Western Fold Belt	E-Clay	ND	11
	Neither	ND	17
North Basin	E-Clay and Lake Deposits	2.7	10
	E-Clay	ND	19
	Neither	ND	39
Kern River Fan	E-Clay and Lake Deposits	4.3	7
	E-Clay	9.6	12
	Neither	1.3	109
South Basin	E-Clay and Lake Deposits	2.9	8
	E-Clay	5.6	29
	Lake Deposits	1.4	3
	Neither	2.3	88
Eastern Margin	Neither	ND	6

Figure 8-32 shows uranium concentration trending of the two municipal wells without uranium treatment in the South Basin HCM. While uranium concentration fluctuates slightly, excluding two outlier data points, both well's uranium levels are consistently near, or over the MCL. Using groundwater elevation of a nearby RMW does not show an apparent response between groundwater elevation and uranium concentration.

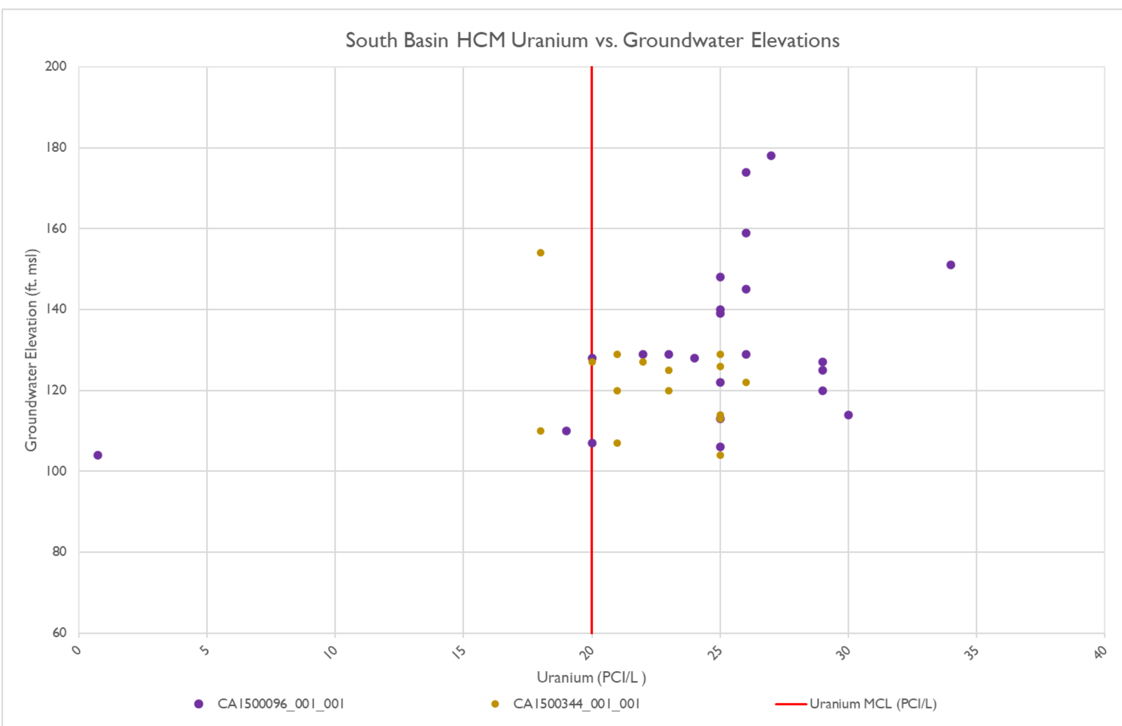


Figure 8-32. South Basin HCM Uranium vs. Groundwater Elevations

8.4.1.6 Nitrate as Nitrogen (N), Nitrite as Nitrogen (N), Nirate + Nitrite

Nitrate and nitrite as nitrogen (N) have acute drinking water MCLs of 10 and 1 ppm, respectively. The sum of these two contaminants, nitrate + nitrite, is also regulated with an acute drinking water MCL of 10 ppm. None of these contaminants have an agricultural goal. Sources of nitrate and nitrite contamination in groundwater are runoff and leaching from fertilizer use; leaching from septic systems and sewage; confined animal facilities; and very small concentrations from erosion of natural deposits. Since nitrate and nitrite sources are typically from the surface, higher concentrations are found in first encountered groundwater in the upper portion of the aquifer at approximate depths of 350 to 550 feet bgs. However, higher concentrations can also occur in deep wells, depending on source concentrations, lithology, and well construction. In the environment, nitrite is typically absent or present to a much lesser extent because it is rapidly converted to nitrate.

A USGS study (Burton et al, 2012) conducted in the Southeast San Joaquin Valley and the Subbasin used statistical analysis of land uses, well construction data, water quality parameters and number of septic systems around each study well to determine that land uses fairly represent nitrate sources (soil, fertilizer, manure, septic or community wastewater) impacting the well.

Studies conducted by UC Davis, Center for Watershed Sciences have evaluated nitrate sources in the Tulare Lake Basin and documented that on a regional scale, groundwater nitrogen loading from sewer collection system leaks and septic systems is negligible compared to fertilizers. While the agricultural industry is believed to be a historical primary contributor to nitrate contamination of the groundwater basins in the Central Valley, based on mass loading calculations, current irrigation and management practices in this Subbasin have been improved to reduce nitrate leaching into groundwater. In a study conducted for the Kern River Watershed Coalition Authority (KRWCA, 2013), it is acknowledged that the irrigation practices in the Subbasin effectively reduces nitrate leaching into the groundwater. This assessment is supported by a comparison of the Nitrate Hazard Index results from 1990 and 2012, which shows a significant reduction in nitrate risk to groundwater.

In addition to irrigation practices and/or livestock as a potential nitrate source, domestic wells located in agricultural areas are influenced by septic systems (Dubrovsky et al, 2010). Septic systems elevate groundwater nitrate concentrations since they only remove half of the nitrogen in the wastewater, leaving the remaining half to percolate to groundwater (McCalasand, 2019). At a local level, septic systems can be a significant source of nitrate contamination to domestic wells in peri-urban areas surrounding cities, or in areas of relatively high rural household density (Viers et. Al, 2012). Findings also indicate that disadvantaged communities with water quality issues are in these same areas. Septic systems are considered low-hanging fruit (Dzurella et al, 2012), but are an important issue to address due to their impact on localized drinking water sources.

An analysis using parcel development status; general soil/septic systems suitability mapping; hydrologic areas; and groundwater basins revealed that approximately 30 percent of developed parcels within the Subbasin rely on septic systems. It is noted that the analysis assumed incorporated areas have municipal sewer systems that either serve or are available to these parcels, therefore only non-sewerage unincorporated areas of the County were included in the analysis. A partial list of the system inspected is provided and is shown in Figure 8-33. Although not all septic system location data is available at the time of this evaluation, it is noted areas with septic systems and domestic wells, generally show elevated nitrate concentrations.

Figure 8-34, Figure 8-35, and Figure 8-36 display the median concentration per well, along with if the well had an exceedance for nitrate, nitrite, and nitrate + nitrite, respectively. High nitrate median concentrations and MCL exceedances are seen throughout the Subbasin, primarily in the North and South Basin HCM's, in areas with agricultural land uses. Nitrite median concentration for the majority of wells is non-detect throughout the Subbasin. Since nitrate + nitrite is the sum of nitrate and nitrite and nitrite is primarily non-detect in the Subbasin, the nitrate + nitrite median concentrations and exceedance locations are similar to the prevalence of nitrate.

This page intentionally left blank.

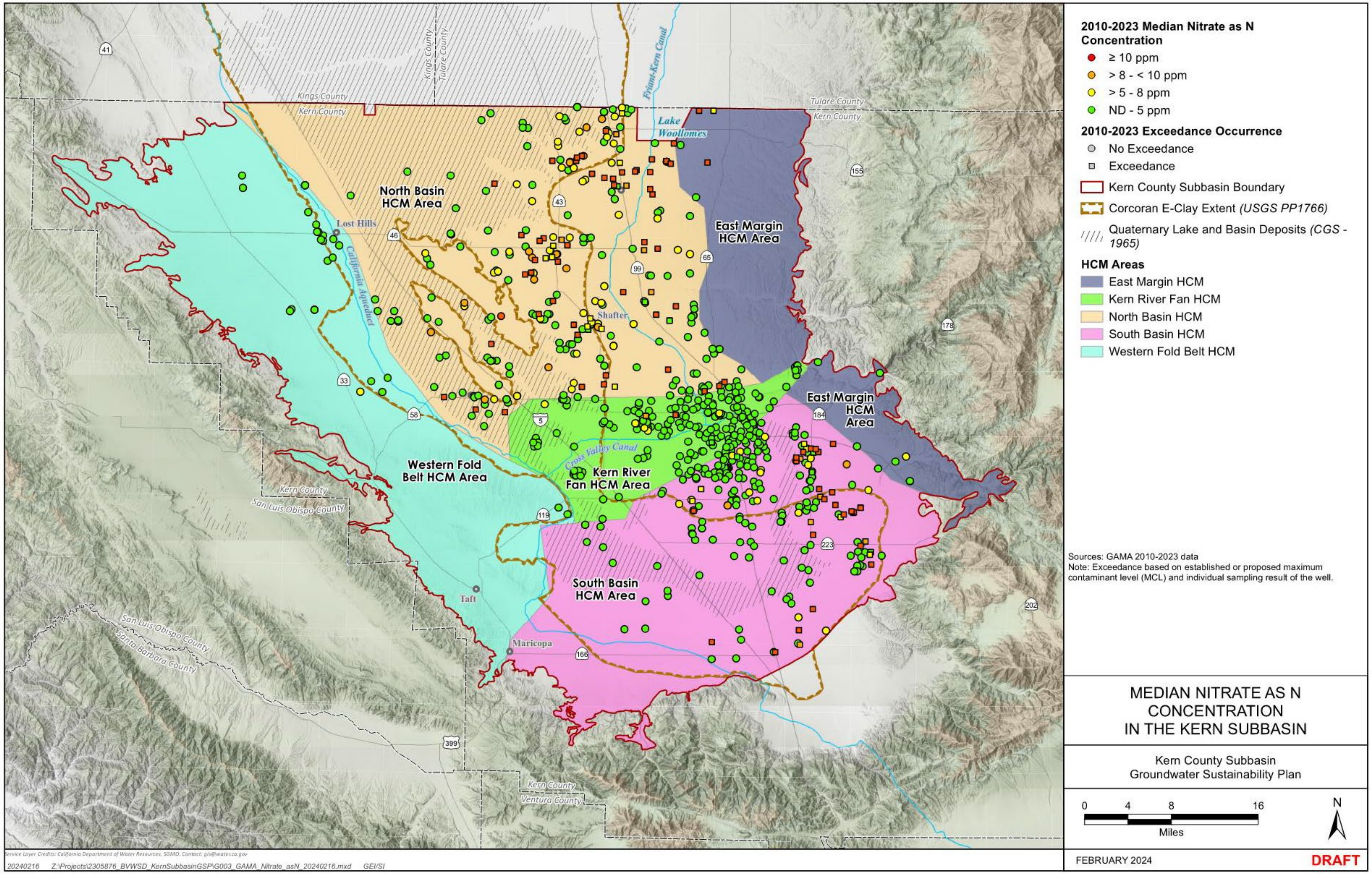


Figure 8-33. Median Nitrate as N Concentration in the Kern Subbasin

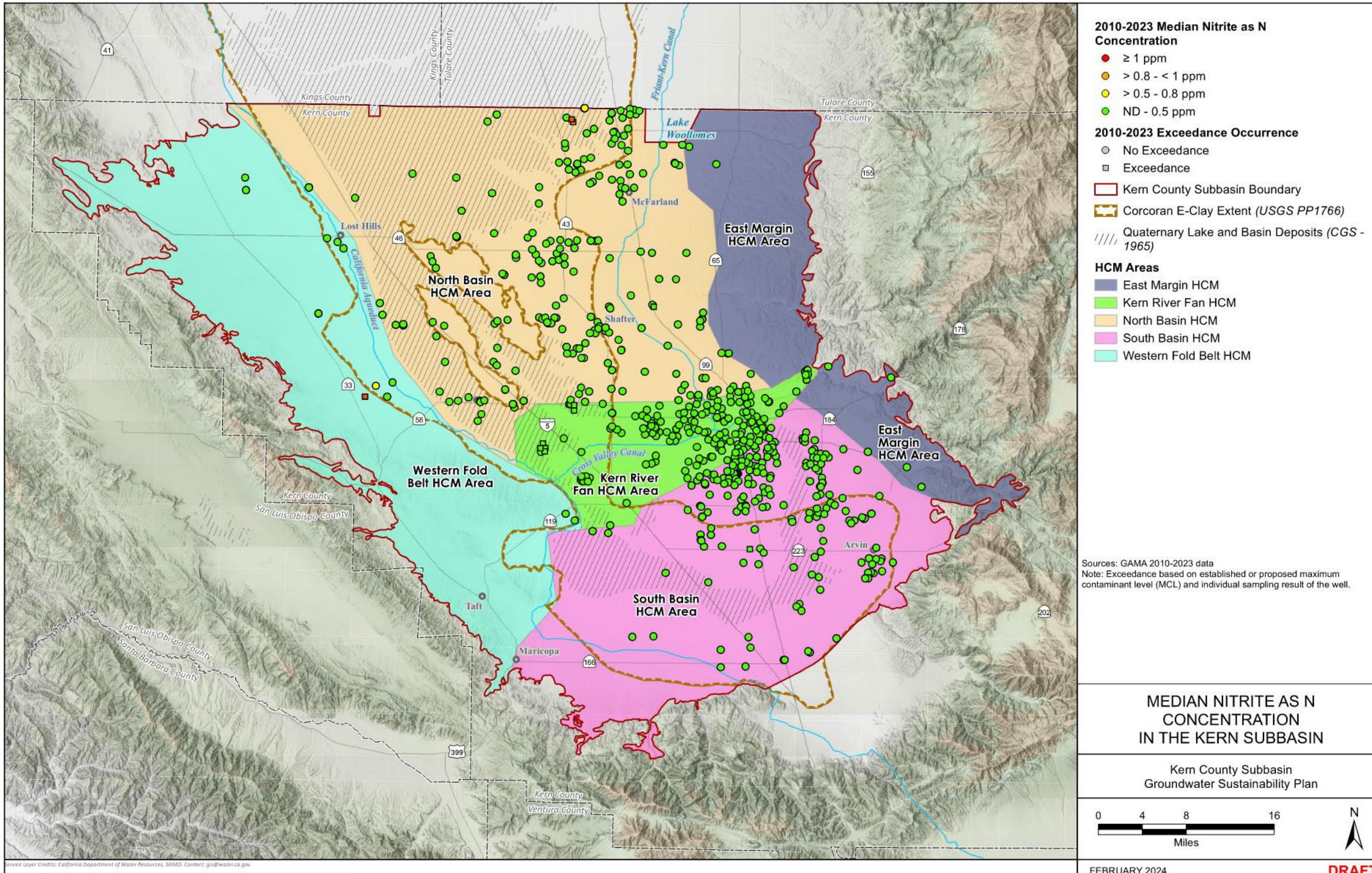


Figure 8-34. Median Nitrite as N Concentration in the Kern Subbasin

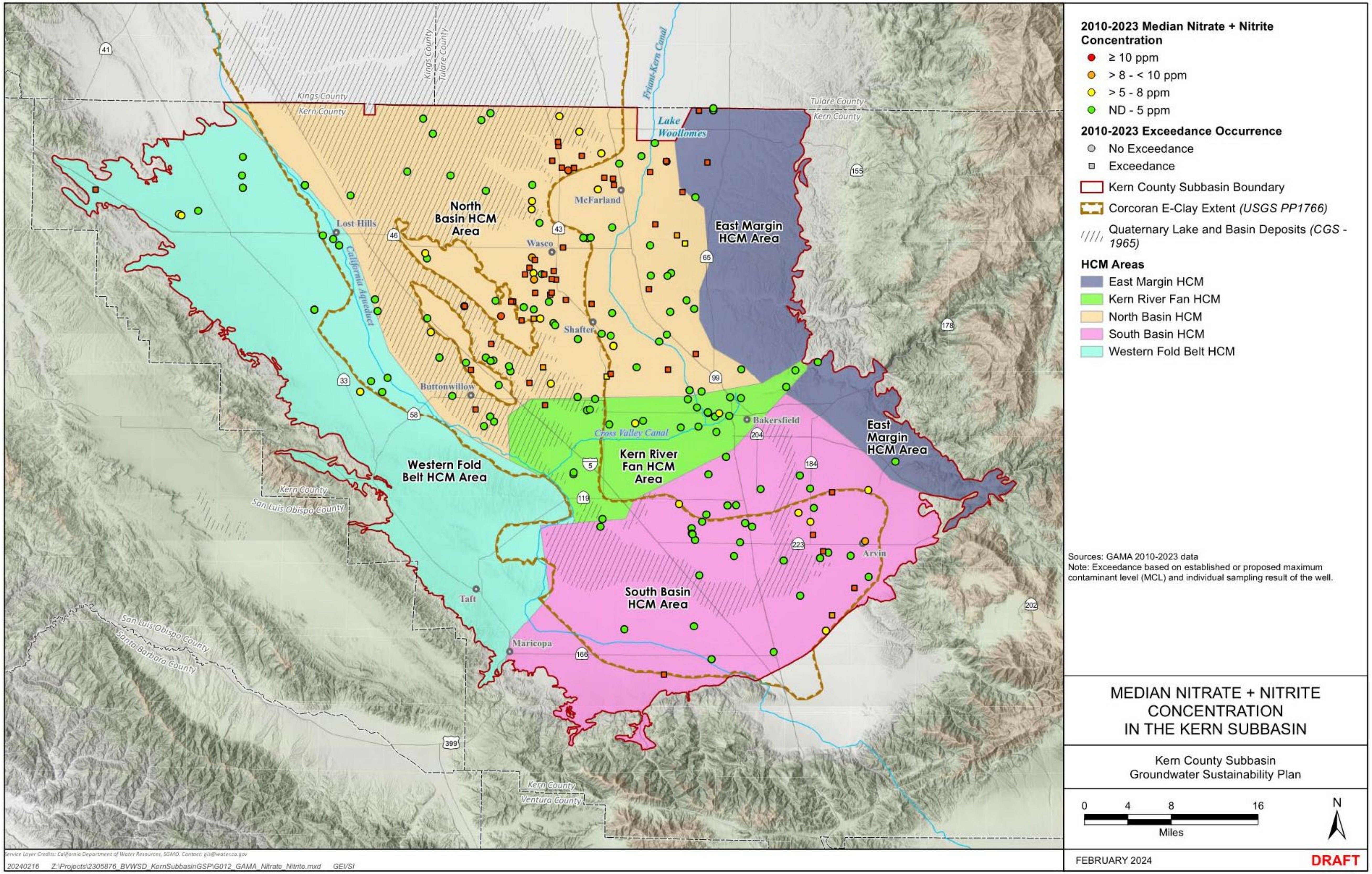


Figure 8-35. Median Nitrate + Nitrite Concentration in the Kern Subbasin

This page intentionally left blank.

Table 8-16 summarizes pre-2015 and 2015 to 2023 nitrate, nitrite, and nitrate + nitrite median and ranges for each HCM. All HCM nitrate, nitrite, and nitrate + nitrite median concentrations are below the MCL; however, in a majority of the HCMs, there are wells with concentrations above the MCL. It is noted that the upper concentration range is higher in 2015 to 2023 conditions except North Basin and Eastern Margin nitrite. Each constituent's median concentration remained relatively the same, except for the nitrate + nitrite median concentration in the Eastern Margin, North Basin and South Basin HCM. This increase is attributed to increased nitrate + nitrate data in 2015 to 2023 compared to 2010 to 2014. Nitrite median concentrations are non-detect for both conditions while nitrate median concentration demonstrate nitrate is prevalent in the Subbasin. This supports that nitrate is the more prevalent nitrogen form in the Subbasin.

Table 8-16. Range and Median Nitrate, Nitrite, and Nitrate + Nitrite Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (ppm)	Median (ppm)	# of Wells Sampled	Range (ppm)	Median (ppm)	# of Wells Sampled
Nitrate as N						
Western Fold Belt	ND	ND	1	ND - 5.9	ND	30
North Basin	ND - 27	3.2	119	ND – 33	3.4	286
Kern River Fan	ND - 11	1.0	158	ND – 43	1	178
South Basin	ND - 22	2.5	157	ND – 34	2.3	233
Eastern Margin	ND	ND	4	ND – 15	2.5	13
Nitrite as N						
Western Fold Belt	ND	ND	1	ND - 1.3	ND	19
North Basin	ND - 4.5	ND	112	ND – 4	ND	218
Kern River Fan	ND	ND	153	ND - 2.9	ND	169
South Basin	ND	ND	144	ND - 1.9	ND	209
Eastern Margin	ND	ND	3	ND	ND	8
Nitrate + Nitrite						
Western Fold Belt	ND	ND	1	ND – 19	ND	22
North Basin	ND – 12	ND	3	ND - 31	5.3	120
Kern River Fan	1.1	1.12	1	ND - 19	1.5	23
South Basin	ND - 8.4	ND	4	ND - 78	2.7	41
Eastern Margin	-	-	-	ND - 13	2.5	7

Table 8-17 summarizes pre-2015 and 2015 to 2023 nitrate, nitrite, and nitrate + nitrite exceedances for each HCM. While the number of wells with nitrate, nitrite, and nitrate + nitrite MCL exceedances is greater between 2015 to 2023 conditions, these increases do not necessarily indicate degradation of groundwater quality. Rather, it may reflect a more comprehensive understanding of nitrate, nitrite, and nitrate + nitrite distribution as the number of wells sampled increased in all HCM's from the pre-2015 to the 2015 to 2023 conditions. Nitrate, nitrite, and nitrate + nitrite is sampling increased with the implementation of the Irrigated Lands Regulatory Program (ILRP).

It is important to highlight that while nitrate is present in each HCM, wells with nitrate exceedances are primarily located in the North Basin HCM, followed by the South Basin HCM. In the Western Fold Belt HCM, no nitrate exceedances have been detected from 2010 to 2023. In the Eastern Margin HCM, nitrate exceedances from 2015 to 2023 occurred in three wells, a domestic and irrigational/industrial well which is part of the ILRP and a domestic well by USGS.

Table 8-17. Nitrate, Nitrite, and Nitrate + Nitrite Well Exceedance Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Nitrate as N						
Western Fold Belt	0	1	0.0%	0	30	0.0%
North Basin	14	119	11.8%	65	286	22.7%
Kern River Fan	1	158	0.6%	3	178	1.7%
South Basin	16	157	10.2%	40	233	17.2%
Eastern Margin	0	4	0.0%	4	13	30.8%
Total	31	439	7.1%	112	740	15.1%
Nitrite as N						
Western Fold Belt	0	1	0.0%	1	19	5.3%
North Basin	2	112	1.8%	3	218	1.4%
Kern River Fan	0	153	0.0%	6	169	3.6%
South Basin	0	144	0.0%	1	209	0.5%
Eastern Margin	0	3	0.0%	0	8	0.0%
Total	2	413	0.5%	11	623	1.8%
Nitrate + Nitrite						
Western Fold Belt	0	1	0.0%	1	22	4.5%
North Basin	1	3	33.3%	43	120	35.8%
Kern River Fan	0	1	0.0%	1	23	4.3%
South Basin	0	4	0.0%	6	41	14.6%
Eastern Margin	-	-	-	2	7	28.6%
Total	1	9	11.1%	53	213	24.9%

As noted, of the five HCMs, the North Basin HCM has highest number of wells with nitrate detection(s) above the MCL. Trending of four wells in the HCM explored the influence on nitrate concentration based on groundwater elevation and well construction. Three wells, with well screens at 500 feet bgs or deeper, demonstrated relatively stable nitrate concentrations with groundwater elevation changes above -13 feet msl. Significant nitrate concentrations fluctuation is seen in one well screened at 500 feet bgs where groundwater elevation is deeper, starting at -19.2 feet msl.

Wasco 8A and Shafter 15 have the higher top screen depths, starting at 500 feet bgs, followed by Delano 25 at 655 feet bgs, and Delano 26 having the deepest top screen depth at 740 feet bgs. Wasco 8A has the highest top screen depth, highest fluctuation of nitrate concentrations and deepest groundwater elevations with ranges of 3.4 to 11.0 ppm and -19.2 to -85.2 feet msl, respectively. On the contrary, Shafter 15 and Delano 25, have consistent nitrate concentrations of non-detect to 1.3 and 3.8 to 4.4 ppm, regardless of groundwater elevation fluctuations above -13 feet msl (20.3 to -12.7 and 153 to -12.8 feet msl, respectively). Delano 26 shows relatively stable nitrate concentrations ranging from 2.2 ppm up to 3.0 ppm at groundwater elevation of 99 to 43 feet msl. Higher nitrate concentration with groundwater decline, as seen in Wasco 8A, may indicate that first encounter groundwater that typically contains nitrate is being introduced to the pumping zone, resulting in increased nitrate. Where first encountered groundwater is being drawn into the pumping zone, wells with more shallow top screen levels will be first to see increasing nitrate. Figure 8-36 demonstrates the nitrate concentration versus groundwater elevation for the four wells.

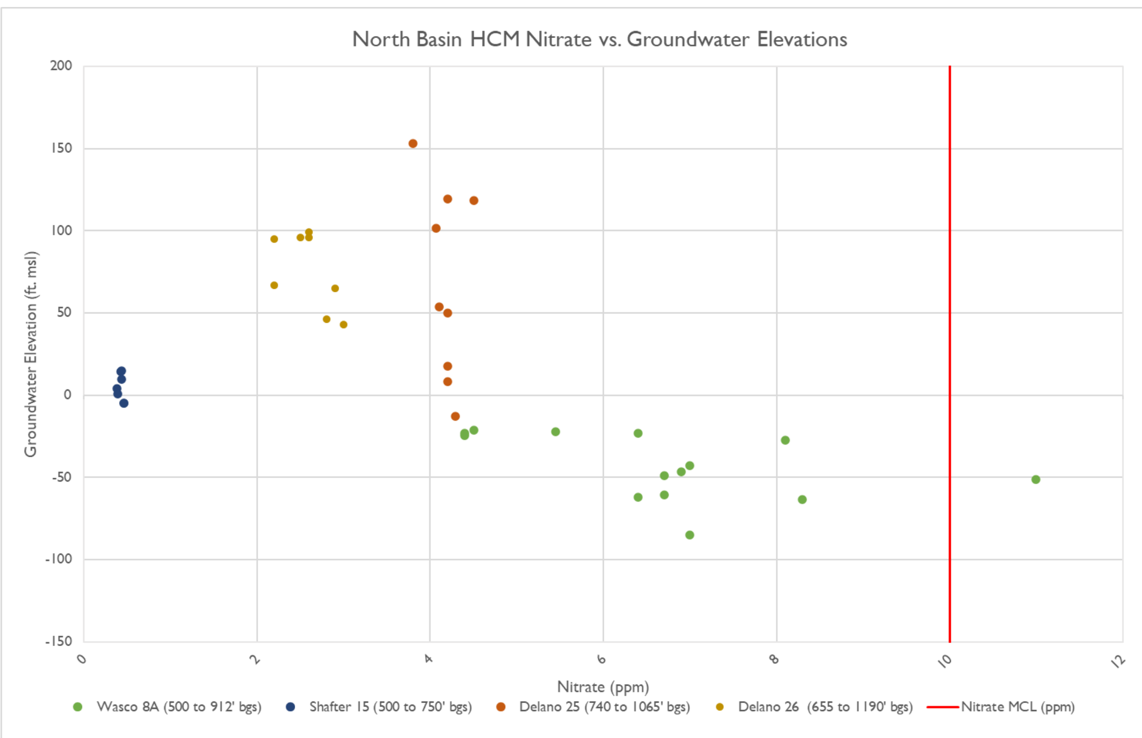


Figure 8-36. North Basin HCM Nitrate vs. Groundwater Elevations

In the Kern River Fan HCM, median nitrate concentrations are typically below half the MCL, with only a few wells with MCL exceedances (Figure 8-33). Figure 8-37 shows nitrate trends for three wells, ENOS, RRBWSD Shop and WKWD Well 6-06, which are situated within recharge basin areas. Each well's nitrate concentrations are consistently below the MCL and demonstrate different response to groundwater elevation changes. ENOS, screened at 260 to 350 feet bgs and located in the distal-fan, and RRBWSD

Shop, screened 310 to 410 feet bgs and located in the mid-fan area, represent shallow first encounter groundwater depths at different locations of the HCM. WKWD Well 6-06, screened at 290 to 750 feet bgs, represents shallow and deeper groundwater depths.

Although ENOS and RRBWSD both represent shallow groundwater depths, nitrate concentration responds differently to groundwater elevation change. In 2003, nitrate concentration for ENOS increased as groundwater elevations declined to 150 feet msl. Subsequent ENOS nitrate concentrations consistently remained below 1.1 ppm, regardless of fluctuations above and below 150 feet msl. In contrast, at RRBWSD shop, nitrate concentration increases when groundwater elevation declines below approximately 150 feet msl. Similar to recent ENOS trends, WKWD Well 6-06's nitrate concentration is consistently below 1.4 ppm, regardless of groundwater elevations between 388 and 47.3 feet msl.

Contrary to wells within a recharge basin area, wells situated outside shows greater nitrate concentration fluctuations and response to groundwater elevation change. Figure 8-37 shows nitrate trends for wells situated one to four miles from a recharge basin. Of the four wells, Gooselake, screened at TD 386 feet bgs, and Frito Lay #1, screened at 304 to 600 feet bgs, are further away from a recharge basin (between 1.9 to 3.9 miles away) and demonstrate increasing nitrate concentration with declining groundwater elevation. Greenley, screened at 310 to 410 feet bgs, and CBK 32, screened at 400 to 710 feet bgs, are situated closer to a recharge basin (between 1.3 to 1.64 miles away) and nitrate concentration remains relatively consistent, regardless of groundwater elevation changes.

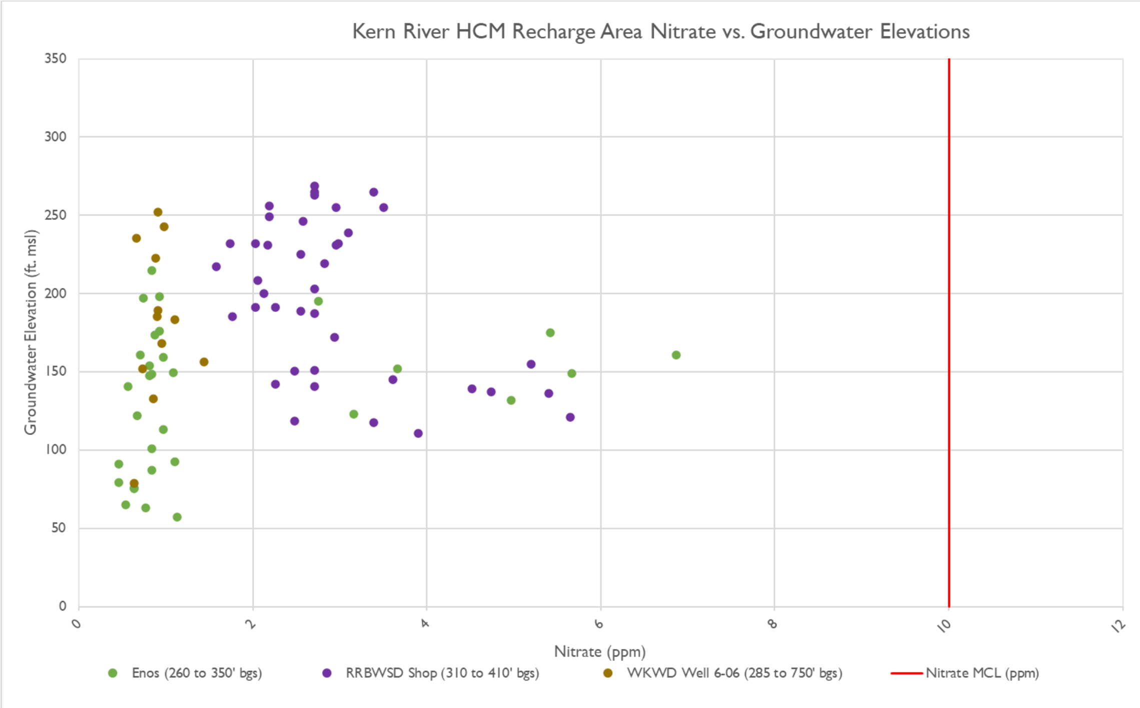


Figure 8-37. Kern River Fan HCM Recharge Basin Area Nitrate vs. Groundwater Elevations

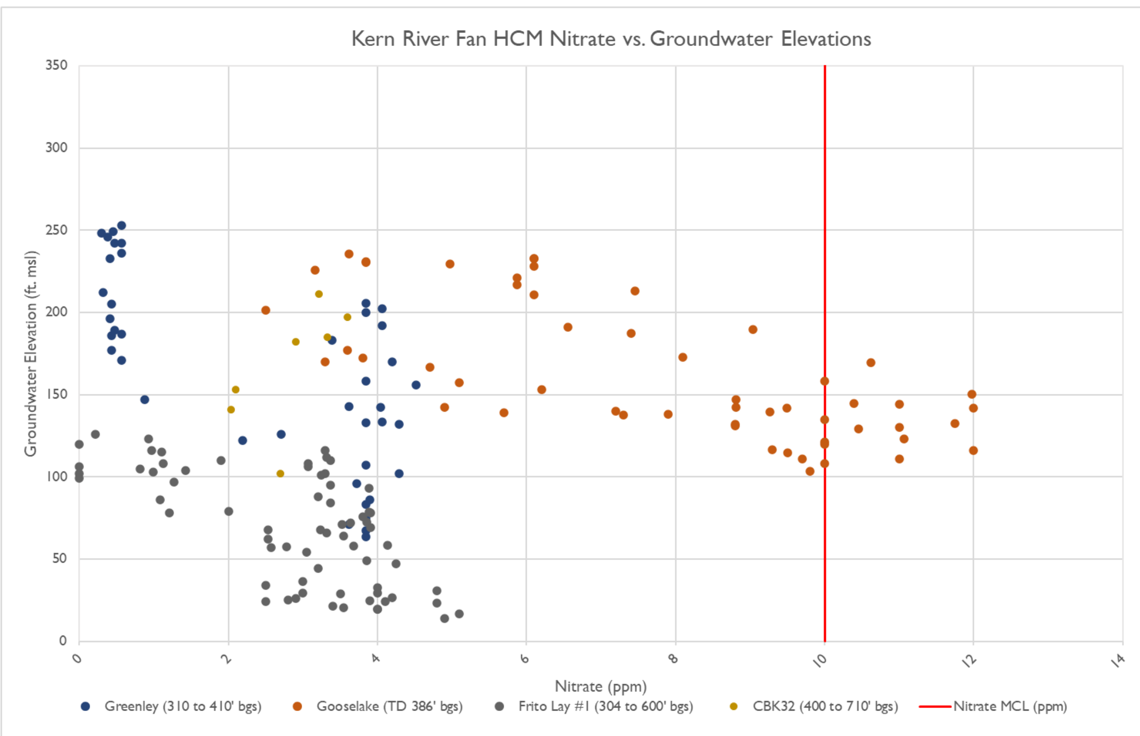


Figure 8-38. Kern River Fan HCM Nitrate vs. Groundwater Elevations

In the South Basin HCM, high median nitrate concentrations are primarily located directly east and west of the lakebed deposits (Figure 8-33). Figure 8-39 shows trending of six wells in the HCM, demonstrating different nitrate concentration response to groundwater elevation and well construction. Where well groundwater elevation data is not available, a nearby RMW well's groundwater elevation is used to represent groundwater elevation fluctuation in the area.

Of the six wells, EL ADOBE POA Well 01 and Holiday Rock Plant #2 Well 02 are screened in the shallow part of the aquifer at 0 to 75 feet bgs and 340 to 400 feet bgs, respectively. Trending of these two wells show nitrate fluctuation regardless of groundwater elevation stability. Contrary, Arvin 14, screened at 600 to 900 feet bgs, represents deeper groundwater elevation and OPOA Well 03, screened at 360 to 600 feet bgs, show nitrate concentration is stable even with groundwater elevation decline. SKMWC Well 01 shows an increase in nitrate as groundwater elevation increase. Well screening information for SKMWC Well 01 is not available therefore correlation of nitrate concentration with well construction cannot be evaluated. LPUD Well 17 demonstrates that nitrate concentration can fluctuate at various groundwater elevation.

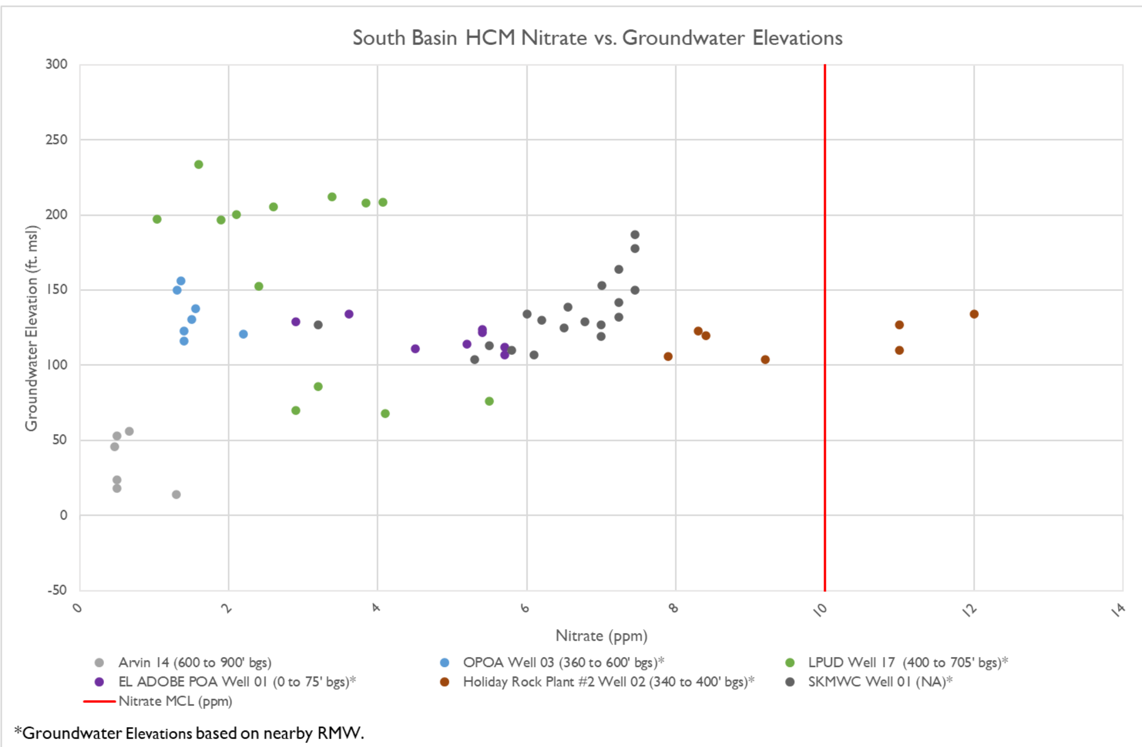


Figure 8-39. South Basin HCM Nitrate vs. Groundwater Elevations

While nitrate sources are typically from the surface, trending demonstrated that nitrate concentration may be influenced by multiple localized factors. Source of contamination, well construction, proximity to recharge basins and groundwater elevation changes may contribute to fluctuations in nitrate concentration.

8.4.1.7 Perfluorooctanoic Acid (PFOA), Perfluorooctane Sulfonic Acid (PFOS)

In April 2024, EPA finalized a MCL of 4 ppt for perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS). There is no agricultural goal for PFOA and PFOS.

Both contaminants are part of a group of Per- and Polyfluoroalkyl Substances (PFAS), a category of manufactured chemicals that have been used in industry and consumer products. Commonly, PFOA is used for nonstick cookware, and PFOS is used in stain and water-repellant fabrics and firefighting foam. PFAS typically breakdown slowly and are highly hydrophobic. Figure 8-40 and Figure 8-41 displays the median PFOA and PFOS concentration per well, along with if the well had an exceedance.

This page intentionally left blank.

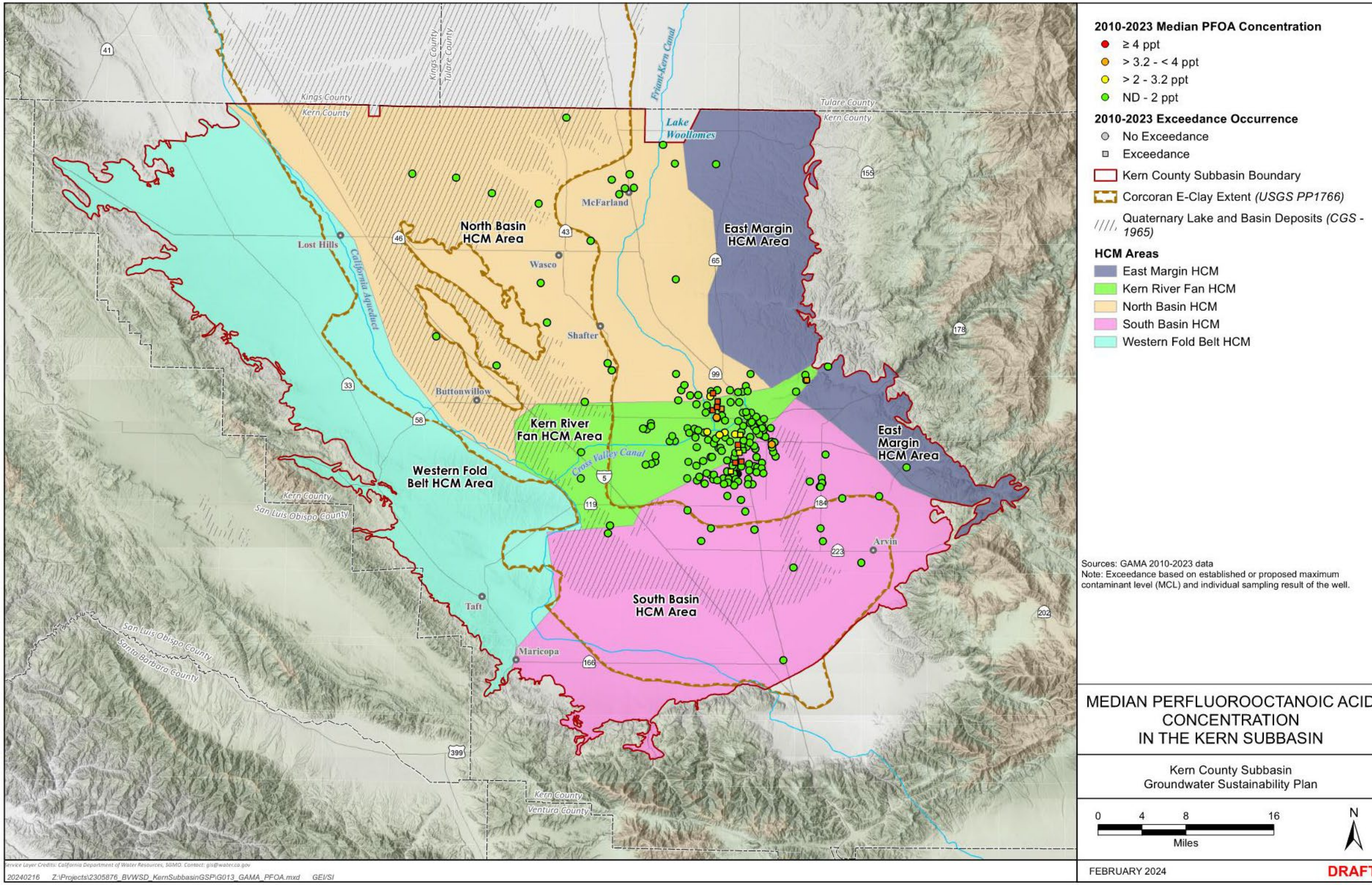


Figure 8-40. Median Perfluorooctanoic Acid (PFOA) Concentration in the Kern Subbasin

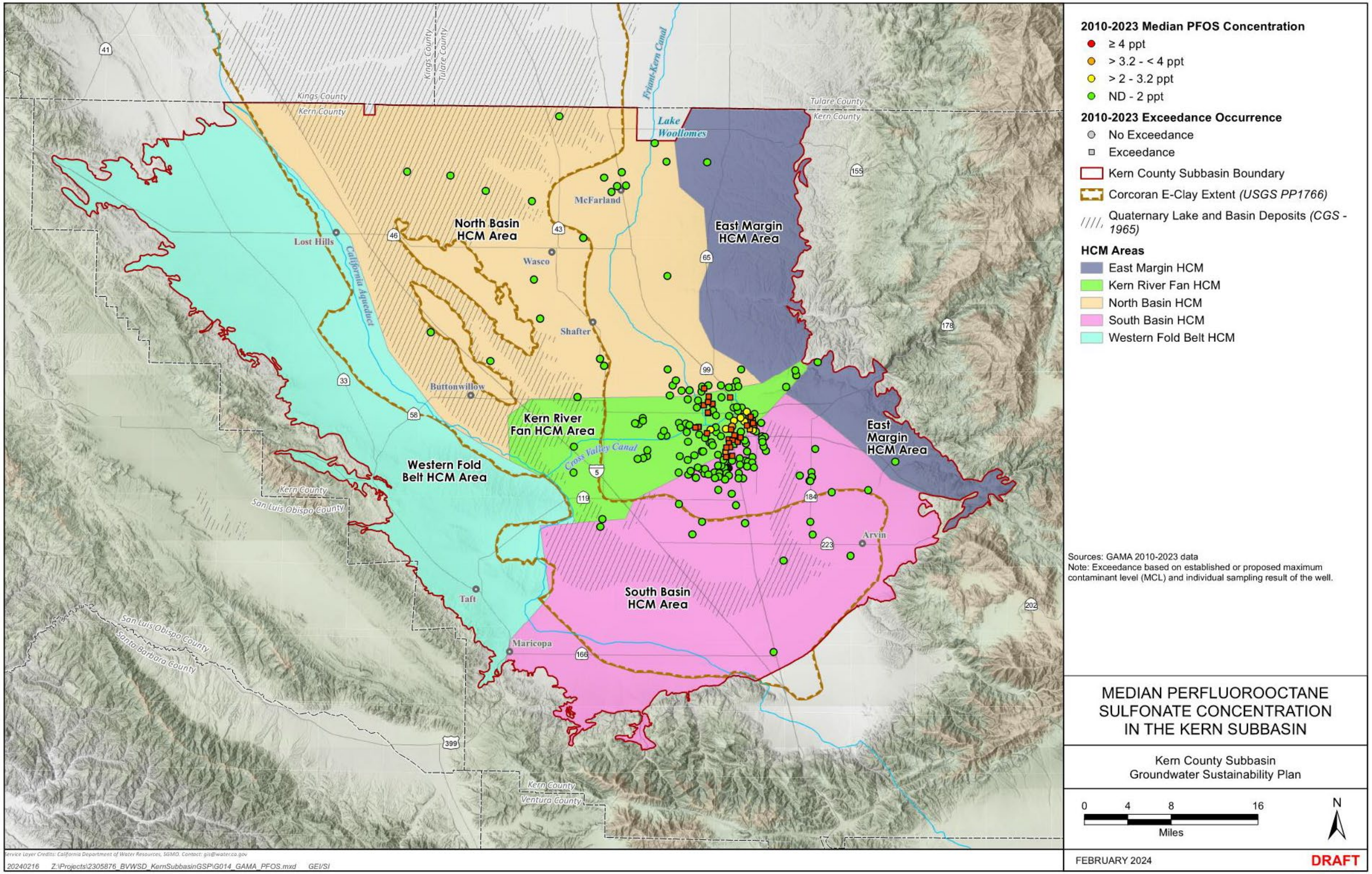


Figure 8-41. Median Perfluorooctane Sulfonic Acid (PFOS) Concentration in the Kern Subbasin

Limited PFAS data is available due to two SWRCB General Orders, DW 2021-0001 (rescinded) and 2022-0001-DDW, which required some public water systems to conduct PFAS monitoring. In the Subbasin, PFOA and PFOS data is available for 205 sources, covering each HCM, with the exception of the Western Fold Belt HCM. Table 8-18 and Table 8-19 summarize PFOA and PFOS prevalence by HCM. The median PFOA and PFOS concentrations are non-detect for both constituents. Sources with detections above the recently established MCL for PFOA and PFOS are primary located in the North Basin and South Basin HCMs, with one source above the MCL in the Kern River Fan HCM. It is expected that additional municipal data since MCLs and monitoring frequency are established for these constituents, allowing for further characterization of these analytes in the basin.

Table 8-18. 2015 to 2023 PFOA prevalence by HCM

Perfluorooctanoic acid (PFOA)					
HCM	**Range (ppt)**	**Median (ppt)**	**# of Wells with Exceedance**	**# of Wells Sampled**	**% of Wells with Exceedance**
Western Fold Belt[1]	-	-	-	-	-
North Basin	ND - 12	ND	1	37	2.7%
Kern River Fan	ND - 9.7	ND	10	88	11.4%
South Basin	ND - 13	ND	3	75	4.0%
Eastern Margin	ND	ND	0	3	0.0%
		Total	14	203	6.9%

[1] No data available for HCM primarily undeveloped lands and limited pumping.

Table 8-19. 2015 to 2023 PFOS prevalence by HCM

Perfluorooctane sulfonate (PFOS)					
HCM	**Range (ppt)**	**Median (ppt)**	**# of Wells with Exceedance**	**# of Wells Sampled**	**% of Wells with Exceedance**
Western Fold Belt[1]	-	-	-	-	-
North Basin	ND - 10	ND	1	37	2.7%
Kern River Fan	ND - 57	ND	27	88	30.7%
South Basin	ND - 11	ND	2	75	2.7%
Eastern Margin	ND	ND	0	3	0.0%
		Total	30	203	14.8%

[1] No data available for HCM primarily undeveloped lands and limited pumping.

8.4.1.8 Selenium

Selenium has a primary MCL of 50 ppb. and does not have an agricultural goal. Selenium is a naturally occurring element found in the upper Cretaceous and Tertiary marine and sedimentary deposits that form the California Coast Ranges and inland Central Valley basin. Sedimentary rocks, particularly shales, have the highest naturally occurring selenium content and the natural weathering of geologic strata containing selenium can lead to selenium leaching into groundwater and surface water. There are two anthropogenic activities known to cause increased selenium mobilization into aquatic systems: human disturbances to the geological sedimentary deposits and irrigation of selenium-rich soils (40 CFR 131 Section 64059). Figure 8-42 displays the median concentration of selenium per well, along with if the well had an exceedance.

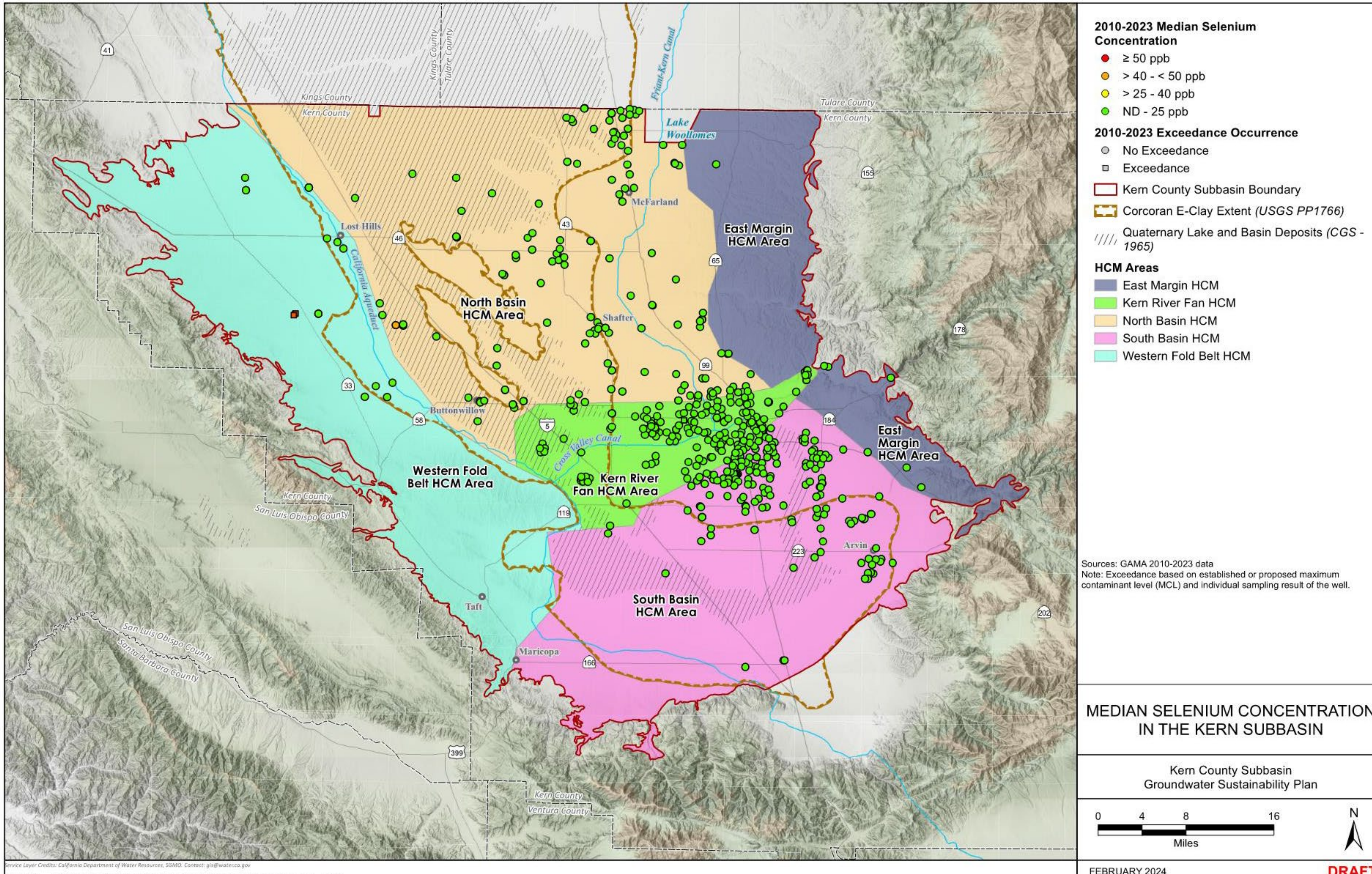


Figure 8-42. Selenium Concentration in the Kern Subbasin

This page intentionally left blank.

Based on the range of concentration, median and count of sources exceeding of the MCL, selenium is not prevalent in the Subbasin. Table 8-20 summarizes pre-2015 and 2015 to 2023 selenium median and range for each HCM. The selenium median concentration in each HCM is non-detect. Selenium is detected in above the MCL in two HCMs. In the Kern River Fan HCM, there is a one-time detection of selenium in a municipal well above the MCL. Subsequent samples for this well shows selenium below 15 ppb and non-detect. In the Western Fold Belt HCM, selenium is detected above the MCL in three USGS other water supply wells. Table 8-21 summarizes selenium exceedances for each HCM.

Table 8-20. Selenium Range and Median Summary by HCM

	2010 to 2014			2015 to 2023		
HCM	Range (ppb)	Median (ppb)	# of Wells Sampled	Range (ppb)	Median (ppb)	# of Wells Sampled
Western Fold Belt	ND	ND	1	ND - 381	ND	20
North Basin	ND - 33	ND	101	ND - 50	ND	132
Kern River Fan	ND - 3.9	ND	147	ND - 140	ND	160
South Basin	ND - 20	ND	133	ND - 39	ND	164
Eastern Margin	ND	ND	3	ND - 10	ND	6

Table 8-21. Selenium Well Exceedance Summary by HCM

	2010 to 2014			2015 to 2023		
HCM	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Western Fold Belt	0	1	0.0%	3	20	15.0%
North Basin	0	101	0.0%	0	132	0.0%
Kern River Fan	0	147	0.0%	1	160	0.6%
South Basin	0	133	0.0%	0	164	0.0%
Eastern Margin	0	3	0.0%	0	6	0.0%
Total	0	385	0.0%	4	482	0.8%

8.4.1.9 Total Dissolved Solids (TDS)

TDS represents the total concentration of anions and cations in groundwater and is used as an indicator of mineralization, salt content, and overall water quality. TDS has a secondary maximum contaminant level (SMCL) with a recommended limit of 500 ppm and an upper limit of 1,000 ppm. Additionally, an agricultural goal for 450 ppm is recommended for irrigation of salt sensitive crops. As summarized in the general water quality sections (Sections 7.2.3.1, 7.2.3.2, and 7.2.3.3), sources of TDS in the Subbasin (and especially on the western margin areas) can be attributed to the source of natural groundwater recharge and the influence of connate waters from older marine formations. In addition to natural sources, anthropogenic sources such as infiltration from produced water disposal ponds; perched water subject to evaporative pumping; or agricultural drainage ponds affect TDS concentrations in groundwater (Metzger and Landon, 2018).

In the Subbasin, higher TDS groundwater is present in shallow perched zones, in the unconfined zone above the E-c-lay, and throughout the western third of the Subbasin. Kern County Water Agency's 2011 Water Supply Report presented groundwater quality maps using data pre-1997. These maps report groundwater is progressively lower in TDS below the E-c-lay, toward the center of the basin, and in the eastern half of the Subbasin. In the unconfined groundwater (typically above the E-c-lay) in the central portion of the Subbasin, TDS concentrations generally range from less than 500 to 1,500 ppm, while the western portion unconfined groundwater ranges from 1,000 to 5,000 ppm. The confined aquifer zone (typically below the E-c-lay) in the central portion of the Subbasin TDS concentrations generally ranges from less than 200 to 500 ppm, while westside confined groundwater typically ranges from 1,000 to 4,000 ppm. The high-TDS (Na-Cl) groundwater is generally found in the deeper parts of the Subbasin, regardless of what type of groundwater it underlies. This saline groundwater is likely to be connate water trapped during the deposition of the marine sediments which is used to define the basin bottom at depth as discussed in Section 7.3.2.

Higher TDS concentrations in Western Fold Belt HCM Area, as compared with Eastern Margin HCM Area, in the Subbasin is related to a combination of natural conditions (westside sediments derived from marine deposits with some connate water) and anthropogenic factors such as infiltration from disposal ponds and/or agricultural drainage ponds (Metzger and Landon, 2018). Groundwater adjacent to Sierra Nevada has the lowest TDS and greatest depths to non-USDWs because of the source of low TDS ($Ca\text{-}HCO_3$ type) recharge, whereas aquifer zones on the westside of the Subbasin have higher TDS. The westside aquifer zones receive very little recharge from the Temblor Range, which is made up of marine deposits, and westside aquifer zones such as the Tulare Formation likely contain connate water derived from marine deposits (Wood & Dale, 1964). This higher TDS water, which is typically $Na/Ca\text{-}SO_4$ type, is consistent with historical reports and is documented for more than 60 miles from north to south in the Subbasin (KCDEH, 1980; KCDEH and KCWA, 1982; Sierra Scientific Services, 2013).

Within the northern portion of Eastern Margin HCM Area, the Santa Margarita and Olcese Formations originally contained marine water. Recharge from the east has fed freshwater into these formations and has displaced some of the original marine waters contained in the aquifers. This recharge has created a freshwater/brackish water interface in these Principal Aquifers just west of Kern-Tulare Water District (the western border of the East Margin HCM Area). In 1963, USGS Publication 63-47 identified the approximate western limits of freshwater in these aquifers where TDS was greater than approximately 2,000 mg/L.

Figure 8-43 displays the TDS median concentration per well, along with if the well had an exceedance. Wells with TDS median concentrations exceeding the SMCL are primarily located in the Western Fold Belt, North Basin, and South Basin HCMs.

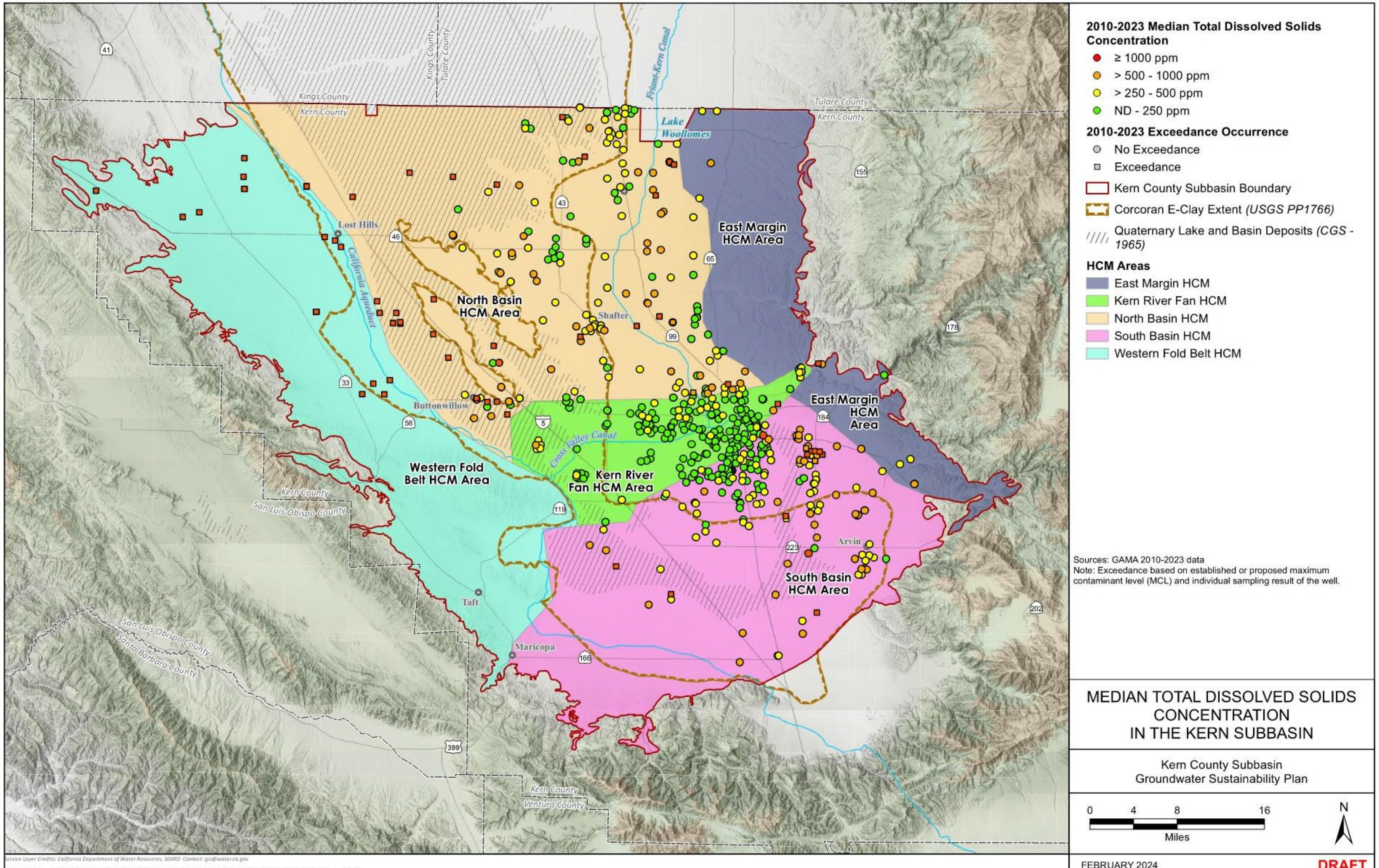


Figure 8-43. Median Total Dissolved Solids Concentration in the Kern Subbasin

This page intentionally left blank.

Table 8-22 summarizes each HCM's pre-2015 and 2015 to 2023 TDS median and range. In each HCM, TDS concentration ranges exceed the SMCL, except for the Eastern Margin HCM during pre-2015 conditions. While the upper range of TDS concentrations exceed the SMCL, TDS median concentrations are below the SMCL in each HCM, except the Western Fold Belt HCM, which primarily rely on imported surface water due to naturally degraded water quality.

Table 8-22. Total Dissolved Solids Range and Median Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	Range (ppm)	Median (ppm)	# of Wells Sampled	Range (ppm)	Median (ppm)	# of Wells Sampled
Western Fold Belt	5850	5850	1	1300 - 16400	3290	21
North Basin	120 - 1400	315	94	110 - 5400	408	178
Kern River Fan	110 - 1100	190	146	32 - 1200	200	158
South Basin	130 - 1800	270	121	110 - 2100	313	172
Eastern Margin	170 - 430	190	3	99 - 1300	473	12

Table 8-23 summarizes pre-2015 and 2015 to 2023 TDS exceedances for each HCM. While the number of wells with TDS SMCL exceedances for each HCM is greater in 2015 to 2023 conditions compared to pre-2015 conditions, these increases do not necessarily indicate degradation of groundwater quality. Rather, it may reflect a more comprehensive understanding of TDS concentration in the Subbasin as the number of wells sampled increased in all HCM's from the pre-2015 to the 2015 to 2023 conditions.

During the 2015 to 2023 period, TDS is detected above the SMCL in 6 domestic wells, 25 irrigation/industrial wells, 24 municipal wells and 10 water supply wells. Of the 24 municipal, four wells had average TDS concentrations below the SMCL, eight wells had one-time detection above the SMCL where the exceedance not confirmed, one well is a standby well, and one well is an inactive well.

Table 8-23. Total Dissolved Solids Well Exceedance[1] Summary by HCM

HCM	2010 to 2014			2015 to 2023		
	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance	# of Wells with Exceedance	# of Wells Sampled	% of Wells with Exceedance
Western Fold Belt [1]	1	1	100.0%	21	21	100.0%
North Basin	6	94	6.4%	31	178	17.4%
Kern River Fan	1	146	0.7%	1	158	0.6%
South Basin	7	121	5.8%	11	172	6.4%
Eastern Margin	0	3	0.0%	1	12	8.3%
Total	15	365	4.1%	65	541	12.0%

[1]Count represents number of wells where TDS is detected above the SMCL and not number of wells out of compliance, as compliance is based on a quarterly average and not a single detection.

TDS median concentrations for wells within and outside the boundaries of E--cay and lake deposits are evaluated and summarized in Table 8-24. Higher median TDS concentrations are present in wells within the boundaries of the E-c-lay and lake deposits throughout the Subbasin. The Eastern Margin HCM has the highest TDS median outside the boundaries of the E-Clay and lake deposits when compared to the eastern half HCM's of the Subbasin (North Basin, Kern River Fan, and South Basin HCM). This is likely due to the original saline waters of the Santa Margarita and Olcese Sand principal aquifers being displaced by the freshwater recharge water. Refer to Sections 7.2.2.4 and 7.2.3.4 for more detailed explanation. It is important to note that Table 8-24 does not distinguish if the well is constructed/screened below or above these deposits.

Table 8-24. Median Total Dissolved Solids Summary for Wells within E-c-lay or Lakebed Deposits Boundaries

HCM	Geology	2010 to 2023 Median (ppm)	2010 to 2023 # of Wells Sampled
Western Fold Belt	E-Clay	4390	9
	Neither	2393	12
North Basin	E-Clay and Lake Deposits	648	40
	E-Clay	350	63
	Neither	420	98
Kern River Fan	E-Clay and Lake Deposits	320	10
	E-Clay	225	13
	Neither	190	141
South Basin	E-Clay and Lake Deposits	650	9
	E-Clay	460	51
	Lake Deposits	230	3
	Neither	260	118
Eastern Margin	Neither	450	14

8.4.2 Point-Source Contamination Sites

Data from SWRCB's GeoTracker and DTSC's EnviroStor databases were used to identify groundwater contaminant sites in the Subbasin. Contaminant plumes are routinely monitored through a designated network of monitoring wells surrounding the site. GSAs are aware of sites within their boundary and coordinate with the appropriate regulatory agency when notified of plume migration. Groundwater contaminated sites were evaluated for the following criteria:

1. Potential media of concern defined as "groundwater," "other groundwater," or "drinking groundwater,"
2. Potential contaminant of concern defined, or "unknown,"
3. Site/case reported as "not closed," and had one of the following statuses:
    - Contains "Active"

- Inactive – Needs Evaluation
- Inactive – Permitted
- Inactive – Unpermitted
- Contains "Open"
- Pending Review
- Refer: EPA or Refer: Other Agency

A total of 86 contaminated groundwater sites were identified. Of the 86 sites, 42 sites are produced water ponds, which are further discussed in Section 8.4.3. The remaining 44 sites consists of 21 SWRCB Cleanup Program sites, five Leaking Underground Storage Tank (LUST) Program sites, one Federal Superfund site, 17 sites for other programs (Corrective Action, Evaluation, Non-Case Information, State Response, and Voluntary Cleanup). Figure 8-44 identifies the location of the point source contamination sites, which are primarily located within the North Basin (13 sites), Kern River Fan (15 sites) and South Basin (11 sites) HCMs. The Western Fold Belt HCM has four-point source contamination sites and Eastern Margin HCM has one point source contamination site. Table 8-25 provides details of each site (identified by the number in Figure 8-44) including site name, Geotracker or EnviroStor site ID, program, status, and potential contaminant of concern.

This page intentionally left blank.

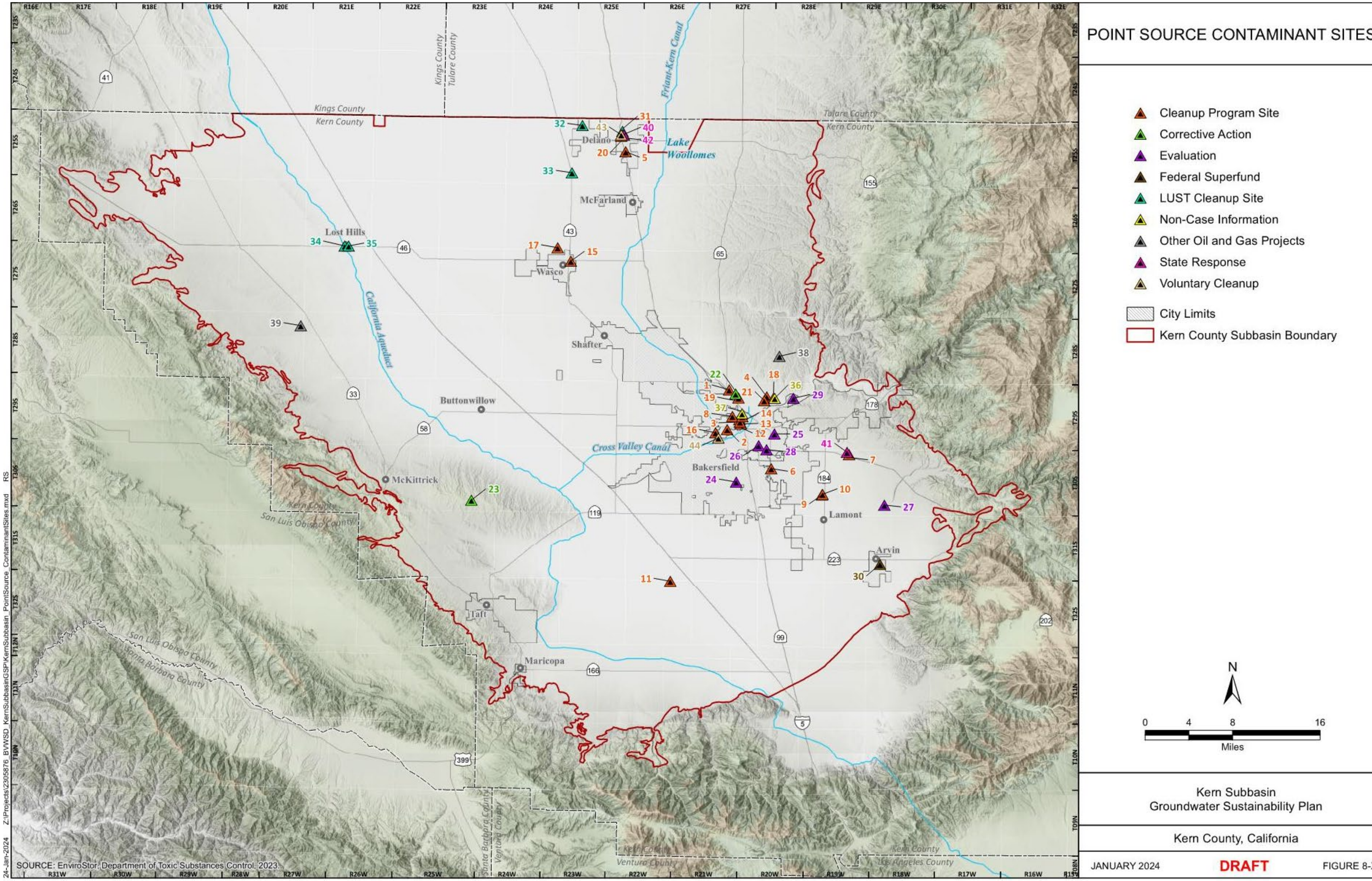


Figure 8-44. Point Source Contaminant Sites

This page intentionally left blank.

Table 8-25. Groundwater Contamination Sites Identified Within Subbasin

# on Figure 8-44	Site Name	Site ID	Source	Program	Status	Chemical
1	Bakersfield Airport Business Park (Chevron Land/D)	SL0602981532	GeoTracker	Cleanup Program Site	Open - Verification Monitoring	Crude Oil
2	Bakersfield Refinery	SL205314279	GeoTracker	Cleanup Program Site	Open - Remediation	Benzene; Other Solvent or Non-Petroleum Hydrocarbon; Toluene; Xylene; Diesel; MTBE / TBA / Other Fuel Oxygenates; Gasoline; Other Petroleum
3	Bakersfield Refinery - Area 3	T10000001848	GeoTracker	Cleanup Program Site	Open - Verification Monitoring	Diesel; Gasoline
4	Chevron USA (AKA: Chevron Refinery & Wait Tank YD)	SL205064267	GeoTracker	Cleanup Program Site	Open - Remediation	Benzene; Lead; Crude Oil; Other Petroleum
5	Crop Production Services (CPS) Delano	SL185724257	GeoTracker	Cleanup Program Site	Open - Remediation	Other Chlorinated Hydrocarbons, Other Solvent or Non-Petroleum Hydrocarbon; DDD / DDE / DDT; 1,1,2-Trichloroethane; 1,2,3-Trichloropropane; 1,4-Dichlorobenzene; 2,4-D; 2,4-DB; Bromoform (THM); DDD; DDE; Dibromochloromethane(THM), Dibromochloropropane (DBCP), Dicamba, Dinoseb, Endosulfan I, Endosulfan II, Heptachlor, Nitrate + Nitrite (as N), Trichlorofluromethane
6	Garriott Cropdusters	SLT5FQ134306	GeoTracker	Cleanup Program Site	Open - Site Assessment	Other Insecticides / Pesticide / Fumigants / Herbicides
7	J. R. Simplot - Edison	SLT5FS324450	GeoTracker	Cleanup Program Site	Open - Remediation	Dibromochloropropane (DBCP)
8	KCL Lease	T10000012038	GeoTracker	Cleanup Program Site	Open - Assessment & Interim Remedial Action	*Chemical information not provided in Geotracker
9	Kern Energy - Kern Energy - PFAS Investigation	T10000021222	GeoTracker	Cleanup Program Site	Open - Site Assessment	Per- and Polyfluoroalkyl Substances (PFAS)

# on Figure 8-44	Site Name	Site ID	Source	Program	Status	Chemical
10	Kern Energy - Kern Energy (Formerly Kern Oil & Refining)	SL372524510	GeoTracker	Cleanup Program Site	Open - Remediation	Benzene, Gasoline, MTBE / TBA / Other Fuel Oxygenates, Toluene, Diesel, Xylene
11	Paloma Station Property	T10000011026	GeoTracker	Cleanup Program Site	Open - Remediation	Arsenic, Chromium, Lead, Other Metal, Benzene, Diesel, Gasoline, Other Petroleum, Total Petroleum Hydrocarbons (TPH)
12	Sabre Refinery	SLT5FQ334326	GeoTracker	Cleanup Program Site	Open - Inactive	Total Petroleum Hydrocarbons (TPH)
13	San Joaquin Drum	SLT5FR634417	GeoTracker	Cleanup Program Site	Open - Site Assessment	*Chemical information not provided in Geotracker
14	San Joaquin Refining - San Joaquin Refining Cc - Fruitvale Refinery	SL205714283	GeoTracker	Cleanup Program Site	Open - Remediation	Diesel
15	Simplot Wasco	SLT5FS184436	GeoTracker	Cleanup Program Site	Open - Remediation	Other Insecticides / Pesticide / Fumigants / Herbicides
16	Sunland Refining Corporation	SL205224272	GeoTracker	Cleanup Program Site	Open - Remediation	Crude Oil, MTBE / TBA / Other Fuel Oxygenates, Gasoline
17	Wasco Airport	SLT5FQ444336	GeoTracker	Cleanup Program Site	Open - Verification Monitoring	DDD / DDE / DDT, Other Insecticides / Pesticide / Fumigants / Herbicides
18	West Coast Oil Refinery, Bakersfield	SL0602978387	GeoTracker	Cleanup Program Site	Open - Assessment & Interim Remedial Action	Lead, Diesel, Gasoline
19	Western Farm Service Inc-1610 Norris Road Bakersfield	SL186364605	GeoTracker	Cleanup Program Site	Open - Site Assessment	Other Chlorinated Hydrocarbons
20	WIP - Delano, PCE	SL0602943992	GeoTracker	Cleanup Program Site	Open - Inactive	*Chemical information not provided in Geotracker
21	Witco Refinery (Oildale)	SLT5FQ474339	GeoTracker	Cleanup Program Site	Open - Site Assessment	*Chemical information not provided in Geotracker
22	KW Plastics of California	80001494	EnviroStor	Corrective Action	Active	Lead

# on Figure 8-44	Site Name	Site ID	Source	Program	Status	Chemical
23	Occidental Of Elk Hills Inc.	80001254	EnviroStor	Corrective Action	Active	Hydrochloric Acid (Hydrogen Chloride); Metals; Petroleum; Polychlorinated Biphenyls (PCBS); Radioactive Isotopes Uuncategorized; Volatile Organics (8260B VOCS)
24	Bakersfield Discovery Project	60001630	EnviroStor	Evaluation	Inactive - Needs Evaluation	Tetrachloroethylene (PCE); Trichloroethylene (TCE)
25	Bakersfield Plating Works	15340012	EnviroStor	Evaluation	Refer: Other Agency	Metals
26	Custom Cleaners	60002831	EnviroStor	Evaluation	Refer: EPA	Tetrachloroethylene (PCE); Trichloroethylene (TCE)
27	Eastland Flying Service	15070006	EnviroStor	Evaluation	Inactive - Needs Evaluation	Carbaryl; Organophosphorus Pesticides (8141A OPPS); Other; Toxaphene; Uncategorized
28	Freeman's Cleaners (Vogue Cleaners)	60002832	EnviroStor	Evaluation	Refer: EPA	Tetrachloroethylene (PCE); Trichloroethylene (TCE)
29	Kern County Gun Club	15860001	EnviroStor	Evaluation	Refer: Other Agency	Lead; Other Organic Solids; Polynuclear Aromatic Hydrocarbons (PAHS)
30	Brown And Bryant, Inc., Arvin Facility	15280011	EnviroStor	Federal Superfund	Active	Dinoseb, Volatile Organics (8260B VOCS)
31	Logrecco Property	T0602925877	GeoTracker	LUST Cleanup Site	Open - Site Assessment	Gasoline
32	North Kerrn State Prison	T0602900672	GeoTracker	LUST Cleanup Site	Open - Eligible for Closure	Gasoline
33	Pond Mercantile	T0602900113	GeoTracker	LUST Cleanup Site	Open - Remediation	Gasoline
34	Robertsons Market	T0602902377	GeoTracker	LUST Cleanup Site	Open - Remediation	Gasoline, Diesel
35	Taylor Automated Fuels	T0602900529	GeoTracker	LUST Cleanup Site	Open - Site Assessment	Gasoline
36	Bakersfield Terminal	T10000016451	GeoTracker	Non-Case Information	Pending Review	Per- and Polyfluoroalkyl Substances (PFAS)

# on Figure 8-44	Site Name	Site ID	Source	Program	Status	Chemical
37	Southern Counties Oil Co LP, dba SC Fuels	T10000016459	GeoTracker	Non-Case Information	Pending Review	Per- and Polyfluoroalkyl Substances (PFAS)
38	Kern River Oil Field, Rambler Lease	T10000011704	GeoTracker	Other Oil and Gas Projects	Open - Site Assessment	TDS
39	South Belridge, MW-12G1	T10000021488	GeoTracker	Other Oil and Gas Projects	Open - Need Additional Information	Boron; TDS
40	Delano PCE Plume	60001327	EnviroStor	State Response	Active	PCE
41	J R Simplot, Edison	15070030	EnviroStor	State Response	Active	Organochlorine Pesticides (8081 OCPS), Volatile Organics (8260B VOCS)
42	Oasis Cleaners	60002269	EnviroStor	State Response	Active	Tetrachloroethylene (PCE)
43	Safe 1 Credit Union - Delano	60002995	EnviroStor	Voluntary Cleanup	Active	Tetrachloroethylene (PCE)
44	Westside Parkway/ Conoco Phillips Coke	60001880	EnviroStor	Voluntary Cleanup	Active	Polynuclear Aromatic Hydrocarbons (PAHS)

8.4.2.1 Permitted Facilities with Waste Discharge Requirements Orders

In addition, SWRCB's California Integrated Water Quality System (CIWQS) database was used to identify permitted facilities with Waste Discharge Requirements (WDR) Order and Confined Animal Facility (CAF) Sites in the Subbasin. The intent of mapping the location of the sites is to provide geographic representation of these WDRs and Confined Animal Sites throughout the Subbasin. A total of 316 sites were identified; however, 54 sites are not included in this figure because latitude/longitude coordinates were not available to confirm that the sites are within the Subbasin. Figure 8-45 provides a graphical representation of known WDRs and CAF sites in the Subbasin. Note: majority of other waste discharge requirement facilities in the Western Fold Belt are associated with non-GSA activities (e.g., oil field activities).

This page intentionally left blank.

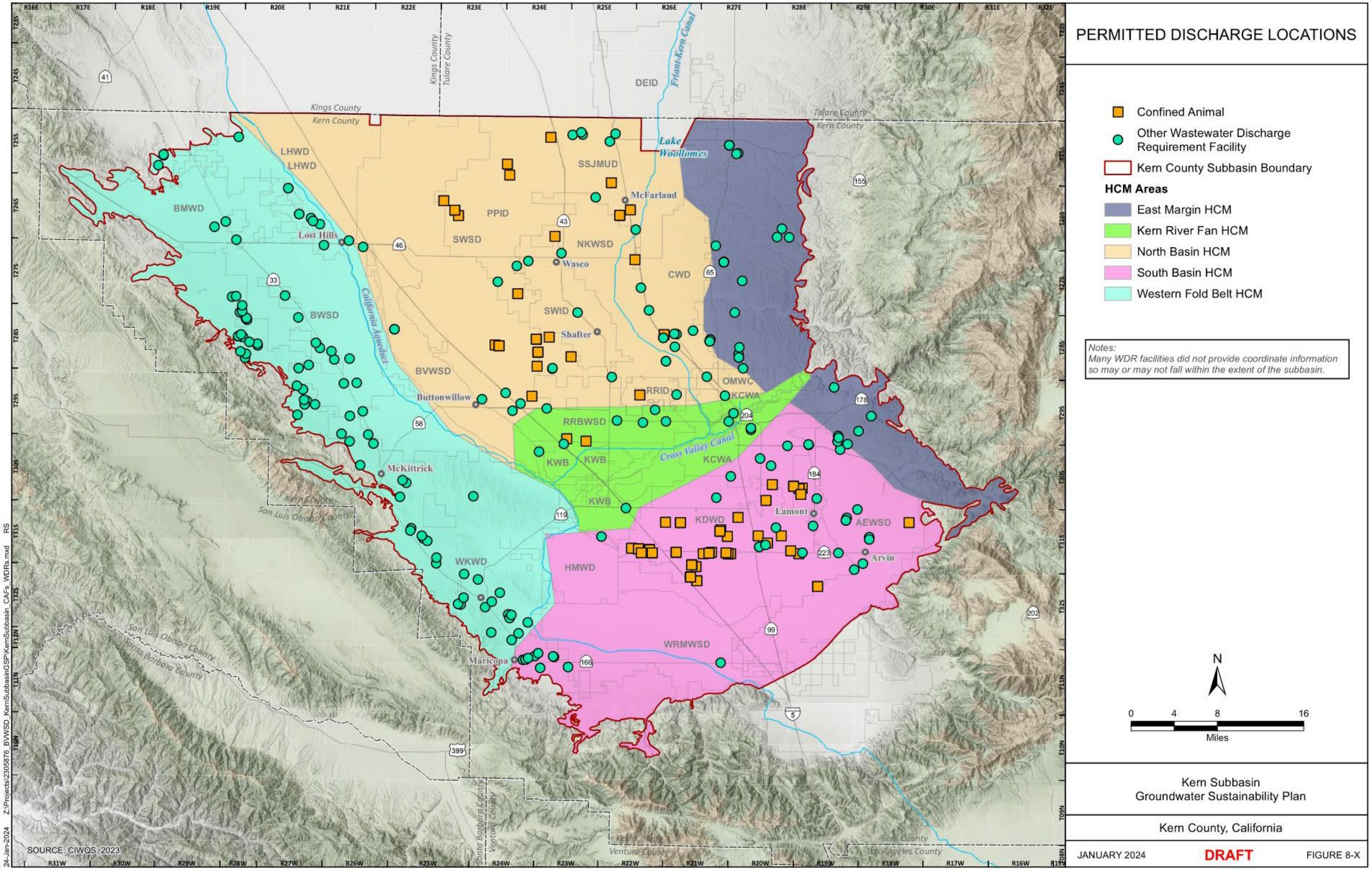


Figure 8-45. Permitted Discharge Locations

This page intentionally left blank.

8.4.3 Oil Field Injection Wells and Produced Water Ponds

Oil fields aquifer exemptions are detailed in Section 7.3.4.1. UIC permitted wells are not included in the list of groundwater contaminant sites because the federal UIC program's objective is to confine injected fluid to the approved injection zone so that injected fluid does not migrate to a zone where it could degrade valuable groundwater or hydrocarbon resources. Wells permitted under the State's Class II UIC program are presented on Figure 8-46.

8.4.3.1 Produced Water

Water brought to the surface when oil is extracted as a byproduct of the extraction process is often referred to as "produced water." Produced water is groundwater that is commingled with hydrocarbons located within the hydrocarbon bearing reservoir. Often, produced water is returned to the original geological formation for enhanced oil recovery or disposal. Some produced water is suitable for beneficial reuse with treatment, though most is higher in salinity and must undergo extensive treatment and be blended with other waters before use. New technologies and the need to find new sources of water are driving the development of new more economical processes to treat produced water for beneficial reuse.

Produced water ponds are a known source for point source groundwater contamination. A total of 30 open or active produced water ponds were identified as contaminated groundwater sites based on the point-source evaluation in Section 8.4.1. Table 8-26 summarizes the produced water ponds identified including site name, Geotracker or EnviroStor site ID, program, status, and potential contaminant of concern. Figure 8-46 shows the location of the produced water ponds and UIC in the Subbasin, which are located within exempt aquifer boundaries.

This page intentionally left blank.

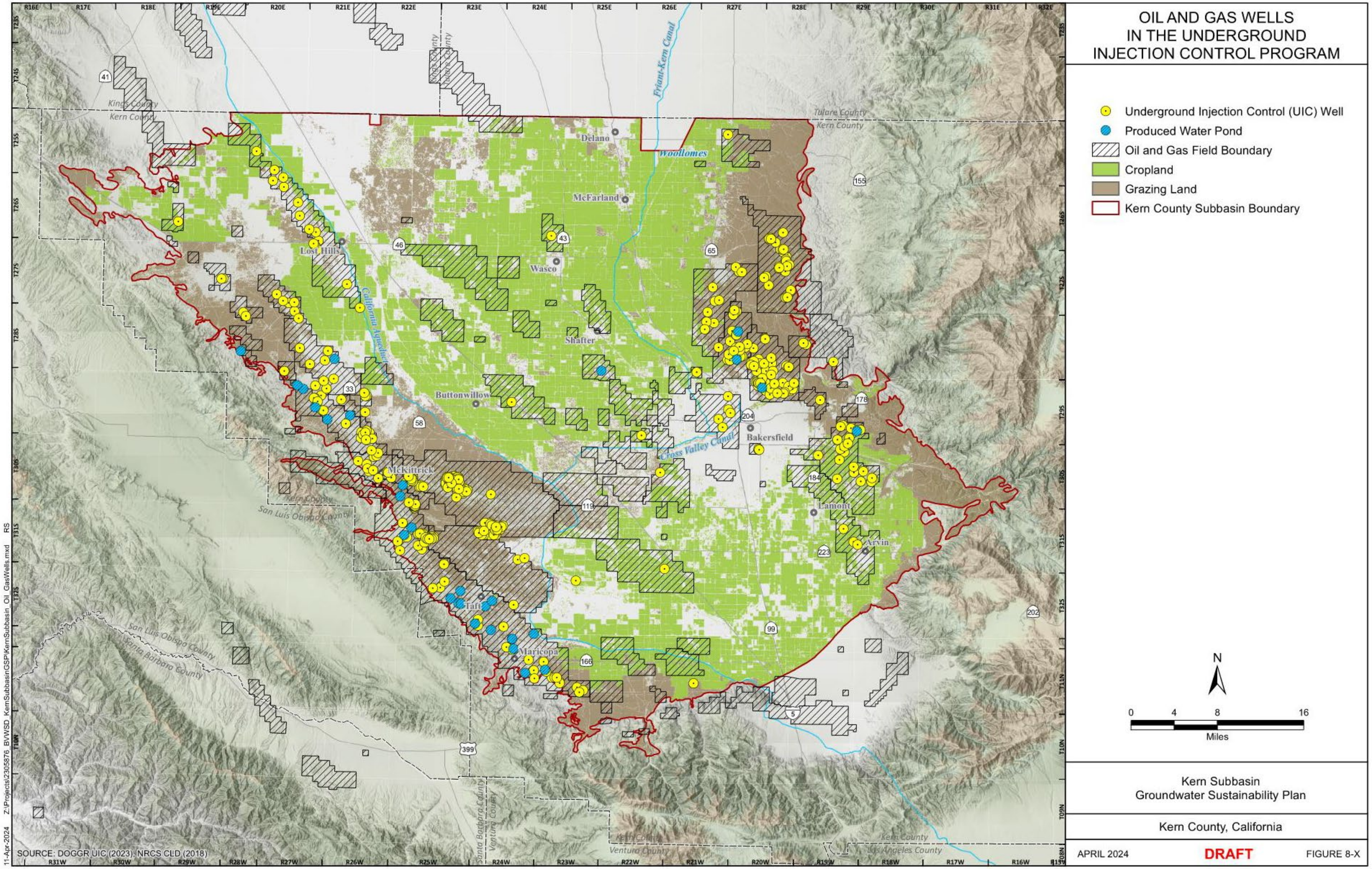


Figure 8-46. UIC Program Wells and GeoTracker Produced Water Ponds Sites

This page intentionally left blank.

Table 8-26. Produced Water Ponds from GeoTracker

Site Name	Site ID	Source	Program	Status	Chemical
25 Hill Properties, Inc., Midway-Sunset, Shell Lease	T10000006950	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker
AERA ENERGY LLC - NORTH BELRIDGE DISPOSAL PONDS	SL0602993186	GeoTracker	Produced Water Ponds	Inactive - Permitted	Other inorganic / salt
Asphalto Oil Field, Bear Valley Lease	T10000006823	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker
BELGIAN ANTICLINE, MCKITTRICK 1 & 1-3 Facility	L10007494132	GeoTracker	Produced Water Ponds	Inactive - Permitted	Nitrate, Other inorganic / salt, Boron, TDS, Benzene, Crude Oil
Belgian Anticline, Mckittrick 1-1 Facility	L10004955136	GeoTracker	Produced Water Ponds	Open - Site Assessment	Nitrate, Boron, TDS, Benzene, Crude Oil, Ethylbenzene, Toluene, Total Petroleum Hydrocarbons (TPH), Xylene
Belridge South Oil Field, Section 27 Lease (Water Plant 27)	T10000011585	GeoTracker	Produced Water Ponds	Active - Permitted	Nitrate, Boron, TDS, Benzene, Crude Oil
CARNEROS CREEK, THETA (30)	L10009422184	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Cymric Oil Field, Bowles Lease	T10000006948	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Cymric Oil Field, Lehi-Richardson Lease	T10000007036	GeoTracker	Produced Water Ponds	Active - Permitted	Crude Oil
Cymric Oil Field, Overland Anderson Lease (Ballard Oil, Inc.)	T10000007035	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Cymric Oil Field, USL Lease	T10000007037	GeoTracker	Produced Water Ponds	Active - Permitted	Crude Oil
Edison Oil Field, Racetrack Lease	T10000007136	GeoTracker	Produced Water Ponds	Open - Site Assessment	Other inorganic / salt, TDS, Crude Oil
Kern Front Oil Field, Section 11 Lease	T10000007104	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker
Kern Front Oil Field, Sill One Lease	T10000007103	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker

Site Name	Site ID	Source	Program	Status	Chemical
Kern River Oil Field, San Joaquin Lease	T10000007105	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Kern River Oil Field, Winspear Lease	T10000011765	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Nitrate, Arsenic, Boron, Chromium, Copper, Lead, Mercury (elemental), Other Metal, TDS, Zinc, Benzene, Crude Oil, Ethylbenzene, Toluene, Xylene
Lost Hills Oil Field, Section 29 Lease	SL0602961924	GeoTracker	Produced Water Ponds	Inactive - Permitted	Other inorganic / salt
Midway-Sunset Oil Field, Anderson-Goodwin Lease	L10001277360	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	*Chemical information not provided in Geotracker
Midway-Sunset Oil Field, Berry and Ewing Lease	T10000007297	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Havenstrite Lease	T10000006789	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Hoyt Lease	T10000006779	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Crude Oil
Midway-Sunset Oil Field, Jameson Trust Lease	L10002548641	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Jameson Trust Lease	T10000006947	GeoTracker	Produced Water Ponds	Active - Permitted	Crude Oil
Midway-Sunset Oil Field, Lockwood Lease	T10000007029	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Moco 35 Lease	T10000007031	GeoTracker	Produced Water Ponds	Active - Permitted	Crude Oil
Midway-Sunset Oil Field, Moco 35 Lease (Plastic-lined Pond 3)	T10000007039	GeoTracker	Produced Water Ponds	Active - Permitted	Crude Oil
Midway-Sunset Oil Field, National USL Lease	T10000007032	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Section 35D Lease	T10000011701	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Shale 14 Lease, AFS DEHYDRATION PLANT	T10000007033	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil

Site Name	Site ID	Source	Program	Status	Chemical
Midway-Sunset Oil Field, Southeast Taft Facility (SE Taft)	T10000013268	GeoTracker	Produced Water Ponds	Open - Active	Nitrate, Boron, TDS, Benzene, Crude Oil, Ethylbenzene, Toluene, Total Petroleum Hydrocarbons (TPH), Xylene
Midway-Sunset Oil Field, Virginia Land Lease	T10000006952	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker
Midway-Sunset Oil Field, W & S Lease	T10000007034	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
Midway-Sunset Oil Field, Webber Lease	T10000006776	GeoTracker	Produced Water Ponds	Open - Site Assessment	Crude Oil
North Coles Levee Oil Field, Coles Levee A Lease	T10000020096	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Benzene, Crude Oil, Polynuclear aromatic hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPH)
Poso Creek, Poso Lease	T10000007301	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Crude Oil
Rio Bravo Oil Field, Kernco Lease	T10000006733	GeoTracker	Produced Water Ponds	Open - Inactive	Crude Oil
S. Belridge Oil Field, Hill Lease	SL0602935481	GeoTracker	Produced Water Ponds	Inactive - Permitted	Other inorganic / salt
Seneca, MIDWAY SUNSET, USC LEASE	L10002250653	GeoTracker	Produced Water Ponds	Open - Inactive	*Chemical information not provided in Geotracker
South Belridge Oil Field, South Wastewater Disposal Facility	SL0602990565	GeoTracker	Produced Water Ponds	Inactive - Permitted	Other inorganic / salt
South Coles Levee Oil Field, SCLU-Section 10 Lease	T10000020110	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Benzene, Crude Oil, Polynuclear aromatic hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPH)
South Coles Levee Oil Field, SCLU-Section 11 Lease	L10001997433	GeoTracker	Produced Water Ponds	Inactive - Unpermitted	Benzene, Crude Oil, Polynuclear aromatic hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPH)
Woodward, Cunning Ham Lease, Midway-Sunset	T10000006949	GeoTracker	Produced Water Ponds	Open - Site Assessment	*Chemical information not provided in Geotracker

This page intentionally left blank.

8.5 Land Subsidence

> ***§ 354.16.*** *Groundwater Conditions*
> *(d) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.*

☑ 23 CCR § 354.16(e)

The San Joaquin Valley has a documented history of subsidence, including historical and recent subsidence across many areas of the Subbasin. Section 8.5.1 presents a summary of historical land subsidence across the subbasin, within each HCM area, and along regional critical infrastructure. Section 8.5.2 identifies the potential various causes of land subsidence in the Subbasin not all of which are within GSA authority. Some examples include the withdrawal of groundwater, hydro-compaction, oil and gas field production, and natural processes such as faulting, compaction, and tectonic down warping. Finally, Section 8.5.3 discusses the rate and extent of subsidence trends observed across the Subbasin.

8.5.1 Historical and Recent Land Subsidence

The San Joaquin Valley has a documented history of subsidence, with the greatest documented subsidence occurring north of the Subbasin where subsidence rates and extent are being influenced by activities in adjacent Subbasins. The following provides a regional summary of land subsidence in the Southern San Joaquin Valley. The discussion includes historical land subsidence occurring in adjacent subbasins to provide context for the regional variability of subsidence with the Subbasin.

8.5.1.1 Historical Land Subsidence 1926 – 1970

Historical land subsidence based on leveling surveys by the National Geodetic Survey was documented by the USGS in the Southern San Joaquin Valley from 1926 to 1970 and is shown on Figure 8-47 (Ireland et al., 1984). Although data represent the accumulated subsidence over a 44-year period, the USGS estimates that about 75 percent of the subsidence occurred in the 1950s and 1960s because of extensive groundwater extraction (Galloway et al., 1999).

Land subsidence for the historical period occurred in two distinct areas: north of Kern County and south of the Kern River (see Figure 8-47). The majority of the Subbasin experienced less than one foot of cumulative subsidence during the historical period. As shown on Figure 8-47, cumulative subsidence north of Kern County along the Subbasin boundary with the adjacent Tule and Tulare Lake Subbasins ranged from 4.0 to 10 feet during the historical period with a maximum subsidence of 12 feet in the Tule Subbasin Figure 8-47. In contrast, cumulative subsidence for this same period was significantly less within the Subbasin with subsidence ranging from 1.0 to 4.0 feet. During the historical period, cumulative subsidence in the area south of the Kern River ranged from 1.0 to 6.0 feet (Ireland et al., 1984). Not all subsidence in the Subbasin is attributable to GSA-related activities.

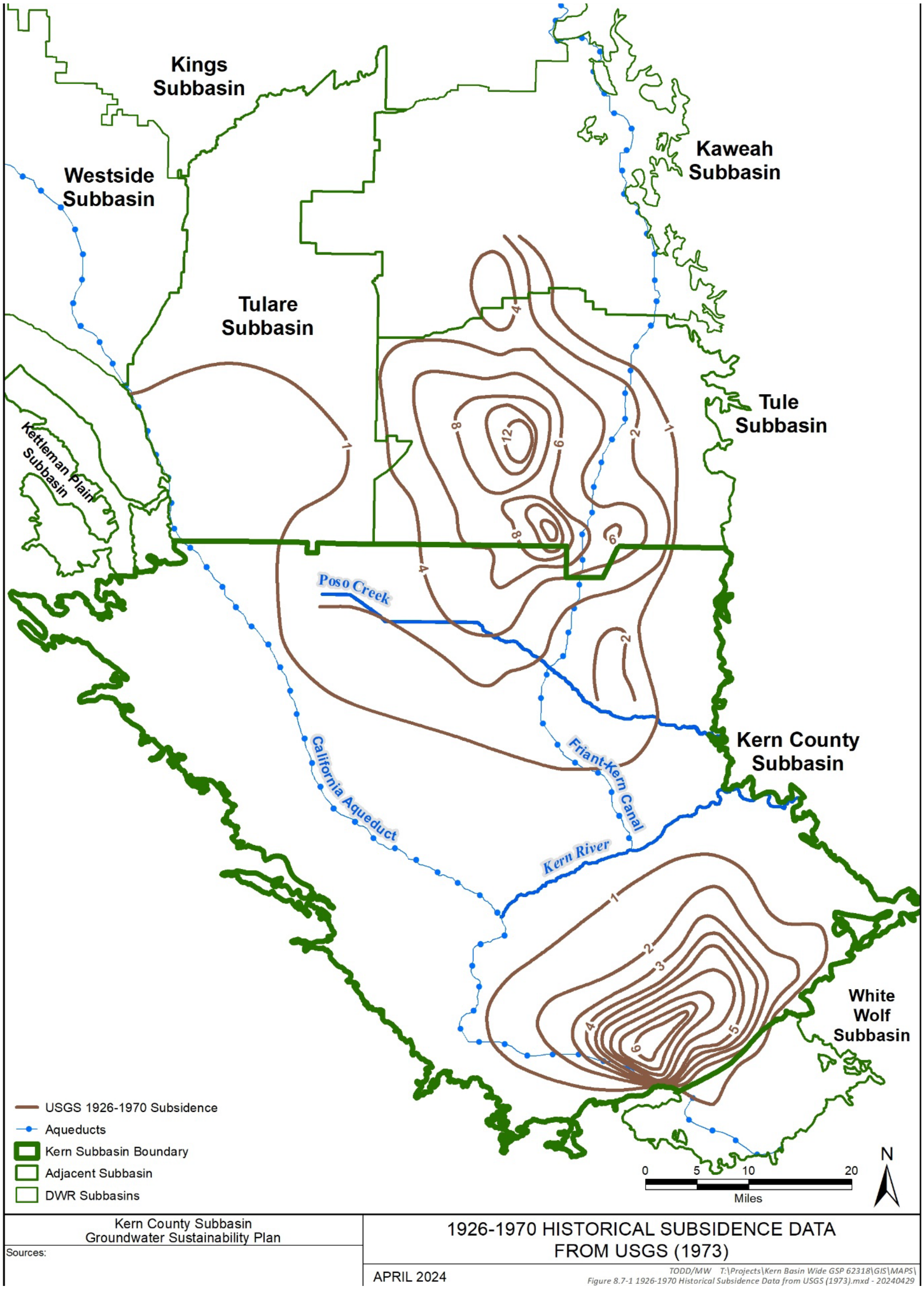


Figure 8-47. 1926-1970 Historical Subsidence Data from USGS (1973)

8.5.1.2 Land Subsidence 2007 to 2019

More recent land subsidence trends based on Interferometric Synthetic Aperture Radar (InSAR) data provided by National Aeronautics and Space Administration - Jet Propulsion Laboratory (NASA-JPL) illustrates total subsidence from 2007 to 2011 and is shown in Figure 8-48**.** (DWR, 2018a, LSCE et al., 2014). Based on the InSAR data, most of the Subbasin has experienced less than 0.5 feet of land subsidence between 2007 through 2011.

Similarly, InSAR data from June 2015 to December 2019 (DWR, 2021) shows cumulative subsidence in the Subbasin was less than 0.5 feet, with a few exceptions related to known oil fields and along the northern boundary of the Subbasin. (Figure 8-49).

8.5.1.3 Land Subsidence 2015 to 2023

The discussion below summarizes InSAR data between October 2015 through September 2023 (DWR, 2024).[1] As shown on Figure 8-50:

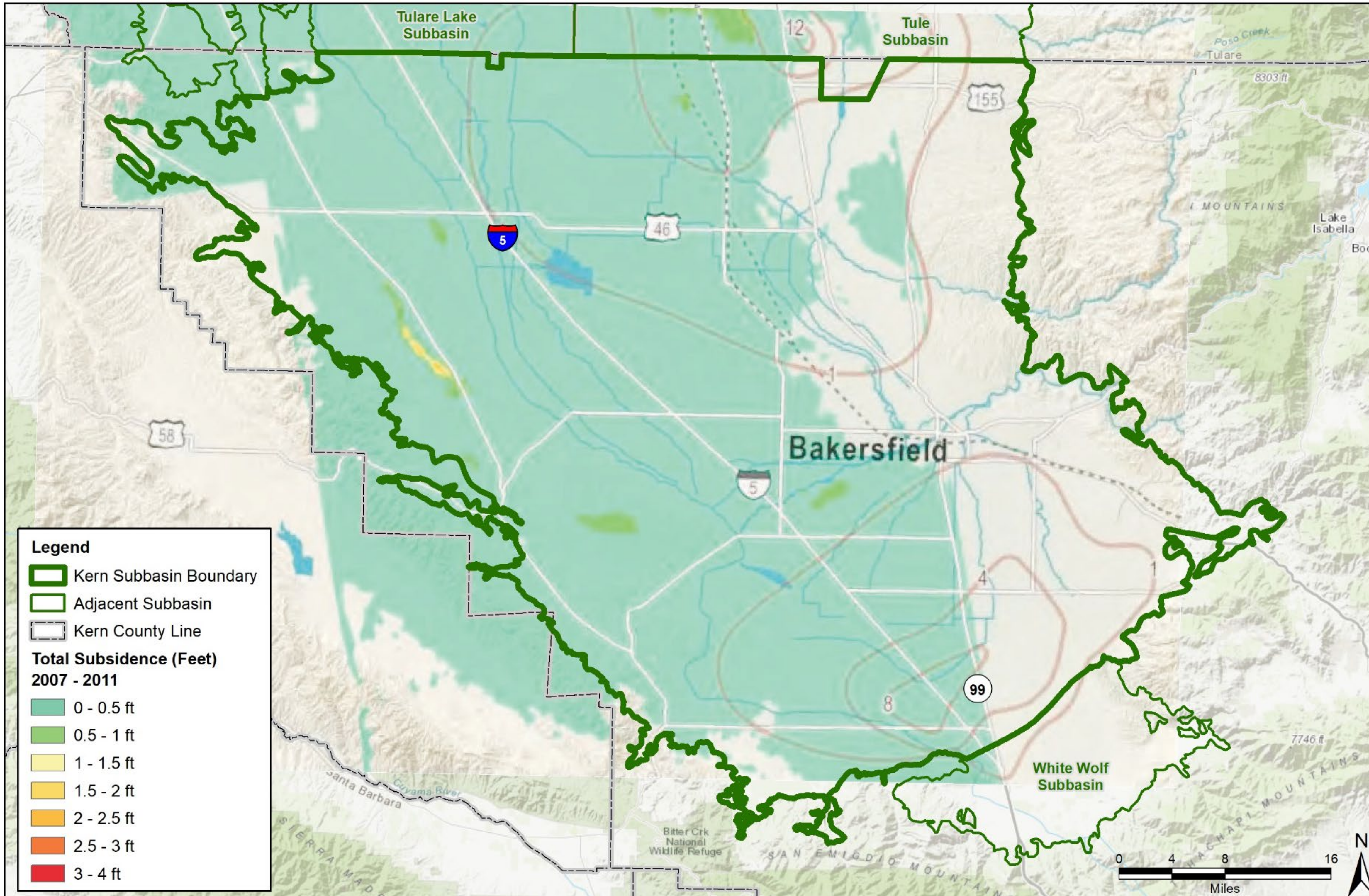
- Maximum cumulative subsidence of 2.0 to 2.41 feet (approximately 3.0 to 3.6 inches/year) has occurred along the northern Subbasin boundary with the Tule Subbasin. This area covers about 3.5 square miles, or about 0.15 percent of the Subbasin.
- Cumulative subsidence ranging from 1.0 to 2.0 feet (approximately 1.5 to 3.0 inches/year) has occurred in scattered areas across the Subbasin, with the largest area along the northern Subbasin boundary. The composite area with subsidence between 1.0 to 2.0 feet covers about 114 square miles, or about 4.8 percent of the Subbasin.
- Cumulative subsidence ranging from 0.33 to 1.0 foot (approximately 0.5 to 1.5 inches/year) borders the scattered areas of higher subsidence across the Subbasin. The composite area with subsidence between 0.33 and 1.0 foot covers about 524 square miles, or about 22 percent of the Subbasin.
- Cumulative subsidence ranging from 0 to 0.33 feet covers a large area of the Subbasin. The composite area with subsidence between 0 to 0.33 feet covers about 1,140 square miles, or about 48 percent of the Subbasin.
- Increases in vertical land displacement ranging from 0 to 0.3 feet occur along the eastern and western margins of the Subbasin. The composite area with

[1] Within the Central Valley, researchers have utilized land-based technology (available GPS and extensometers), and remote sensing techniques such as satellite- InSAR and aircraft-based L-band SAR or Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR). These surveys have been conducted by NASA-JPL, DWR, and the Subbasin. A benefit of remote sensing is that large areas of land can be accurately surveyed with no invasive actions or land surface access complications. DWR has commissioned studies (TRE Altamira, 2019, 2023) to evaluate the accuracy of remote sensing and identify additional processing and calibration methods for accuracy.

increases in vertical land displacement covers about 581 square miles, or about 25 percent of the Subbasin. There are documented non-GSA-related activities in these areas.

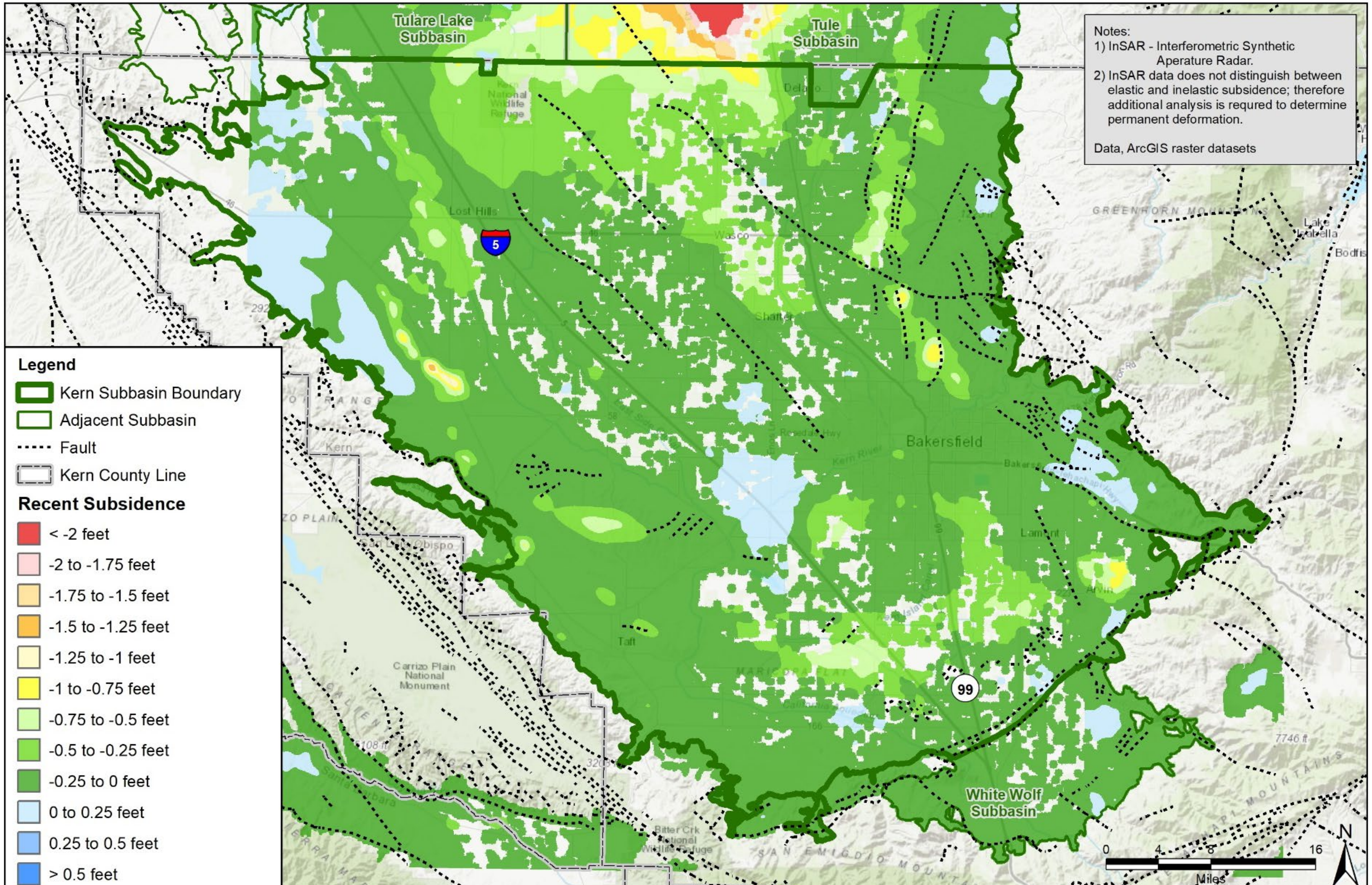
During this period, areas to the north of the Subbasin experienced maximum subsidence of up to about 7 feet (approximately 10.5 inches/year) with certain areas of subsidence ranging from 3 to 7 feet (4.5 to 10.5 inches/year), which is significantly greater than the maximum subsidence in the Subbasin during this same eight-year period.

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	TOTAL SUBSIDENCE FROM 2007 TO 2011 (LSCE ET AL., 2014)
Sources:	APRIL 2024 · TODD/MW T:\Projects\Kern Basin Wide GSP 62318\GIS\MAPS\ Figure 8.7-2 Subsidence 2007-2011.mxd - 20240429

Figure 8-48. Total Subsidence from 2007 to 2011



Kern County Subbasin
Groundwater Sustainability Plan

Sources:
Tre Altamira INSAR Subsidence - (Vertical_Displacement_TRE_ALTAMIRA_v2020_Total_Since_20150613_20200101)

REGIONAL SUBSIDENCE FROM 2015 THROUGH 2019 FROM INSAR DATA

APRIL 2024

TODD/MW T:\Projects\Kern Basin Wide GSP 62318\GIS\MAPS\ Figure 8.7-3 Regional Subsidence from 2015 through 2019 from InSAR data.mxd - 20240429

Figure 8-49. Regional Subsidence from 2015 through 2019 from InSAR Data

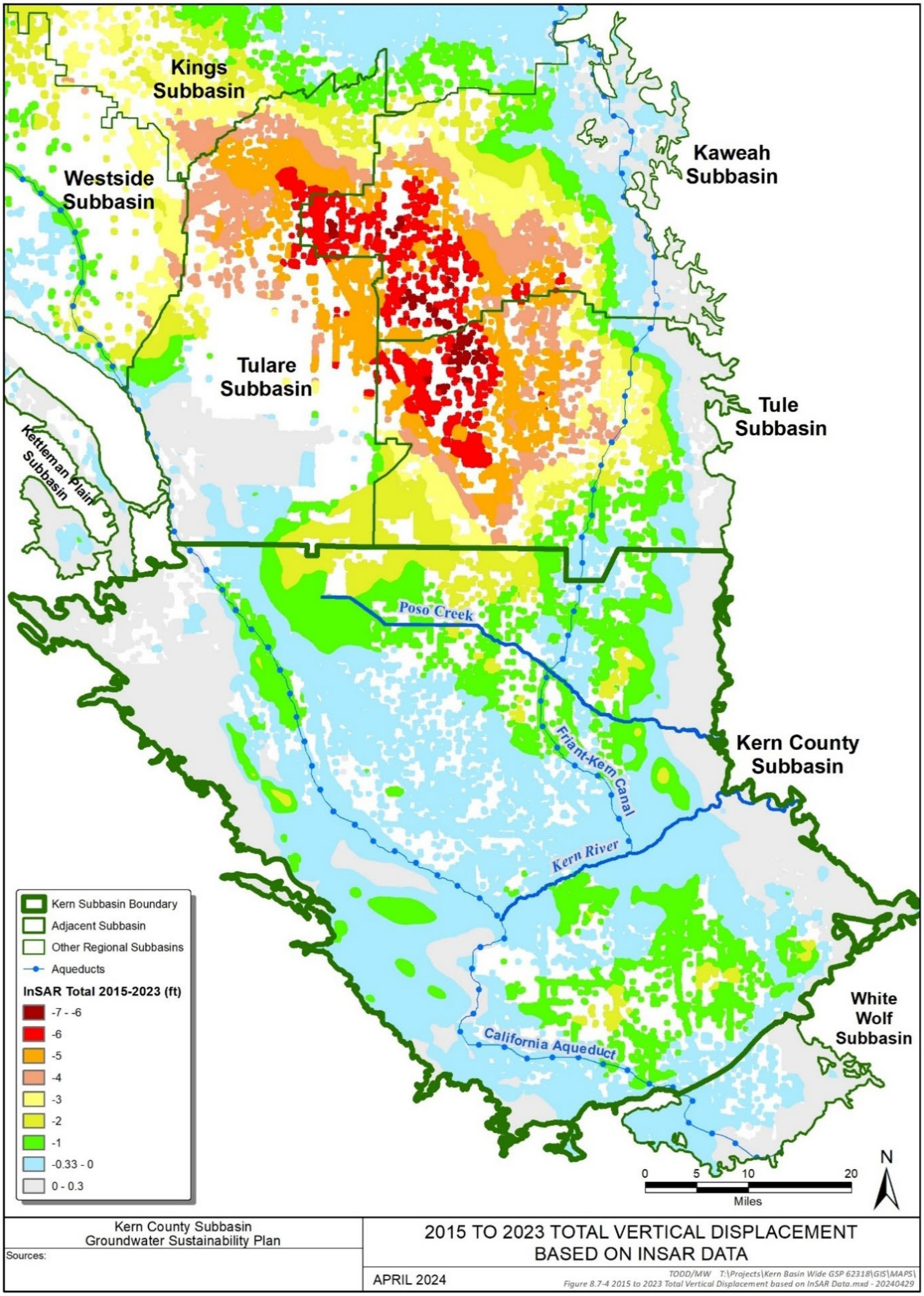


Figure 8-50. 2015 to 2023 Total Vertical Displacement based on InSAR Data

The annual DWR InSAR subsidence data for WY 2016 through WY 2023 is shown on Figure 8-51. In general, the data shows:

- A persistent subsidence bowl north of the Subbasin that expands during dry years.
- Areas of subsidence in the Subbasin during dry years, that are concomitant with known E-Clay distribution, and areas of oilfield activities predominately along the Western Fold Belt HCM and Eastern Margins HCM of the Subbasin.
- Large areas of the Subbasin experience some recovery during wet years.
- Subsidence rates in the Subbasin, with a few exceptions, are generally low.

As shown on Figure 8-51 changes in subsidence rates in the Subbasin, with a few exceptions, been low, historically low, especially when compared to the persistent subsidence bowl to the north of the Subbasin. The activities to the north of the Subbasin have influenced the extent of subsidence in the northern most parts of the Northern HCM.

During the seven-year period between WY 2016 through WY 2023, areas to the north of the Subbasin continued to experience subsidence rates greater than the maximum subsidence observed in the Subbasin during the same period.

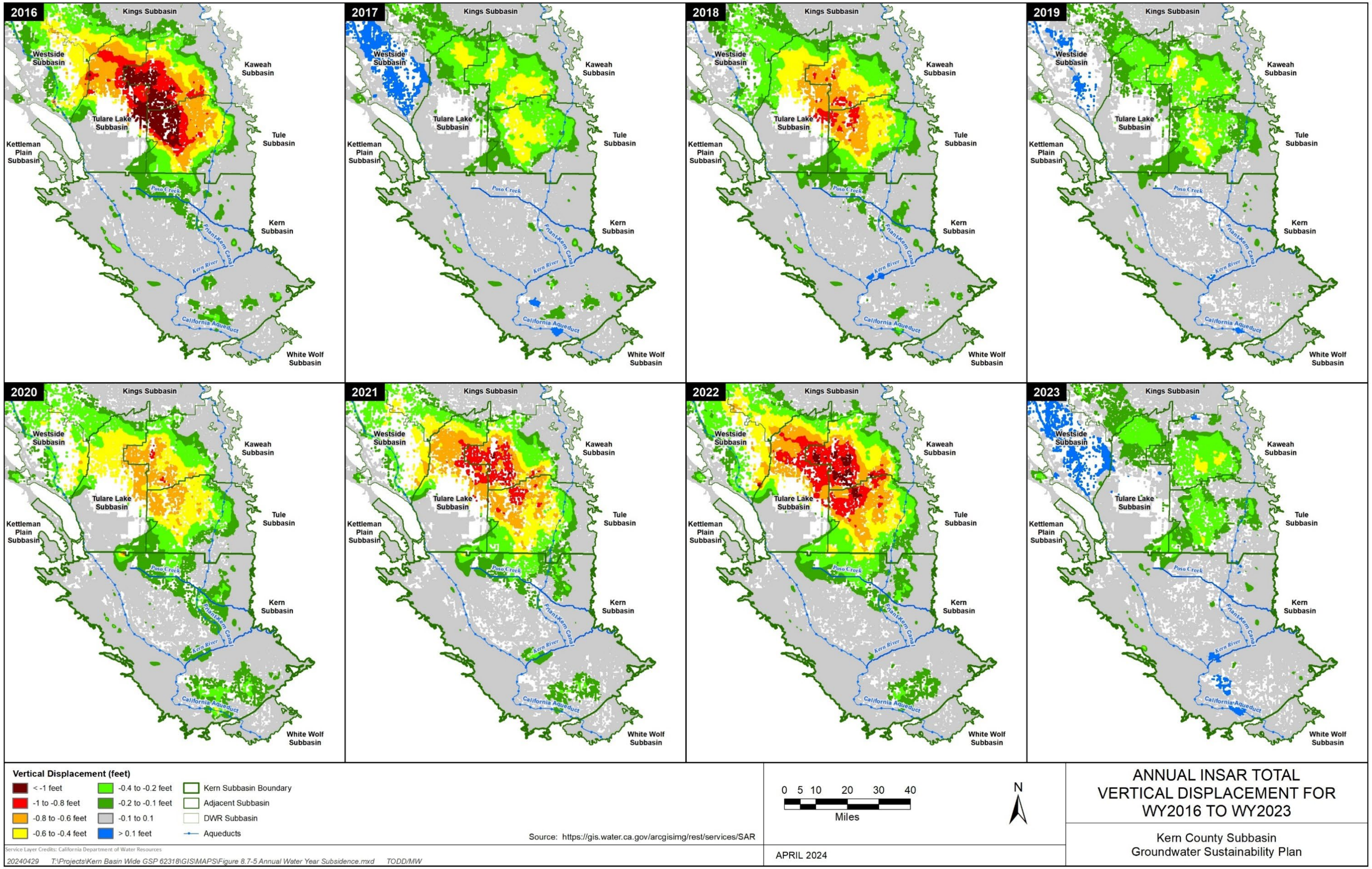


Figure 8-51. Annual InSAR Total Vertical Displacement for WY2016 to WY2023

This page intentionally left blank.

8.5.1.4 Distribution of Subsidence by HCM

As reported in Section 7 of this Plan, the Subbasin is large and geologically complex with regional faulting, folding and three principal aquifers. To help present how this complex geology applies to various components of this Plan, including subsidence, five HCM areas (and one subdivision area) have been defined within the Subbasin to discuss subsidence. These areas include the North HCM Area, the Kern River Fan HCM Area, the South Subbasin HCM Area, the Eastern Margin HCM Area and the Western Fold Belt HCM Area.

Total subsidence between October 2015 through September 2023, as measured by InSAR data (DWR, 2024) for each HCM area, is shown on Figure 8-52. A summary of subsidence trends for each HCM area is discussed below:

- **North Subbasin HCM Area** – Historical subsidence rates in the North Central Basin HCM Area have generally ranged from moderate to low, with occasional higher rates observed during extended dry periods. Moderate or higher rates of subsidence are typically experienced in the area proximal to the Subbasin boundary. In this area, historical pumping in neighboring subbasins to the north has created a large subsidence bowl which propagates into the Subbasin during dry periods when seasonal groundwater extraction rates are apt to increase. Figure 8-57 provides a comparison of recent versus historical subsidence in the Subbasin**.** Because natural groundwater flow in the subsurface is northward toward the axis of the Subbasin, pumping by areas to the north of the Subbasin boundary exacerbates both local groundwater levels and the potential for subsidence in this area. Historical InSAR data in the Subbasin shows that regional wet cycles and/or seasonal reductions in pumping during winter months have the effect of ameliorating the rate of subsidence and allowing for some minor recovery.
- Central Subbasin HCM Area (subdivision of the North Subbasin HCM Area) – Subsidence rates are generally characterized as low.
- **Kern River Fan HCM Area** –The Kern River Fan HCM Area has little clay and exhibits land surface recovery during wet years when water is typically banked. Subsidence rates are generally low to minimal. Like groundwater levels, subsidence in the Kern River Fan HCM Area reflects the influence of seasonal water banking operations.
- **South Subbasin HCM Area** – Historical subsidence rates have ranged from low to moderate in the central parts of the South Subbasin HCM Area, with minimal rates observed closer to the Kern River and along the area’s east and south margins.
- **Eastern Margin HCM Area** – Historical subsidence rates have tended to range from low to minimal in areas away from oilfield operations.

- **Western Fold Belt HCM Area** – Historical InSAR data show that subsidence rates in areas distal to oil field operations have been low to minimal. In proximity to the Aqueduct the subsidence rates are characterized as low although subsidence-related loss of freeboard between Mile Posts (MP) 195 and 215 have been identified. InSAR and other data indicate this subsidence is not related to agricultural groundwater pumping (i.e., non-GSA-related).

The annual rate and cumulative subsidence for the period 2015 to 2023 for the HCM areas was calculated using InSAR data, as shown on Table 8-27

Table 8-27. HCM Subsidence Data

Area Name	WY 2023				
	MIN	MAX	MEAN	Subsidence (ft)	Area (Sq. Miles)
North Basin HCM Area (Upper)	-0.291453	0.126175	-0.006058	-0.4 to -0.2	3.1
				-0.2 to -0.1	34.6
				-0.1 to 0.1	302.4
				> 0.1	10.4
North Basin HCM Area (Lower)	-0.141931	0.135411	0.002966	-0.2 to -0.1	1.2
				-0.1 to 0.1	416.2
				> 0.1	4.8
Western HCM Area	-0.429005	0.079715	-0.009083	-0.6 to -0.4	0.1
				-0.4 to -0.2	1.4
				-0.2 to -0.1	8.1
				-0.1 to 0.1	659.0
Kern River Fan HCM Area	-0.154055	0.210481	0.00598	-0.2 to -0.1	0.2
				-0.1 to 0.1	179.7
				> 0.1	6.8
South Basin HCM Area	-0.167682	0.308578	0.002207	-0.2 to -0.1	4.1
				-0.1 to 0.1	522.7
				> 0.1	40.9
East Margin HCM Area (North)	-0.162174	0.121175	-0.009824	-0.2 to -0.1	6.5
				-0.1 to 0.1	213.7
				> 0.1	1.0
East Margin HCM Area (South)	-0.027064	0.036207	0.007636	-0.1 to 0.1	97.7

1. Negative values indicate a decrease in elevation, while positive values indicate an increase in elevation..

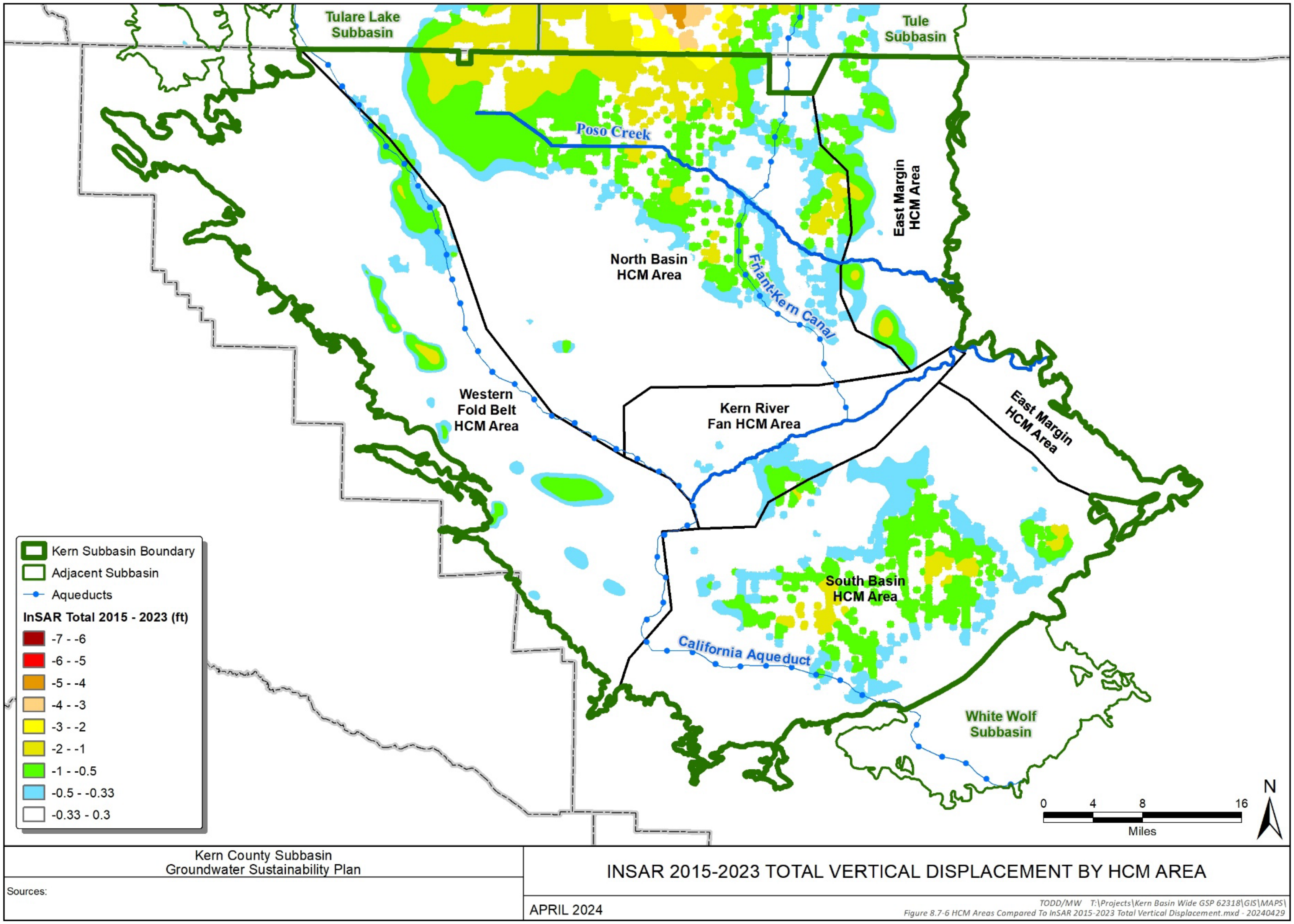


Figure 8-52. InSAR 2015-2023 Total Vertical Displacement by HCM Area

This page intentionally left blank.

8.5.1.5 Land Subsidence in Relation to Critical Infrastructure

Two major water conveyance infrastructure systems traverse the Subbasin -- the California Aqueduct and the Friant-Kern Canal (FKC). The discussion below focuses on land subsidence along the California Aqueduct and FKC. Due to the length of the California Aqueduct and the varied and complex geologic and hydrologic terrain it traverses in the Subbasin, it has been bifurcated in a “northern” and “southern” section as follows. The Northern Aqueduct extends from near the Kern County line southward along the western side of the Subbasin and includes Pools 23 through 30, approximately MP 195 to 250. The Southern Aqueduct, located south of the Kern River, includes Pools 31 to 35 or approximately MP 251 to 278 (Figure 8-53).

This page intentionally left blank.

- California Aqueduct in the North is primarily impacted by non-GSA factors
- California Aqueduct in the South may be impacted by both GSA and non-GSA factors

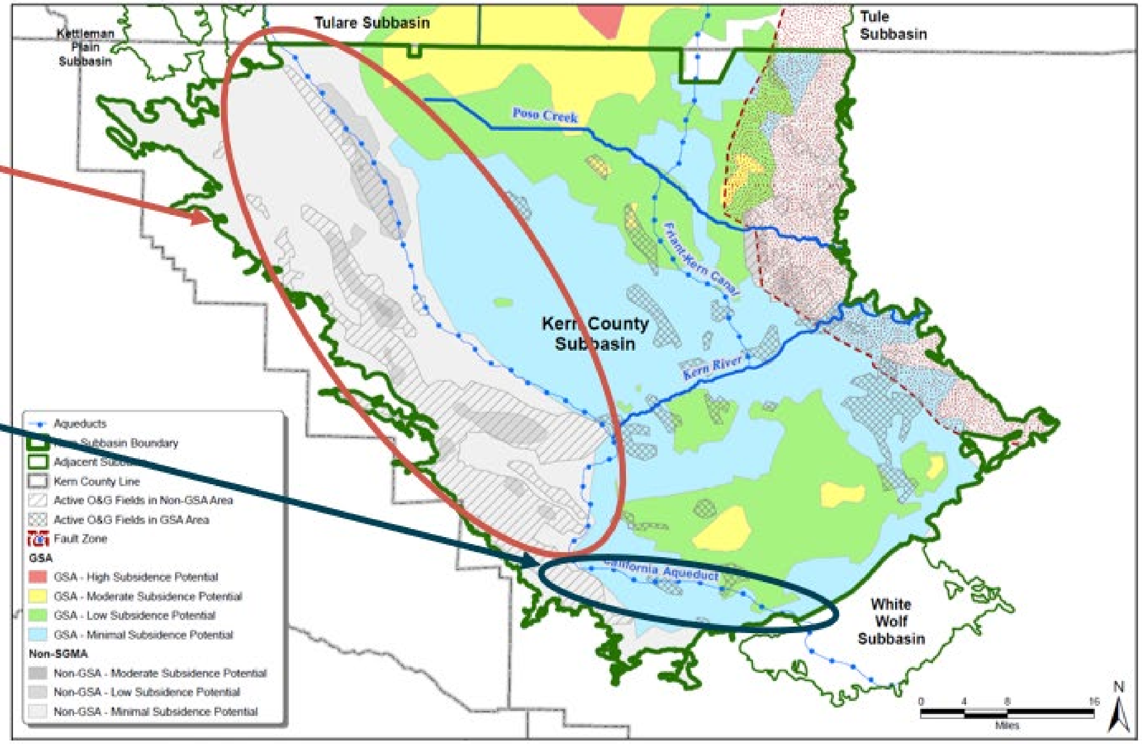


Figure 8-53. Regional Critical Infrastructure #1: California Aqueduct

This page intentionally left blank.

Northern Aqueduct

The "Northern Aqueduct" traverses the Western Fold Belt HCM Area and includes Pools 23 to 30. As reported elsewhere herein, the Western Fold Belt HCM Area is characterized by expansive geologic folding (anticlines) which are dominated by large oil fields and open range land. Agricultural activities are limited due to low precipitation, naturally poor groundwater quality (high TDS) and saline-alkali soils. The principal water source for irrigation is surface water delivered via the Aqueduct. As such, agricultural and domestic groundwater well density is low and only minimal agricultural, domestic, and municipal groundwater pumping occurs. Due to these factors, principal agricultural and municipal water supplies are either imported (e.g., via the Aqueduct) or derived from other HCM areas (e.g., the town of Lost Hills water supply is in the Semitropic GSA).

InSAR data for the period 2015 to 2020 show that, aside from non-GSA-related conditions (e.g. expansive soils, age of infrastructure related geotechnical factors and oil field activities), the potential for subsidence is minimal, with corresponding minimal future subsidence risk (i.e. no vulnerable infrastructure or surface land use). In areas with non-GSA activities such as between MP 195 and MP 215, the potential for subsidence caused by factors within the GSA authority to control is low (refer to Figure 13-21). However, various factors outside the GSA authorities to control (i.e., deficient pre-construction hydro-compaction, expansive soils, oil field activities and age of infrastructure) are thought to be the cause of subsidence leading to operational issues (e.g., loss of freeboard and conveyance capacity) along this reach of the Aqueduct. Data derived from various Subbasin studies pertaining to the rate and cause of subsidence along the northern Aqueduct has been shared with CASP senior management in a series of technical meetings. These issues are further discussed in Section 8.5.2.

Southern Aqueduct

Approximately 22 miles of the Aqueduct, including Pools 31 through 35 from approximately MP 254.5 to MP 278.13 (Teerink Pumping Plant), is defined as the "Southern Aqueduct" which primarily traverses through the South Basin HCM Area. DWR has documented subsidence by milepost of the Aqueduct with a baseline of 1967 or 1969 ground surface elevation and estimated hydraulic impacts of differential settling (DWR, 2017). DWR has noted that between 7.5 and 9.0 feet of land subsidence was observed between 1965 and 1968 as a result of hydro-compaction upon the development of pre-construction ponds along the proposed alignment of the Aqueduct MPs 255.7 – 274.3 (DWR, 2017). Within the Southern Aqueduct, measured values for survey benchmark locations show up to approximately 1.7 feet of settlement from the 1967/1969 baseline through 2013 (DWR, 2017), and up to approximately 1.2 feet of additional settlement between 2013 and 2017 (DWR, 2019).

InSAR data and yearly benchmark surveys completed by SWP California Aqueduct Subsidence Program (CASP) were used to assess recent (i.e., post-SGMA) subsidence in the southern pools (see Figure 8-54). InSAR data show that over the 2015 to 2021 period, cumulative subsidence along the Southern Aqueduct ranged from less than 0.1 feet to almost 0.7 feet. Similarly, yearly benchmark surveys suggest that from 2016-2023, cumulative subsidence ranged from 0.2 to 0.75 feet (see Figure 8-55).

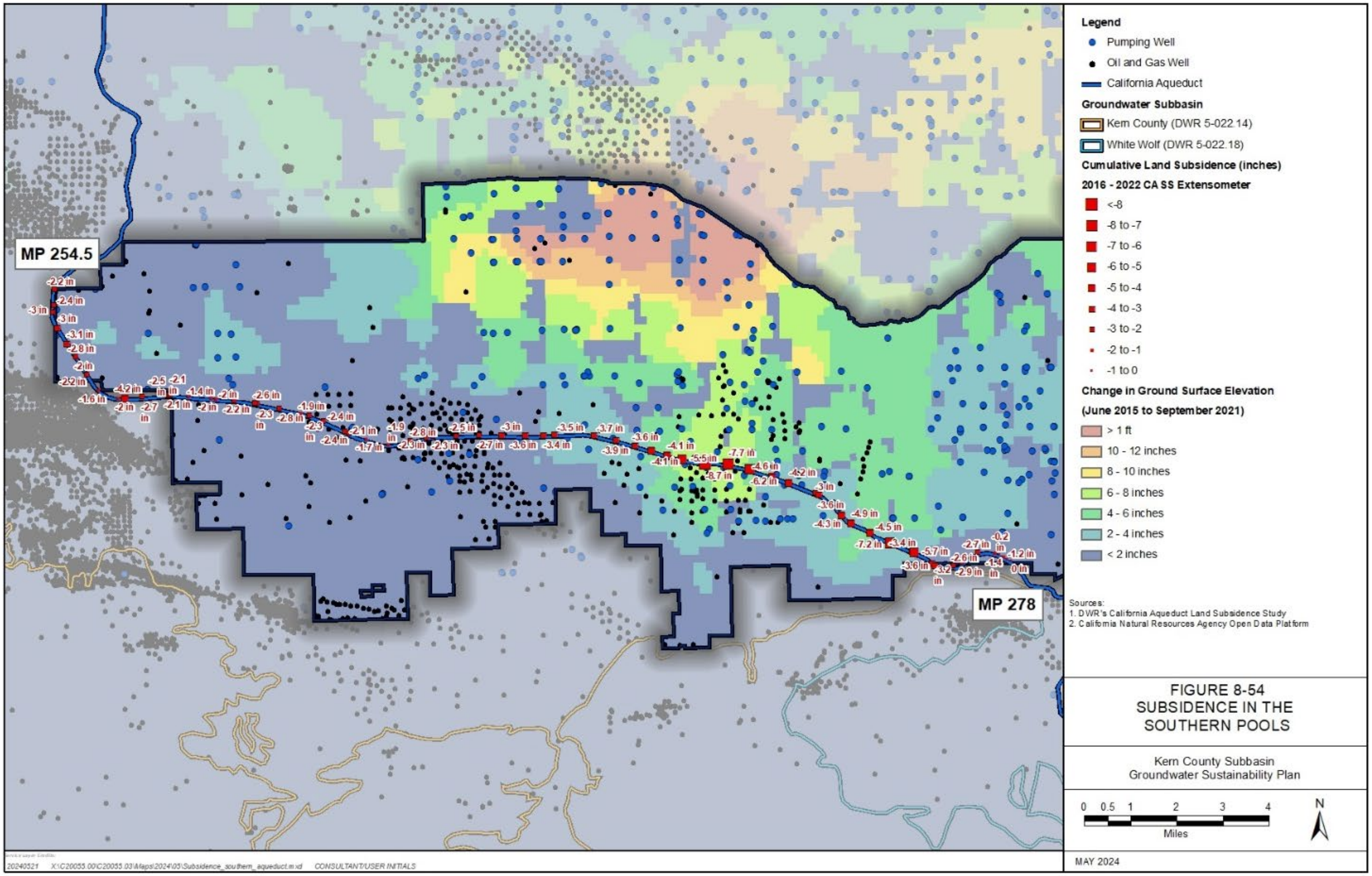


Figure 8-54. Subsidence in Southern Pools

This page intentionally left blank.

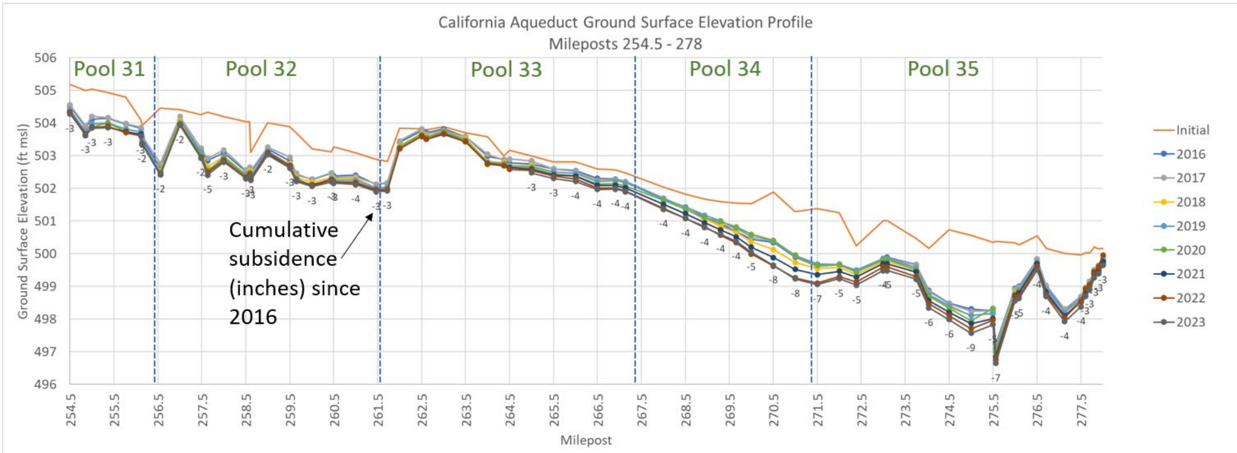


Figure 8-55. Cumulative Subsidence Southern Pools 2016 to 2023

Friant-Kern Canal

The FKC facilities include the Friant Dam (Millerton Reservoir) completed in 1944, and the 152-mile FKC completed in 1951. On average, the canals deliver 1.2 million AF of irrigation water annually to more than 15,000 farms on over one million acres of the most productive farmland in the world (FWA, 2020). The Friant Division was designed and is operated as a conjunctive use project to convey surface water for direct beneficial uses, such as irrigation and municipal supplies, and to recharge groundwater basins in the southern San Joaquin Valley. The ability to move significant water through the Friant Division's canals in wetter years to store in groundwater recharge basins is critically important for the project to work as intended. These operations sustain the primary source of drinking water for nearly all cities, towns, and rural communities on the Valley's East side (FWA, 2020).

Within Kern County, the FKC extends from approximately MP 122 at the Kern County line and flows south for approximately 30 miles to MP 152 near Bakersfield, California. Figure 8-56 displays the location of the FKC, cumulative vertical surface deformation in feet from June 2015 to October 2023 as measured by InSAR satellite data within the Subbasin and corresponding cumulative subsidence in feet along the profile of the FKC for select years from 2017 to 2023 (TRE ALTAMIRA 2023). The maximum amount of measured subsidence in the Subbasin from 2015 to 2023 is 2.4 feet with the greater amount of subsidence in the northern part of the Subbasin in a depression along the County boundary with Tulare County.

According to the FKC profile, the maximum subsidence from 2015 to 2023 is about 0.9 feet between MP 133.43 and MP 135.45 (Figure 8-56).

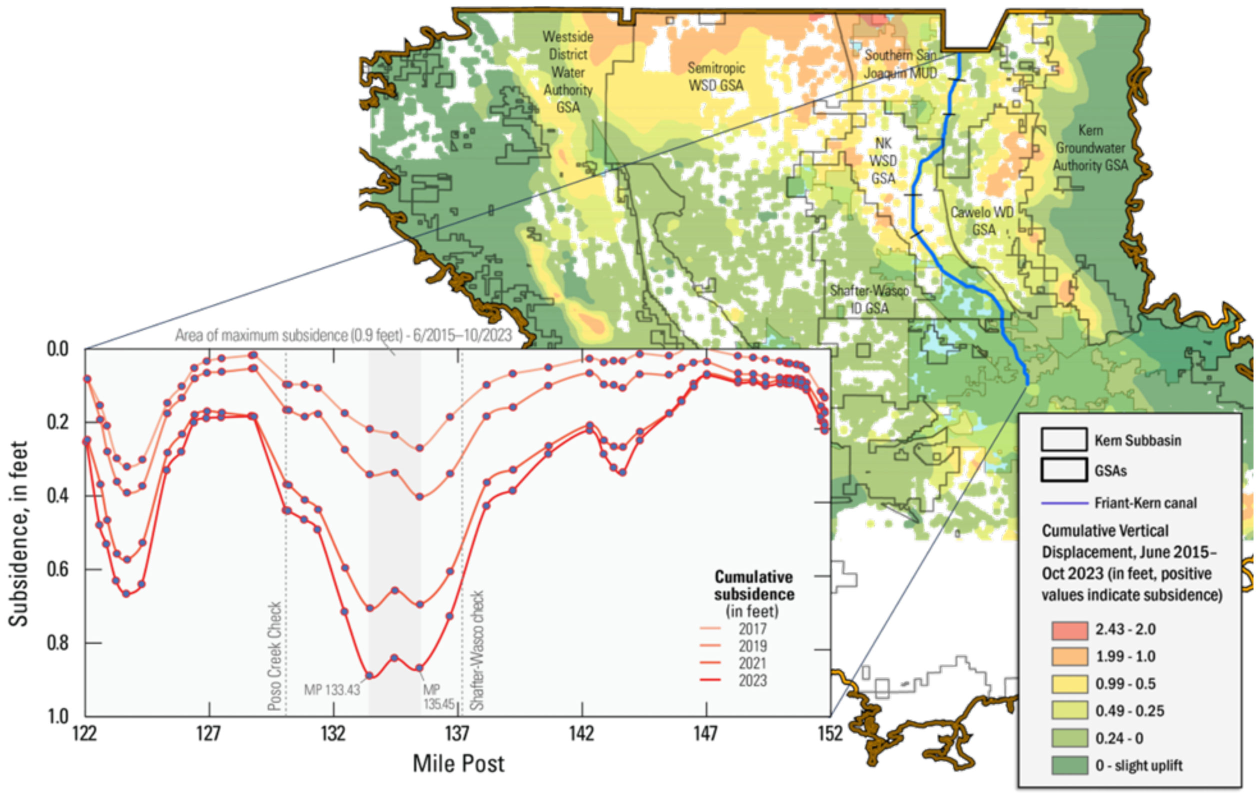


Figure 8-56. Kern Subbasin Cumulative Subsidence 2015 to 2023 and FKC Subsidence Profile (INTERA 2024)

8.5.2 Causes of Subsidence

Land subsidence is often caused by dewatering of subsurface clays and other fine-grained sediments. This process is illustrated by two conceptual diagrams shown on Figure 8-58. The upper diagram depicts an alluvial groundwater basin with a regional clay layer and numerous smaller discontinuous clay layers. Water level declines associated with pumping cause a decrease in water pressure within the pore space (pore pressure) in the aquifer system (Galloway et al., 1999). Since the water pressure in the pores helps support the weight of the overlying aquifer, the pore pressure decrease causes more weight of the overlying aquifer to be transferred to the grains within the structure of the sediment layer. The difference between the water pressure in the pores and the weight of the overlying aquifer is termed the effective stress. If the effective stress borne by the clay sediment grains exceeds the structural strength of the sediment layer, the aquifer system begins to deform. This deformation consists of rearrangement and compaction of fine-grained units as illustrated on the lower diagram of Figure 8-58.

To assess the causes of subsidence, the Subbasin has conducted a series of studies in communication with DWR and CASP. The studies incorporated data from published academic and government studies and reports, oil field aquifer exemption applications prepared for the California Geologic Energy Management Division (CalGEM) and the

U.S. Environmental Protection Agency (USEPA), DWR InSAR data, and InSAR studies conducted by Lawrence Berkeley National Laboratory (LBL) and Earth Consultants International (ECI) on behalf of the Subbasin. Two key takeaways from these studies are 1.) it is possible using InSAR to discern the difference between subsidence due to seasonal (cyclical) groundwater extraction and subsidence caused by non-seasonal extraction (i.e. long term) activities not under the control of Subbasin GSAs and, 2.) a risk-based methodology is best suited to accommodate Subbasin complexities and SGMA objectives pertaining to the monitoring and assessment of subsidence.

Subsidence in the Subbasin is driven by multiple factors, chief among these is agricultural and municipal pumping, which are within the GSAs authority to manage and are therefore referred to herein as "GSA-related" factors. Other factors not under the control or authority of Subbasin GSAs include expansive soil types susceptible to hydro-compaction, oil field activities, age (lifespan) of critical infrastructure, historical pre-construction geotechnical deficiencies (e.g., lack of hydro-compaction on the Aqueduct) and subsidence caused by natural processes (e.g., faulting, compaction, and tectonic down warping). For convenience, these other factors are collectively referred to herein as "non-GSA" factors.

8.5.2.1 Land Subsidence Caused by Factors Within the GSAs Authority

Groundwater Pumping Induced Land Subsidence (GSA related)

Although extraction of groundwater by pumping wells causes a more complex deformation of the aquifer system than discussed herein, the simplistic concept of vertical compaction is often used to illustrate the land subsidence process (Galloway et al., 1999; LSCE et al., 2014). The tabular nature of the fine-grained sediments allows for preferred alignment and compaction. As the sediments compact, the ground surface can sink, as illustrated by the 2nd column on the lower diagram of Figure 8-58.

Land subsidence due to groundwater withdrawals can be temporary (elastic) or permanent (inelastic). Elastic deformation occurs when sediments compress as pore pressures decrease but expand by an equal amount as pore pressures increase. A decrease in water levels from groundwater pumping causes a small elastic compaction in both coarse- and fine-grained sediments; however, this compaction recovers as the effective stress returns to its initial value. Because Subbasin deformation rates may exhibit some small recovery during wet years and rates have been generally low impacts with few exceptions, have been relatively minor with no significant interference to infrastructure or other beneficial use.

Figure 8-59 presents the C2VSimFG-Kern modeled extent of groundwater pumping (i.e., agricultural and municipal) overlaid on the DWR cumulative subsidence for the period 2015 to 2023. The area of modeled concentrated groundwater pumping, which includes Subbasin GSA Annual Report data, correlates with areas of historical subsidence (i.e., pre-2015). There is also a clear correlation with more recent InSAR data for the period 2015 to 2023. It should be noted that other areas (e.g., west of the Aqueduct and along the east side of the Subbasin) have undeveloped range land and/or oilfields and thus little or no GSA-related groundwater pumping. In addition, and as noted previously, groundwater quality in the western portion of the Subbasin is naturally degraded by high TDS, which also limits groundwater pumping.

8.5.2.2 Land Subsidence Caused By Factors Outside the GSAs Authorities

Historical Oil Field Land Subsidence

Figure 8-60 shows the relationship between subsidence and oil field operations in the Subbasin from 2015 to 2023. InSAR data clearly demonstrate that subsidence and oil field activities are concomitant along the Subbasin margins (Western Fold Belt, South Subbasin and Eastern Margin HCM areas) and with some oil fields in the center of the Subbasin. Subsidence due to oil field operations has been documented in various studies across the Subbasin:

- At the Kern Front and Poso Creek oil fields on the order of 1 foot based (Castle et al., 1983).
- Based on InSAR data collected by the European Space Agency's Remote Sensing Satellites, a maximum subsidence rate as high as 40 mm (1.57 in) in 35 days, or more than 400 mm/year (15.748 in/yr), was measured in the Lost Hills and Belridge oilfields. This data demonstrates the spatial and temporal dynamics of subsidence due to oil extraction from diatomite reservoirs (Fielding, Blom, & Goldstein, 1998).
- Another study involved operational acquisition of repeat-pass InSAR data since late 1998 to monitor subsidence rates, validated with GPS monument survey measurements. This ongoing monitoring reflects changes due to field development and operational practices (Kooij & Mayer, 2002).
- A related study highlighted that during a 105-day period, the subsidence in the center of the Lost Hills field reached 15 cm (5.91 in), attributed to vertical shrinkage of the reservoir from oil production and resulting pore pressure drops. This measurement was possible using spaceborne InSAR, indicating the feasibility of monitoring hydrocarbon production through satellite-based earth deformation measurements (Xu, Dvorkin, & Nur, 2001).

Natural Causes of Land Subsidence

Figure 8-61 presents the areas with known mapped faults in the Subbasin. With a few exceptions, most faults are concentrated on the east and west margins of the Subbasin. The Kern Front and Premier (Poso Creek) faults are known to have sustained historical rupturing (Castle, 1983). Deep-seated tectonic settling or down warping in the North

Basin HCM Areas (i.e., synclinal axis of the of the Subbasin) also contribute to subsidence over the long term. Other natural causes such as expansive soils and hydro-compaction, found mainly on the west side of the Subbasin, cause embankment failure and other geotechnical issues for water conveyance infrastructure (Lofgren 1975).

Other Non-GSA Causes of Land Subsidence

Six studies have been conducted in the Subbasin utilizing InSAR and other data to assess the causes of subsidence along a portion of the Aqueduct (MP 195 to 215). These studies found that various factors not under the control of the Subbasin GSAs were primarily responsible for the observed subsidence. These factors include expansive soils, deficient Aqueduct pre-construction hydro-compaction, oilfield activities and age of the infrastructure. The findings from the six studies were shared with CASP and DWR. The Subbasin has identified other areas on the Aqueduct (e.g., Yowlumne Oil field) that are likely experiencing non-GSA related subsidence. These areas will be the subject of future monitoring and studies in cooperation with CASP.

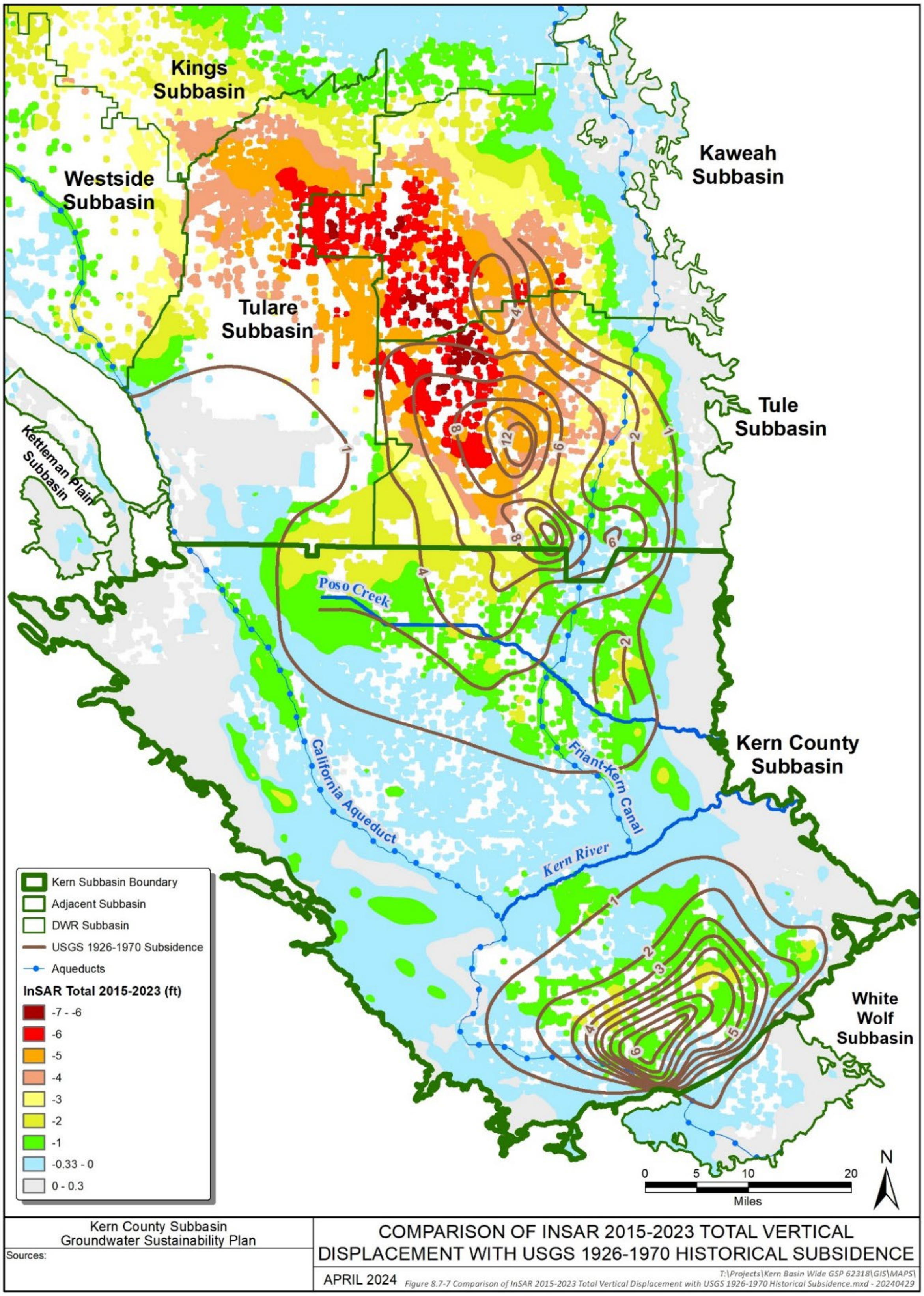
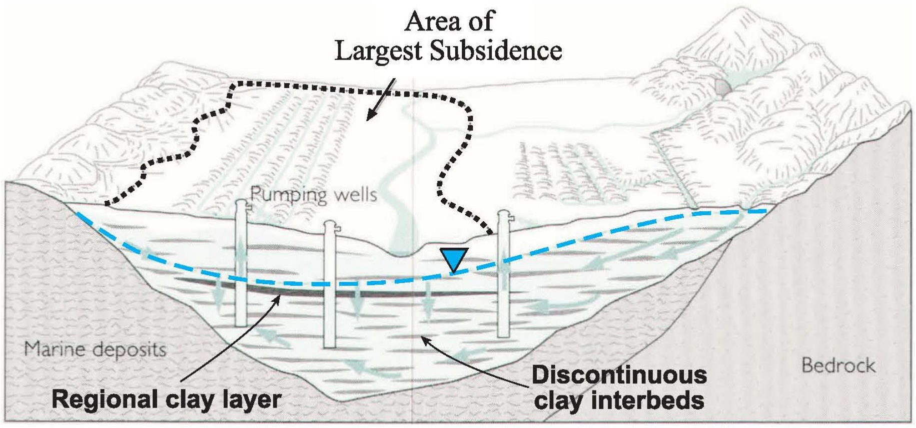
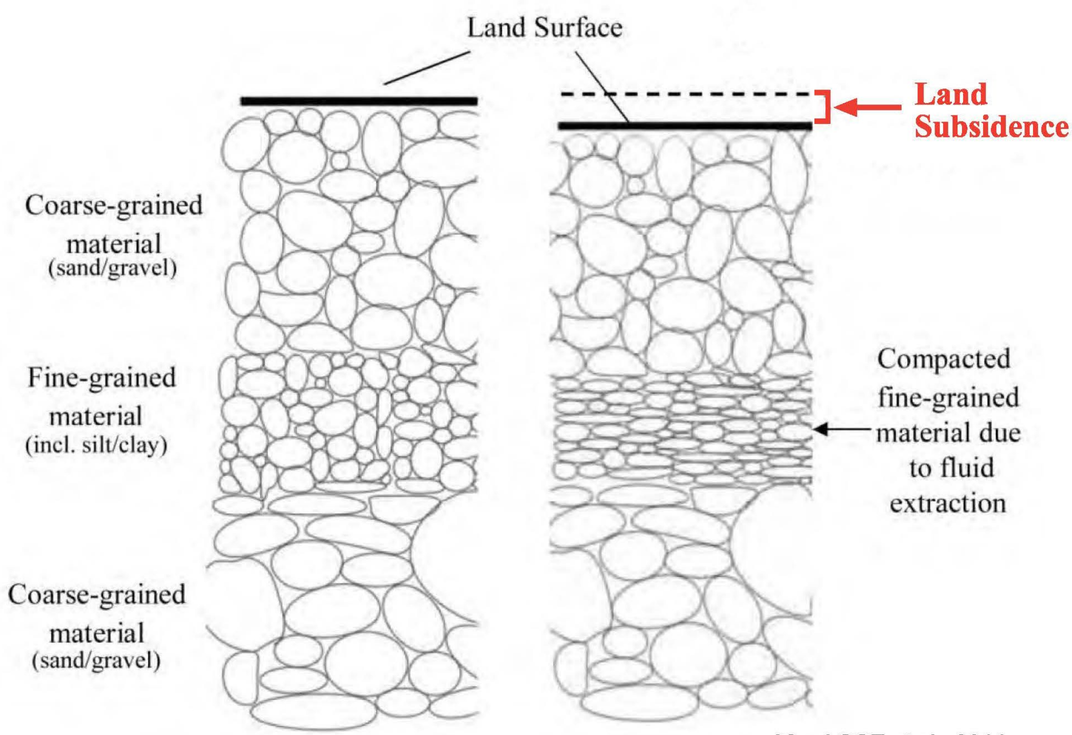


Figure 8-57. Comparison of InSAR 2015 to 2023 Total Vertical Displacement with USGS 1926-1970 Historical Subsidence



Source: Galloway et al., 1999.



After LSCE et al., 2014.

January 2024

TODD GROUNDWATER

Figure 8.7-7
Concepts of
Land Subsidence

Figure 8-58. Concepts of Land Subsidence

This page intentionally left blank.

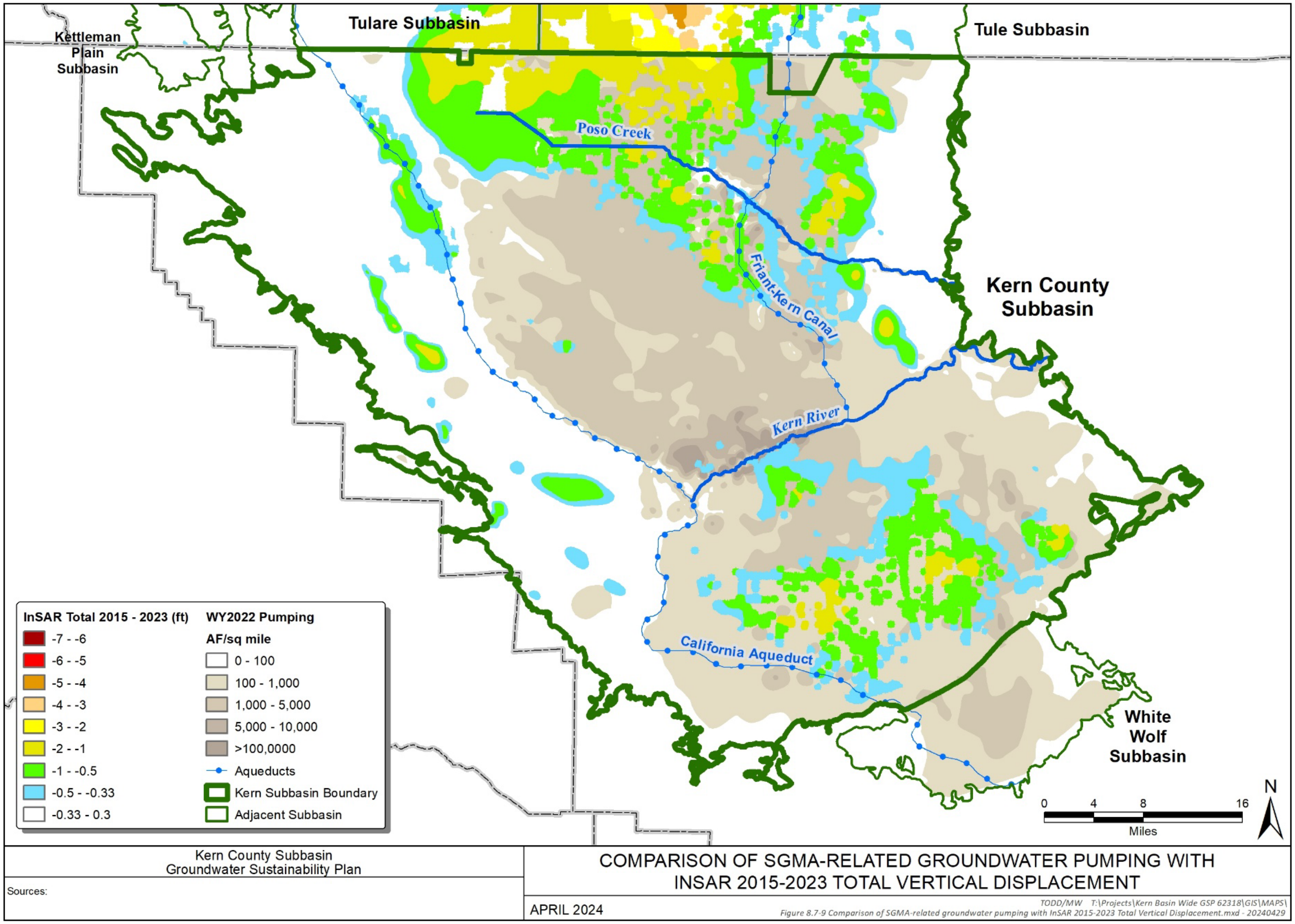


Figure 8-59. Comparison of Groundwater Pumping With InSAR 2015 to 2023 Total Vertical Displacement

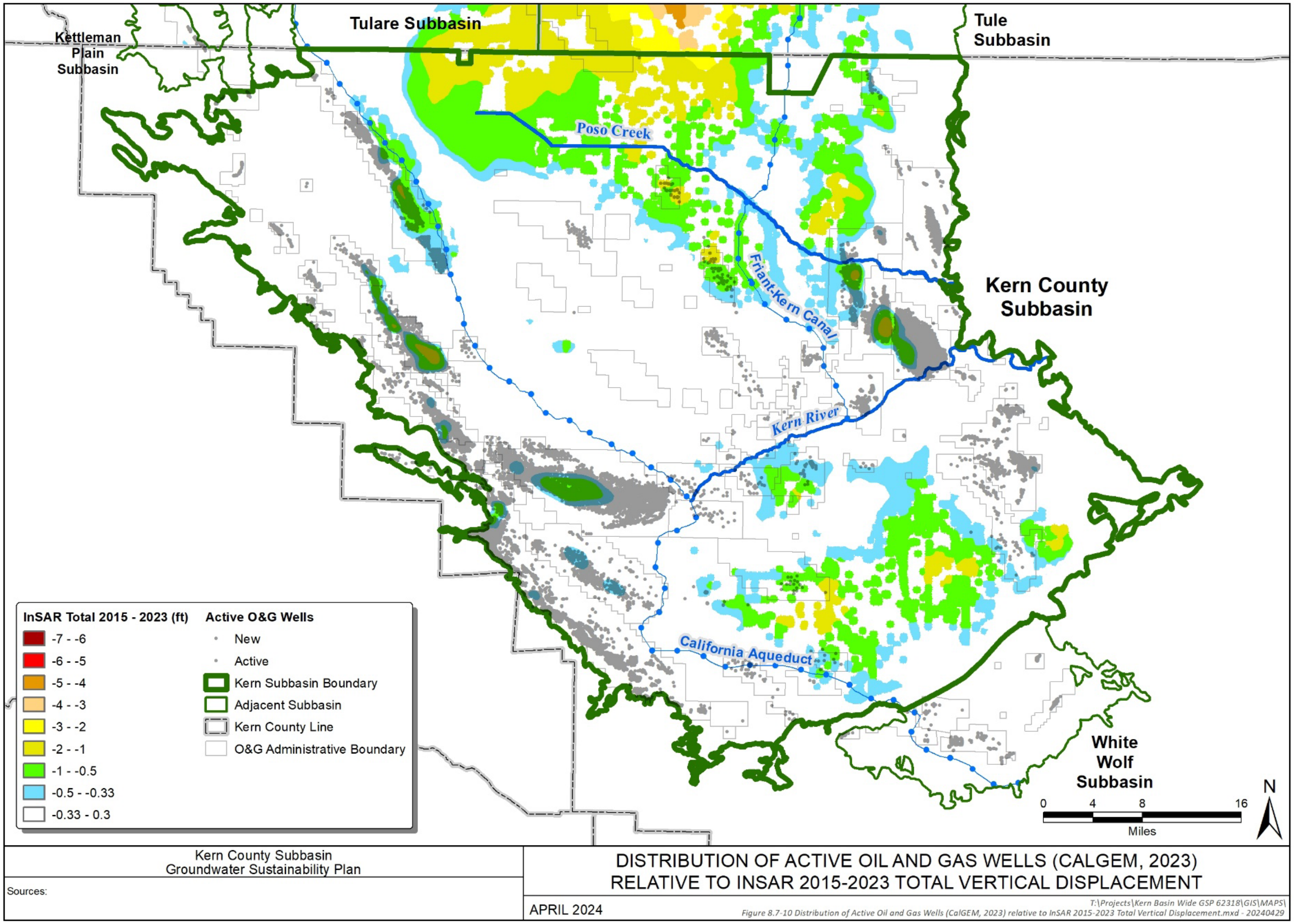


Figure 8-60. Distribution of Active Oil and Gas Wells (CalGEM, 2023) Relative to InSAR 2015 to 2023 Total Vertical Displacement

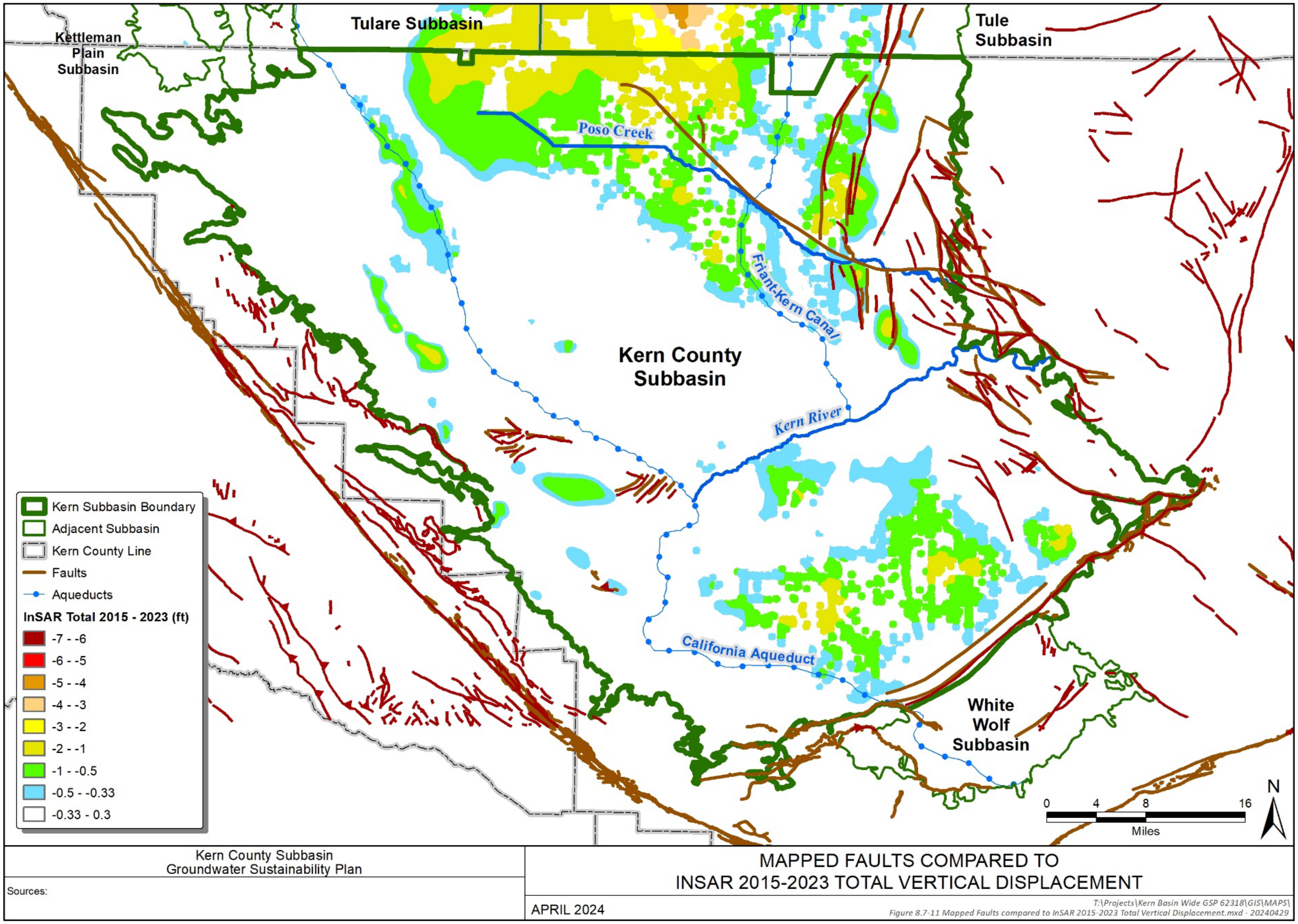


Figure 8-61. Mapped Faults Compared to InSAR 2015 to 2023 Total Vertical Displacement

This page intentionally left blank.

8.5.3 Magnitude of Subsidence

The magnitude of subsidence (rate and cumulative total) in the Subbasin was assessed using DWR InSAR data, historical benchmark survey data along the California Aqueduct and FKC, and by the six subsidence studies conducted by the Subbasin mentioned above. The focus of these studies was determining the cause, rate and extent of subsidence.

To assess the presence and potential subsidence effects of GSA versus non-GSA pumping, the Subbasin first identified five Areas of Interest (AOIs) for focused subsidence monitoring (Figure 8-62). The AOIs are:

- AOI-1 Friant Kern Canal Mile Post (MP) 120-130
- AOI-2 Aqueduct MP 195-215
- AOI-3 Friant-Kern Canal MP 130-137
- AOI-4 Aqueduct MP 262-267
- AOI-5 Northern Area near the town of Delano

InSAR time series are a proven and reliable method for evaluating the annual and cumulative InSAR satellite line-of-sight land subsidence. The following InSAR time series were extracted in each of the AOIs:

- One time series each was extracted in AOI-1 and AOI-3, both assessing the Friant-Kern Canal in agricultural areas.
- Three time series were extracted in AOI-2, sited across the Aqueduct and the adjacent Lost Hills Oil Field.
- Two time series were extracted in AOI-4, one across the Aqueduct and adjacent Yowlumne Oil Field, and the other across the Aqueduct in an agriculture area.
- One time series was extracted in AOI-5 near the town of Delano.

Using InSAR time series it is possible to differentiate between different types of extraction actives. As previously reported, agricultural pumping (e.g., a GSA-related type of extraction) has a seasonal pattern that is discernible in InSAR data as a sine wave-like pattern over a period of extended time.

To assess the potential for future subsidence and demonstrate the ability to discern between SGMA (GSA) and non-GSA-related subsidence, eight InSAR time series were extracted from available InSAR data. The current time series transects depict annual rates and cumulative displacement between 2019 and 2022. The placement of the transects evaluates identified regional critical infrastructure. (Figure 8-63). For orientation purposes, markers showing the location of canals, major roads and oil fields etc., were inserted into the time series transects. Extraction of transects and raster calculations for conversion between millimeters and inches were done with Quantum GIS (QGIS). The resulting text files with the cross sections were subsequently plotted with the Generic Mapping Tools (GMT) software. A similar technique was used when extracting data from the interferometric stacks. GMT was used to extract the deformation values stored in the InSAR pixels at chosen geographic locations in the raster files that make up the interferometric stack, then transferring the values to text files. These text files were subsequently plotted in GMT together with data from the nearby continuously operating GPS stations used to ground-truth the data. The time series data was also used to create pseudo-3d sections (aka wireframe diagram) showing displacement along the transects over time (Figure 8-64 through Figure 8-71). These graphs were created in Golden Software's "Surfer" software package by letting the X-axis representing distance along the transect, the Y-axis representing displacement and the Z-axis representing time since the start of the time series.

Figure 8-71 provides an example of agricultural pumping (i.e., GSA-related) times series signal. In this time series all the time series lines are in harmony and have a shape indicative of seasonal pumping activities.

By contrast, non-seasonal pumping, for example oilfield activities near Aqueduct MP 204, tend to have a "busy" or "noisy" less sinuous pattern and a steeper declining slope reflecting non-seasonal (i.e. full time) pumping. Figure 8-66 provides an example of a non-GSA time series signal. In this example the red line represents InSAR timeseries data extracted at a point on the crest of the oil field anticline. The blue and green time series lines were extracted at locations proximal to either side (east and west) of the anticline crest. All the time series lines exhibit the same "busy" character and mimic the data extracted from the crest of the oil field (red line).

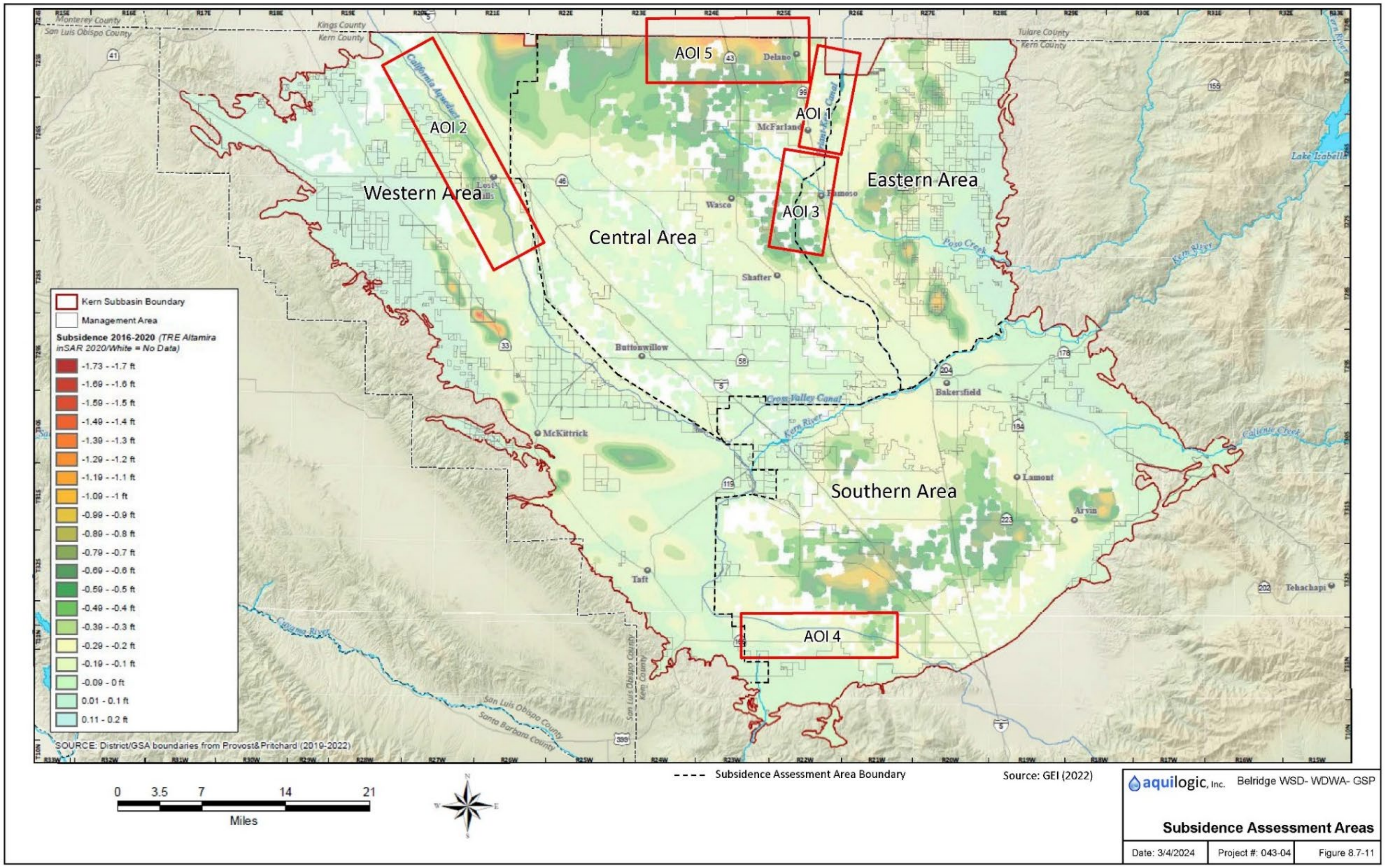


Figure 8-62. Subsidence Assessment Areas'

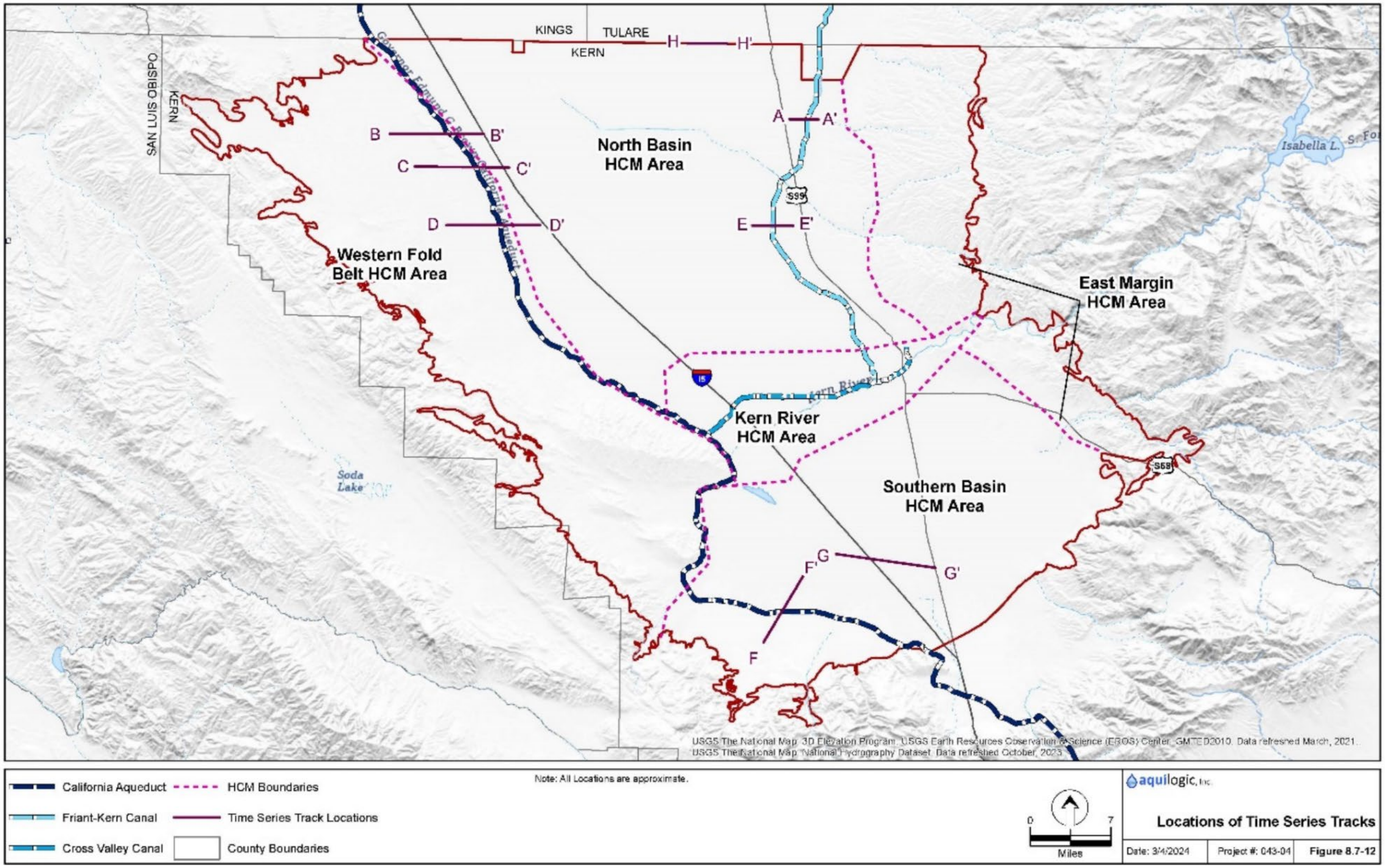
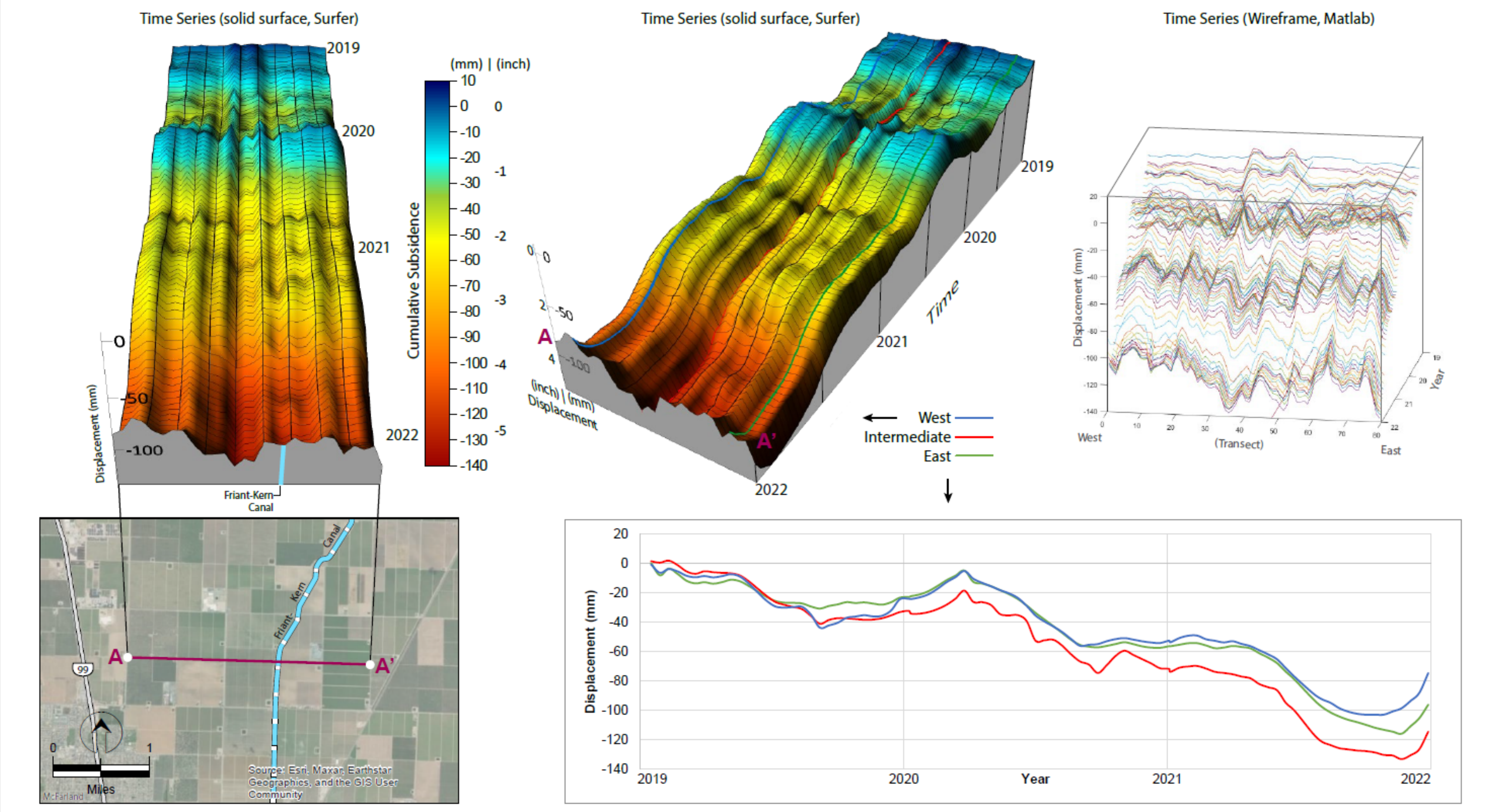


Figure 8-63. Location of Time Series Tracks



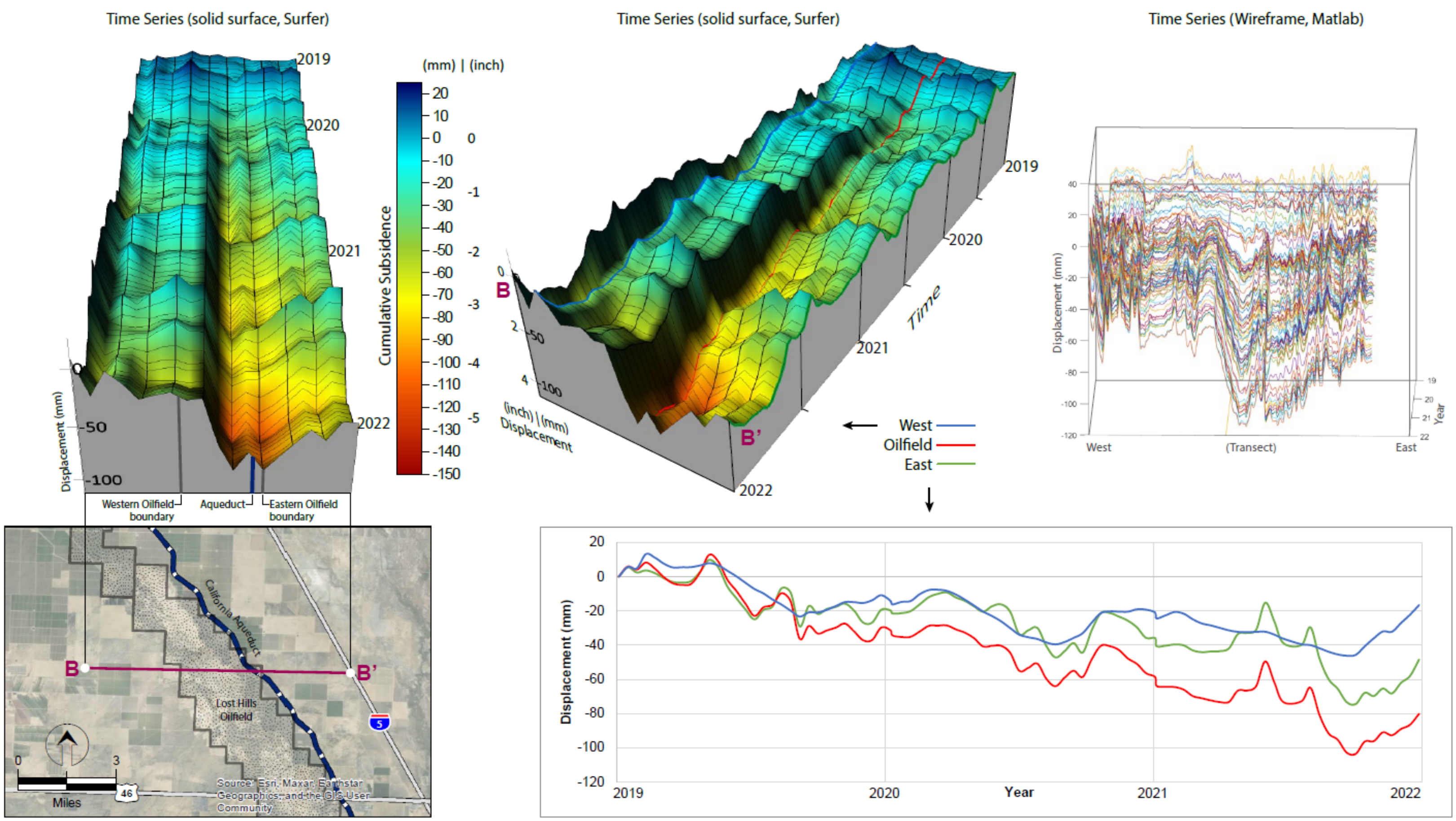
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series for AOI-1 Track A-A'

Kern County Subbasin Groundwater Sustainability Plan

Figure 8-64. Time Series for AOI-1 Track A-A'



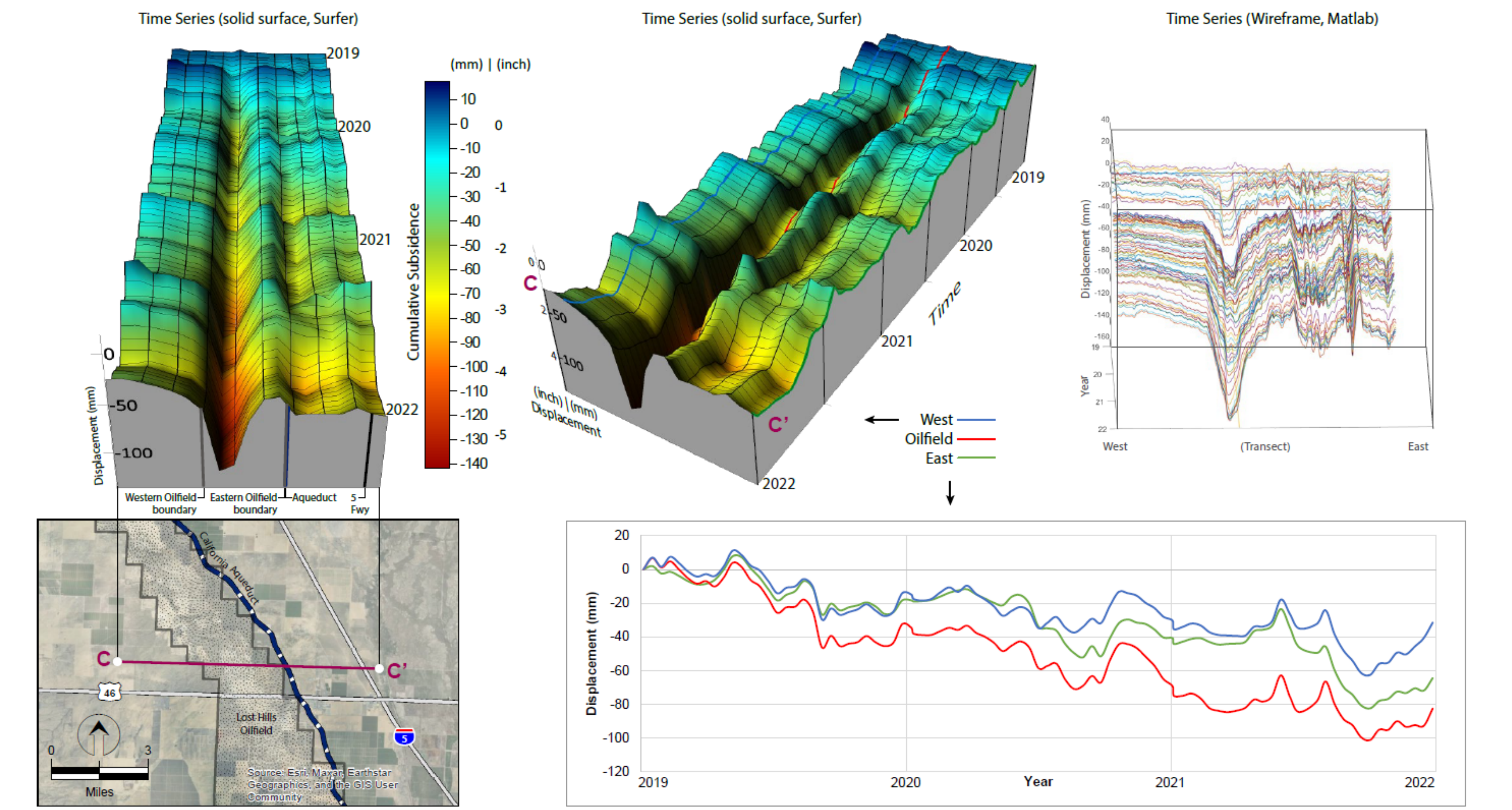
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series for AOI-2
Track B-B'
Aqueduct Milepost 200

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-65. Time Series for AOI-2 Track B-B' Aqueduct Milepost 200



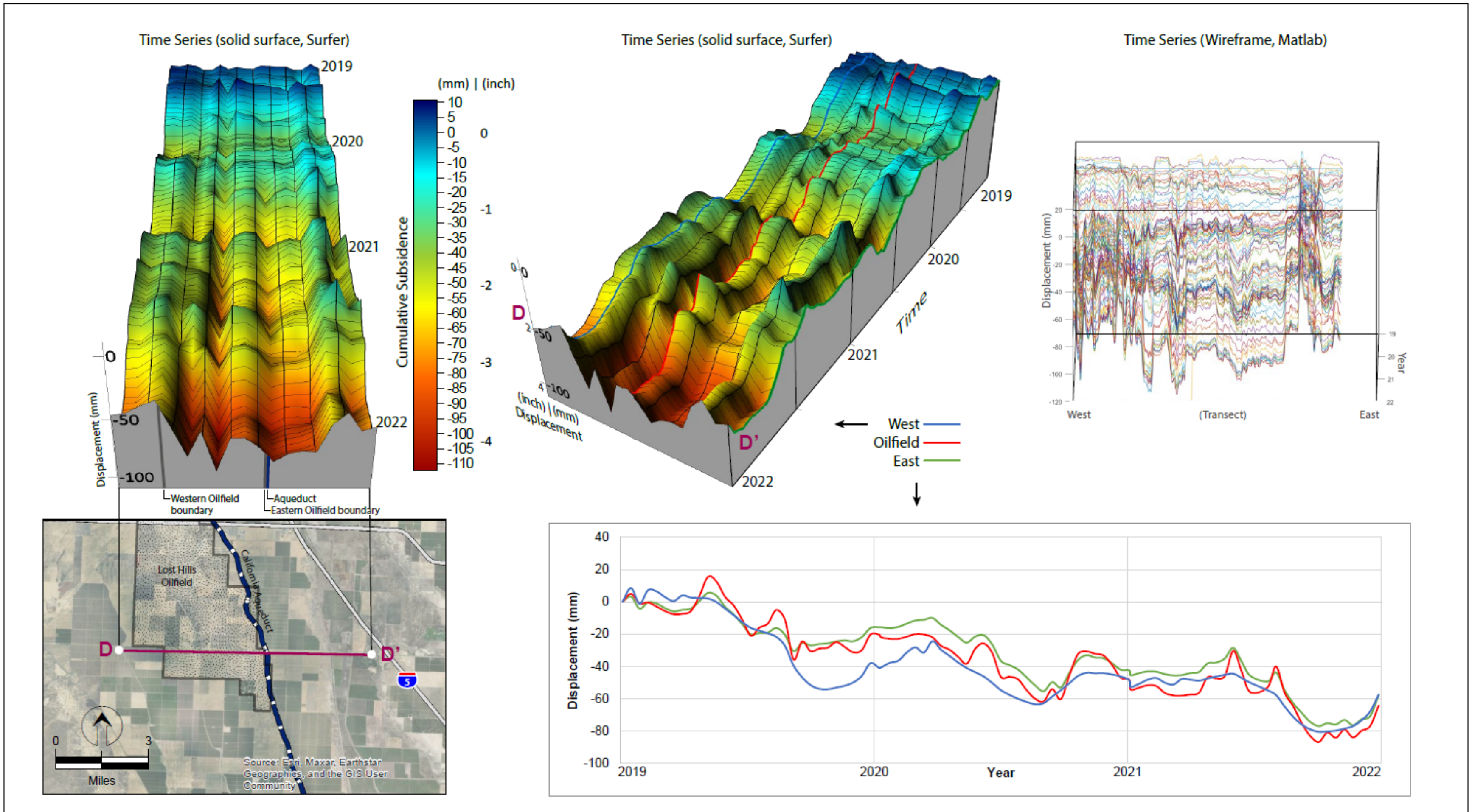
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series for AOI-2
Track C-C'
Aqueduct Milepost 204

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-66. Time Series for AOI-2 Track C-C' Aqueduct Milepost 204



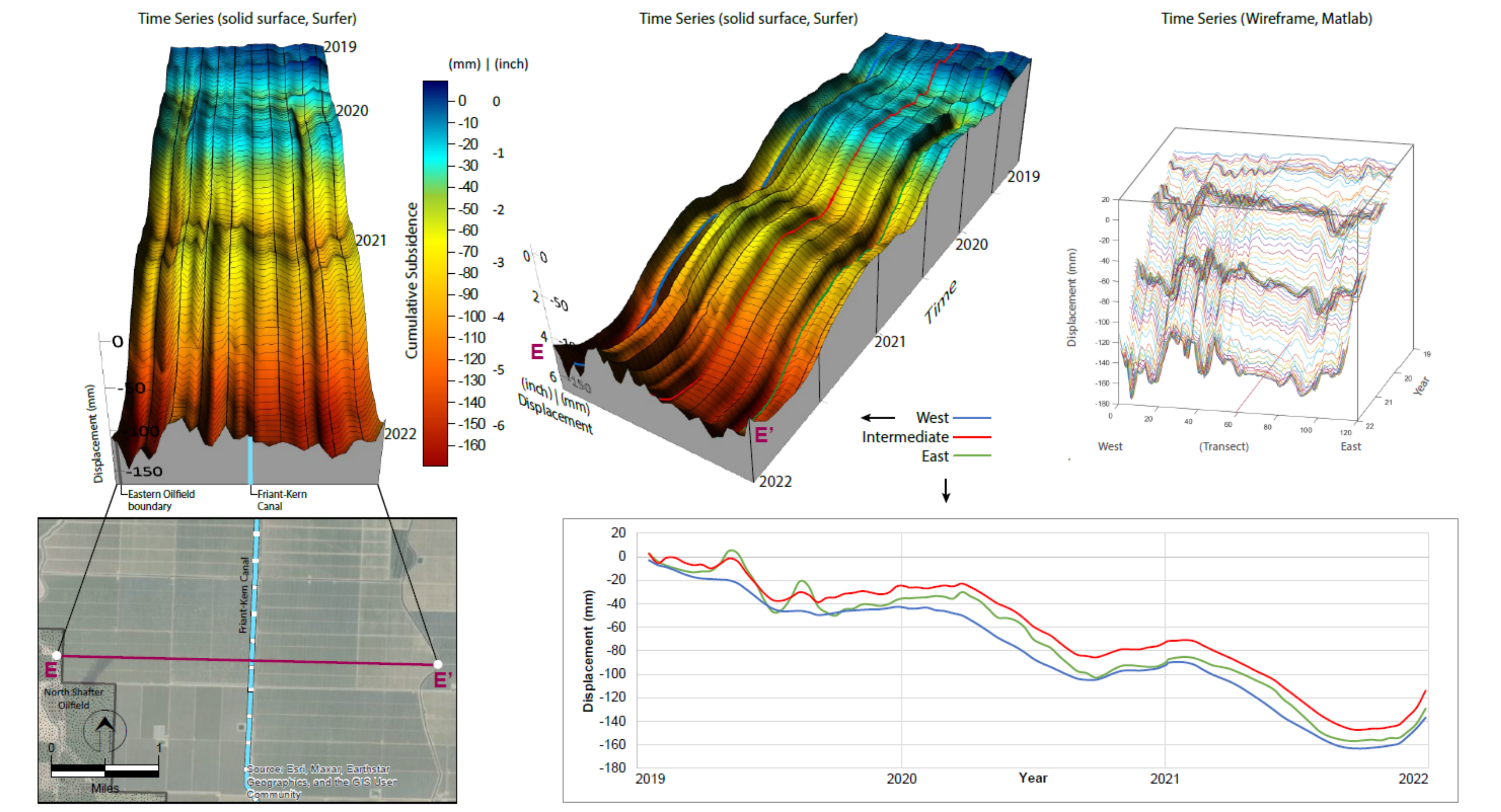
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series for AOI-2
Track D-D'
Aqueduct Milepost 210

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-67. Time Series for AOI-2 Track D-D' Aqueduct Milepost 210



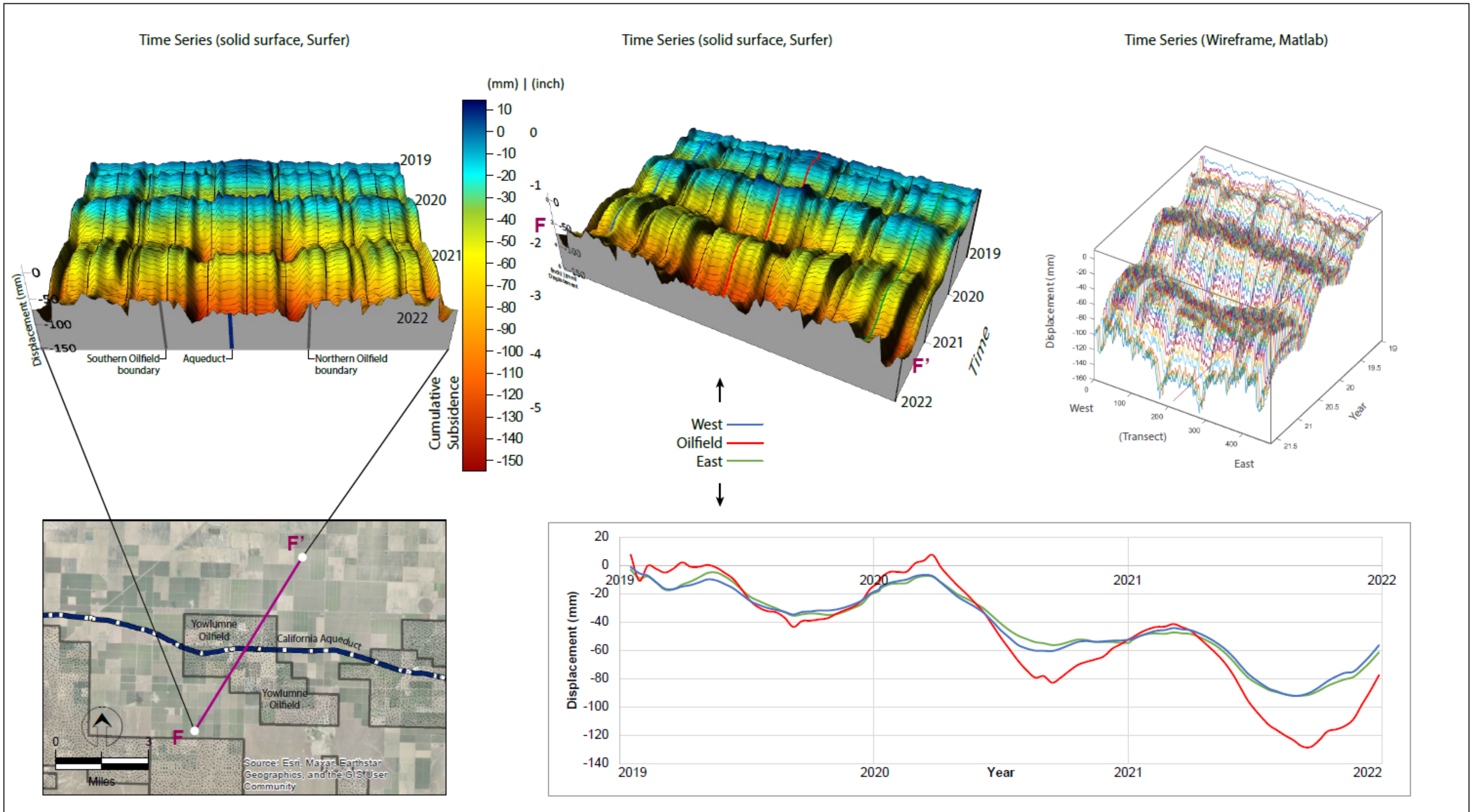
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series
for AOI-3
Track E-E'

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-68. Time Series for AOI-3 Track E-E'



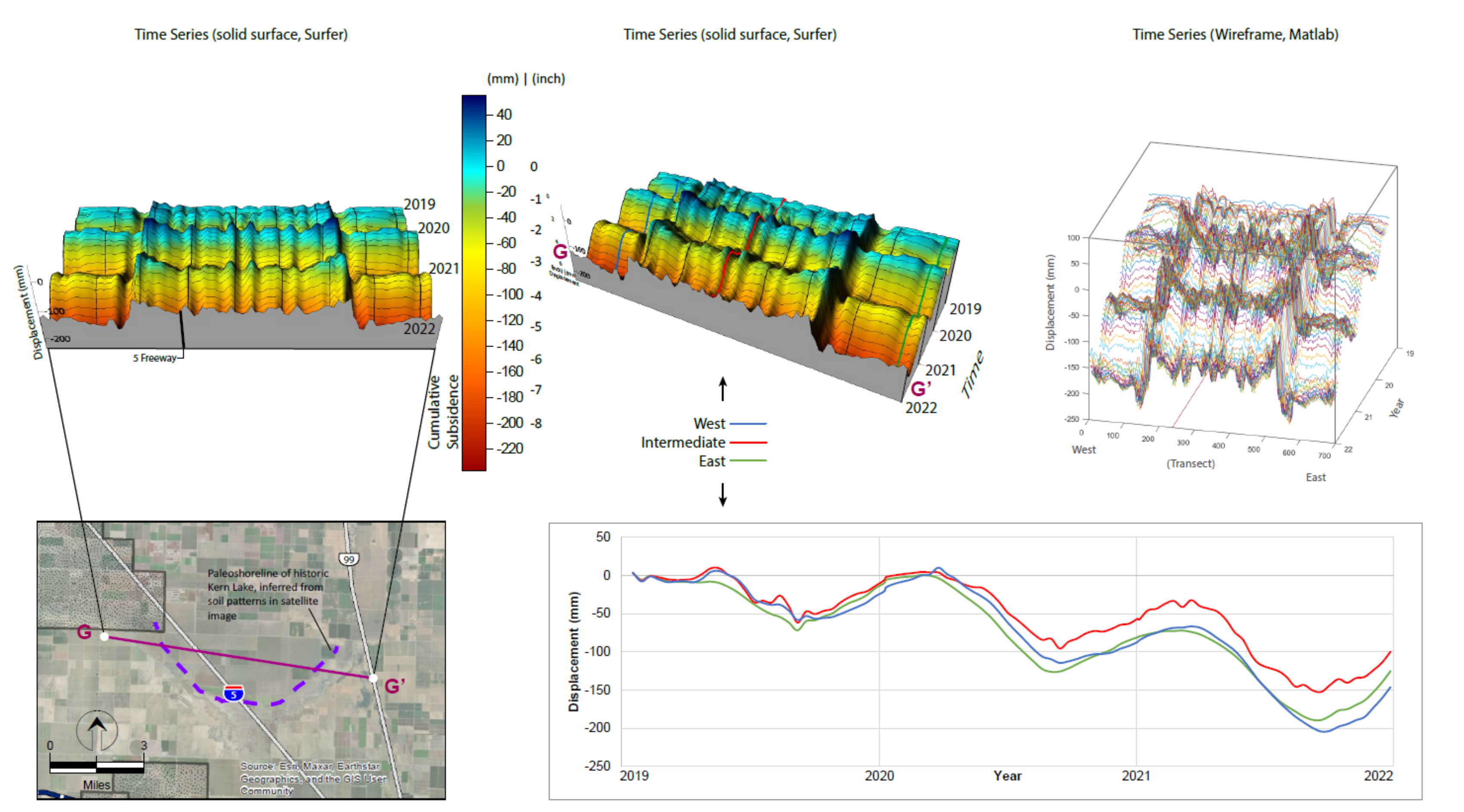
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series
for AOI-4
Track F-F'

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-69. Time Series for AOI-4 Track F-F'



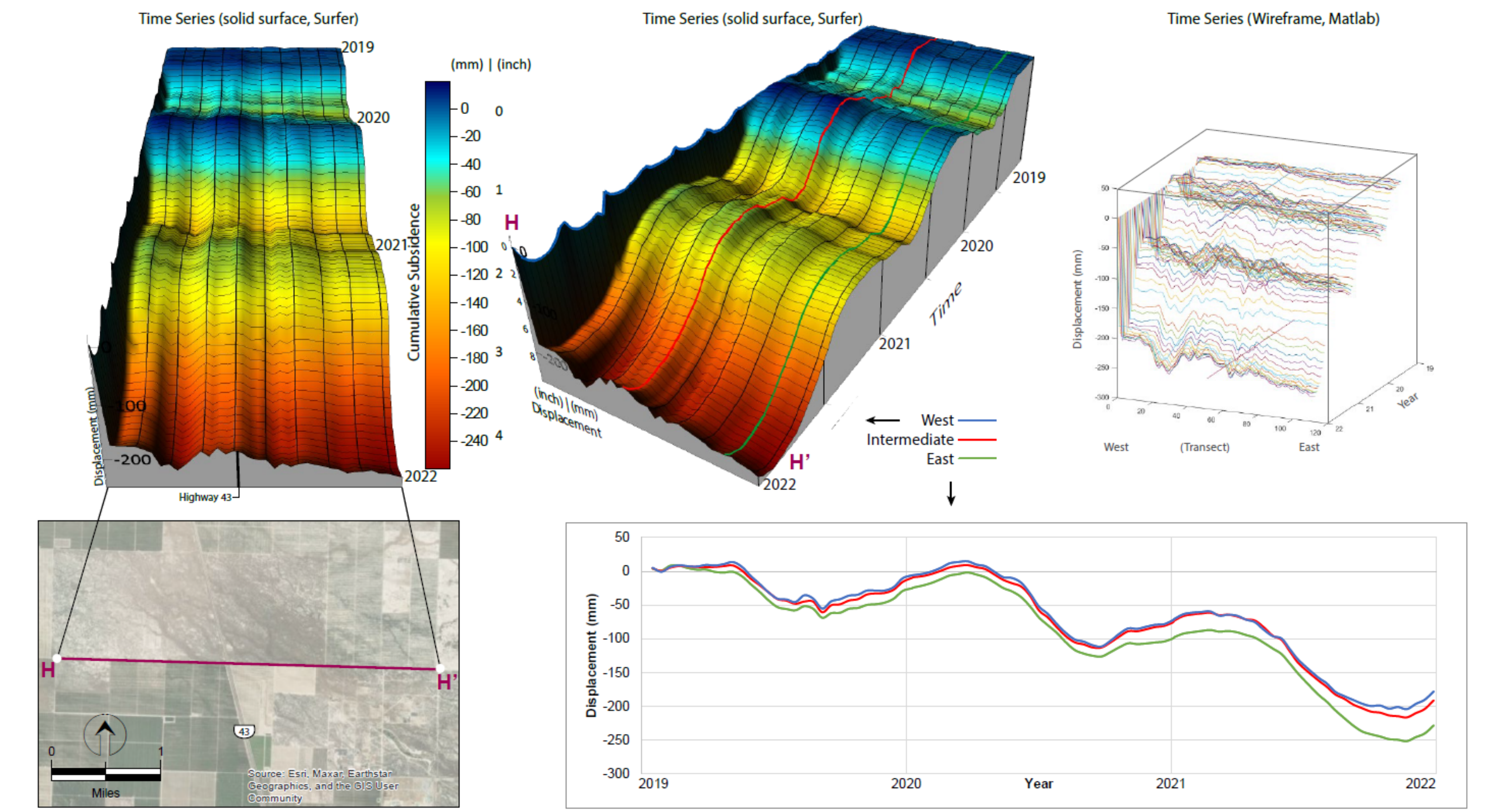
Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series
for AOI-4
Track G-G'

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-70. Time Series for AOI-4 Track G-G'



Note: Locations of (represented by thick lines) projecting locations of infrastructure and oilfields (top left solid surface), and locations of select locations (top center solid surface) represented on the chart (bottom right) are approximate.
Solid surface figures (top left, top center) generated in Surfer 21. Wireframe figure (top right) generated in Matlab.

MAY 2024

Time Series
for AOI-5
Track H-H'

Kern County Subbasin
Groundwater Sustainability Plan

Figure 8-71. Time Series for AOI-5 Track H-H'

All identified AOIs, with one exception, have historically shown low to moderate annual subsidence rates. AOI-5 has experienced higher rates of subsidence, likely due to its geology and proximity to the subsidence bowl immediately to the north of the Subbasin.

The analysis of the Subbasin InSAR time series in AOIs 2 and 4 found that non-GSA related subsidence was found on four of the five total time series extracted. In AOIs 1, 3, and 5 GSA pumping activities (i.e., agriculture) were found to be a contributor to subsidence on all three times series extracted for these areas.

Going forward, as part of the coordinated approach for monitoring subsidence in the Subbasin, InSAR time series will be extracted annually at the same current locations in all five AOIs. The InSAR data will be supplemented by available benchmark survey data along the FKC and the Aqueduct, as discussed in detail in Section 13. This approach, which has been explained and shared with CASP and Friant Water Authority staff, will enable the Subbasin to assess future changes in subsidence magnitude.

8.6 Interconnected Surface Water Systems and Groundwater Dependent Ecosystems

§ 354.16. *Groundwater Conditions*
(e) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
§ 354.16. *Groundwater Conditions*
(f) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

☑ 23 CCR § 354.16(f)

GSP Regulations define interconnected surface water (ISW) as surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (California Code of Regulations Title 23). DWR is developing a multi-paper series on ISW and depletions of ISW to provide GSAs with tools to better incorporate quantitative approaches in GSPs. The first white paper was released in February 2024 and focuses on the foundational concepts and definitions (DWR, 2024). The following discussion on ISWs aligns with these key terms. The two additional papers, Techniques for Estimating Depletions of Interconnected Surface Water and Examples of Approaches for Estimating Depletions of Interconnected Surface Water have not yet been released. The Kern Subbasin GSAs will review and incorporate this guidance when available for inclusion in future periodic evaluations.

Groundwater Dependent Ecosystems (GDEs) collectively refer to plant, animal, and natural communities that rely on groundwater to sustain all or part of their water needs

(TNC, 2018). GDEs occur in areas where groundwater either discharges to the surface (springs, seeps, or wetlands) or where the water table is sufficiently shallow to support natural communities. This includes vegetation with rooting depths sufficiently deep to draw a water supply from the underlying water table, referred to as phreatophytes. GDEs can occur along interconnected surface water but can also occur in any area where natural communities are supported by shallow groundwater. However, the presence of riparian vegetation or wetlands does not necessarily indicate that they are GDEs.

The Kern County Subbasin sustainability goal includes support for current and future beneficial users of groundwater, including the environment. Data and maps provided by DWR were used to support understanding of potential environmental reliance on groundwater. Specifically, the DWR's Natural Communities Commonly Associated with Groundwater dataset (hereafter referred to as the NCCAG or Natural Communities dataset) is a compilation of 48 publicly available State and Federal agency datasets that map vegetation, wetlands, springs, and seeps in California. To develop the NCCAG dataset, a working group composed of representatives from DWR, the California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) reviewed the compiled datasets and conducted a screening process to exclude vegetation and wetland types less likely to be associated with groundwater and to retain types commonly associated with groundwater. Two habitat classes are included in the NCCAG dataset: (1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions; and (2) vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes). DWR notes that the data included in the NCCAG dataset do not represent DWR's determination of a GDE but are a starting point for identifying GDEs.

The NCCAG dataset includes mapped areas of vegetation and wetlands provided as polygons in GIS shapefiles, which also contain information on vegetation types and species. Data on rooting depths and local habitat are available in separate databases developed by TNC (TNC, 2018). The NCCAG maps were evaluated along with local groundwater conditions to identify potential interconnected surface water and GDEs. In this manner, the locations of current and potential future environmental uses of groundwater were estimated.

Table 8-28 summarizes the number of vegetation and wetland polygons in the NCCAG dataset for each HCM Area. There are a total of 1,832 vegetation polygons and 908 wetland polygons in the Subbasin; these areas are shown on Figure 8-72.Most of these wetlands and vegetation areas occur near the Kern National Wildlife Refuge and along Poso Creek in the North Subbasin HCM Area and along the Kern River in the Kern Fan HCM Area. Additional polygons are mapped away from the major streams, consisting primarily of small local drainageways in the northeast and undeveloped areas in the south (Figure 8-72).

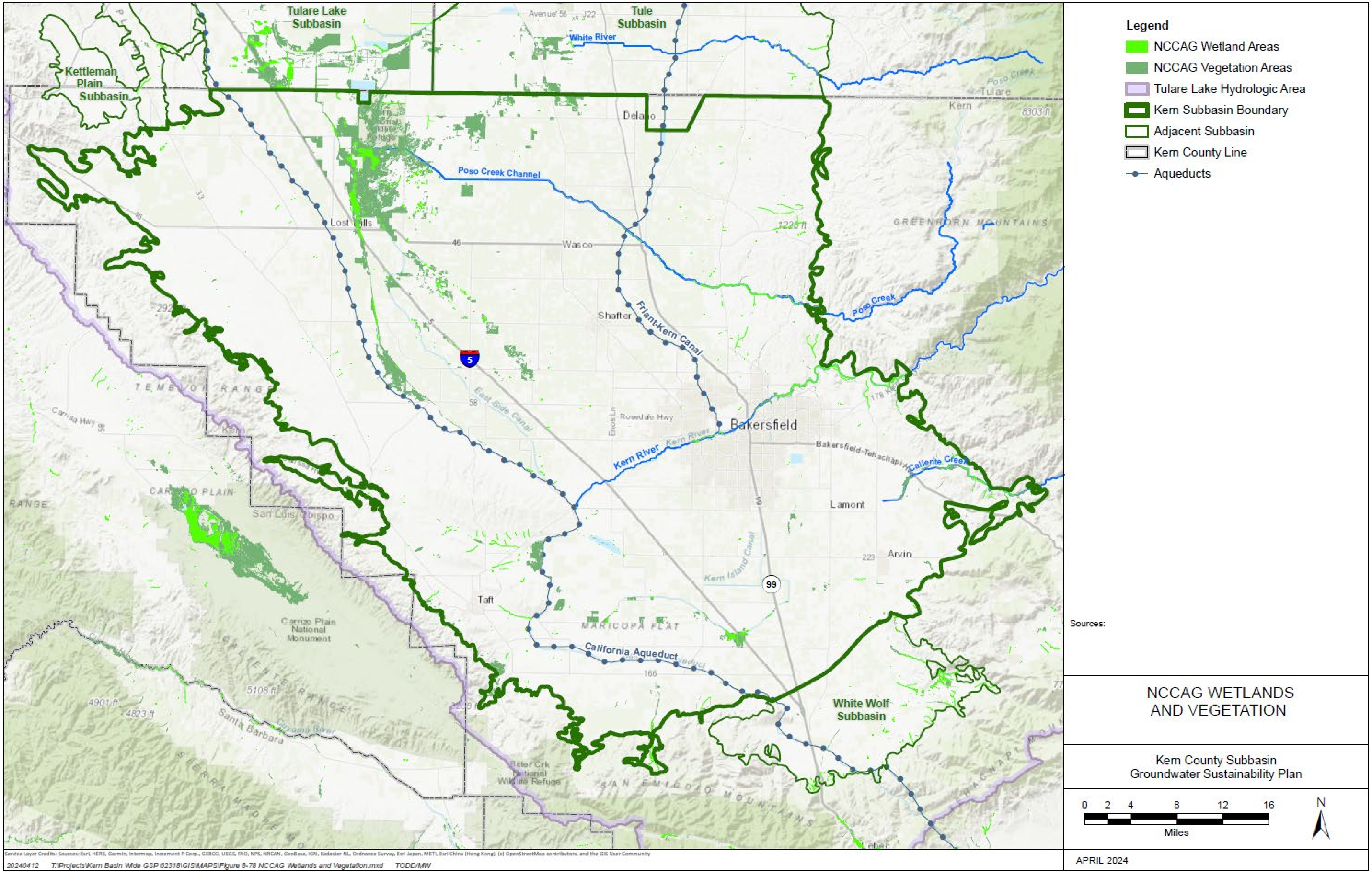


Figure 8-72.NCCAG Wetlands and Vegetation

This page intentionally left blank.

Table 8-28. NCCAG-Mapped Natural Communities Polygons and Area by HCM Area

HCM Area	Vegetation		Wetlands		Total Natural Communities Areas	
	number of polygons	Acres	number of polygons	Acres	number of polygons	Acres
North Subbasin	1,101	34,287	332	1,539	1,433	35,826
Eastern Margin	282	1,953	208	435	490	2,388
Kern River Fan	123	684	62	139	185	823
South Subbasin	201	3,257	181	359	382	3,616
Western Fold Belt	125	5,389	125	144	250	5,533
TOTAL	**1,832**	**45,570**	**908**	**2,616**	**2,740**	**48,186**

An additional dataset called ICONS: Interconnected Surface Water in the Central Valley was used to support understanding of potential interconnection between surface water and groundwater. This dataset, also developed by TNC in collaboration with DWR, uses topographic and groundwater elevation information to assess whether surface water features may have been in hydraulic connection with groundwater at any point during the period from Spring 2011 through Fall 2018. The ICONS analysis uses a conservative estimate of interconnection in that it compares the minimum depth to groundwater during that period to the surface water elevation. Surface water is considered likely connected if the minimum depth to groundwater is less than 20 feet below the surface water elevation, likely disconnected if the depth to groundwater is greater than 50 feet below the surface water elevation, and uncertain for intermediate conditions. Figure 8-73 shows the identified areas of potential ISWs in the Subbasin. Most of the surface water ways are categorized as likely disconnected (dark blue) including the Kern River and Poso Creek. There are two local areas categorized as likely connected- one in the North HCM along Goose Lake Canal and in the Kern Fan HCM near banking facilitates. These areas are discussed further in their respective HCM discussions.

This page intentionally left blank.

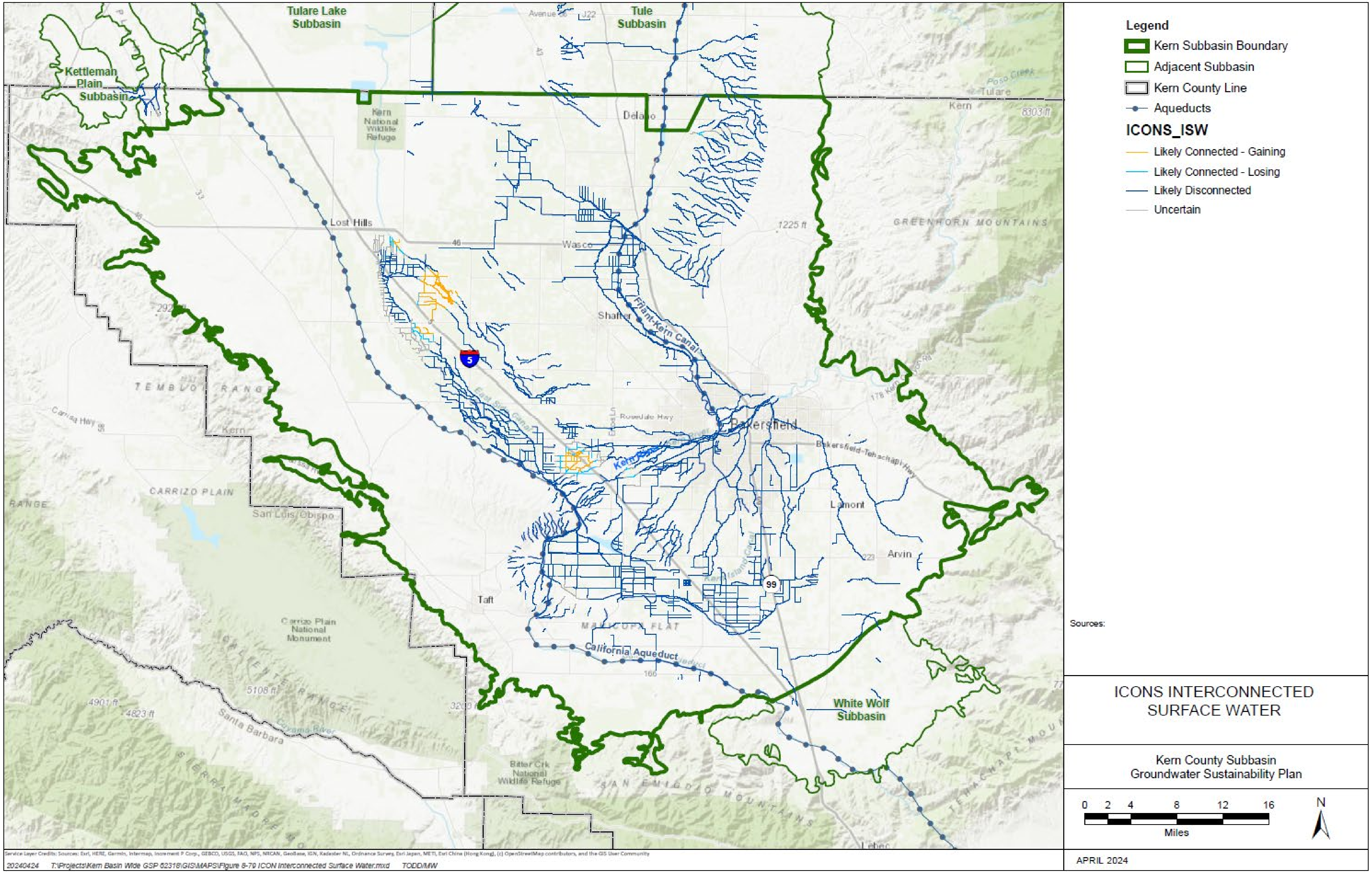


Figure 8-73. ICONS Interconnected Surface Water

This page intentionally left blank.

8.6.1 North Subbasin HCM Area

In the North Subbasin HCM Area the major surface water features include Poso Creek, the Kern River Flood Canal, and the Goose Lake Canal, each of which flow toward the topographically low Kern National Wildlife Refuge area. As shown in Figure 8-72, many of the mapped NCCAG areas are in these areas, and each are discussed below.

8.6.1.1 Kern National Wildlife Refuge

The Kern National Wildlife Refuge is part of the network of 15 national wildlife refuges and wildlife management areas in California's Central Valley and San Francisco Bay region that provide wintering habitat for migratory waterfowl and other waterbirds in the Pacific Flyway. The refuge was established in 1958, originally as the Mariposa National Wildlife Refuge. The refuge is now comprised of 6,400 acres of wetlands sustained by imported surface water typically wheeled from the California Aqueduct and conveyed by the Goose Lake Canal to the refuge (USFS, 2005). The refuge does not rely on groundwater. As such, the wetlands and vegetation within the refuge are not considered GDEs.

8.6.1.2 Poso Creek

Poso Creek is an intermittent stream that flows from east to west across the North Basin HCM. The average annual volume of flow for Poso Creek ranges from zero in dry years to 110,990-acre feet in WY 1998 (based on the USGS Poso Creek near Oildale gage). During the drought period from WY 2012 through 2015, no flow occurred in WY 2015. Poso Creek is a losing stream across the area that acts as a major recharge area to the underlying groundwater aquifer.

To determine whether interconnected surface water is present, groundwater elevation profiles were developed along Poso Creek (Figure 3-40). Figure 8-71 illustrates the substantial vertical separation between Poso C`reek and the water table throughout the entire stretch of Poso Creek within the Cawelo GSA in 1998, 2013 and 2017. Groundwater elevations were hundreds of feet below Poso Creek during this time and there was no baseflow into Poso Creek. Therefore, groundwater is not hydraulically connected to Poso Creek within the HCM. Poso Creek is also categorized as likely disconnected from groundwater based on the ICONS dataset.

Figure 8-72 illustrates vegetation and wetlands commonly associated with groundwater from the NCCAG mapping. This map shows that there are wetlands and vegetation along Poso Creek, small patches of vegetation to the north and south of Poso Creek, and small areas of wetlands at the Poso-Kern County Airport. Depth to groundwater in Spring of 1998 is shown, which represents historic high groundwater levels. Despite 1998 being classified as a wet year having nearly 16 inches of precipitation, groundwater remained hundreds of feet below ground surface. Within the HCM groundwater is very deep, ranging from 200 to greater than 500 feet below ground surface. Groundwater is deeper with proximity to the eastern foothills and becomes shallower in the western portion of the HCM. Within the eastern extension of the GSA, groundwater is deepest in the northern portion, representing the eastern foothills, and becomes shallower approaching the Kern River to the south of the HCM.

As illustrated by the hydrologic profiles on Figure 8-74, groundwater elevations are hundreds of feet below Poso Creek and therefore, groundwater is not hydraulically connected to Poso Creek (Todd 2022).

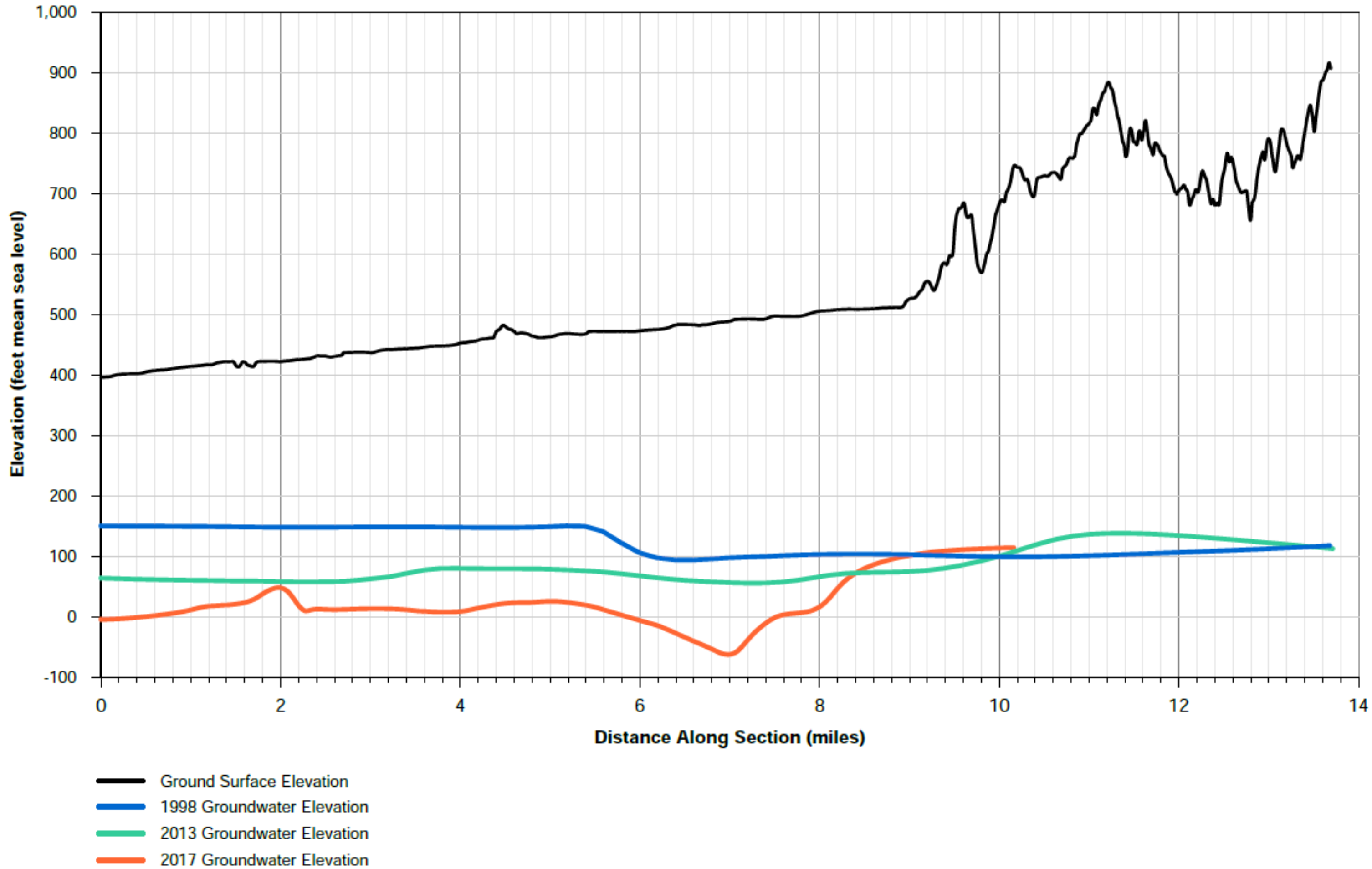
8.6.1.3 Goose Lake Canal

The Goose Lake Canal and Jerry Slough are conveyances used to transport surface water. Although there are additional mapped vegetation areas along these conveyances and identified areas of connected ISWs in the ICONS dataset, it is likely these areas are sustained through surface water deliveries or isolated perched water and do not rely on groundwater.

Conditions in this HCM Area suggest that the primary production aquifer does not approach the ground surface and lies at depths that prevent surface water expressions or accessibility for vegetation. Therefore, there are no GDEs in the North Subbasin HCM Area that are supported by the primary aquifer.

Shallow groundwater is present in the west-central and southern portions of the North Subbasin HCM Area. Ephemeral wetlands covered by water seasonally are likely to be supported by irrigation deliveries and precipitation and are unlikely to be surface expressions of groundwater. As noted, the Kern National Wildlife Refuge is now sustained by imported surface water (USFS, 2005). Other features having the potential to provide habitat, such as groundwater recharge basins that are artificially flooded with surface water, also depend on diversion of surface water rather than a shallow groundwater table.

In the west-central and south-central portion of this HCM Area, groundwater is present in zones perched above shallow clay layers. These clays have historically been a concern regarding encroachment of poor-quality perched groundwater into crop root zones. The shallow groundwater in this area is not well suited for agricultural or domestic water supply; therefore, existing water management practices and practices that may be introduced during SGMA implementation are unlikely to draw on the shallow groundwater that may support potential GDEs.



Kern County Subbasin Groundwater Sustainability Plan	GROUNDWATER ELEVATION PROFILES ALONG SECTION A-A'
Sources:	APRIL 2024

Figure 8-74. Groundwater Elevation Profiles Along Section A-A'

This page intentionally left blank.

The ICONS dataset shows that a small portion of the Goose Lake Canal, approximately 2-3 miles long, is classified as likely connected (to groundwater). However, as noted above, the ICONS dataset uses a conservative method for classifying surface waters as potentially interconnected which uses the minimum depth to water during any seasonal snapshot between spring 2011 and fall 2018. While the minimum depth to groundwater in this area is shown as less than 10 feet below ground surface, this condition is not typical; the ICONS dataset shows that the average depth to groundwater in this area is greater than 100 ft below ground surface. As such, any potential interconnection in this area is likely transitory, infrequent, and associated with poor quality perched groundwater that is not used for supply purposes (ICONS 2024).

8.6.2 Eastern Margin HCM Area

In the Eastern Margin HCM Area, groundwater is primarily pumped from the Olcese Sand and the Santa Margarita Formation, which are deep, confined aquifers typically encountered several hundred to over one thousand feet below ground surface. Surface water flows are therefore disconnected from groundwater of the primary aquifers due to the presence of a thick vadose zone and/or the presence of confining finer-grained units above the primary aquifers. The ICONS dataset shows no areas of likely connected surface water in the Eastern Margin HCM area, although the dataset's coverage does not include all of this HCM area.

The NCCAG dataset shows some limited sections of certain surface water features classified as NCCAG wetland areas. A review of aerial imagery for potential GDEs in the Eastern Margin HCM Area indicates that some may be related to residual vegetation established during historical discharge of produced water to ponds associated with oilfield operations, as opposed to shallow, naturally occurring hydrologic interaction between groundwater and surface flows. Given the large depths to groundwater in the principal aquifers and the thick confining units, these areas are likely to be dependent on either ephemeral perched groundwater or wastewater discharges unrelated to naturally occurring groundwater at the surface and are therefore unlikely to be impacted by pumping from principal aquifers. As such, there are no GDEs or interconnected surface waters in the Eastern Margin HCM Area.

8.6.3 Kern Fan HCM Area

For the Kern Fan HCM Area, the mapped NCCAG vegetation and wetland areas are along the Kern River as shown in Figure 8-72.

The Kern River is a heavily managed system. Surface water flows and losses in the river channel and along the network of adjacent unlined canals are monitored to allocate river water diversions by surface water rights holders, and data are published in annual hydrographic reports prepared by the City of Bakersfield on behalf of the Kern River Watermaster. Operations and management of the Kern River by the City of Bakersfield, including measurements along the channel from First Point to Second Point, have demonstrated that the Kern River is a losing stream across the Kern Fan HCM Area. A comparison of stream gage data upstream between First Point and Isabella Dam (40 miles upstream of First Point) show that groundwater is likely contributing to baseflow somewhere along this reach (accounting for Kern River tributary flow), indicating some interconnected surface water. Although the exact location of these contributions could not be determined, the analysis suggested that they are more likely to occur outside of the Subbasin boundary in the Kern River Canyon as evidenced by the presence of local springs.

The Kern River channel, along with adjacent recharge basins and unlined canals, is used extensively to support managed aquifer recharge operations in the Kern Fan HCM Area. Flows in the Kern River include regulated releases from Isabella Reservoir, as well as surface water and imported water that is intentionally released into the channel for water banking and/or replenishment of groundwater to support local wellfields.

Managed diversions from the Kern River typically create low flow conditions or dry reaches in certain portions of the channel. According to an evaluation of the river's biological resources, the relatively short reach of the river from First Point to Calloway Weir supports the most extensive, vigorous, and biodiverse riparian habitat of the river within the Kern Fan HCM Area (City of Bakersfield, 2012). The reach includes portions of the Kern River Parkway and the Panorama Vista Preserve. Habitat includes stands of mature cottonwood-sycamore riparian forest, the most continuous riparian corridor in the HCM Area, and the greatest diversity of riparian trees and shrubs (City of Bakersfield, 2012). Between 1970 and 2010, about 80 percent of the flow at First Point was diverted above the Calloway Weir, located in the northeastern portion of the City of Bakersfield (DBS&A, 2012). Since most of the Kern River flow is diverted above the weir, the river below the weir has significantly less flow volumes.

During the period from 1970 to 2010, the river was dry at the Calloway Weir during an entire year for more than 25 percent of the years, indicating that the Kern River is often dry downstream of the Calloway Weir. In addition, if periods of very low flow are also considered, then little to no flow occurs downstream of the Calloway Weir for almost one-half of the time. During years with relatively low total flows, the river would have produced very few discharge events to sustain a wet channel very far downstream. Given that natural surface water flows in the Kern River channel downstream of the Calloway Weir are near zero for long periods (months to years), the river below the weir is not interconnected surface water.

At Rocky Point Weir (Figure 3-40), the unlined Carrier Canal is used to divert Kern River water for agricultural use. The Carrier Canal runs parallel to the river before turning south at the Calloway Pool. Flow measurements on the river and the canal indicate that this entire reach from Rocky Point Weir to the Calloway Weir is a losing stream.

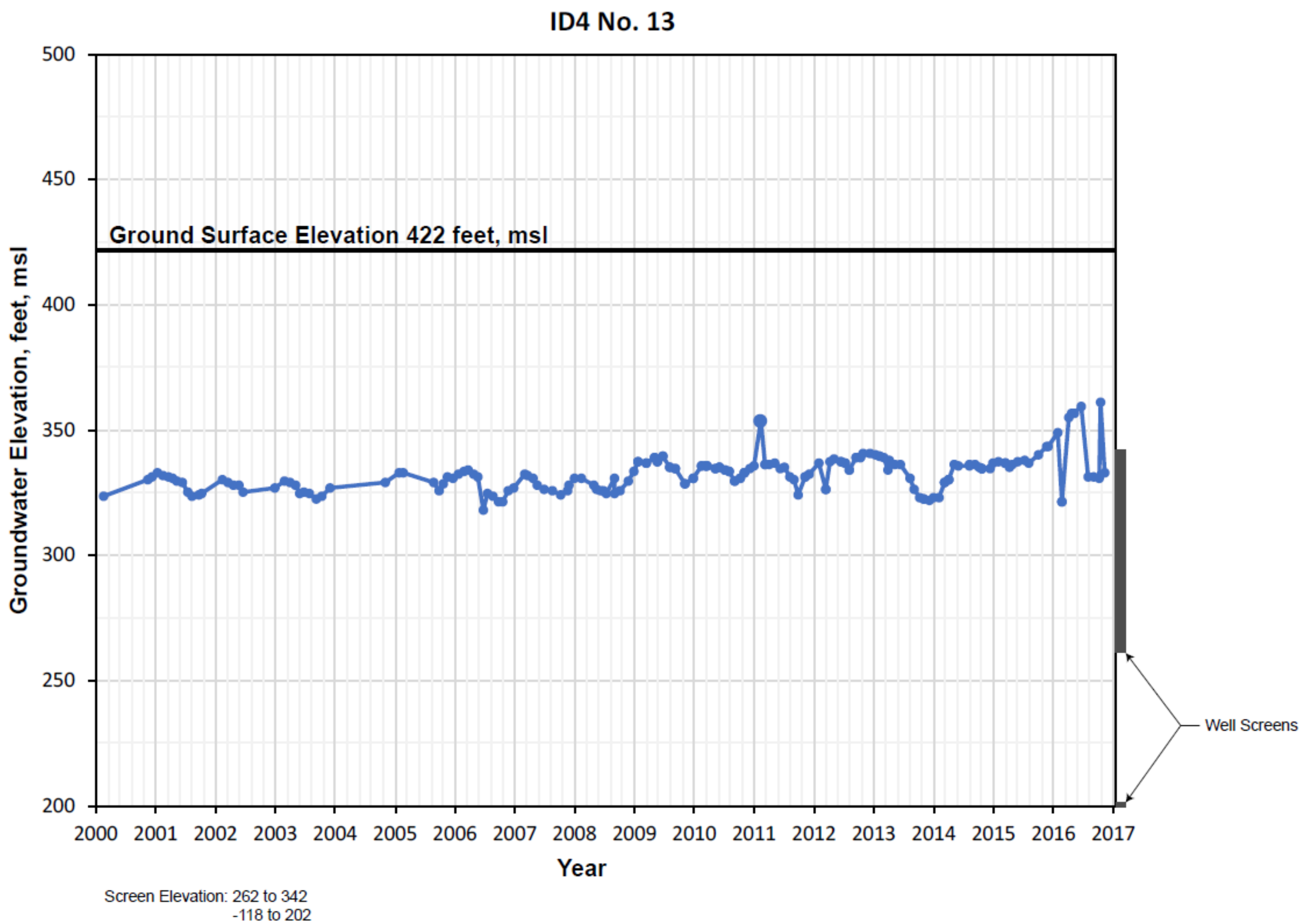
Recharge at the Calloway Pool and along the Carrier Canal is recorded in annual hydrographic reports.

Groundwater levels are significantly below the elevation of the Kern River in the Kern Fan HCM Area. Despite the relatively large quantities of recharge, the depth to groundwater adjacent to the river is typically more than 50 feet. Water levels at the Calloway Pool are measured by ID4 in a dedicated monitoring well (ID4 No. 13) located in the Kern River Parkway on the south side of the Calloway Pool and the Kern River channel. Groundwater elevations in the well are shown in the hydrograph on Figure 8-75. The top of the well screen is relatively shallow and capable of measuring the local water table (i.e., when water levels are low, the water table is below the top of the screen). As shown by the hydrograph, water levels from 2000 through 2017 have been relatively stable, ranging from elevations of about 320 to 360 feet msl, roughly 60 to 100 feet below the ground surface which has an elevation of 422 feet msl. This large vertical separation between the water table and the river demonstrates that there is no interconnected surface water at the Calloway Pool. With greater ground surface elevations upstream, the water table is expected to be even deeper below the ground surface upstream of Rocky Point Weir to the edge of the HCM Area. Given these conditions, the Kern River does not appear to be interconnected surface water in the Kern Fan HCM Area.

The ICONS dataset shows that the Kern River is likely disconnected throughout the Kern Fan HCM Area with the exception of a small reach (less than 1 mile long) west of Stevens whose classification as likely connected likely stems from the conservative use of minimum depth to groundwater as a criterion, similar to the situation along the small portion of Goose Lake Canale in the North Basin HCM Area described above.

In addition, a groundwater elevation profile developed for each annual spring map is plotted on Figure 8-73 in relation to the ground surface elevation. The profiles are color-coded according to DWR Indices for the San Joaquin Valley water year type, which are not always coincident with water year type in Kern County. Although the large number and crisscrossing nature of the profiles make it difficult to follow any single profile, the clustered nature of the data provide a method of viewing a wide range of spring water levels over 20 years beneath the river. The range of groundwater elevations and the amount of groundwater separation from the ground surface can be readily seen on Figure 8-76, regardless of the year type or the actual year. The profiles on Figure 8-76 suggest that groundwater elevations occur well below the entire reach of the Kern River within the HCM Area throughout the 20-year Study Period and indicate an absence of interconnected surface water.

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	WATER LEVELS AT CALLOWAY POOL
Sources:	APRIL 2024 — TODD/MW \\TODD-FILE\Data\Projects\Kern Basin Wide GSP 62318\GRAPHICS\ Figure 8-80 Water Levels at the Calloway Pool.ai

Figure 8-75. Water Levels at Calloway Pool

This page intentionally left blank.

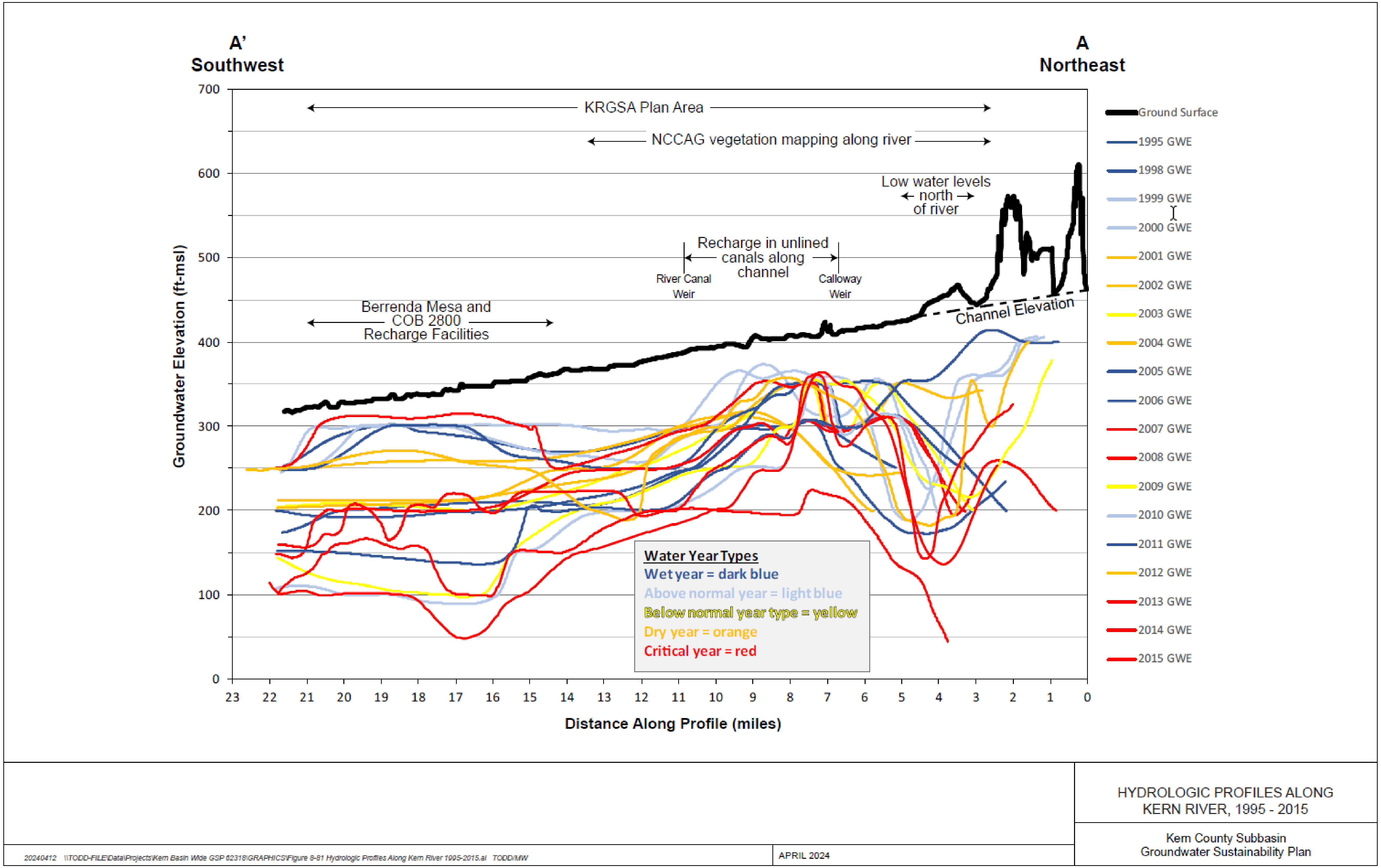


Figure 8-76. Hydrologic Profiles Along Kern River, 1995-2015

This page intentionally left blank.

Collectively, the hydrologic profiles across the Kern Fan HCM Area do not indicate interconnected surface water or sufficiently high groundwater levels to support GDEs along the Kern River. Although groundwater levels may rise on occasion to within 20 feet of the base of the channel in some areas, this appears to occur only in wet years and/or as a result of intentional recharge along the channel. The profiles corroborate the information in the annual Kern River hydrographic reports, which show the Kern River channel to be a losing stream from First Point to Second Point. This includes the area along the river where NCCAG mapped vegetation and wetlands (Mile 2.5 to Mile 13.4). This riparian vegetation appears to be supported by surface water in the river channel (when and where it occurs), local irrigation and runoff, and local infiltration of water on sides and bottoms of nearby unlined canals and recharge basins; the vegetation does not appear to be supported by groundwater. The ICONS mapping shows a localized area that is categorized as likely connected – gaining in the area to the west of the Kern Water Bank. The ICONS methodology uses water levels as a potential indicator of ISWs. However, the areas newer recharge facilities may experience high water levels during recharge cycles that does not represent natural groundwater conditions but may support riparian habitat. There are no GDEs or interconnected surface waters in the Kern Fan HCM Area.

8.6.4 South Basin HCM Area

In South Basin HCM Area, groundwater levels are generally deep below the ground surface, largely precluding interconnected surface water. For example, in areas in the eastern South Basin HCM Area, the depth to groundwater generally exceeds 150 feet bgs, including in wells near natural surface water features (i.e., ephemeral streams). In the southern portion of the HCM depths to groundwater are generally 100 feet bgs or more, and greater than 350 feet bgs in the southernmost portions of the GSA where streams exist. In the southeastern South Basin HCM Area, groundwater depths in the principal aquifer in the southern portion of the HCM range between 300 to 400 feet bgs, while to the northwest, available observational data indicate groundwater elevations in the principal aquifer ranging between approximately 50 and 290 feet bgs. The NCCAG maps (Figure 8-72) shows some areas of wetlands and vegetation along the south side of the Old Canal. This vegetation is likely reliant on disconnected perched water in the area and not the Principal Aquifer.

The ICONS dataset shows no interconnected surface waters in the South Basin HCM area. Although coverage of the ICONS dataset is lacking in the far southwest portion of the HCM area, that area has very deep groundwater levels and is therefore known to not have interconnected surface water.

Based on the depths to groundwater in the principal aquifer that are several hundred feet below ground surface, it is therefore highly unlikely that any ecosystems depend on groundwater from the principal aquifer system. There are no GDEs in the South Basin HCM Area.

8.6.5 Western Fold Belt HCM Area

Figure 8-72 shows areas of NCCAG mapped vegetation along the boundary of the Western Fold Belt and North Subbasin HCM areas. These areas are between the California Aqueduct and the Kern River Flood Canal and are likely sustained by surface water or direct precipitation disconnected from the principal aquifer, due to shallow clay layers as discussed in Section 7. Other than along the flood canal, there is little surface water and few areas of mapped vegetation and wetlands. All streams are ephemeral, and not connected to the groundwater system. The ICONS dataset shows no interconnected surface water in this area, although the dataset's coverage is limited. There are no GDEs in the Western Fold Belt HCM Area.

8.6.6 Summary

Data on depth to groundwater and other local conditions indicate that the vast majority of surface water features in the Subbasin are not connected to groundwater, and in the few limited areas where a connection may occur, the connection is likely transient, short-lived, and involves shallow or perched groundwater that is not part of the principal aquifer systems. As such, the areas of vegetation mapped as NCCAG are not likely GDEs but rather supported by irrigation water infiltration and agricultural return flows. In these areas, infiltration of irrigation water and agricultural return flows is impeded by clay soils and subsurface clay sediments creating shallow perched groundwater disconnected from regional groundwater. To the extent the mapped vegetation is supported by surface water or locally perched water, this condition will likely continue during Plan implementation as surface water continues to be an important source for irrigation in the Subbasin.

As noted, DWR is in the process of developing new guidelines for evaluation of ISWs in the context of SGMA and the Subbasin will continue to monitor surface water and GDE conditions and will adapt management approaches based on observed conditions and these new guidelines.

9. WATER BUDGET INFORMATION

*§ **354.18.** Water Budget*

(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

☑ **23 CCR § 354.18(a)**

The Kern County Subbasin, the largest in the State, was designated as critically-overdrafted by the California Department of Water Resources (DWR). The complex water management in the Subbasin involves more than 40 water districts/systems, multiple large water banking projects of State-wide importance, and provides large quantities of surface water and groundwater to support both large urban centers and one of the top agricultural-producing areas in the country. In addition, most agencies are involved in conjunctive management of local surface water, imported state and federal water, and groundwater.

Within this complex water management setting, the Subbasin GSAs recognized that a numerical modeling tool would be needed to meet SGMA regulations for assessment of historical, current, and future projected water budgets that are developed on a Subbasin-wide basis (§357.4(b)(3)). During the development of the original Subbasin GSPs (Submitted in January 2020), the Subbasin GSAs held a series of meetings and workshops to evaluate potential modeling tools. Although numerous existing models had been developed by various entities in the Subbasin over time, none of those models covered the entire Subbasin or incorporated all the local water budget components necessary to meet GSP requirements. The California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) is DWR's primary tool for evaluating water management in the Central Valley and is specifically referenced in the SGMA regulations for application to GSP water budgets (§354.18(f)); therefore, C2VSim was selected by the Subbasin GSAs for SGMA compliance.

In compliance with SGMA, the Subbasin GSAs present this coordinated Subbasin-wide water budget. Section 9 describes the process and approach for selection, revisions, and application of the C2VSim to the Subbasin for the development of Subbasin water budgets and presents the results.

9.1 Water Budget Methodology

§ 354.18. *Water Budget*
(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

☑ **23 CCR § 354.18(f)**

The Subbasin GSAs have coordinated to provide data to update the regional C2VSim model developed by DWR as the base model for developing Subbasin-wide water budgets that utilize consistent data sets and methodologies (Figure 9-1). The Subbasin GSAs have continued to update this model in order to provide water budget updates for the DWR SGMA Annual Reports. The most recent model version includes updates through WY2023.

9.1.1 C2VSim

C2VSim uses DWR's modeling code *Integrated Water Flow Model* (IWFM) and covers the entire California Central Valley. Kern County is located at the southern end of the Central Valley (Figure 9-2). C2VSim simulates the full hydrologic cycle, calculating water demands and tracking water movement through surface water and groundwater systems, and is therefore well suited to support Subbasin GSP development.

DWR developed C2VSim to simulate water demands and supplies in the Central Valley. C2VSim is an application of DWR's IWFM software. IWFM is an integrated hydrologic model that simulates water flows on the linked land surface, unsaturated zone, groundwater, and surface water flow systems. A key feature of IWFM is DWR's agricultural and urban water supply and demand management module that dynamically simulates the delivery of both surface water and groundwater supplies based on both water availability and calculated water demands, as affected by use and climatic conditions.

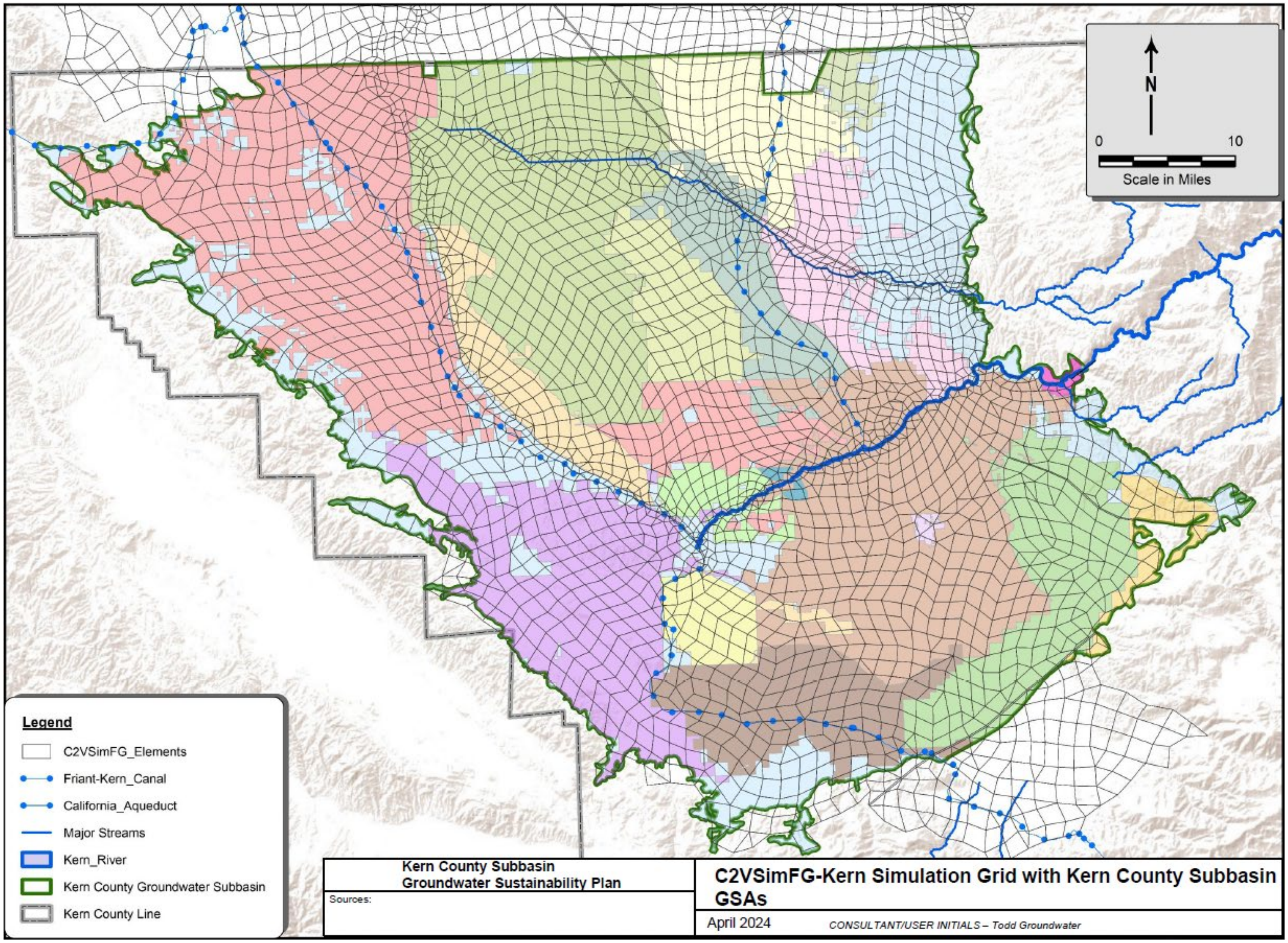
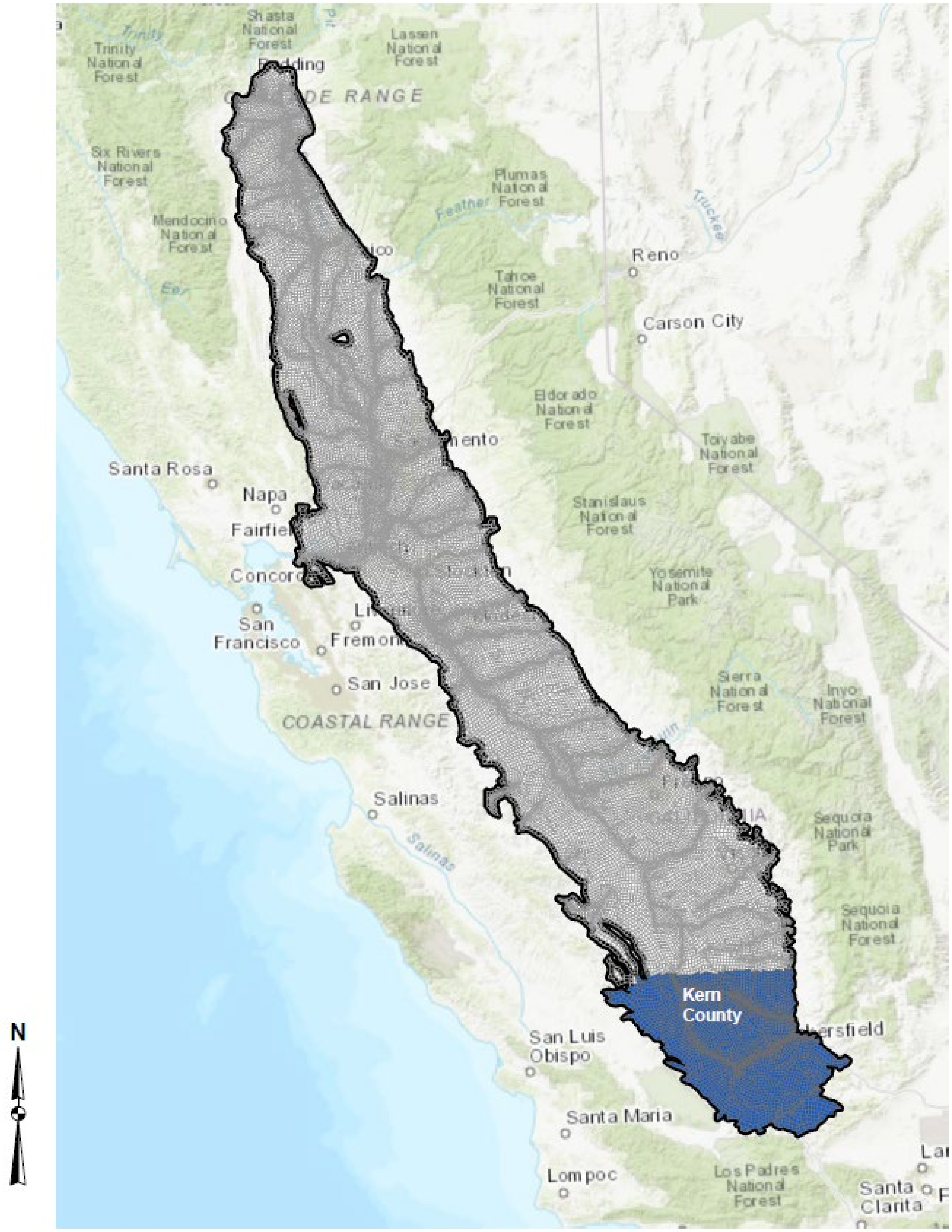


Figure 9-1. C2VSimFG-Kern Simulation Grid with Kern County Subbasin GSAs

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	C2VSimFG Simulation Grid for Central Valley Showing Kern County Subbasin
Sources:	May 2024 Todd Groundwater/MM

Figure 9-2. C2VSimFG-Kern Simulation Grid for Central Valley Showing Kern County Subbasin

The C2VSim model is derived from a series of Central Valley hydrologic models developed by DWR and other agencies beginning in the early 1990s. Each model in this series has incorporated significant improvements over the previous version (Brush, Dogrul, and Kadir, 2013). The groundwater flow system is modeled in IWFM using the finite element method and uses a highly efficient solver developed at UC Davis. The IWFM Demand Calculator (IDC) and land surface simulation process were developed with input from California irrigation management professionals. Given DWR's emphasis on water management, detailed water budgets produced by C2VSim provide good representations of the surface water and groundwater flow systems and make it a preferred platform for developing water budgets.

DWR released the C2VSim Fine Grid Public Beta model (C2VSimFG-Beta) on May 18, 2018 (CNRA, 2018). DWR's 2018 release of C2VSimFG-Beta includes historical input data for WY1922 to WY2015. C2VSimFG-Beta includes historical precipitation, stream inflow, land use and crop acreage for the entire Central Valley. This data includes monthly precipitation and annual land use for each model element and estimated monthly evapotranspiration for each modeled land use type and agricultural crop. Historical surface water data include monthly surface water inflow for each river entering the model boundary and monthly surface water diversions and deliveries.

The C2VSimFG-Beta finite element grid divides the Central Valley into 32,537 model elements (Figure 9-1). Element areas are small near streams and in developed areas and expand to larger sizes in undeveloped areas. Element sizes average 407 acres and range from 4 to 1,770 acres. Central Valley rivers and streams are represented with a network of 110 stream reaches. Surface water and groundwater inflows from uplands along the model boundary are simulated with 1,033 small watersheds.

The groundwater aquifer system is represented with four aquifer layers and one regional confining layer. The aquifer thickness in the Subbasin varies from 857 to 9,054 feet and the deepest aquifer location is 8,752 feet below msl. The Central Valley aquifer is simulated with the following hydrostratigraphic layers, listed from top to bottom:

- Shallow, unconfined aquifer.
- Regional confining layer.
- Active confined aquifer (contains high level of pumping).
- Inactive confined aquifer (contains limited pumping).
- Saline confined aquifer.

C2VSimFG-Beta includes annual land use and crop acreages and monthly precipitation, evapotranspiration, stream inflows, surface water deliveries and specified groundwater pumping rates for WY1922 to WY2015. C2VSimFG-Beta uses IDC to dynamically calculate distributed monthly water demands, allocate available water supplies to meet these demands, and calculate unmetered groundwater pumping necessary to satisfy unmet demands. C2VSimFG-Beta produces detailed monthly water budgets for arbitrary sets of elements grouped into zones.

Water demands are calculated dynamically for each model element using the IDC for agricultural, urban, native, and riparian land use types. Agricultural demand is calculated based on annual crop type distribution mapping and user-specified evapotranspiration rates for 20 irrigated crop types and managed seasonal wetlands at the Kern National Wildlife Refuge (Refuge). Agricultural water demand is determined based on a soil moisture balance that uses local soil properties to assess the amount of applied water (precipitation and specified surface water applications) available to meet the crop demand. If water demands in an element are not satisfied from these sources, the C2VSim model calculates the groundwater pumping needed to eliminate any deficit.

Urban demands are calculated based on population and per-capita water demands. Water demands for native, undeveloped, fallow, or riparian settings are calculated from monthly evapotranspiration rates and the amount of precipitation. If water demands in an element are not satisfied, no applied water is provided to these areas, and the vegetation is assumed to be in a stressed state. Runoff of precipitation in developed and undeveloped areas within the Subbasin and surrounding small watersheds is calculated using methodology included in IWFM that is based on the U.S. Department of Agriculture (USDA) Soil Conservation Service Curve Number Method (NRCS, 2004).

C2VSimFG-Beta was released after a preliminary model calibration. The distribution of aquifer parameters was based on a texture analysis of lithologic well logs compiled by the US Geological Survey (USGS, 2009) from Well Completion Reports submitted to DWR by well drillers. The texture analysis interpolated the percentage of coarse-grained material at each well location and depth of the C2VSimFG-Beta mesh. Aquifer parameters were then calculated for the model mesh based on the percentage of coarse-grained material and estimated properties for pure coarse- and fine-grained materials. Transmissivities were estimated using specific capacity tests, where available. Soil properties for each model element were derived from digitized soil maps published by the USDA Natural Resources Conservation Service (NRCS, 2018).

9.1.2 C2VSimFG-Kern Model

An initial model review indicated that the C2VSimFG-Beta generally has good historical precipitation, streamflow, land use and crop acreage for the entire Central Valley. Historical water supply and demand data are also generally good in the Sacramento Valley and San Joaquin River hydrologic regions; however, data are considered less reliable in the Tulare Lake hydrologic region including Kern County. To address this concern, Todd Groundwater – working with all Subbasin GSAs – revised the Kern County portion of C2VSimFG-Beta for WY1985 to WY2023. This revised version of C2VSim for the Subbasin, referred to herein as the C2VSimFG-Kern model, is used to develop historical, current, and projected-future water budgets in accordance with the requirements in the GSP regulations.

C2VSimFG-Beta input files were revised to incorporate locally derived managed water supply and demand data to better represent the local water budgets for the Subbasin. Additional revisions were made to C2VSimFG-Beta model to address issues that were identified with the physical representation of the Subbasin. The result of these Kern County specific modifications is a local version of C2VSimFG-Beta that is referred to here as C2VSimFG-Kern. A listing of the changes made for C2VSimFG-Kern is provided in Appendix M (Table 1).

These regional model revisions were enhanced by the participation of the many agencies that provided local water budget input data. Todd Groundwater worked with the Subbasin GSAs and other local agencies to coordinate acquisition of input data from other agencies in formats that could be easily incorporated into the C2VSimFG-Kern model. Concurrent review of interim model results by these agencies, including local zonal water budgets, groundwater hydrographs and other model results, helped ensure that the revised model reproduced local mass balance estimates across the Subbasin and represents the best available information and science.

9.1.3 Quality Assurance Process

The Subbasin GSAs provided support to have Woodard & Curran conduct an ongoing peer review of model input files. Todd Groundwater worked with Woodard & Curran throughout the historical model revision process. Tabulated input data, model files and model-derived water budgets were provided to the Technical Peer Review Team for review of accuracy and appropriateness. Additional discussion of the validation and performance of C2VSimFG-Kern is provided in **Appendix N**.

9.1.4 Coordination with DWR on Future C2VSimFG Updates

The C2VSimFG-Kern input files for the Subbasin revised historical simulation were provided to DWR for incorporation into future C2VSim public releases in 2020. Since then, the Subbasin GSAs have continued this coordination by providing annual updates to C2VSimFG-Kern to the DWR modeling staff to support their efforts to update C2VSim with current data. The Subbasin GSAs have provided C2VSimFG-Kern input files with data through WY2023 to DWR. The Subbasin modeling team has had several meetings with DWR modeling staff and DWR consultants to discuss the C2VSimFG-Kern model. Through this effort the Subbasin GSAs have continued to support DWR in further improving their C2VSim model and receive support from DWR for improving the Subbasin model. DWR incorporated data from C2VSimFG-Kern into DWR's current model version C2VSimCG v1.0 that was released in November 2022.

9.1.5 Related Grant Studies to Improve Future Water Budget Estimates

The Subbasin GSAs have continued to support improvements in addressing data gaps and model improvements to better evaluate historical, current, and projected-future water budgets. The Kern County Subbasin began implementation in WY2023 of a $7.6 million Round 1 sustainable groundwater management grant for critically overdrafted basins under the Sustainable Groundwater Management (SGM) Grant Program authorized by the California Budget Act of 2021 and Proposition 68. The grant supports projects that encourage sustainable management of groundwater resources as required by SGMA. Two of the components specifically are related to the water budget. These include the following:

- **Grant Component: Basin Study** – A systematic, Subbasin-wide analysis that addresses technical data gaps in the hydrogeological conceptual model, watershed hydrology and water budgets. The Basin Study provides the framework for more refined water budget analyses to support ongoing GSP planning and implementation.
- **Grant Component: Evapotranspiration Analysis & Study – Field by Field** – A consistent Subbasin-wide methodology, based on service provided by LandIQ, for calculating ET based on local climatic and cropping data for all irrigated agricultural areas within the Subbasin. These stations provide improved calculation of ET on a field and crop basis; field data for the calibration and validation of ET models to better understand the overall water balance within the subbasin and comply with necessary regulatory requirements that will serve all communities within the Subbasin.

The emphasis of the Basin Study grant component is to better represent local groundwater elevations in the principal aquifers and provide higher accuracy in simulating changes in groundwater elevations over time. A key objective of the model recalibration is to improve the simulation of groundwater elevations relative to Minimum Thresholds and Measurable Objectives (MT/MOs) across the Subbasin and provide improved support to long-term GSP implementation planning. The calibrated IWFM-Kern model will produce an updated historical water budget and change in groundwater storage estimates for ongoing GSP implementation in the Subbasin over the SGMA planning and implementation horizon.

9.2 Water Budget Data

§ 354.18. *Water Budget*

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

(6) The water year type associated with the annual supply, demand, and change in groundwater stored.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

☑ **23 CCR § 354.18(b)**
☑ **23 CCR § 354.18(d)**

9.2.1 General Approach

The current C2VSim model has a detailed finite element mesh that closely follows local hydrologic features. As a regional model, the C2VSimFG-Beta may over-generalize local conditions within the Subbasin so as to be inconsistent with local site-specific data and knowledge. To address this concern, the managed water supply and demand inputs were updated to better represent the local water balance. To do this, the more general assumptions in C2VSimFG-Beta were replaced with local data and knowledge that are regionally or locally significant over the period covering WY1993 to WY2023. Locally managed water supply input data (e.g., surface water deliveries, land use, irrigation demand, return flows, and water banking) were collected and applied to C2VSim. Improvement of Kern County data focused on incorporating:

- Surface water delivery volumes, application areas and use by agency,
- Water banking and conjunctive use recharge and recovery projects,
- Irrigation demand from recent analyses of remote sensing data of evapotranspiration in the Subbasin (Irrigation and Training Research Center [ITRC], 2017, 2020, 2021, 2022, and 2023),
- Urban demand for the Subbasin focusing on Metropolitan Bakersfield, and

- Data on other water sources and demands of local significance to individual districts/GSAs.

Historical surface water diversion, water bank recharge and recovery data were collected from local GSAs and local water agencies. Urban land use was restricted to developed areas, and urban populations and per-capita water demands were updated. Model structure (elements, streams, stratigraphy, etc.) was not modified. Model parameters were not calibrated, although some model parameters were adjusted to improve model performance in specific geographic areas.

The Subbasin GSAs also coordinated model revision efforts with the Technical Peer Review Team and local agencies to ensure input data were accurately represented in the model. Tabulated input data, model files and model-derived water budgets were provided to the Technical Peer Review Team for review of accuracy and appropriateness. Model input data and results were also provided to Subbasin water districts and local water purveyors for their review. Comments and data issues were reconciled and incorporated into the revised C2VSimFG-Kern model.

9.2.2 Data Sources

☑ **23 CCR § 354.18(b)**

Compiling the data needed for the model revision required a coordinated effort from the Subbasin GSAs to provide locally derived data on managed water supply and demand that was used to revise the C2VSimFG-Beta for the Subbasin.

Participating agencies compiled water budget input data sets (using their staff, consultants, or other resources) based on data templates that conformed to IWFM model data needs and used them to facilitate obtaining input data from local agencies. This included monthly data for the following:

- Surface water imports and diversions (inflows and outflows) by source, conveyance, and application area.
- Banked surface water recharge and recovery pumping by water banking and conjunctive use project.
- Urban area population and per capita water use.
- Crop evapotranspiration (ET) rates based on an analysis of satellite data.

Recently developed crop ET rates derived from remote sensing data were used to develop monthly crop ET rates for agricultural crops. Urban land use was restricted to developed areas, urban populations and per-capita water demands were updated, and urban wastewater recharge operations were added.

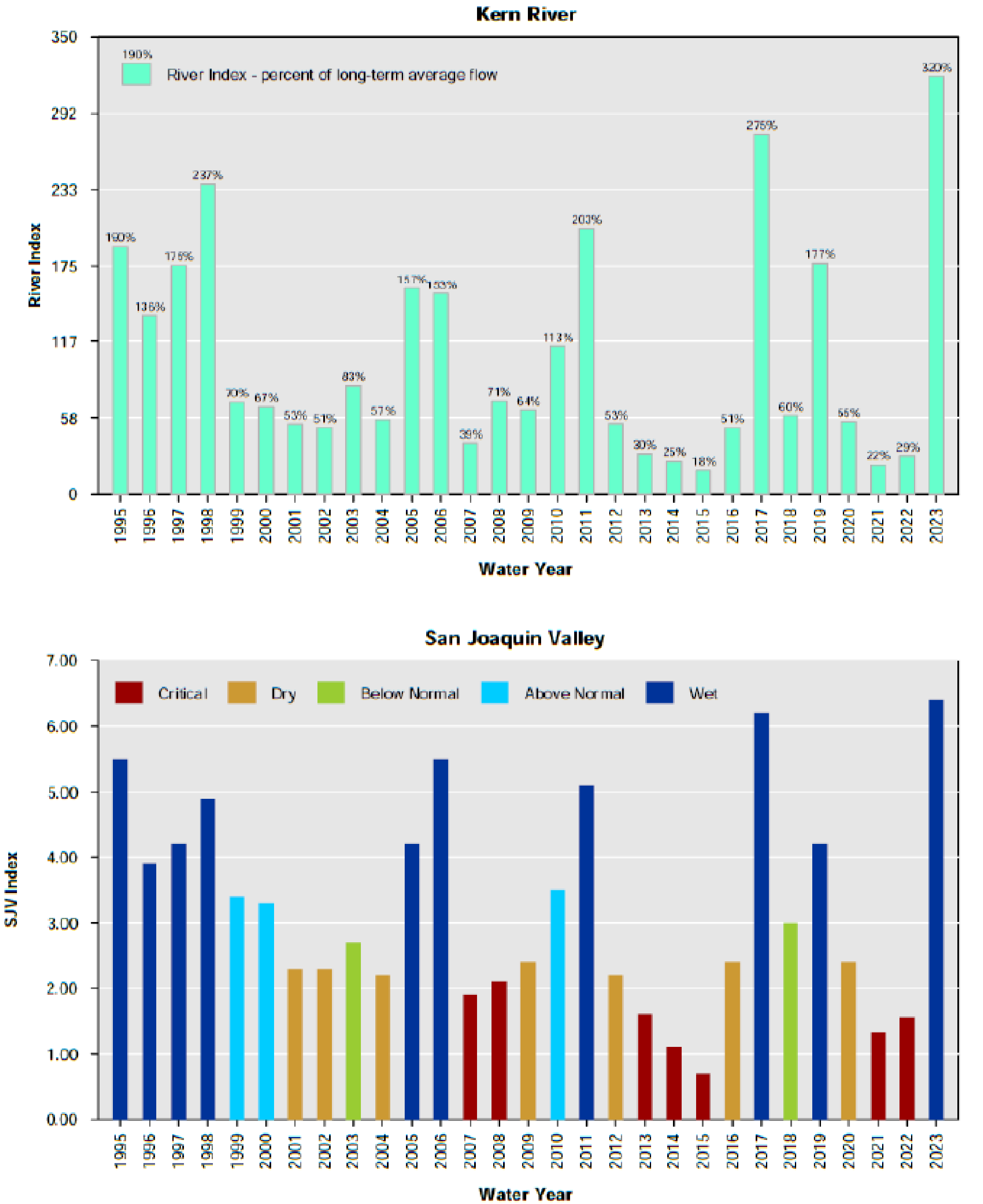
9.2.3 Water Year Types for Base Periods

☑ **23 CCR § 354.18(b)(6)**

The simulation period for C2VSimFG-Kern was set to WY1986 to WY2023 (October 1, 1985 through September 30, 2023), which includes for a 10-year period prior to the start of the historical base period. The C2VSimFG-Beta simulation period ran from October 1973 through September 2015 (WY1974 to WY2015). The period from October 1973 to September 1985 was not included in the simulation due to concerns about lack of comparable data from these earlier periods. Kern County water agencies provided locally derived water budget data for WY1993 to WY2023 for this study so that data input extended beyond the historical base period. Additional water budget data prior to WY1993 were also collected where available and input into the model.

GSP requirements indicate a need to identify an average hydrologic study period for purposes of the groundwater analyses in the Subbasin-wide water budgets. In order to select a consistent study period, the Subbasin GSAs agreed upon historical hydrologic study period covering WY1995 through WY2014 (October 1, 1994 through September 30, 2014). The selection of the historical hydrologic study period was based on a variety of technical criteria including:

- Covers at least 10-years, consistent with GSP regulations (§354.18(c)(2)(B)).
- Contains 10 years characterized as above normal or wet water year types based on precipitation, and 10 years of below normal, dry or critically dry water year types, including four critically dry years from the San Joaquin Valley Index.
- 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent (Figure 9-3), including 9 years above 100 percent and 11 below 100 percent.
- About 104 percent of long-term average precipitation (NOAA Bakersfield Meadows Field Airport Station).
- Widely available high-quality data available across the Subbasin.
- Time period with current water management practices, intensive water banking operations, and more recent land use patterns.
- Begins at a time of relatively stable water levels (October 1994).
- Overlaps a time period with consistently developed Subbasin-wide contour maps by Kern County Water Agency (KCWA).



Kern County Subbasin
Groundwater Sustainability Plan

Sources: California Data Exchange Center (CDEC, 2023)
City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)

Water Year Types, Kern River and San Joaquin Valley Index, WY1995-2023

May 2024 *Todd Groundwater/MM*

Figure 9-3. Water Year Types for Kern River and San Josquin Valley Index, WY1995 through 2003

The primary criteria for selecting the historical water budget period is to have a hydrologically balanced period to minimize any bias toward wetter or drier hydrologic conditions. The Subbasin GSAs also coordinated on selection of consistent study periods for the C2VSimFG-Kern water budget analyses. Based on technical considerations and a review of regional data, the following study periods were selected:

- Historical Water Budget – WY1995 through WY2014.
- Current Water Budget – WY2015 through WY2023.
- Projected Water Budget – WY2021 through WY2070 using 50 years of hydrologic data based on Historical Water Budget data.

The current water budget period of WY2015 through WY2023 is the most recent period following the historical water budget period. This nine-year period includes three wet water year types and six below average water year types including three critically dry years based on the San Joaquin Valley Index (Figure 9-3), representing dry conditions two-thirds of the time. The current water budget period represents an unbalanced base period that leans to dry hydrologic conditions.

9.2.4 Surface Water

☑ **23 CCR § 354.18(b)(2)**

A majority of the surface water entering the Kern Subbasin flows in via the Kern River, Friant-Kern Canal and California Aqueduct. Within the Kern Subbasin, this water is distributed to end users through a complex system of conveyances, with real-time transfers between purveyors balancing available water with immediate needs while honoring contractual obligations.

For this study, locally derived monthly surface water inflow and outflow volumes for WY1993 to WY2023 were collected from Subbasin GSAs and water agencies, with some providing data for earlier periods. Data were provided by conveyance and were cross-referenced with flows of neighboring agencies and with data from the major conveyances to ensure consistency and avoid double-counting. Water delivery areas and recharge basins were also delineated within agencies.

Kern County surface water diversions in C2VSimFG-Beta were grouped by project or water source, and some surface water deliveries were applied to large regions rather than to individual districts. In addition, some local surface water deliveries were missing from C2VSimFG-Beta. For C2VSimFG-Kern, the 43 Kern County surface water diversions from C2VSimFG-Beta were replaced with 113 surface water diversions developed with data provided by local agencies.

The Arvin-Edison WSD, Wheeler Ridge-Maricopa WSD and Tejon-Castac WD overlie both the Kern County and White Wolf Subbasins. Similarly, the Kern-Tulare Water

District overlies portions of both the Kern County and Tule Subbasins. In these cases, surface water deliveries were apportioned as separate diversions to the Kern County Subbasin and the appropriate adjacent subbasin.

9.2.4.1 River and Stream Inflow

Inflows to the Subbasin via the Kern River and Poso Creek are based on historical gauge data. Kern River inflows at the First Point gauge and downstream gauges were verified and updated based on the annual Kern River Hydrographic Reports produced by the City of Bakersfield (COB, 1985-2023). C2VSimFG-Beta contained Poso Creek inflows for WY1961 to WY1986. Poso Creek inflows for WY1987 to WY2023, based on flow records for the Coffee Canyon and Trenton stream gauges provided by local agencies, were added to C2VSimFG-Kern.

9.2.4.2 Surface Water Diversions

Monthly surface water diversion data for WY1993 to WY2023 were collected for 21 agencies and water banking projects in Kern County. The data from each water district or agency included monthly surface water inflow by source and monthly surface water outflow by destination. The C2VSim finite element grid was overlaid onto a map of surface water delivery areas to determine the model elements for each diversion. Owing to the complexity of the surface water delivery system and the large number of real-time water transfers occurring within the Subbasin, all surface water diversions were simulated as exports, and all surface water deliveries were simulated as imports.

Surface water diversions were added for Subbasin streams (Kern River and Poso Creek), imported surface water supplies (State Water Project (SWP), Central Valley Project (CVP) and other local sources (recycled wastewater, treated produced water). The surface water diversions input into C2VSimFG-Kern is as follows:

- 125 time series for Kern County surface water diversions were added, replacing 43 surface water diversions in C2VSimFG-Beta.
- Detailed elemental delivery areas were defined for each of the 113 diversions.

The monthly surface water inflow and outflow data collected for this study did not have sufficient detail to track this water and create an accurate historical water budget for each canal for each month. The data provided sufficient information to identify monthly surface water diversions from each source and deliveries to each end use.

Each C2VSim surface water diversion is linked to two groups of model elements: the elements of the end use and the elements receiving the recoverable losses. A single set of elements was used for both purposes in C2VSimFG-Kern. Model elements for agricultural, urban and Refuge deliveries were selected by overlaying the model grid on delivery area maps. Model elements for recharge diversions were selected by overlaying the model grid on recharge basin maps.

Monthly water delivery data for the SWP, CVP, and Kern River were also provided by the agencies. Monthly turnout-level deliveries for the SWP were also compiled from the monthly SWP Report of Operations published by DWR. Monthly CVP deliveries were compiled from the U.S. Bureau of Reclamation (USBR) Report of Operations. Monthly Kern River flow and diversions were compiled from Kern River Hydrographic Reports. Water agencies in the Subbasin trade and wheel water in real time to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. Water delivery reports from water suppliers (such as the CVP and SWP) generally identify the owner of delivered water, not where it was actually delivered.

Some surface water conveyances discharge water into stream or river channels for re-diversion downstream. A key part of the surface water system in Kern County is the Kern River. Kern River operations data were reviewed for calendar years 1970 to 2023. The surface water deliveries and Kern River diversions by turnout location as applied in C2VSimFG-Kern are summarized in Appendix M (Tables 2 and 3).

9.2.4.3 Surface Water Deliveries

Water flow through the Kern River and its associated canal system is very complex. Water is diverted from the Kern River into a parallel canal system at several locations, with some diverted water flowing back to the river. Some water from the CVP and SWP is discharged into the Kern River for diversion downstream. Some water agencies are served from multiple diversion points along the Kern River. Several canals that receive water diverted from the Kern River also exchange water with other canals and receive some water from recovered banked water pump-ins, so deliveries from many canals cannot be attributed to a single source. Figure 9-4 shows the locations of the primary streams, regional surface water canals, water bank operations and conjunctive use projects in the Subbasin.

Each surface water diversion in C2VSim is allocated to a specified destination and water use. Five water use types are simulated in C2VSimFG-Kern: agricultural, urban, refuge, recharge, and export. Agricultural and refuge diversions are applied to a group of model elements that corresponds to a surface water service area within a specific water agency or to the Refuge. Urban diversions are allocated to an urban service area. The annual surface water deliveries for agricultural use by water district in Kern County and surface water diversions for urban use, wastewater land disposal and wildlife management in Kern County are summarized in Appendix M (Tables 2 and 4), respectively.

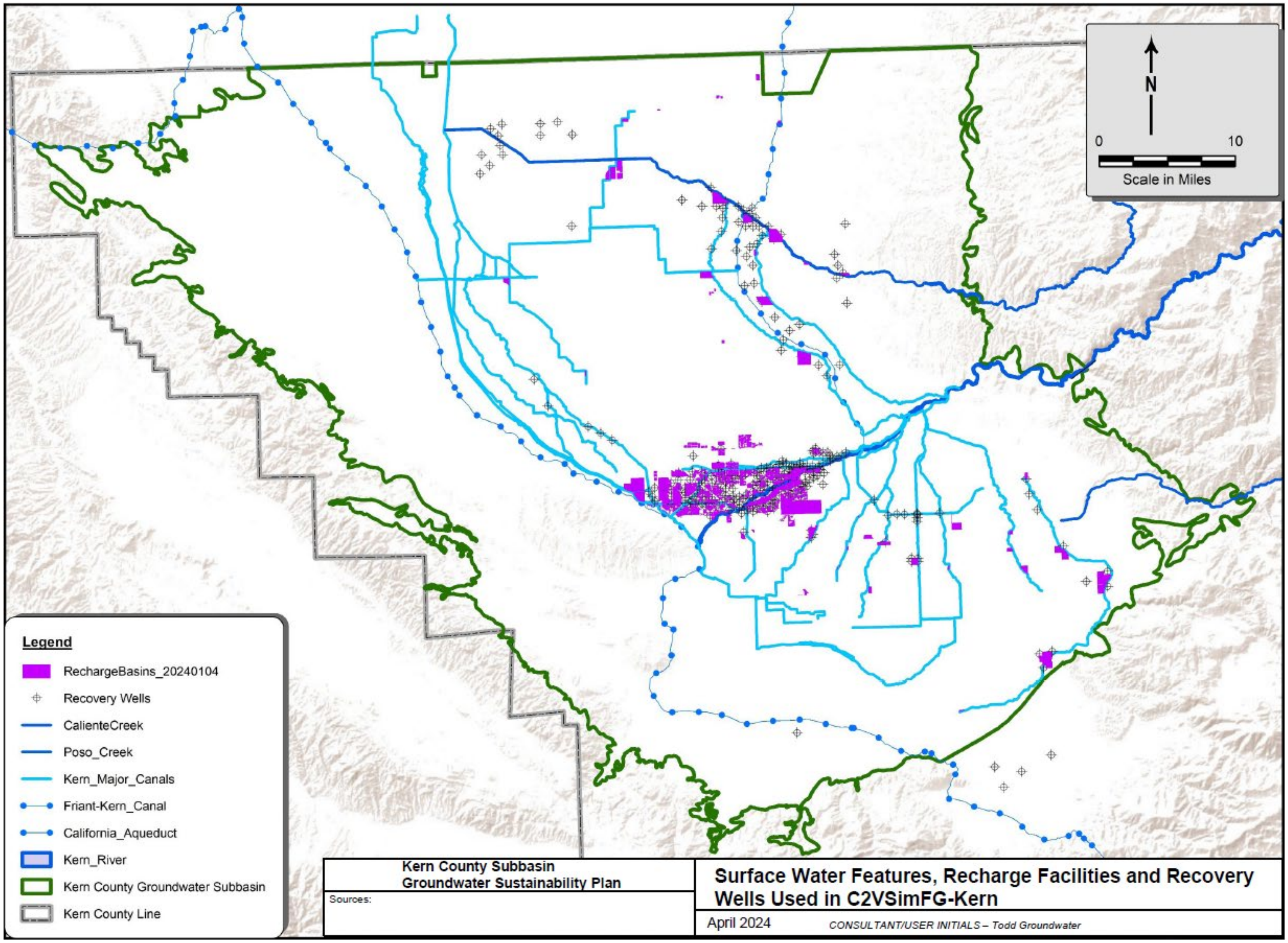


Figure 9-4. Surface Water Features, Recharge Facilities, and Recovery Wells Used in C2VSimFG-Kern

This page intentionally left blank.

9.2.5 Water Banking and Conjunctive Use Projects

☑ **23 CCR § 354.18(b)(2)**
☑ **23 CCR § 354.18(d)**

During initial discussions with the C2VSim developers at DWR in 2019, it was revealed that significant model uncertainty was related to incomplete data regarding water banking and conjunctive use projects in the Subbasin. Recognizing the importance of these water banking projects for simulating groundwater conditions, the water banking and conjunctive use projects were updated using the earliest available records.

9.2.5.1 Recharge and Recovery Operations

A monthly time-series of recharge rates was determined for each recharge project. Recharge rates were allocated to individual recharge basins using the initial data whenever possible or were shared proportionally between basins based on historical monthly data. Recharge basin locations and recovery well locations were provided by each agency or project (Figure 9-4). The C2VSim finite element grid was overlaid onto a map of recharge basins to determine the model elements for each recharge location. Well location coordinates were added to C2VSimFG-Kern.

Monthly volumes for recharge at water banking and conjunctive use projects were compiled for 16 agencies and projects (Appendix M, Table 5). This information originated from multiple sources, and included data provided by agencies, compiled from agency reports, and compiled from Kern River Hydrographic Reports. The data includes monthly recharge for years prior to 1995 for many projects. Several agencies and projects provided data for multiple recharge basins. Some wells used for recovery of banked water are also used for other purposes such as supplementing agricultural or urban surface water deliveries.

Recognizing that several of the water banking and conjunctive use projects (especially those on the Kern Fan) pre-date the 20-year base period, and that future studies might simulate periods prior to 1985, all available historical data for water banking operations was reviewed and updated. This data is included with the data provided to DWR for their ongoing updates to C2VSim. These include:

- Arvin-Edison WSD (since 1966).
- Berrenda Mesa Project (since 1977).
- Buena Vista WSD (since 1963).
- City of Bakersfield 2800 Recharge Facilities (since 1973).
- North Kern WSD (since 1956).
- Rosedale-Rio Bravo WSD (since 1980).

Recharge and recovery data for the Kern Fan banking projects, including the Kern Water Bank, Berrenda Mesa Project, Pioneer Project are tracked by the Kern County

Water Agency. Banking data for district-specific water banking projects are provided by each of the districts. A summary of the data input for stored water recovery added to C2VSimFG-Kern is provided in Appendix M (Table 6).

9.2.5.2 Model Application

Surface water used for direct recharge at water banking and conjunctive use projects is applied to the model elements where the recharge basin is located. Three delivery fractions apportion are applied to each surface water diversion that include delivery to the direct recharge facility, loss to groundwater (recoverable loss), and loss to evaporation (non-recoverable loss).

Recovery well locations and screen intervals were used to enter each recovery well into C2VSimFG-Kern. The model includes 313 simulated pumping wells and 225 pumping time series for recovery of stored. Data reported by local water districts and agencies and used in the model for this purpose is listed on (Appendix M, Table 6).

Recovery of stored water for return obligations from the water banking projects is summarized in Appendix M (Table 7). Monthly stored water recovery was generally provided by well field and destination (e.g., agriculture, urban, canal pump-in, or export). This information was used to develop a pumping time series for each well field and destination.

9.2.6 Urban Water Demand

☑ **23 CCR § 354.18(b)(3)**
☑ **23 CCR § 354.18(d)**

C2VSim calculates urban water demands for specified urban delivery zones, allocates specified surface water and groundwater supplies to meet these demands, and can optionally pump additional groundwater to satisfy unmet urban demands in each zone. Urban demands were represented with nine urban zones in C2VSimFG-Beta. These zones were reconfigured, and a tenth urban zone was added representing Metropolitan Bakersfield in C2VSimFG-Kern. Historical urban populations and per capita water use rates were reviewed and updated.

9.2.6.1 Urban Zones

C2VSimFG-Kern dynamically calculates urban water demands for urban zones using time-series data of urban populations and monthly per capita water use. The urban delivery zones of C2VSimFG-Beta were modified to better represent Kern County population centers, jurisdictional boundaries, and urban water sources. Although Kern County urban water delivery systems are operated by many diverse entities, their water generally comes from two sources: surface water deliveries and agency-operated groundwater wells. The nine Kern County urban zones in C2VSimFG-Kern are numbered 97 through100 and 102 through 106. The Urban Zone boundaries from C2VSimFG-Beta were adjusted, as shown in Figure 9-5.

9.2.6.2 Urban Population and Per Capita Use

Historical annual urban populations for the urban zones are estimated using United States Census total population data from 1990, 2000, 2010 and 2020 (US Department of Commerce, 2018, 2023). Figure 9-6 shows the population density by census block within the Kern County Subbasin based on the 2020 Census. The Metropolitan Bakersfield area has the highest population with about 72 percent of the total Subbasin population. The smaller cities including Delano, McFarland, Wasco, Shafter, Arvin, and surrounding areas have about 23 percent of the Subbasin population. The rest of the Subbasin has about 5 percent of the population, mostly in small unincorporated communities. The population within the Subbasin has grown substantially over time. The total population in the Subbasin based on U.S. Census data has changed as follows:

- 426,233 in 1990, an increase of 73 percent from the 1980 census.
- 538,925 in 2000, an increase of 26 percent from the 1990 census.
- 700,146 in 2010, an increase of 30 percent from the 2000 census.
- 767,048 in 2020, an increase of 10 percent from the 2010 census.

The majority of that growth has occurred in the Metropolitan Bakersfield area and in the smaller cities including Delano, McFarland, Wasco, Shafter, Arvin and surrounding areas.

Tabular historical census data and census block shapefiles were obtained from the Integrated Public Use Microdata Series (IPUMS) National Historical Geographic Information System Database (IPUMS 2018). These data were combined to produce maps of the geographic distributions of populations within Kern County. The historical populations for each Urban Zone are estimated by mapping census block centroids to the ten Urban Zones using ArcGIS. The 1990, 2000, 2010 and 2020 populations of each Urban Zone were then estimated as the sum of the populations of the associated census blocks. Populations for other years were estimated using interpolation and extrapolation. The population values by Urban Zone used for C2VSimFG-Kern are listed in Appendix M (Table 8).

This page intentionally left blank.

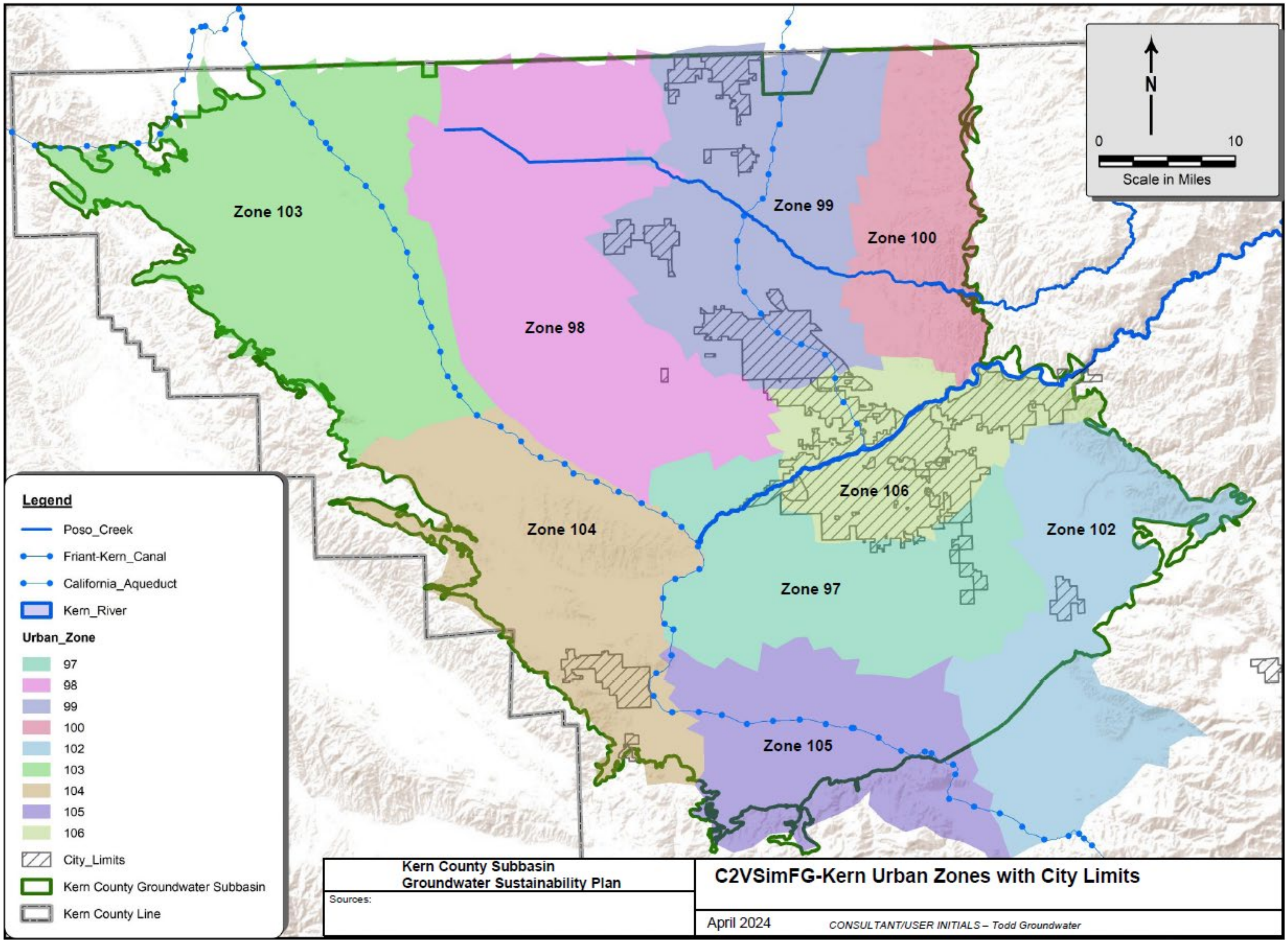


Figure 9-5. C2VSimFG-Kern Urban Zones with City Limits

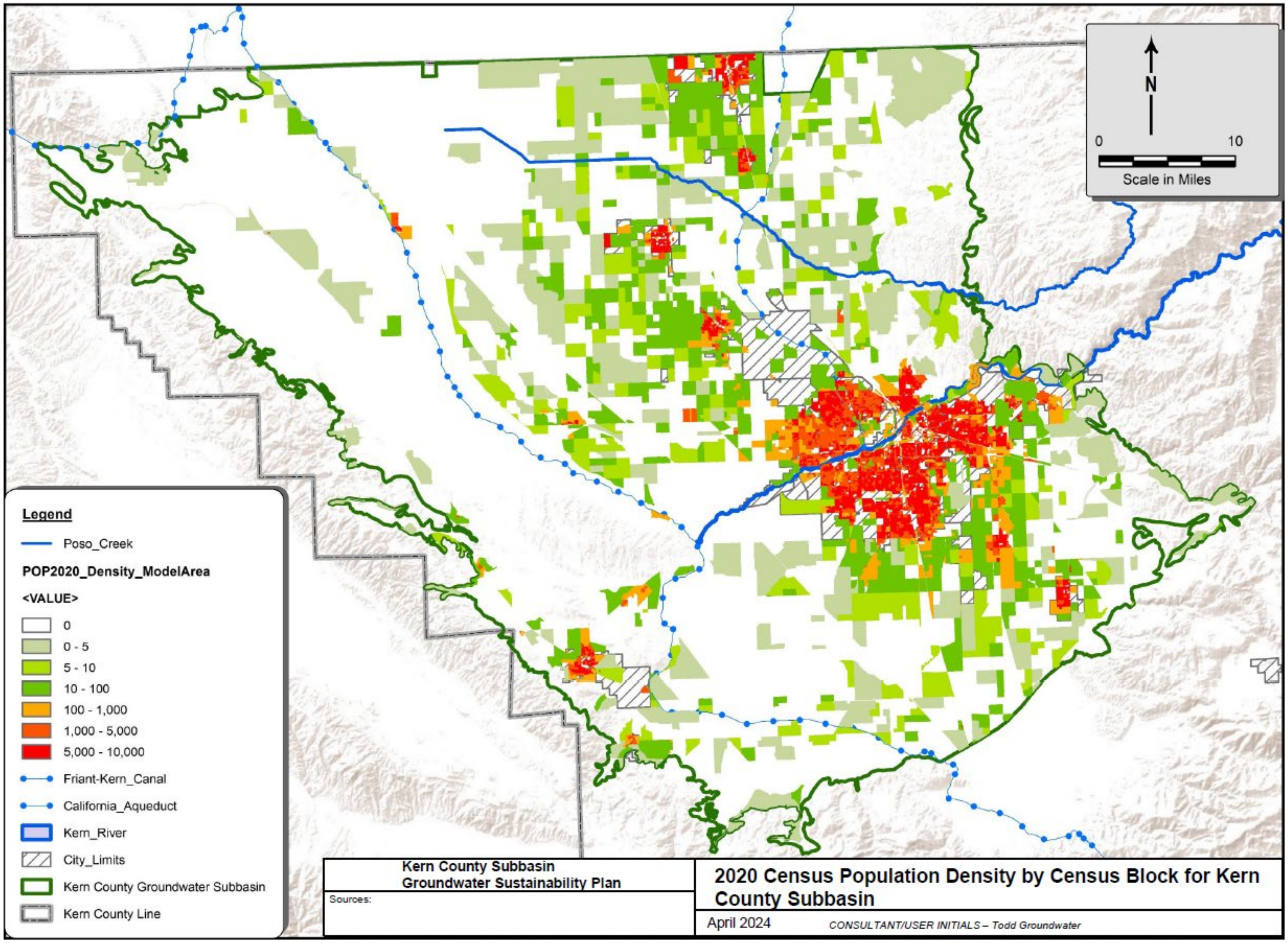


Figure 9-6. 2020 Census Population Density by Census Block for Kern County Subbasin

9.2.6.3 Urban Water Use Specifications

Monthly historical urban water demands for Urban Zone 106 are calculated using water delivery data from the water purveyors in the Metropolitan Bakersfield area. Monthly historical urban water demands for the other urban zones in the Subbasin are estimated using available water use data from published urban water management plans for the communities served in those zones. The historical monthly water use in each zone is then divided by the historical population to obtain the monthly per capita urban water demand. Monthly historical per capita water demands for zones without urban water management data are estimated using the per capita water demand from zones with similar demographics.

The urban water use specifications indicate the portion of total urban water that is used indoors. In C2VSimFG-Kern, the portion used indoors becomes urban return flow, and the remainder is added to the urban root zone where it contributes to evapotranspiration and deep percolation. C2VSimFG-Beta included monthly urban water use specifications for each model subregion. The urban per capita water use is based on local water supply data and urban water management plans. Appendix M (Table 9) lists the per capita water use data used for C2VSimFG-Kern.

9.2.6.4 Urban Wastewater

Urban wastewater for the Metropolitan Bakersfield area is treated at local wastewater treatment plants. However, wastewater disposal is primarily evaporation ponds or land disposal at locations outside of the Metropolitan Bakersfield area. C2VSimFG-Beta does not have a direct means to redirect wastewater to an outside location. Urban wastewater, based on indoor use, is applied uniformly within the urban zone. To get around this limitation, application of wastewater for the Metropolitan Bakersfield area was turned off in C2VSimFG-Kern. The wastewater deliveries to evaporation ponds and land disposal areas from the wastewater treatment plants is assigned to the appropriate location using data provided by the plants. This conserved the water balance by not double counting wastewater, and it is applied at the appropriate locations for evaluating groundwater levels.

9.2.6.5 Model Application

Historical annual urban population estimates are placed in the C2VSimFG-Kern urban population input file. Historical monthly urban per capita water demand estimates for each urban zone are placed in the C2VSimFG-Kern urban per capita water use file. Urban demand is calculated by C2VSimFG-Kern and the water supply to meet these demands is met first by specified surface water and groundwater pumping deliveries for urban use. The remaining water demand in each model element is met with groundwater pumped from the aquifer portion of that element.

9.2.7 Agricultural Crop Water Demand

☑ **23 CCR § 354.18(b)(3)**
☑ **23 CCR § 354.18(d)**

C2VSim dynamically calculates agricultural crop water demands and allocates supplies to meet these demands for each model element. Agricultural demands are calculated for 20 crops using historical crop acreage data and crop evapotranspiration (ETc) rates. Crop water demands in each model element are first met with stored soil moisture, precipitation, surface water deliveries and specified groundwater deliveries. If the agricultural demands are not satisfied, the model can optionally calculate the additional groundwater pumping required to satisfy the unmet demands and extract that water from the groundwater component of the model element.

C2VSimFG--Beta contained one set of monthly ETc rates for each model subregion that are applied to all years despite climatic variation. New monthly ETc rates for three model subregions (northeast, northwest, south) in Kern County were calculated for 1993-2023 using monthly remote sensing imagery and detailed annual crop maps. ETc rates for 1974 to 1992 were estimated from 1993 to 2015 values by using the values for similar water year types based on the San Joaquin Index. Satellite data are not available for 2012, so ITRC was unable to provide Mapping of Evapotranspiration with Internal Calibration (METRIC) data for 2012. In C2VSimFG-Kern, 2013 was applied as an appropriate proxy for ETc data in 2012 because of their hydrologic similarity.

A remote sensing study of historical ETc rates across the entire Subbasin by the ITRC (ITRC, 2017) provided detailed Subbasin-wide agricultural demands that corresponded to the WY1995 to WY2022 base period. These data were used to develop monthly ETc rates for the Kern County portion of the model. ET data for WY2023 are provided by LandIQ under the Subbasin's SGMA GSP Implementation Round 1 Grant following the same process used for the ITRC METRIC data.

9.2.7.1 ET Rates

The ITRC at California Polytechnic State University, San Luis Obispo, has developed a procedure to use remote sensing imagery from Landsat satellites to calculate historic ETc rates (ITRC, 2017). The METRIC method was originally developed by Richard Allen of the University of Idaho. ITRC made several modifications to the original METRIC method to better match California data and conditions (named the ITRC-METRIC method). These modifications include using grass for reference evapotranspiration (ETo), incorporating a semi-automated calibration procedure and spatially interpolating ETo rates. An example of the METRIC ET data for the total annual ET in 2013 is shown in Figure 9-7.

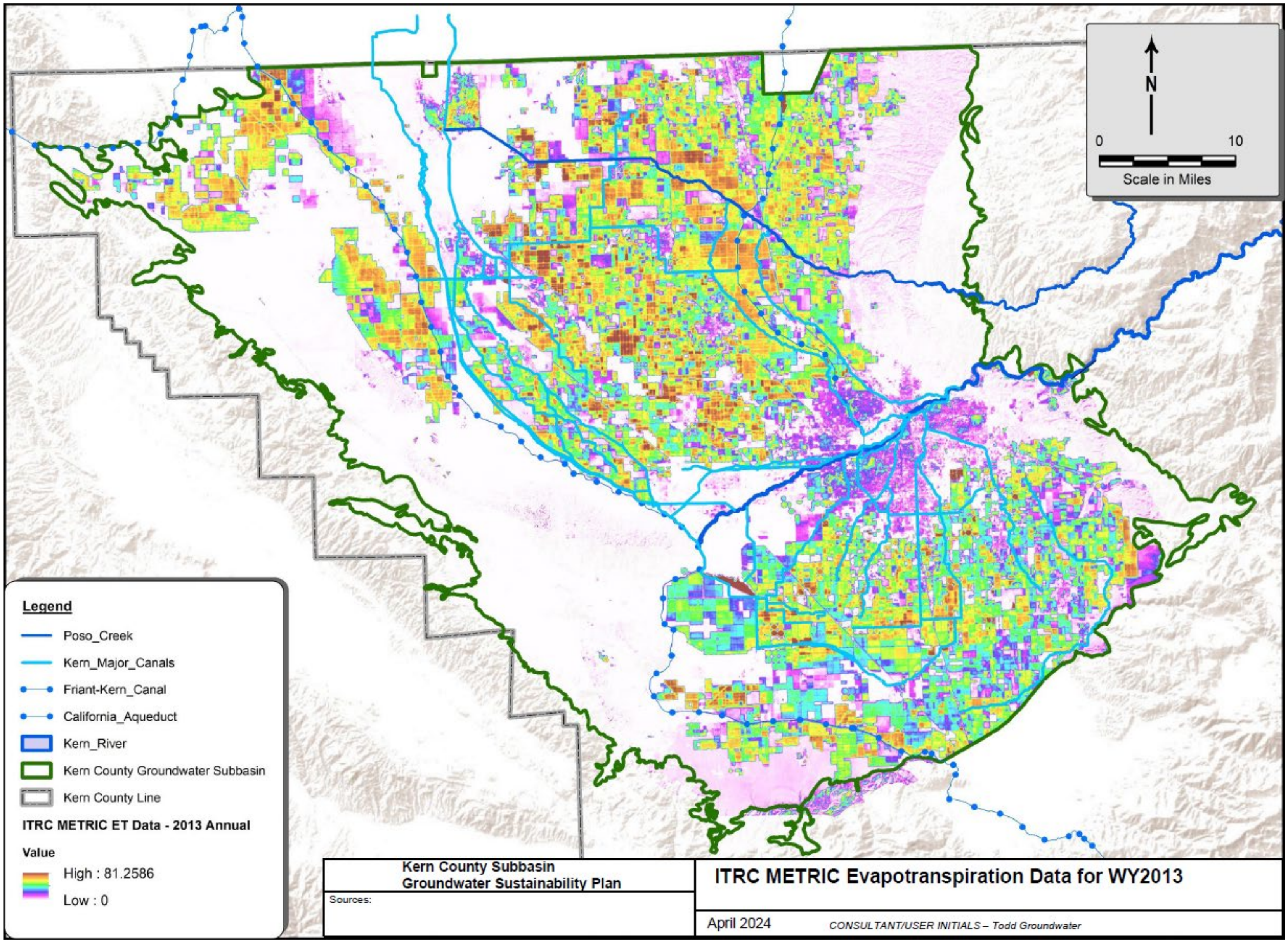


Figure 9-7. ITRC METRIC Evapotranspiration Data for WY2013

This page intentionally left blank.

ITRC used Landsat imagery for 1994 to 2022 (except 2012 when no imagery was available) and the ITRC-METRIC method to develop monthly raster maps of ETc at 30 x 30-meter resolution for the Kern County portion of the Central Valley (ITRC, 2017, 2020, 2021, 2022, and 2023). For WY2023, similar ET data sets were provided by LandIQ as part of their Round 1 SGM Grant Component 3.

The monthly ETc raster maps were used with annual DWR crop maps to calculate the average ETc by crop type for the three Kern County C2VSim subregions. ITRC-METRIC raster data were used to determine the exact areas of applied irrigation and total annual ETc. A raster pixel was assumed to be irrigated if the total annual ETc was greater than 20 inches. The following data processing steps were used to determine monthly ETc rates for each crop and C2VSim subregion:

- Create irrigation coverages – ITRC-METRIC monthly ETc raster data were summed to calculate total annual ETc for each year for each raster location. The ArcGIS Reclassify tool was then used on each annual ETc raster to create a binary polygon coverage for each year for 1994 to 2015 (except 2012), setting the attribute "IRR" to 1 if total annual ETc was over 20 in/year, and to 0 if total annual ETc was equal to or less than 20 in/year.
- Create land use coverages – Annual DWR land use rasters were converted to polygon coverages with the attribute "Crop" set to the corresponding integer crop value used in C2VSimFG-Kern. The land use rasters were checked against GIS maps produced by the Kern County Agricultural Commissioner and errors in the DWR land use rasters were corrected. DWR land use maps for 1994 to 1997 were missing large areas of data, so the 1998 land use map was used to approximate the land use for 1994 to 1997.
- Create monthly zone maps – One zone shapefile was created for each month by using the ArcGIS Union tool to combine a shapefile of the three C2VSim subregions with the irrigation coverage (produced in step 1) and the land use coverage (produced in step 2). Each monthly zone polygon shapefile has three attributes: C2VSim subregion, binary irrigation indicator, and a land use crop value. The dissolve function was used to combine zones with identical parameters.
- Calculate average monthly ETc for each zone – The ArcGIS Zonal Statistics by Table tool was used to calculate the average ETc value for each zone for each month. The individual pixels in each monthly ETc raster were averaged within each zone (produced in step 3). ITRC-METRIC data for 2013 were used in place of missing data for 2012.
- Combine tables – The MS Access Append function was used to combine the monthly ETc tables into a master table of monthly ETc by crop and C2VSim subregion.

- Output data – Data from the Access database was exported in a form consistent with the C2VSimFG-Kern input files. The output was also summarized to show the average monthly ETc for the irrigated area of each crop type in each model subregion.

The monthly ETc rates for the three Kern County subregions for WY1993-2023 were then replaced with the monthly ETc rates calculated. The annual ETc rates applied to C2VSimFG-Kern by crop type are listed in Appendix M (Table 10).

9.2.7.2 Irrigation Periods

The C2VSim Irrigation Periods file contains monthly parameters for each crop and subregion that indicate whether or not the crop is irrigated in that month. C2VSimFG-Beta irrigation periods for the three Kern County subregions were adjusted to match crop irrigation practices from ITRC-METRIC water usage. Simulated irrigation water usage for the C2VSimFG-Kern better reflects observed irrigation practices.

9.3 Historical and Current Water Budgets

§ 354.18. *Water Budget*

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(4) The change in the annual volume of groundwater in storage between seasonal high conditions.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.

(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:

(C) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.

(D) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.

(E) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and

C2VSimFG-Kern was used to develop historical (WY1995 to WY2014) and current (WY2015 to WY2023) water budgets for the Subbasin. The following summarizes the simulated water budgets from C2VSimFG-Kern. A summary of these results is provided below.

9.3.1 Total Surface Water Inflows and Outflows

☑ **23 CCR § 354.18(b)(1)**

The volume of surface water supplies delivered to the Kern County Subbasin is summarized below follows GSP regulations and DWR Water Budget BMP (DWR 2016a) reporting requirements for total surface water entering and leaving the Subbasin. Descriptions of the surface water supply are provided above in the Section 9.2.

Surface water supplies and water use for the Subbasin are compiled from data collected using the "best available measurement methods." For the Kern County Subbasin, surface water supplies are directly measured by local water agencies at the point of diversion from a river, stream or canal. The measured surface water supplies were provided by local agricultural water districts, urban water purveyors and city water departments. These meter data were compiled by local water agencies following their monitoring protocols. Therefore, these data were obtained using a "high accuracy" method consistent with typical accuracy ranges of surface water diversions. Using the methods described above, the surface water supply by source in the Kern County Subbasin was tabulated and is summarized in Table 9-1 and shown graphically in Figure 9-8.

Table 9-1. A Average Annual Surface Water Supplies in the Kern County Subbasin

Surface Water Supply Source	Historical Period WY1995 to WY2014 (acre-feet)	Current Period WY1995 to WY2014 (acre-feet)
Central Valley Project	360,362	316,952
State Water Project	856,255	777,185
Colorado River Project	0	0
Local Supplies	728,805	648,631
Local Imported Supplies	23,939	39,244
Recycled Water	40,265	48,359
Desalination	0	0
Other Water Source	12,340	987
Total Surface Water Supply	2,021,966	1,831,358

Following the DWR Water Budget BMP (DWR 2016a), the surface water supplies are presented by water source. For the Kern County Subbasin, the water supply sources are described as follows:

- **Central Valley Project (CVP)** – surface water deliveries from the CVP diverted from the Friant-Kern Canal and/or California Aqueduct (westside CVP – Cross Valley Contractors, San Joaquin River Restoration Program Recapture and Recirculation).
- **State Water Project (SWP)** – surface water deliveries from the SWP diverted from the California Aqueduct.
- **Colorado River Project** – Currently, no surface water from the Colorado River is delivered to the Kern County Subbasin.
- **Local Supplies** – surface water diversions from local surface water sources. The primary local supply is from the Kern River, but also includes other local sources such as Poso Creek and water exchanges.
- **Local Imported Supplies** – surface water from local sources imported from areas outside of the Kern County Subbasin. The primary source of local imported water is from treated oilfield produced water.
- **Recycled Water** – wastewater and recovered stormwater that is treated and used for either agriculture or groundwater recharge.

- **Desalination Water** – Currently, no desalination water is available in the Kern County Subbasin. However, proposed SGMA projects include this source as a future water supply.
- **Other Water Source** – Reuse of tailwater or irrigation return flow that re-enters the local surface water system and is then diverted back for irrigated agriculture water supply.

The total water use for the Kern County Subbasin as summarized by water use sector in Table 9-2.

Table 9-2. Average Annual Surface Water Use by Sector in the Kern County Subbasin

Surface Water Use Water Use Sector	Historical Period WY1995 to WY2014 (acre-feet)	Current Period WY1995 to WY2014 (acre-feet)
Urban	42,547	49,325
Industrial	2,369	2,263
Agricultural	1,726,262	1,405,005
Managed Wetland	17,635	14,303
Managed Recharge[1]	233,153	360,461
Native Vegetation	0	0
Other Water Uses	0	0
Total Water Use	2,021,966	1,831,358

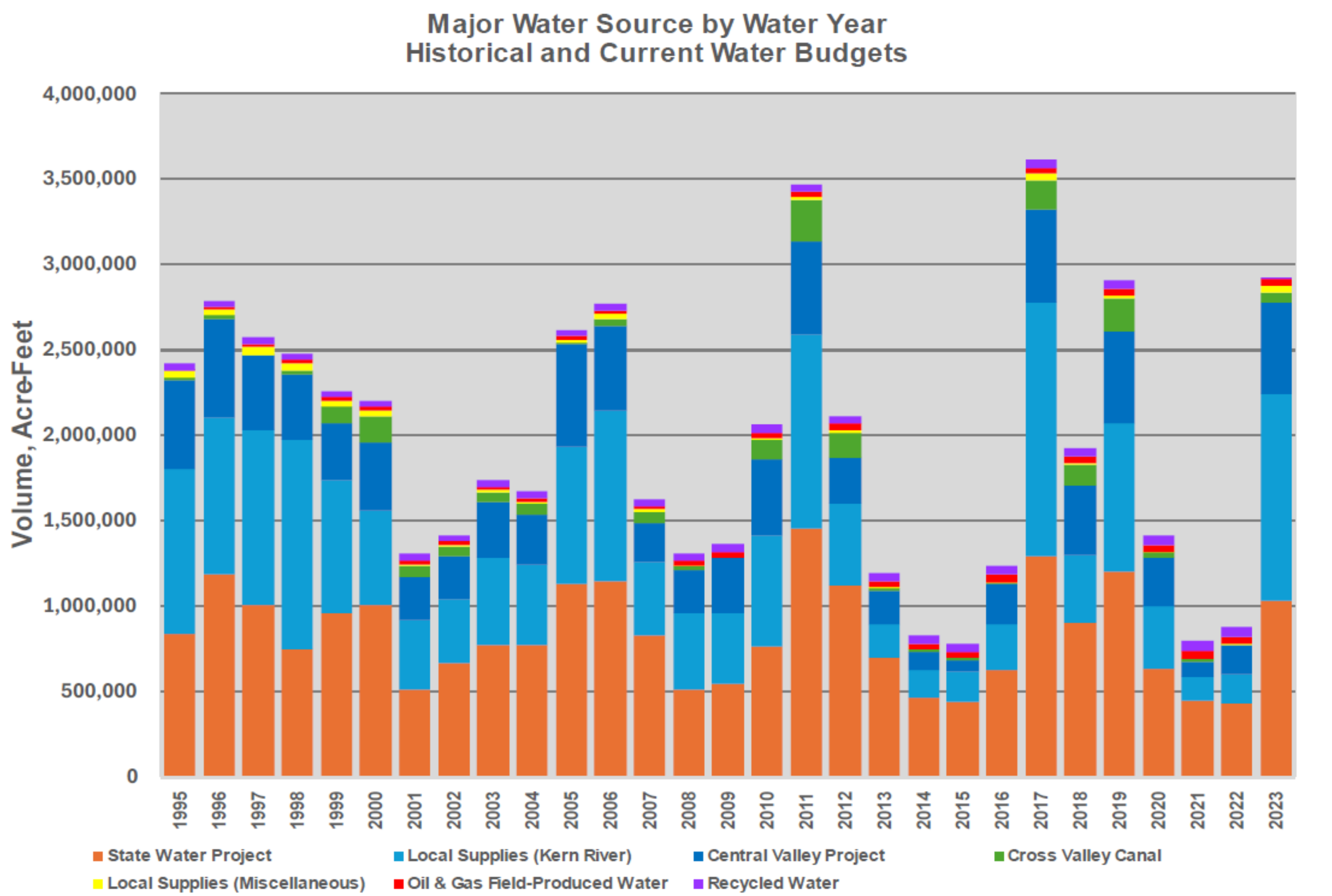
[1]includes Water Banking and Conjunctive Use Projects

The water use sectors shown on Table 9-2 are described as follows:

- **Urban –** total surface water use for all urban water uses including residential, commercial, municipal, industrial, landscaping, and other uses.
- **Industrial** – total surface water use for industrial use.
- **Agricultural** – total surface water use for all agricultural water uses including consumptive use and return flows.
- **Managed Wetlands –** total surface water use for maintaining managed wetlands at the Kern National Wildlife Refuge.
- **Managed Recharge** – total surface water use for active recharge at the water banking and conjunctive use projects.
- **Native Vegetation** – total surface water use for maintaining native vegetation. No surface water deliveries ae used on native vegetation.
- **Other Water Uses** – total surface water use for uses other than those listed above or from unspecified uses.

The surface water supplies in the Kern County Subbasin vary from year-to-year due to water year type (Figure 9-3), statewide water demand and operational considerations.

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	Simulated Historical Surface Water Deliveries for Kern County Subbasin
Sources:	April 2024 *Todd Groundwater /MM*

Figure 9-8. Simulated Historical Surface Water Deliveries for Kern County Subbasin

This page intentionally left blank.

9.3.2 Historical and Current Groundwater Budgets

☑ **23 CCR § 354.18(c)(1)**
☑ **23 CCR § 354.18(c)(2)**
☑ **23 CCR § 354.18(b)(4)**

As discussed in Section 9.2.3, the historical period of WY1995 to WY2014 represents a hydrologically balanced period that provides a well-balanced base period for evaluating long-term conditions. This period represents a hydrologically balanced period as characterized by the following:

- For the San Joaquin Valley Index (Figure 9-3), the 20-year historical period contains 10 years characterized as above normal or wet water year types and 10 years of below normal, dry, or critically dry water year types, including four critically dry years from.

- For the Kern River Water Year Index (Figure 9-3), the 20-year historical period streamflow conditions on the Kern River (Figure 9-3) include 9 years above 100 percent and 11 years below 100 percent.

The current water budget period of WY2015 through WY2023 includes recent available data following the historical water budget period. However, this period does not represent a hydrologically balanced period. This period represents a hydrologically balanced period as characterized by the following:

- For the San Joaquin Valley Index (Figure 9-3), the 9-year current period contains 3 years characterized as above normal or wet water year types and 6 years of below average water year types including three critically dry periods.

- For the Kern River Water Year Index (Figure 9-3), the 9-year current period streamflow conditions on the Kern River (Figure 9-3) include 3 years above 100 percent and 6 years below 100 percent.

- During the 9-year current period, dry years represent two-thirds of the time period. Despite the three wet water year types, the current period is considered to represent an unbalanced base period that skews towards to dry hydrologic conditions.

The historical and current water budget components are summarized in Table 9-3 based on C2VSimFG-Kern results provided in Appendix M (Table 11). Figure 9-9 shows a histogram illustrating the average annual historical water budget for the Subbasin.

The simulated annual water budgets based on C2VSimFG-Kern for the WY1995 through WY2023 simulation period are presented in Appendix M (Table 11) and are graphically depicted on Figure 9-8. This timeframe includes both the historical water budget period and the current water budget period.

Table 9-3. Historical and Current Water Budget Summary

Water Budget Component	Historical Water Budget Summary for WY1995 to WY2014	Current Water Budget Summary for WY2015 to WY2023
INFLOWS		
Deep Percolation	668,340	652,709
Water Banking and Conjunctive Use	583,598	731,434
Groundwater-Surface Water Interactions	98,600	95,425
Small Watershed Inflow	48,760	61,995
Subtotal - Inflow	1,399,298	1,541,563
OUTFLOWS		
Groundwater Pumping	-1,586,418	-1,817,881
Net Subbasin Subsurface Outflow	-87,080	-67,702
Subtotal - Inflow	-1,673,498	-1,885,583
Change in Groundwater Storage	-274,200	-344,019

The results for the historical and current water budget are summarized under the following categories:

- **Deep Percolation** – Precipitation and applied water that percolates below the root zone and through the unsaturated zone to provide groundwater recharge. More detailed information is provided in Appendix M (Table 12).
- **Water Banking and Conjunctive Use** – Direct recharge of surface water at water banking operations, conjunctive use projects, and other managed recharge sources. More detailed information is provided in Appendix M (Table 12).
- **Groundwater-Surface Water Interactions** – Net volumetric exchange of surface water and groundwater between the aquifer and simulated streams, which include Kern River and Poso Creek. These are both losing streams where surface water infiltrates to groundwater. More detailed information is provided in Appendix M (Table 13).
- **Small Watershed Inflow** – Inflows to the Subbasin from the surrounding small watersheds as percolation of stream inflow and subsurface inflow from the watershed area. More detailed information is provided in Appendix M (Table 13).
- **Groundwater Pumping** – Total groundwater pumping by wells. Water banking stored surface water recovery pumping is specified as fixed input values and agricultural and municipal pumping is calculated by C2VSimFG-Kern based on demand minus surface water diversions. More detailed information is provided in Appendix M (Table 14).

- **Net Subbasin Subsurface Outflow** - Net subsurface groundwater flow to and from the Kern County Subbasin with adjoining groundwater basins: negative is a net flow out of the Subbasin and positive is a net flow into the Subbasin. More detailed information is provided in Appendix M (Table 13).
- **Change in Groundwater in Storage** – This term includes both groundwater and banked surface water stored in the aquifer a. A positive change in storage represents water that is removed from the aquifer to supply water for pumping or another outflow that results in a decline in groundwater levels. A negative change in storage represents water being added to the aquifer from one of the recharge components of the water budget, resulting in a decline an increase in groundwater levels. The change in storage term represents the net sum of the inflow and outflow components. More detailed information is provided in Appendix M (Table 11).

Table 9-4 shows the volumetric range of annual variability for each water budget component from WY1995 though WY2023 in acre-feet from Appendix M (Table 11). This high variability in year-to-year water budgets is generally due to seasonal variations in precipitation, imported water availability and utilization of water banking and conjunctive use projects. During wet and above normal water years, increased availability of surface water supplies meets a large percentage of the local water use which thereby reduces total groundwater pumping in the Subbasin. Conversely, in dry and critically dry water years, the limited availability of surface water supplies results in a greater reliance on pumping from the Subbasin.

Table 9-4. Annual volumetric range for each water budget component from WY1995 though WY2023 in acre-feet

Water Budget Component	Minimum	Maximum	Median	Average
Deep Percolation	427,452	1,111,864	594,742	663,489
Water Banking and Conjunctive Use	84,456	1,879,808	462,522	629,478
Groundwater-Surface Water Interactions	26,256	259,377	80,305	97,615
Small Watershed Inflow	17,832	155,312	36,058	52,867
Groundwater Pumping	-2,817,057	-882,967	-1,529,196	-1,658,251
Subsurface Flow with Adjacent GW Basins	-96,620	-58,578	-83,943	-81,066
Change in Groundwater Storage	-2,303,716	2,289,354	-392,758	-295,868

The simulated change in groundwater in storage varies over the historical and current water budget periods is closely related to climatic conditions and surface water supply availability (Figure 9-11). During the periods, there are eleven years (WY1995 to WY1999, WY2005, WY2006, WY2011, WY2017, WY2019, and WY2023) with stable to increasing groundwater storage volume correlating to the above average rainfall and surface water availability. During the historical and current periods, there are eighteen years (WYs2000 to 2004, WYs2007 to 2010 and WYs2012 to WY2016, WY2018, WY2020 to 2022) where groundwater storage volume decreased, correlating to periods of drought and low surface water availability. The simulated historical and current groundwater recharge also reflects this climatic pattern with high volumes of deep percolation to groundwater and large increases in water banking and conjunctive use projects and canal seepage during years with above average surface supplies and lower groundwater recharge during the drought years (Figure 9-11).

The severe drought conditions from WY2013 to WY2022, that included by five critically dry water years over this ten-year period, exasperated the reduced reliability of surface water supplies. To increase the Subbasin's water supply portfolio resiliency, the Subbasin's use of water banking and conjunctive use projects has grown. During wet and above normal water types, a portion of the available surface water supplies are stored in water banking and conjunctive use projects, resulting in a large increase in Water Banking and Conjunctive Use volumes in the model. This stored surface water is later recovered by pumping or other surface water exchanges that results in an increase in the total pumping in the Subbasin. However, the water banking projects are operated so that the total recovered surface water is less than the total recharged water. The portion of water not recovered, or the "leave-behind" percentage, accounts for potential losses and provides a long-term groundwater benefit to the Subbasin.

The annual surface water deliveries for managed recharge in the Subbasin is shown in Figure 9-12 and is based on reported data from the water banking and conjunctive use project operators for direct aquifer recharge that is input directly into the model. The data shows that recharge is highest during above normal and wet water year types and lowest during below normal, dry, and critically dry water year types. The increase in the wet water year type recharge over time reflects the growth of water banking and conjunctive use projects in the Subbasin over the historical and current periods.

The annual groundwater pumping for the Subbasin from C2VSimFG-Kern Table 9-2 and Figure 9-13 is based on a combination of reported pumping entered directly into the model and simulated pumping to account for unreported pumping. The pumping on Figure 9-13 shows agricultural, urban, and managed recharge pumping. Agricultural and urban pumping increased over the historical period with the highest uses during critically dry water years and substantially lower use during wet water years. However, agricultural pumping shows a general decreasing trend over the current period relative to the latter part of the historical period. Managed recharge pumping is the recovery of stored surface water for water banking and some conjunctive use projects for local agricultural and urban supply, as well as water banking obligations both for use within the Subbasin and for banking partners outside of the Subbasin. The increase in managed recharge pumping illustrates the growth in water banking and conjunctive use projects over the historical period.

The annual surface water supplies for agricultural, urban, and other beneficial uses within the Subbasin are shown in Figure 9-8 and are based on reported surface water supplies from the water agencies that are input directly into the model. Agricultural uses account for the about 96 percent of the surface water use, urban accounts for about 3 percent, and miscellaneous other uses account for about one percent. Surface water supplies are strongly associated with water year type. During dry and critically dry conditions, surface water supplies are severely limited. Figure 9-8 shows a general declining trend in surface water supplies over the historical period.

Agriculture is a primary water use within the Subbasin. Figure 9-14 shows the annual change over time in irrigated agricultural acreage and agricultural crop evaporation or crop demand. More detailed information is provided in Appendix M (Table 15). During the historical period, irrigated agricultural acreage was highest in the mid-1990s, ranging from 800,000 to 900,000 acres. During this period, annual crops accounted for about two-thirds of the total acreage with cotton and alfalfa the dominant crop. From WYs2000 to 2014, the irrigated agricultural acreage ranged from 700,000 to 800,000 acres. During this period, crop types were shifting from predominantly annual to permanent crops. Over the historical period, the average annual crop demand decreased from 2.5 million to 2.0 million acre-feet per year that generally correlates to the decrease in irrigated acreage. Over the current period of WY2015 to 2023, irrigated agricultural acreage has ranged between 750,000 and 800,000 with permanent crops, primarily tree nuts, being predominant. Over the current period, the average annual crop demand decreased from 2.1 million to 1.9 million acre-feet per year. This is considered to represent a combination of a decrease in irrigated acreage and improvements in irrigation efficiency. Agricultural land use and evapotranspiration (crop water demand) during the historical and current periods is shown in Figure 9-14.

Urban demands in C2VSimFG-Kern are based on agency supplied information and/or regional population and per-capita water demand. Population information was from projected-future baseline population. In general, total urban use rose during the historical period in response to increasing population. Urban water use peaked in 2011. Since 2011, urban water use has decreased due to mandated water conservation measures. Between 2010 and 2020, population growth moderated (see Section 9.2.6.2) allowing for urban water use to show a declining trend over the current period. More detailed information on urban water use is provided in Appendix M (Table 16).

Deep percolation includes the precipitation and applied water that percolates below the root zone and through the unsaturated zone to provide groundwater recharge. Agricultural areas have the highest deep percolation that accounts for both precipitation and applied water in these areas. Urban areas also include both precipitation and applied water from outdoor water use but are smaller in area. Native or undeveloped areas includes only precipitation but is covers are larger area. More detailed information is provided in Appendix M (Table 12).

Groundwater flow exits the Subbasin across the northern Subbasin boundary with the Tulare Lake and Tule Subbasins (Section 8.1.1.1). Along the western half of the northern Subbasin boundary, groundwater flow is typically northward. This produces a consistent outflow towards the Tulare Lake and Tule Subbasins. Along the southern Subbasin Boundary, groundwater flow is typically northward indicating a consistent inflow from the White Wolf Subbasin that is restricted by the bounding White Wolf Fault. The northern outflow is greater than the southern inflow, so the net subsurface flow with adjoining Subbasins is an outflow. More detailed information on the net boundary subsurface flow is provided in Appendix M (Table 13).

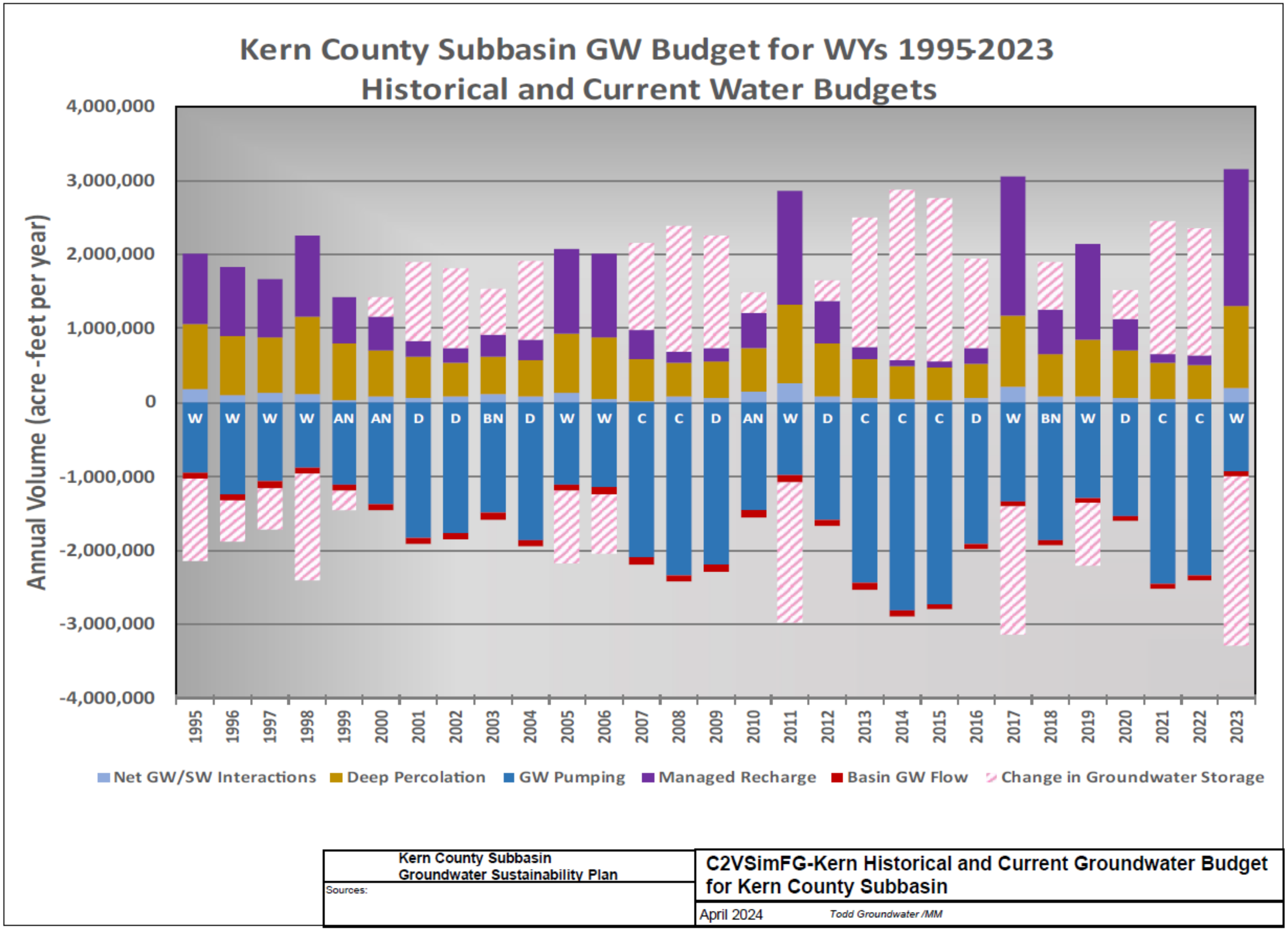
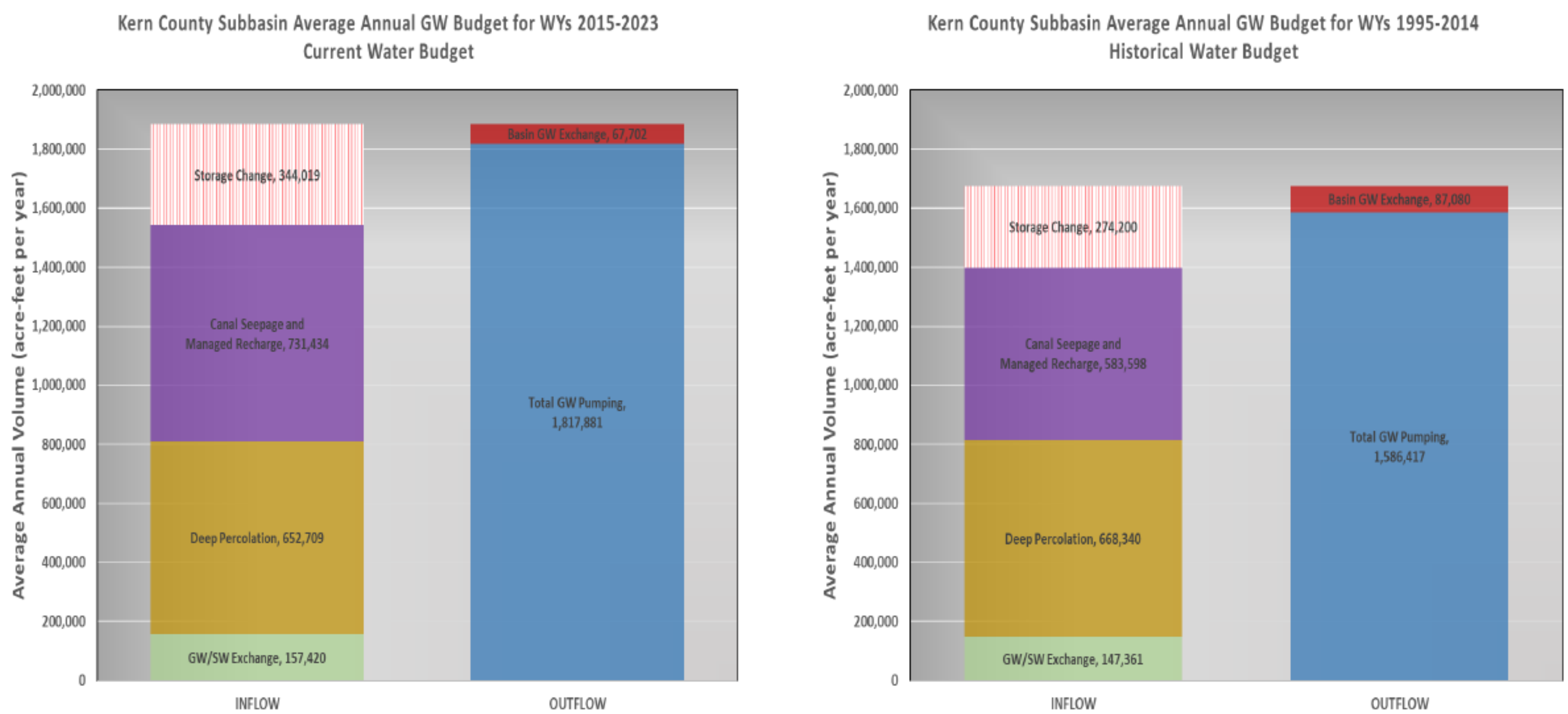


Figure 9-9. C2VSimFG-Kern Historical and Current Groundwater Budget- for Kern County Subbasin



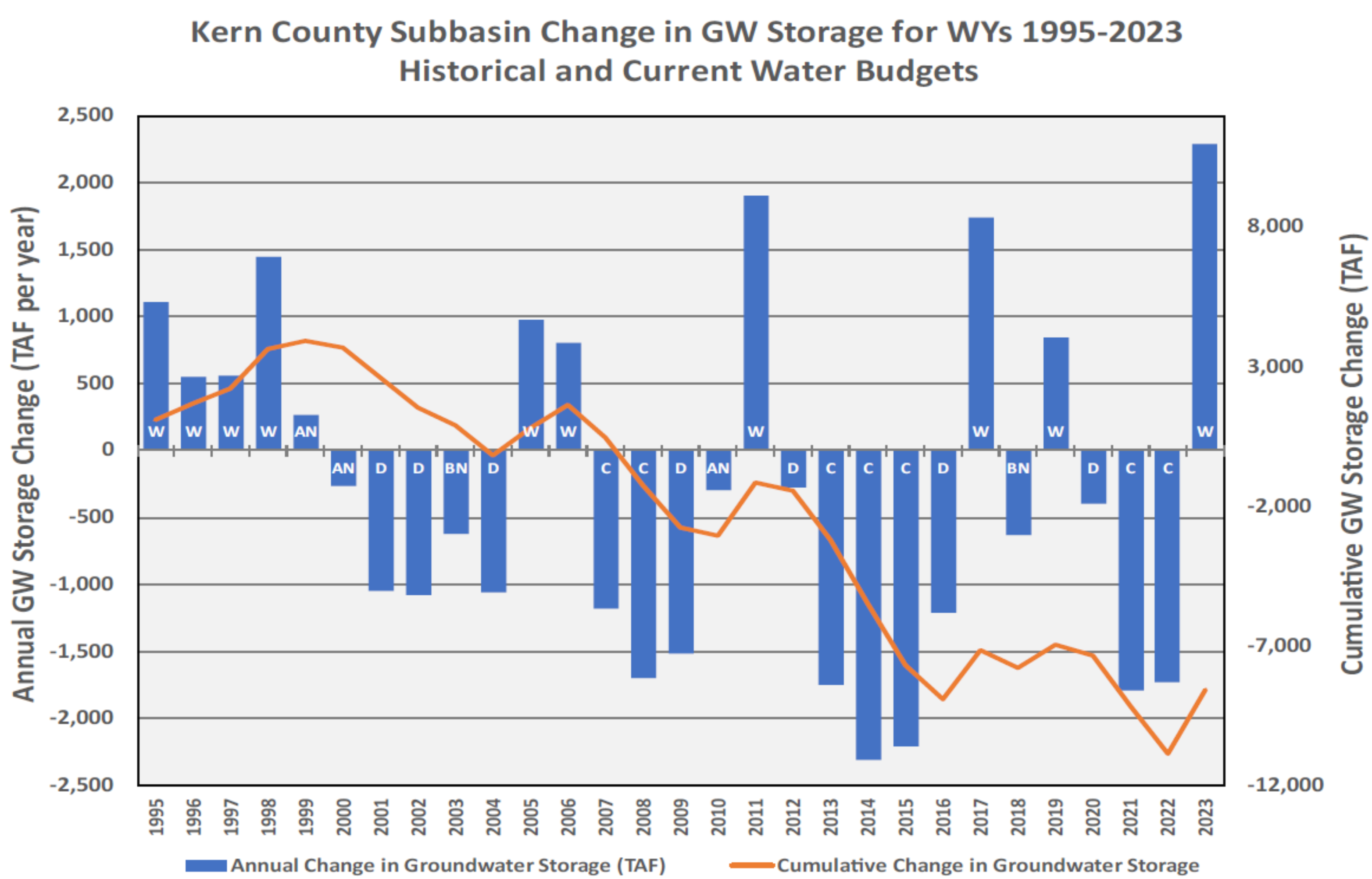
Kern County Subbasin
Groundwater Sustainability Plan

Sources:

C2VSimFG-Kern Average Annual Historical and Current Water Budget for Kern County Subbasin

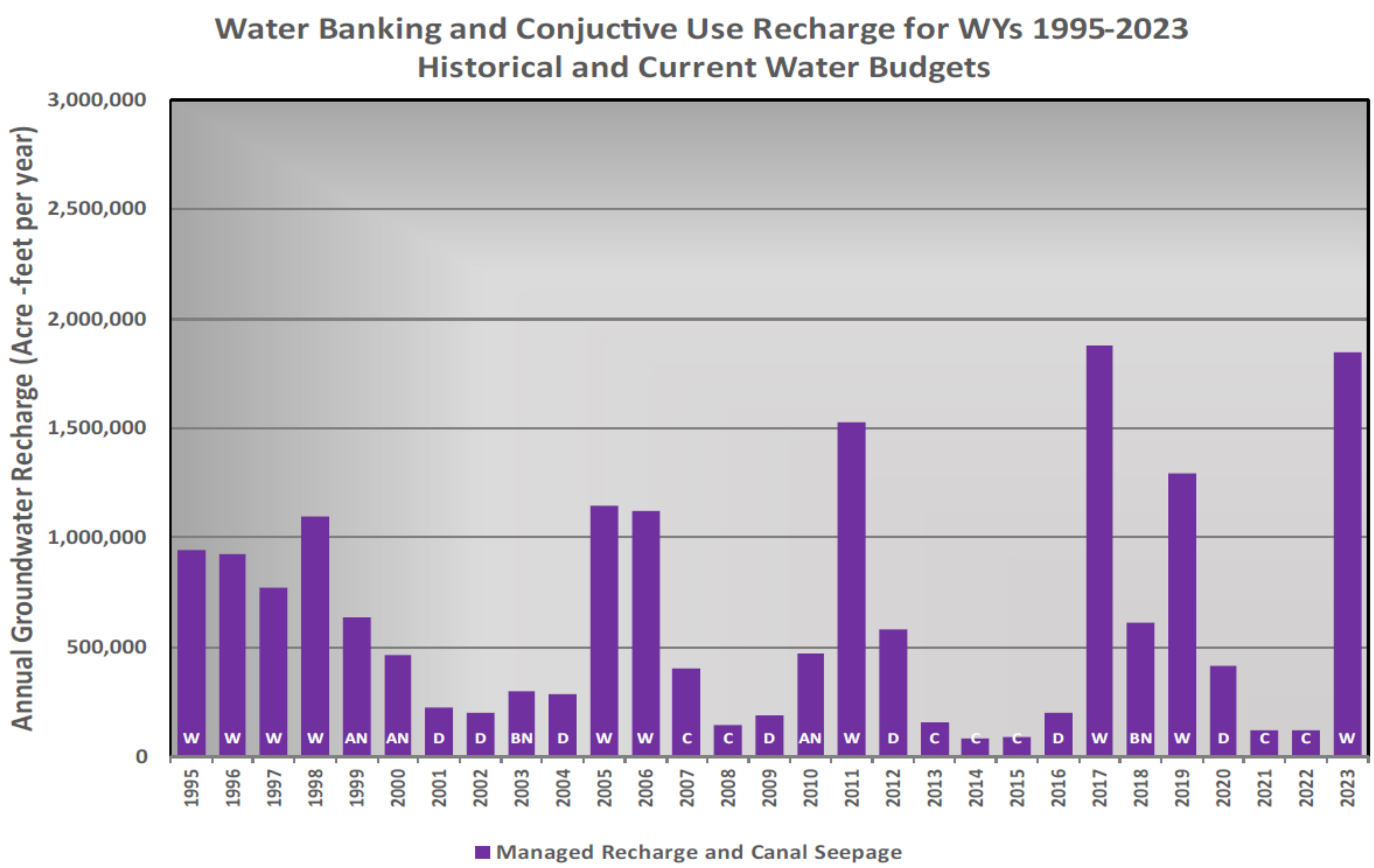
April 2024 *Todd Groundwater /MM*

Figure 9-10. C2VSimFG-Kern Average Annual Historical and Current Water Budget for Kern County Subbasin



Kern County Subbasin Groundwater Sustainability Plan	Simulated Historical and Current Change in Groundwater Storage for Kern County Subbasin
Sources:	April 2024 Todd Groundwater /MM

Figure 9-11. Simulated Historical and Current change in Groundwater for Kern County Subbasin



Kern County Subbasin Groundwater Sustainability Plan	Simulated Historical Recharge Operations for Kern County Subbasin
Sources:	April 2024 *Todd Groundwater /MM*

Figure 9-12. Simulated Historical Recharge Operations for Kern County Subbasin

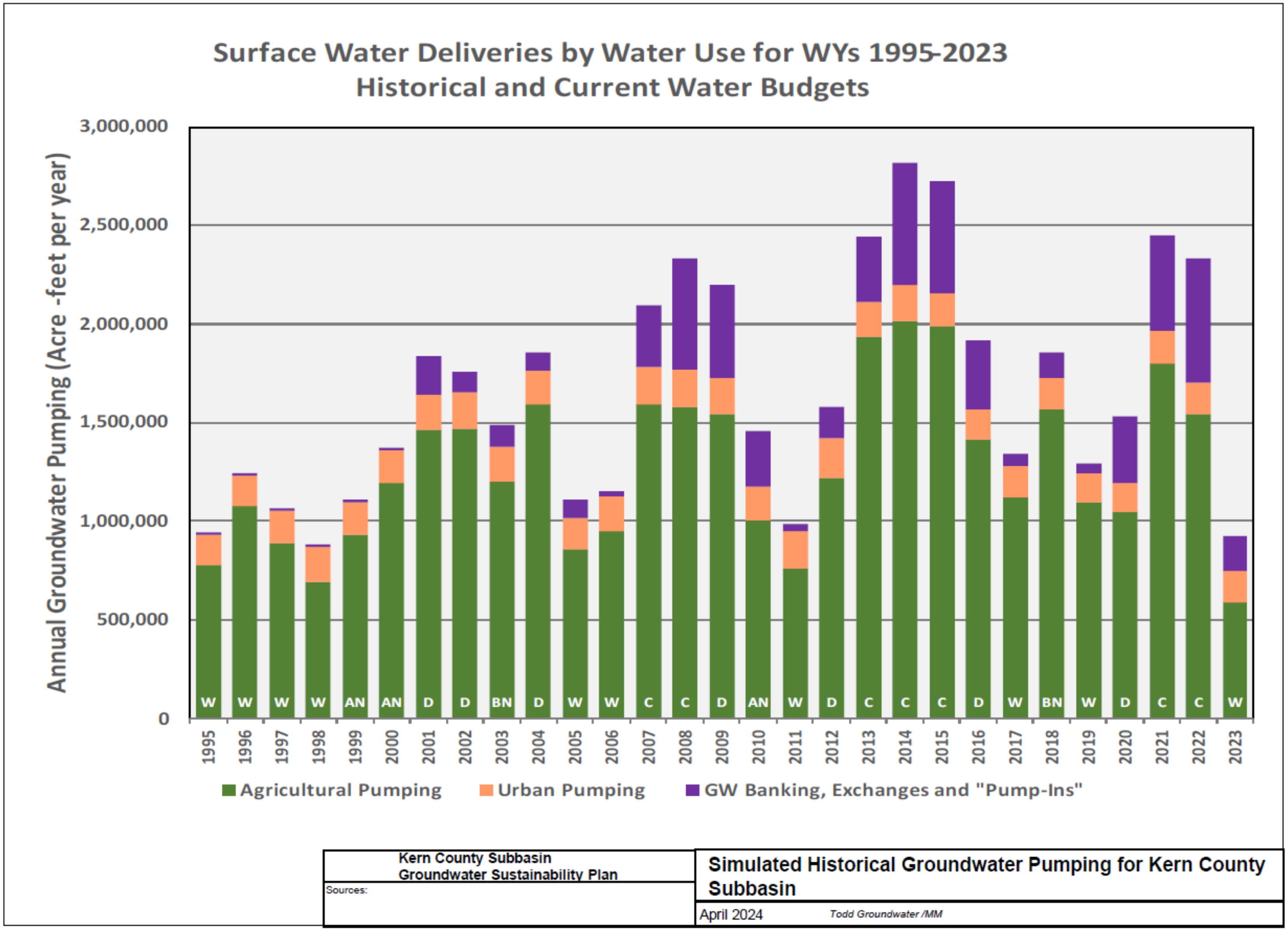
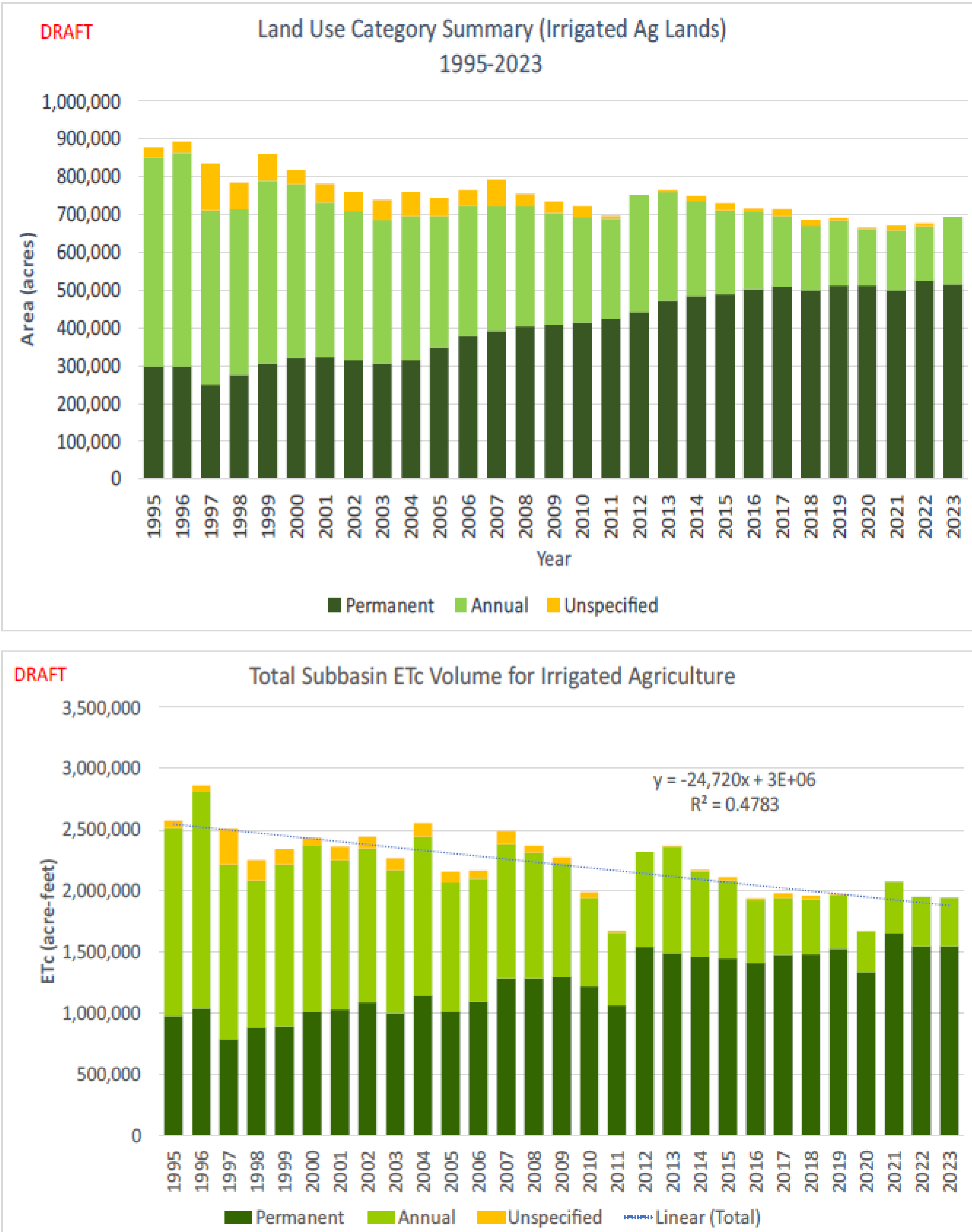


Figure 9-13. Simulated Historical and Current Groundwater Pumping for Kern County Subbasin

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	Annual Irrigated Agricultural Land by Crop Type and Total Crop Evapotranspiration (ETc)
Sources: California Data Exchange Center (CDEC, 2023) City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)	May 2024 *Todd Groundwater/MM*

Figure 9-14. Annual Irrigated Agricultural Land by Corp Type and Total Crop Evapotranspiration (ETc)

9.3.3 Groundwater Extraction Maps

☑ **23 CCR § 354.18(c)(1)**
☑ **23 CCR § 354.18(c)(2)**

Total groundwater extraction maps were developed based on C2VSimFG-Kern simulation results to illustrate the distribution of pumping across the Subbasin. The specified metered pumping is directly input into C2VSimFG-Kern while the IDC tool estimates the unmeasured portion of agricultural and urban pumping based on land use calculations.

Developing this map required accessing the groundwater extraction for each element from the binary output files of model results. The model output is the total volume of groundwater extracted within a model element. Because model elements vary in size, the simulated groundwater extraction rate from C2VSimFG-Kern is then normalized by dividing by the element area to obtain units of acre-feet per square mile. These groundwater extraction rates are then interpolated onto a uniform one-square mile grid superimposed over the Subbasin. Therefore, the model output represents the total pumping per square mile over the Subbasin included in C2VSimFG-Kern.

Figure 9-15 shows the distribution of total groundwater extractions over the Subbasin for WY2022 and WY2023. In WY2022 agricultural pumping accounted for 66 percent of the total groundwater extractions. The pumping distribution generally corresponds to the distribution of irrigated agriculture. The exception is in the northwestern portion of the Subbasin in the Western Fold Belt HCM, where irrigated agriculture depends almost solely upon imported surface water supplies due to poor local groundwater quality, which is unsuitable for irrigation. In general, groundwater extraction in the irrigated areas ranges between 250 to 2,000 acre-feet per square mile. In WY2023 (Figure 9-15) the distribution of total groundwater extractions over the Subbasin shows the effect of the high availability of surface water supplies with substantially lower groundwater pumping rates for irrigated agriculture in WY2023 relative to WY2022 (Figure 9-13)

Areas of concentrated pumping are typically associated with water bank recovery operations. The areas where groundwater pumping exceeds 2,000 acre-feet per square mile are located in the vicinity of water banking operations where the pumping is recovering previously stored surface water for use. Recovery of stored surface water from large water banking projects was relatively high in WY2022 due to the critically dry conditions. In WY2023, the wide availability of imported surface water minimized the need to pump groundwater for recovery operations.

9.3.4 Change in Groundwater in Storage Maps

☑ **23 CCR § 354.18(b)(4)**

The total change in groundwater storage within the Subbasin is the sum of the total groundwater inflows and outflows. This change in storage manifests physically as a change in groundwater levels. The magnitude of change in groundwater levels is a function of the storage properties of the aquifer which varies for groundwater under confined and unconfined conditions.

Figure 9-16 presents the annual Subbasin-wide change in groundwater in storage map for WY2022 and WY2023. A positive value represents an increase in the volume of groundwater stored in the aquifer, which physically results in a rise in groundwater levels whereas a negative represents a decrease in groundwater in storage resulting in a decline in groundwater levels.

WY2022 was rated a critically dry water year under the San Joaquin Valley Index (California Data Exchange Center [CDEC], 2023), and the Kern River Index was 29 percent of average Kern River flows (COB, 2022). The largest change in storage of groundwater and stored surface water in WY2022 (Figure 9-16) is concentrated in the center of the Subbasin in the vicinity of the large water banking operations along the Kern River. Other areas of concentrated groundwater and/or stored surface water recovery are noted to the north and southeast near Kern Fan Banking Area. Widespread, but lesser, declines in groundwater in storage are observed over most other areas of the Subbasin.

WY2023 was rated a wet water year under the San Joaquin Valley Index (CDEC, 2024), and the Kern River Index was 320 percent of average Kern River flows (COB, 2023). The largest change in groundwater and stored surface water in storage in WY2023 is concentrated in the center of the Subbasin in the vicinity of the large water banking operations along the Kern River (Figure 9-16). Other areas of concentrated water recharge are noted near other large water banking and conjunctive use projects. Widespread increases in groundwater in storage are observed over most of the Subbasin. The minor changes along the Subbasin margins are consistent with the water use in these more undeveloped areas.

9.3.5 Overdraft Conditions

☑ **23 CCR § 354.18(b)(5)**

GSP regulations require that the water budget include an assessment of groundwater overdraft conditions. Determination of overdraft conditions requires the evaluation of current and historical water budget conditions. Following DWR's *Water Budget Best Management Practice*s (DWR, 2016), overdraft conditions should be assessed by calculating change in groundwater storage over a period of years during which water year and water supply conditions approximate average conditions. Overdraft conditions should be evaluated as changes in groundwater storage by water year type.

As discussed previously, the historical water budget approximates average hydrologic conditions, whereas the current water budget period does not represent average hydrologic conditions as previously described in Section 9.3. Therefore, the Subbasin overdraft calculated from the historical water budget (WY1995 to WY2014) is currently defined as 274,200 acre-feet, which is the average annual change (decrease) in groundwater storage over the historical period.

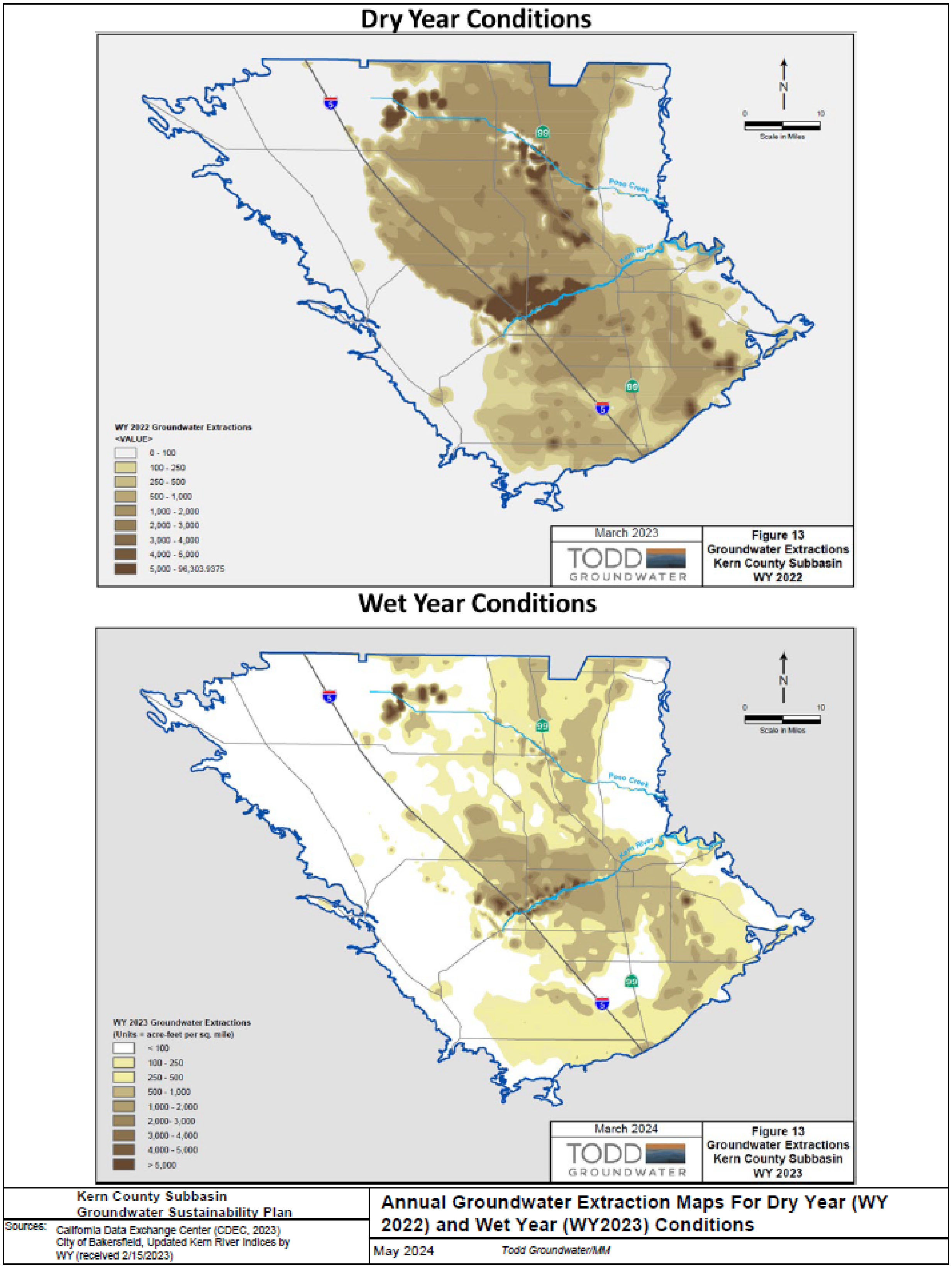
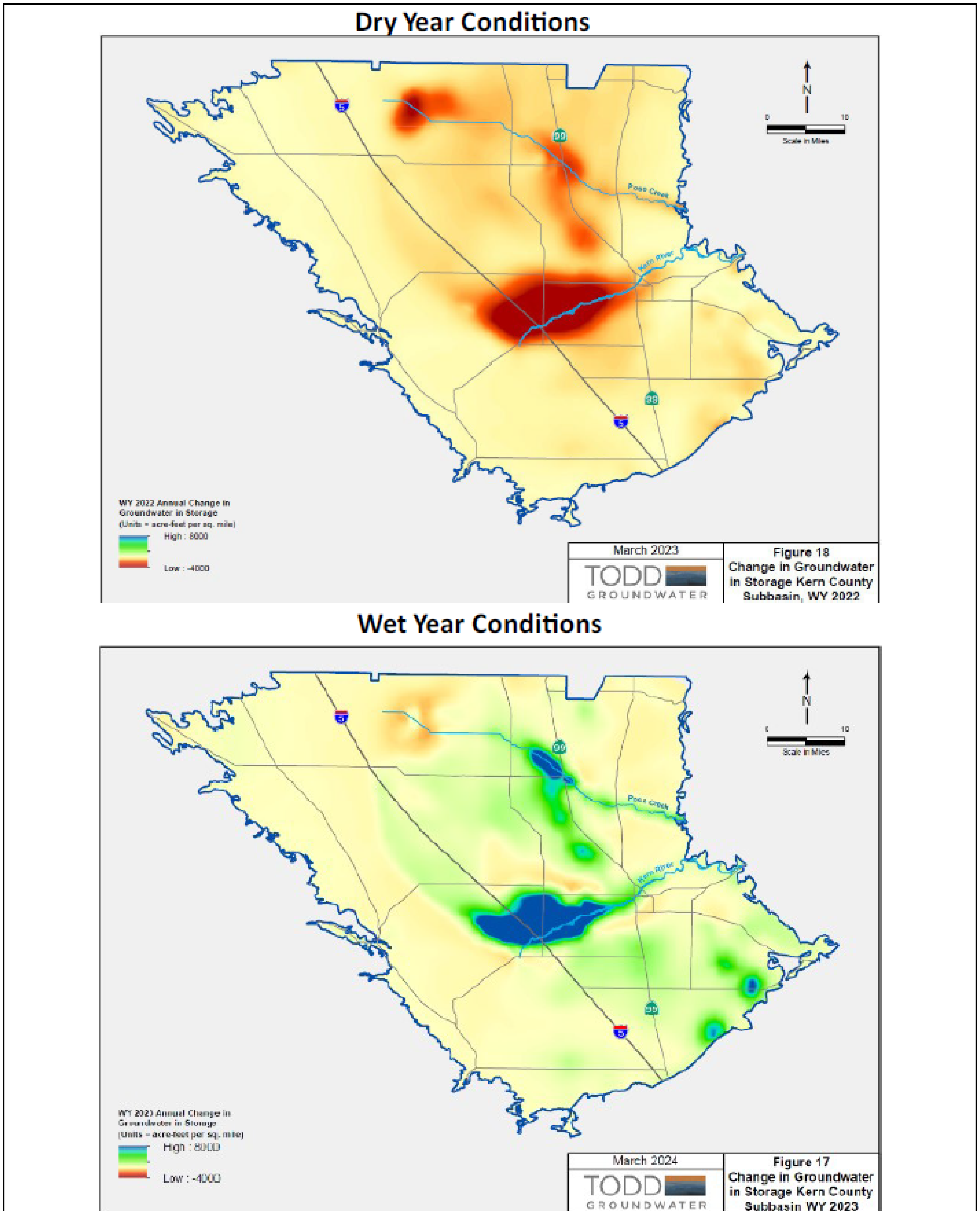


Figure 9-15. Annual Groundwater Extraction Maps for Dry Year (WY2022) and Wet Year (WY2023) Conditions



Kern County Subbasin Groundwater Sustainability Plan	**Annual Change in Groundwater in Storage Maps For Dry Year (WY 2022) and Wet Year (WY2023) Conditions**
Sources: California Data Exchange Center (CDEC, 2023) City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)	May 2024 *Todd Groundwater/MM*

Figure 9-16. Annual Change in Groundwater in Storage Maps for Dry Year (WY2022) and Wet Year (WY2023) Conditions

9.4 Sustainable Yield

§ 354.18. *Water Budget*
(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(7) An estimate of sustainable yield for the basin.
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:
(C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.

☑ **23 CCR § 354.18(b)(7)**
☑ **23 CCR § 354.18(c)(2)(A)**

Section 354.18(c) of the GSP Regulations requires that an estimate of the basin's sustainable yield. SGMA defines "sustainable yield" as:

> "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, which can be withdrawn annually from a groundwater supply without causing an undesirable result."

SGMA does not incorporate sustainable yield estimates directly into sustainable management criteria. Sustainable yield is considered in SGMA as part of the estimated Subbasin-wide water budget and as the outcome of avoiding undesirable results. Subbasin-wide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the six sustainability indicators.

9.4.1 Determination of Sustainable Yield

To determine the sustainable yield for the Subbasin, the results of the C2VSimFG-Kern model are used with two methods to estimate the amount of groundwater pumping that would avoid the undesirable result of a reduction in groundwater storage over the historical base period WY1995 to WY2014. The results are summarized below:

- **Sustainable Yield from Groundwater Pumping –** The model results produce an average annual groundwater pumping in the Subbasin of 1,586,417 AFY with an average annual decrease in groundwater storage of 274,200 AFY (Table 9-5). Subtracting the groundwater storage decline from groundwater pumping produces a sustainable yield of approximately 1,312,218 AFY.

- **Sustainable Yield from Groundwater Recharge –** The model results produce an average annual groundwater recharge in the Subbasin of 1,399,299 AFY. The subsurface outflow from the GSA was estimated to be 87,080 AFY (Table 9-6). Subtracting these outflow losses from the groundwater recharge produces a sustainable yield of approximately 1,312,219 AFY.

Sustainable yield estimates are part of SGMA's required basin-wide water budget. In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. This sustainable yield estimate can be helpful for evaluating the projects and programs needed to achieve sustainability. Although the SGMA regulations require a single value of sustainable yield calculated basin-wide, it should be noted that the sustainable yield can be changed by implementation of recharge projects, variations in climate, or changes in stream flow conditions.

Using WY1995 to WY2014 as the base period, C2VSimFG-Kern results show declining groundwater levels and a long-term reduction of groundwater storage. During this period, average annual inflow to the aquifer is 1,399,299 AFY, and outflow is 1,673,498 AFY. This yields an average annual deficit of 274,200 AFY. Based on these historical C2VSimFG-Kern results, the sustainable yield of the Subbasin is approximately 1,312,218 AFY (Appendix M (Table 12)), with an estimated level of uncertainty on the order of plus or minus 10 to 20 percent.

Table 9-5. Estimated Subbasin Sustainable Yield based on C2VSimFG-Kern – Sustainable Yield from Groundwater Pumping

Water Years Units	Total Average Annual Volume (acre-feet)	Agricultural Average Annual Volume (acre-feet)	Urban Annual Volume (acre-feet)	GW Banking Exchanges and "Pump-ins"
Groundwater Pumping	1,586,417	1,237,746	176,146	172,525
Percentage of Pumping	100%	78%	11%	11%
Change in Groundwater in Storage	-274,200	-240,039	-34,160	
Percentage of Pumping		88%	12%	
Sustainable Yield	**1,312,218**	**997,707**	**141,985**	**172,525**
Average Annual Difference	**-274,200**	**-240,039**	**-34,160**	
Percent Difference	**-21%**	**-24%**	**-24%**	

Table 9-6. Estimated Subbasin Sustainable Yield based on C2VSimFG-Kern – Sustainable Yield from Basin Recharge and Outflow

Water Years (units)	Total Average Annual Volume (acre-feet)	Agricultural Average Annual Volume (acre-feet)	Urban Annual Volume (acre-feet)	GW Banking Exchanges and "Pump-ins"
Groundwater Recharge	1,399,299			
Subsurface Outflow	-87,080			
Sustainable Yield	1,312,219			
Average Annual Difference	**-274,200**			
Percent Difference	**-21%**			

9.4.2 Native Yield

The native yield is summation of the natural, or unmanaged, recharge components of the water budget as shown in Appendix M (Table17). This includes groundwater recharge derived from precipitation and inflows from the surrounding watersheds. For the larger streams (Kern River and Poso Creek), specific agencies or parties have water rights to specific volumes of flow; therefore, these streams treated separately and are not included in this estimate of the native yield.

As with sustainable yield, the C2VSimFG-Kern model results over the historical base period WY1995 to WY2014 are used for estimation of native yield. The model results are used to determine the amount of precipitation recharge over agricultural, urban undeveloped areas and the small watershed annual inflow volume. The total and average annual volume of precipitation that percolates to groundwater during the WY1995 to WY2014 base period are listed in Appendix M (Table17). The results of this assessment based on the C2VSimFG-Kern results are shown in Appendix M (Table17) and are summarized below:

- The average annual volume of precipitation that recharges the groundwater in the Subbasin is 231,994 AFY.
- The average annual volume of inflow from small watersheds is 48,760 AFY.

Totaling these inputs results in a native yield for the Subbasin of approximately 280,754 AFY. The annual contribution per acre of approximately 0.15 acre-feet per acre is estimated by dividing the average annual contribution by the total area of the Subbasin (Appendix M (Table13)).

Similar to the sustainable yield, the native yield at this time is based on the best available data. However, as data gaps are eliminated and management actions/plans are implemented, the native yield could change, and any changes to native yield will be reflected in future GSP updates.

9.4.3 Application of Sustainable and Native Yield

In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. The native yield is similar to the sustainable yield except that the only recharge that is included in the calculation is the natural, unallocated portion of the groundwater recharge. The following estimates of the Subbasin sustainable and native yields are derived from the C2VSimFG-Kern historical model results for the purpose of supporting assessment of the types and magnitude of projects and programs needed to achieve sustainability.

The C2VSimFG-Kern estimates of sustainable and native yield presented here are based on available data and the current level of model calibration. Therefore, these estimates are considered appropriate as guides to SGMA planning. However, the C2VSimFG-Kern sustainable and native yield estimates are initial estimates that are not intended for determination of individual landowner allocations or groundwater rights. Additional technical and legal analysis, along with stakeholder involvement, is necessary to fully quantify the sustainable and native yields.

9.5 Projected Future Water Budget

§ 354.18. Water Budget

(b) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.

(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

☑ **23 CCR § 354.18(c)(3)**
☑ **23 CCR § 354.18(d)(3)**

Projected (future)water budgets for the Subbasin were developed using the C2VSimFG-Kern. These projected water budgets establish expected Baseline conditions to evaluate the impacts of GSP implementation. Three projected scenarios, each representing a different expected future hydrologic condition, were developed for the Subbasin by adapting C2VSimFG-Kern as follows:

- Future Baseline Conditions: Repeat historical hydrology with expected future water supply.
- 2030 Climate Conditions: Adjust historical hydrology for 2030 climatic conditions and expected water supply.
- 2070 Climate Conditions: Adjust historical hydrology for 2070 climatic conditions and expected water supply.

Projected future water budgets were developed for the three scenarios listed above (Baseline conditions, 2030 Climate Conditions, and 2070 Climate Conditions) over a 50-year planning and implementation horizon. To assess the sustainability of the proposed Plan, the C2VSimFG-Kern model future scenario input files were then modified to create three additional scenarios that incorporate all the proposed SGMA projects and management actions. The six total scenario models provide a basis of comparison for evaluating proposed SGMA projects and management actions over the SGMA planning and implementation horizon with varying degrees of climate change impacts.

9.5.1 Projected Water Budget Methods and Data Sources

☑ **23 CCR § 354.18(c)(3)**
☑ **23 CCR § 354.18(d)(3)**

C2VSimFG-Kern was modified to incorporate projected future hydrology and land use using analog data from the historical C2VSimFG-Kern model. This approach meets GSP requirements using:

- A 50-year time-series of historical precipitation, evapotranspiration, and stream flow information as the future Baseline hydrology conditions.
- The most recent land use, satellite-based evapotranspiration, crop coefficient and urban population growth information as the Baseline condition for estimating future water demands.
- The most recent water supply projections as the Baseline condition for estimating future surface water supply.
- DWR (2018a) Climate Change Guidance and Data Sets to incorporate estimated climate change conditions for the Subbasin.
- Specialized analysis of the Kern River watershed and estimated runoff volumes under climate change conditions.

- Specialized analysis of CVP deliveries to Kern County under climate change conditions incorporating implementation of the San Joaquin River Restoration Program.
- Specialized analysis of SWP deliveries to Kern County under climate change conditions incorporating implementation of the Operations, Criteria, and Plan (OCAP) Biological Opinion and recent changes in Table A and Article 21 allocations.

9.5.2 Development of Projected Water Budget Scenarios

☑ **23 CCR § 354.18(c)(3)**
☑ **23 CCR § 354.18(d)(3)**

Projected water budgets for the Subbasin were developed using the C2VSimFG-Kern to evaluate the performance of proposed SGMA projects and management actions with respect to achieving groundwater sustainability. Participating agencies provided a list of projected future SGMA projects and management actions to be implemented between WY2021 and WY2040. Projected future conditions under Baseline conditions, 2030 Climate Conditions, and 2070 Climate Conditions were simulated both with and without these projects through WY2070 using the C2VSimFG-Kern model, for a total of six projected scenarios.

Proposed future projects and management actions were provided by GSAs. The types of proposed SGMA projects and management actions are summarized as follows:

- "Demand Reduction" projects/management actions involve reducing the volume of water use, typically through changes in land use, including:
    - Agricultural demand reduction projects through incentives or actions to reduce crop water use.
    - Agricultural land retirement and conversion of agricultural land to recharge basins.
    - Conversion of agricultural land to urban land.
- "Supplemental Water Supply" projects/management actions involve increasing water supplies, including:
    - Increased surface water imports generally resulting from projected, or already contracted, water purchases.
    - New water conveyance facilities including pipelines and reservoirs to increase flexibility.
    - Expansion of surface water delivery areas to reduce groundwater usage.

- "Other Local Water Supply" projects/management actions involve increasing local water supplies, including:
  - Utilizing treated wastewater derived from both urban areas and oil production operations; increased utilization occurs in both existing and new locations.
  - Increased stream flow diversions: these include exercising riparian water rights and diverting flood flows.
  - Reallocation of water; generally reducing sales of surface water and stored surface water in some GSAs and using this water within the agency.
  - Augmenting surface water supplies with treated brackish water.

Some projects/management actions are implemented gradually over many years, with savings increasing each year over the implementation period. Some are implemented only in certain years (wet years, for example). The anticipated average-annual water supply benefit of the proposed SGMA projects and management actions steadily increases over the 20-year period from WY2021 to WY2040 to represent the implementation of the Subbasin Plan. This increasing trend, as shown as the average-annual water supply benefit over five-year increments shown in Figure 9-17, is summarized as follows:

- About 116,000 AFY over the first five-year period (WY2021 to WY2025).
- About 216,000 AFY over the second five-year period (WY2026 to WY2030).
- About 343,000 AFY over the third five-year period (WY2031 to WY2035).
- About 361,000 AFY over the fourth five-year period (WY2036 to WY2040).

The anticipated water supply benefit of the proposed SGMA projects and management actions included in the C2VSimFG-Kern projected future simulations is 422,000 AFY over the period from WY2041 to WY2070. Benefits of implementing these projects and management actions over the 20-year implementation period are summarized in Figure 9-17.

9.5.2.1 Projected Future Baseline Development

Projected water budgets are required by GSP regulations to represent future conditions over a 50-year planning and implementation horizon. A Baseline condition was developed that projects water supply, demand and operations based on current land use and expected water supply availability over 50 years. The Baseline then serves as a basis of comparison for evaluating proposed SGMA projects and management actions for achieving sustainability over the planning and implementation horizon. Each predictive scenario model simulates the 50-year planning and implementation period WY2021 to WY2070. Development of the projected future Baseline conditions is summarized below.

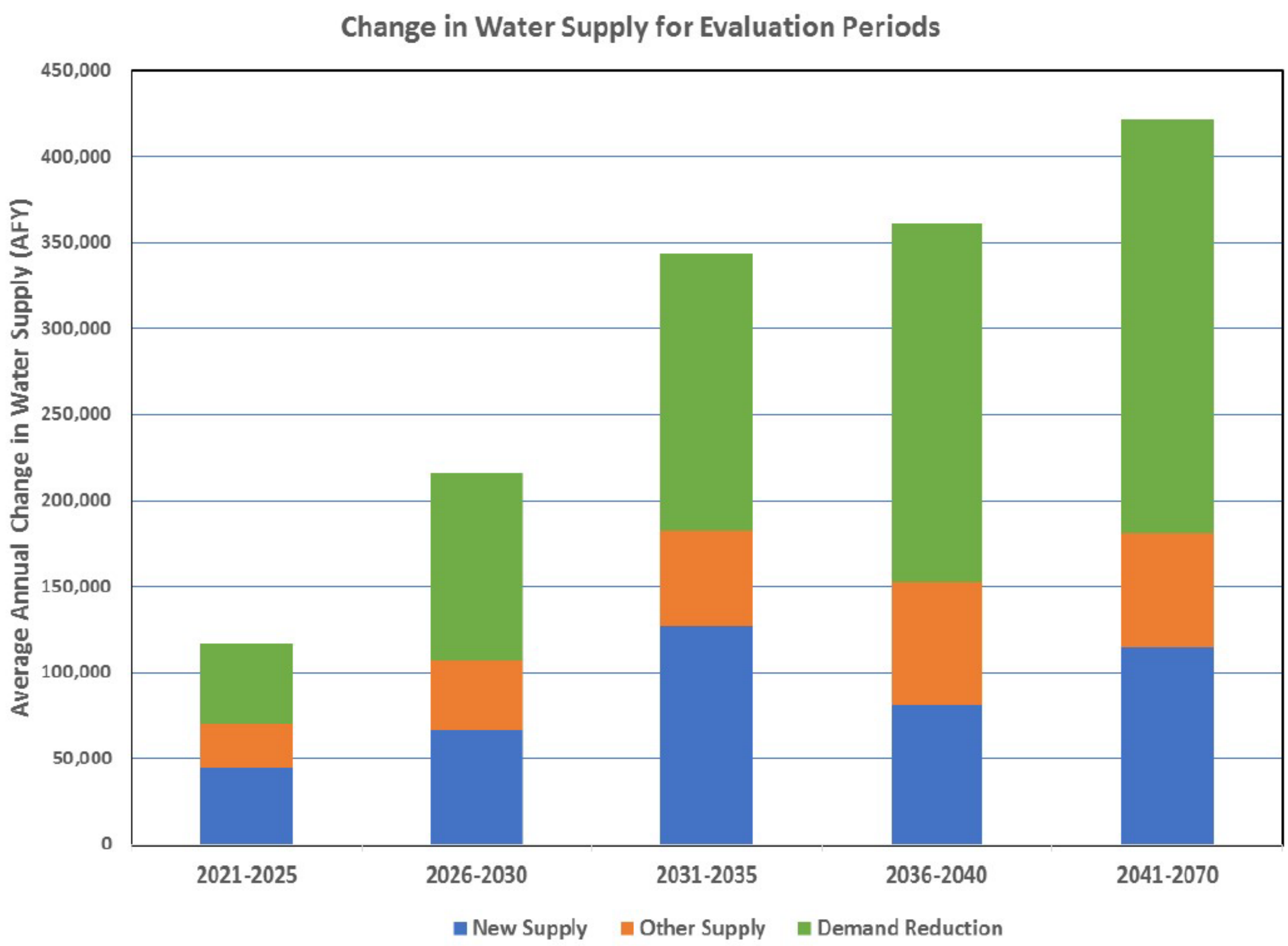
9.5.2.2 Projected Future Time Period Development

WY1995 to WY2014 is used as a historical hydrology period because detailed demand and supply data are available for this period, and because most Subbasin water delivery infrastructure was fully developed by the middle of this period. The average Kern River inflow for this period is also very close to the long-term average Kern River inflow.

The projected future simulation period is based on repeating the WY1995 to WY2014 historical study period. Since the historical period is only 20 years long, the 50-year sequence of hydrology was developed by repeating data from the historical period as shown in Appendix M (Table18) and summarized below:

- Simulation period WY2021 to WY2032 uses the historical period WY2003 to WY2014.
- Simulation period WY2033 to WY2052 uses the historical period WY1995 to WY2014.
- Simulation period WY2053 to WY2070 uses the historical period WY1995 to WY2012.

This sequence is used to match long-term average flows on the Kern River, and to ensure that the 50-year simulation period does not end in an extreme drought or extreme wet year. By starting the projected 50-year future simulation period with WY2003, the period has approximately 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent. The sequence includes the appropriate range of hydrologic conditions including extremely wet years and extended periods of drought.



Kern County Subbasin Groundwater Sustainability Plan	Average Annual Benefit of Proposed SGMA Projects and Management Actions
Sources:	April 2024 Todd Groundwater /MM

Figure 9-17. Average Annual Benefit of Proposed SGMA Projects and Management Actions

This page intentionally left blank.

9.5.2.3 Development of Key Baseline Data Sets

Key required components for the Projected Future Baseline, as summarized in the DWR *Water Budget Best Management Practices* guidance document (DWR, 2016B) include the following:

- The projected Baseline hydrology conditions use 50-years of historical precipitation and streamflow following the sequence outlined in Section 6.1.
- Surface water supplies are based on available information from DWR and others to project future water imports from the SWP, CVP, and Kern River diversions. For the Kern River, recent diversion practices based on entitlements are used to develop water use consistent with the Baseline hydrology.
- WY2013 land use is used as current land use as representative of land use prior to implementation of SGMA in 2015. Drought conditions in WY2014 and WY2015 resulted in reduced agricultural production, and more recent land use begins to include changes as a result of SGMA.
- Consumptive use for agriculture and undeveloped lands is based on the current land use and ITRC METRIC-based evapotranspiration. Following DWR guidance, ITRC METRIC data over the Baseline period is varied according to varying hydrologic conditions (e.g., water year type).
- Urban water demand is based on projections from recent urban water management plans to meet regulations for future water use. Urban demand is estimated in the model based on projected urban population growth and per capita water demand information (including recent regulatory guidance).
- Small watershed inflows use the same parameters as the historical C2VSimFG-Kern model; however, volumes varied based on changes in the precipitation and ET under the 2030 and 2070 climate change conditions.

Time-series input data were first developed for the Baseline scenario model for WY2021 to WY2070. Development of this time-series input data generally involved repeating time-series data from the historical C2VSimFG--Kern in the appropriate sequence. The following time-series data were developed for each scenario:

- Precipitation rates,
- Evapotranspiration rates,
- Surface water inflow rates,
- Surface water diversion and delivery rates, and
- Specified groundwater pumping rates.

Baseline scenario model time-series data files were then modified following DWR guidelines to produce time-series input data for the 2030 Climate Conditions and 2070 Climate Conditions scenarios. C2VSimFG-Kern? input data were modified only in Kern

County. C2VSimFG-Kern? input data for areas outside of Kern County were not modified.

These baseline data sets are incorporated into the model files to develop the projected future water demand and supply under Baseline, 2030 Climate and 2070 Climate conditions. A summary of the development of the projected future water demand and supply is discussed below.

9.5.2.4 Projected Future Water Demand

The projected future water demand uses fixed WY2013 land use areas with historical evapotranspiration rates for the Baseline and modified evapotranspiration rates for the 2030 and 2070 Climate Scenarios. An increasing urban population was projected based on urban water management plans and other information to develop projected-future water demand for the Baseline, 2030 and 2070 Climate Scenarios.

9.5.2.5 Agricultural Water Demand

Evapotranspiration rates for the Baseline scenario model use repeating input evapotranspiration rates from C2VSimFG-Kern in the appropriate sequence. DWR provided monthly change factors for ETo values under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km Variable Infiltration Capacity Model (VIC) grid for calendar years 1915 through 2011 (DWR 2018A). The VIC grid IDs for each C2VSim subregion in the Subbasin were identified and area weighted monthly ETo change factors were calculated for each subregion. Baseline scenario ETc rates for each subregion were then multiplied by the appropriate area-weighted ETo change factors to produce time-series ETc rates for the 2030 Climate and 2070 Climate scenarios. Factors for calendar years 1959 to 1961 are used as analogs for calendar years 2012 to 2014.

9.5.2.6 Urban Water Demand

Urban water demand calculations include an indoor component and an outdoor component. Indoor urban water demands are based on the urban population and monthly per capita water demand. Future urban populations for Kern County urban areas are estimated using California Department of Finance population projections. Future per capita urban water demands are estimated using projections from urban water management plans and California urban water conservation regulations, including SB 606 and AB 1668. Future outdoor urban water demands are based on ETc rates, which were modified as described in the Agricultural Water Demand section above.

9.5.2.7 Water Banking Recovery

Future water banking recovery rates use repeating historical recovery rates in the appropriate sequence. No adjustments were made to Baseline rates or to rates for 2030 and 2070 climatic conditions.

9.5.2.8 Projected Future Water Supply

Projected future precipitation, stream inflow and surface water imports time series were developed following DWR guidelines.

9.5.2.9 Precipitation Rates

Precipitation rates for the Baseline scenario model use repeating input precipitation rates from C2VSimFG-Kern in the appropriate sequence. DWR provided monthly change factors for precipitation under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km VIC grid for calendar years 1915 through 2011 (DWR 2018A). The VIC grid ID for each C2VSim element in the Subbasin was identified and the Baseline scenario precipitation rates were multiplied by the appropriate factors to produce time-series precipitation rates for the 2030 Climate and 2070 Climate scenarios. Factors for calendar years 1959 to 1961 are used as analogs for calendar years 2012 to 2014.

9.5.2.10 Surface Water Inflow Rates

Surface water inflow rates for Poso Creek and the White River for the Baseline scenario model use repeating input inflow rates from C2VSimFG-Kern in the appropriate sequence. DWR (2018a) provided unimpaired streamflow change factor datasets for Central Valley streams, and an Excel spreadsheet tool to modify basin unimpaired streamflow using these change factors. The unimpaired streamflow change factors and spreadsheet were used to modify Baseline inflows to produce 2030 Climate and 2070 Climate scenario time series inflows for Poso Creek and White River.

Surface water inflow rates for the Kern River at First Point for the Baseline scenario model use repeating historical inflow rates from C2VSimFG-Kern in the appropriate sequence. Flows on the Kern River are regulated, so the unimpaired streamflow method is not appropriate for estimating future flows under 2030 and 2070 climatic conditions. Projected Kern River flows at First Point under 2030 and 2070 central tendency conditions were estimated by GEI (2018) using calendar years 1956 to 2010 hydrology. The analysis considered the impacts of changed runoff in each sub-watershed contributing to the Kern River to develop revised streamflow estimates for Kern River at First Point. Projected scenario flows for the Kern River at First Point for calendar years 2011 to 2014 are estimated using flows for analog years with similar annual flows and monthly flow pattern. Analog years 1986, 1991, 1990 and 1961 are used for calendar years 2011 to2014 in the projected scenarios. Figure 9-18 graphically summarizes the changes in Kern River water supplies relative to historical data. The lower graph shown in Figure 9-18 shows the average monthly shift in Kern River inflows after applying 2030 and 2070 climate change guidance to historical flows. In general, the annual Kern River flows remain similar; however, the peak flows shift in time. The monthly shifts show an increase in flow during December through February and a decrease in flow during May, June, and July.

9.5.2.11 Surface Water Deliveries

Surface water delivery rates for the Baseline scenario model were developed by first repeating input surface water delivery rates from the C2VSimFG-Kern in the appropriate sequence, and then modifying selected data sets. Surface water deliveries from local imported sources such as recycled produced water are held constant at WY2015 rates for all projected scenarios.

The Subbasin is served by both the CVP and the SWP. Recent changes in CVP and SWP operations and their impacts on future surface water supplies are reflected in surface water diversion rates for the three scenarios.

Future CVP deliveries will be affected by implementation of the San Joaquin River Restoration Program (SJRRP) that includes the 2008 U.S. Fish & Wildlife Service biological opinion (BO) on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the CVP and SWP.

Future CVP delivery projections developed by the Friant Water Authority (FWA) were used in place of DWR’s CVP projections. FWA (2018) used CalSim-II to develop projected surface water deliveries with SJRRP implementation under hydrological conditions representing the Baseline, 2030 Climate and 2070 Climate conditions by delivery class for WY1922 to WY2003, and estimated allocations to each CVP contractor. The 2015.c data set is used for Baseline scenario CVP deliveries, the 2030.c data set is used for the 2030 Climate scenario CVP deliveries, and the 2070.c data set is used for the 2070 Climate scenario CVP deliveries. CVP deliveries for WY2004 to WY2014 are estimated using deliveries for analog years WY1951 to WY1961; these analog years have a similar distribution of water availability. Figure 9-19 graphically presents the average annual CVP deliveries to the Subbasin based on the FWA (2018) guidance. The monthly values show a general decrease in deliveries but not a temporal shift. The net result of the climate change modifications is that CVP deliveries to the Subbasin for the 2030 Climate scenario are 80 percent of the Baseline scenario and CVP deliveries for the 2070 scenario are 68 percent of the Baseline scenario.

Future SWP deliveries will be affected by operational changes implemented between 2004 and 2008 including the OCAP BO, reduced Table A contract amounts and reduced Article 21 deliveries. DWR provided projected future deliveries from the CVP and SWP for WY1922 to WY2003, derived from CalSim-II modeling conducted for the Water Supply Investment Program (WSIP) (California Water Commission, 2016). Future SWP deliveries will be affected by operational changes including the OCAP Biological Opinion, reduced Table A contract amounts and reduced Article 21 deliveries.

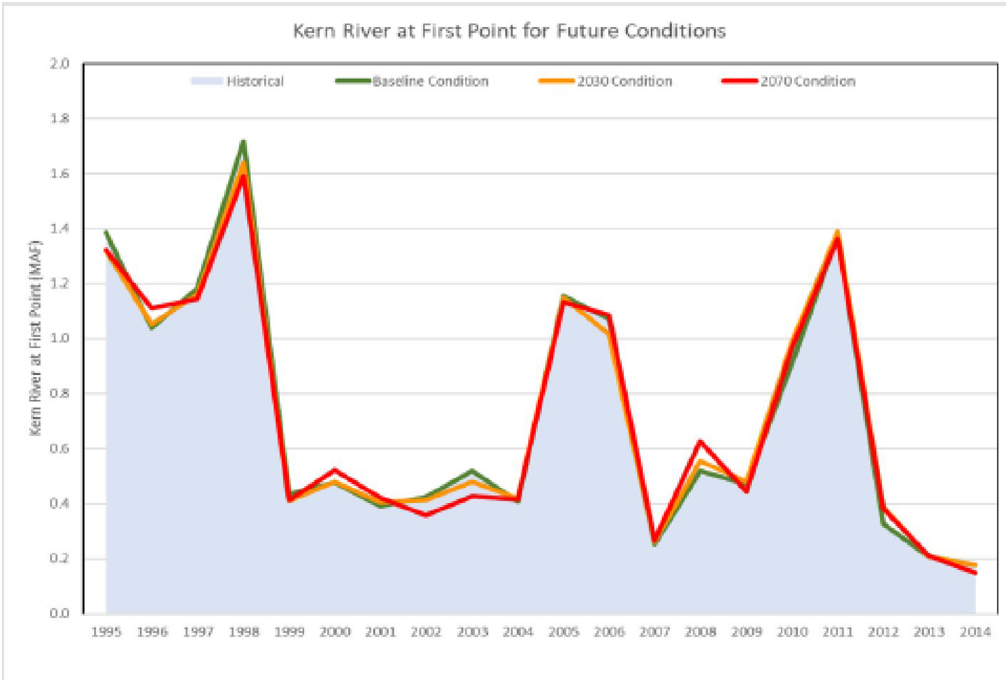
The SWP projections provided by DWR for WY1995 to WY2003 and historical deliveries for WY2004 to WY2014 were modified to incorporate the impacts of SWP operational changes in the three projected scenarios. A summary of the modifications to historical

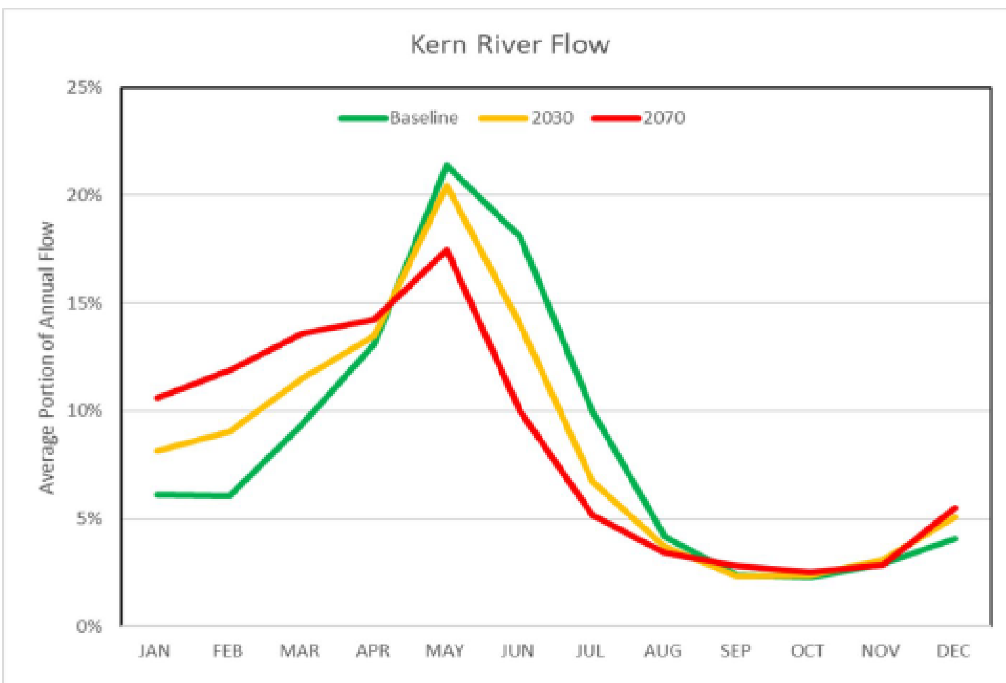
SWP deliveries to develop an equivalent projected-future SWP delivery schedule are summarized below:

- Baseline Hydrologic Conditions
    - WY1995 to WY2003 conditions are based on 2030-Level CALSIM increased by 3.03 percent.
    - WY2004 to WY2007 conditions are based on historical data adjusted for OCAP BO.
    - WY2008 to WY2014 conditions are based on historical data with the assumption that OCAP BO adjustments are already factored into the data.
- 2030 Climate Conditions
    - WY1995 to WY2003 conditions are based on the 2030-Level CALSIM Projection.
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 3.03 percent.
    - WY2008 to WY2014 conditions are based on historical data reduced by 3.03 percent
- 2070 Climate Conditions
    - WY1995 to WY2003 conditions are based on the 2070-Level CALSIM Projection.
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 8.09 percent.
    - WY2008 to WY2014 conditions are based on historical data reduced by 8.09 percent.

Figure 9-20 graphically illustrates the total changes in SWP deliveries to the Subbasin. The net result of the climate change modifications is that SWP deliveries to the Subbasin for the Baseline scenario are 83 percent of historical; for the 2030 Climate scenario are 80 percent of historical; and for the 2070 scenario are 76 percent of historical.

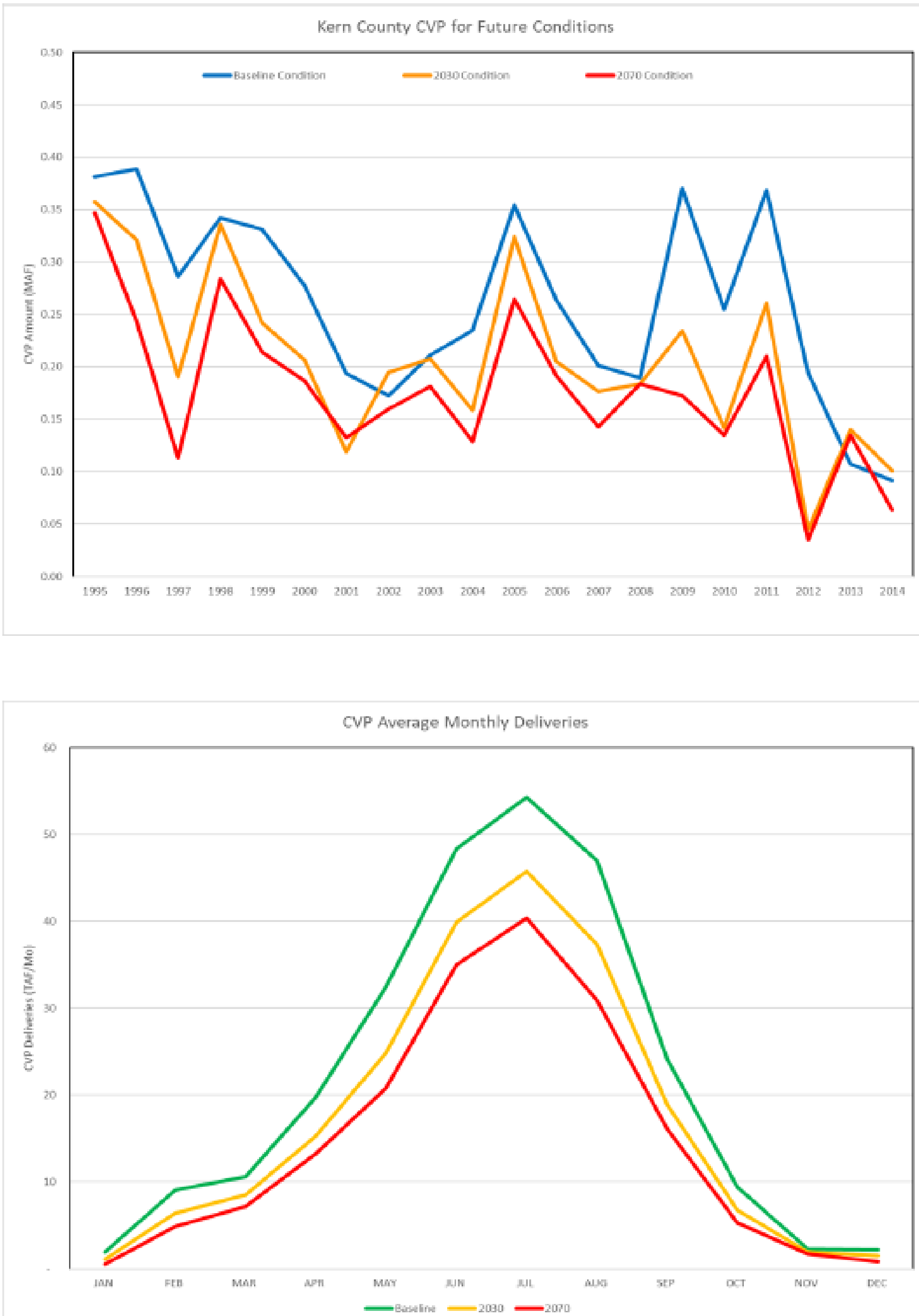
Figure 9-21 shows the composite changes in total surface water supplies from the Kern River, CVP and SWP. The net result of the climate change modifications is that Kern River, CVP and SWP deliveries to the Subbasin for the Baseline scenario are 93 percent of historical; for the 2030 Climate scenario are 88 percent of historical; and for the 2070 Climate scenario are 85 percent of historical.





Kern County Subbasin Groundwater Sustainability Plan	Projected-Future Water Supplies from the Kern River
Sources: California Data Exchange Center (CDEC, 2023) City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)	May 2024 Todd Groundwater/MM

Figure 9-18. Projected-Future -Water Supplies from the Kern River



Kern County Subbasin
Groundwater Sustainability Plan

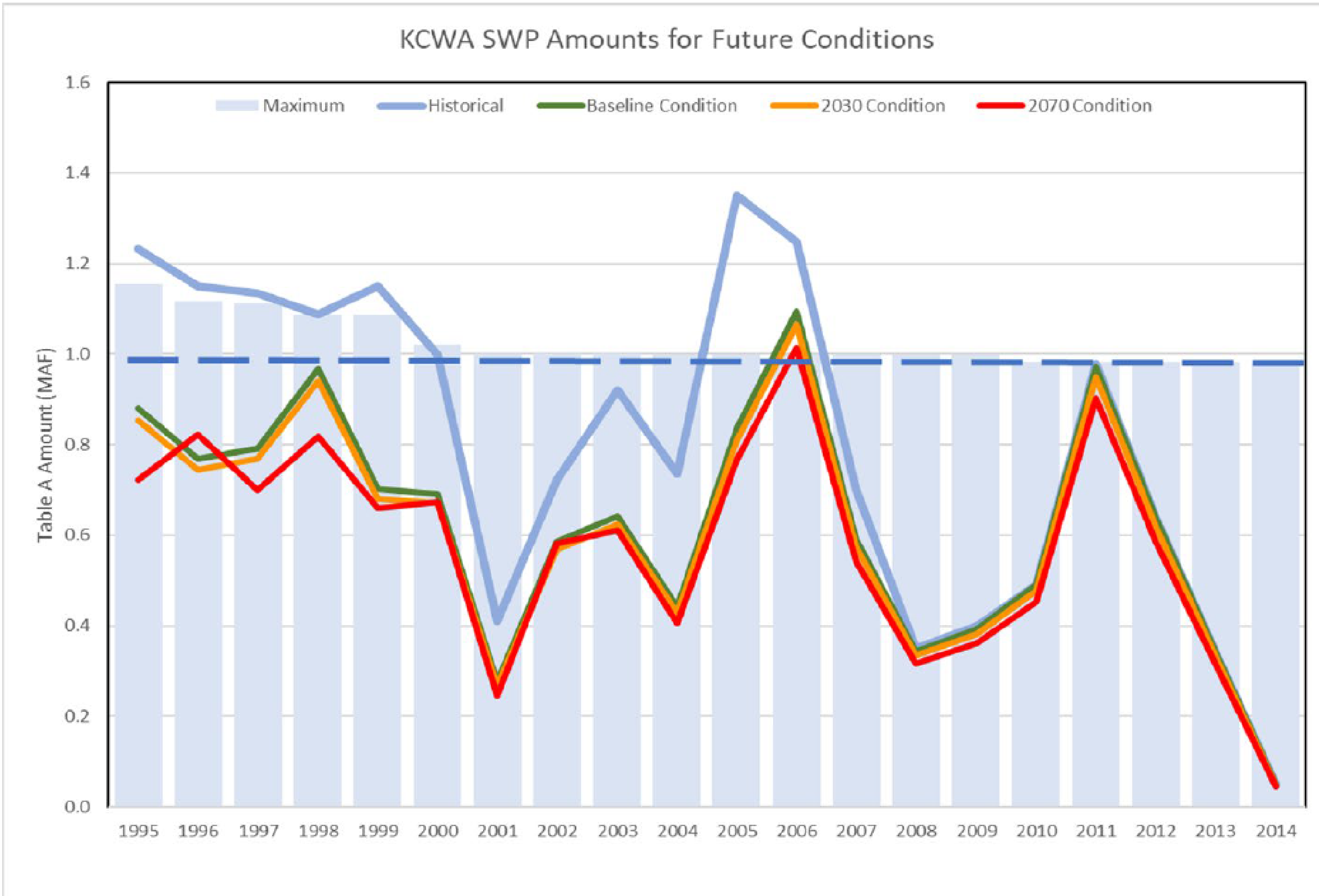
Sources: California Data Exchange Center (CDEC, 2023)
City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)

Projected-Future Water Supplies from the Friant-Kern Canal for the Federal Central Valley Project

May 2024 *Todd Groundwater/MM*

Figure 9-19. Projected-Future Water Supplies from the Friant--Kern- Canal for the Federal Central Valley Project.

This page intentionally left blank.



Kern County Subbasin Groundwater Sustainability Plan	Projected-Future Water Supplies from the State Water Project via the California Aqueduct
Sources:	April 2024 Todd Groundwater /MM

Figure 9-20. Projected Future Water Supplies from the California Aqueduct for the State Water Project.

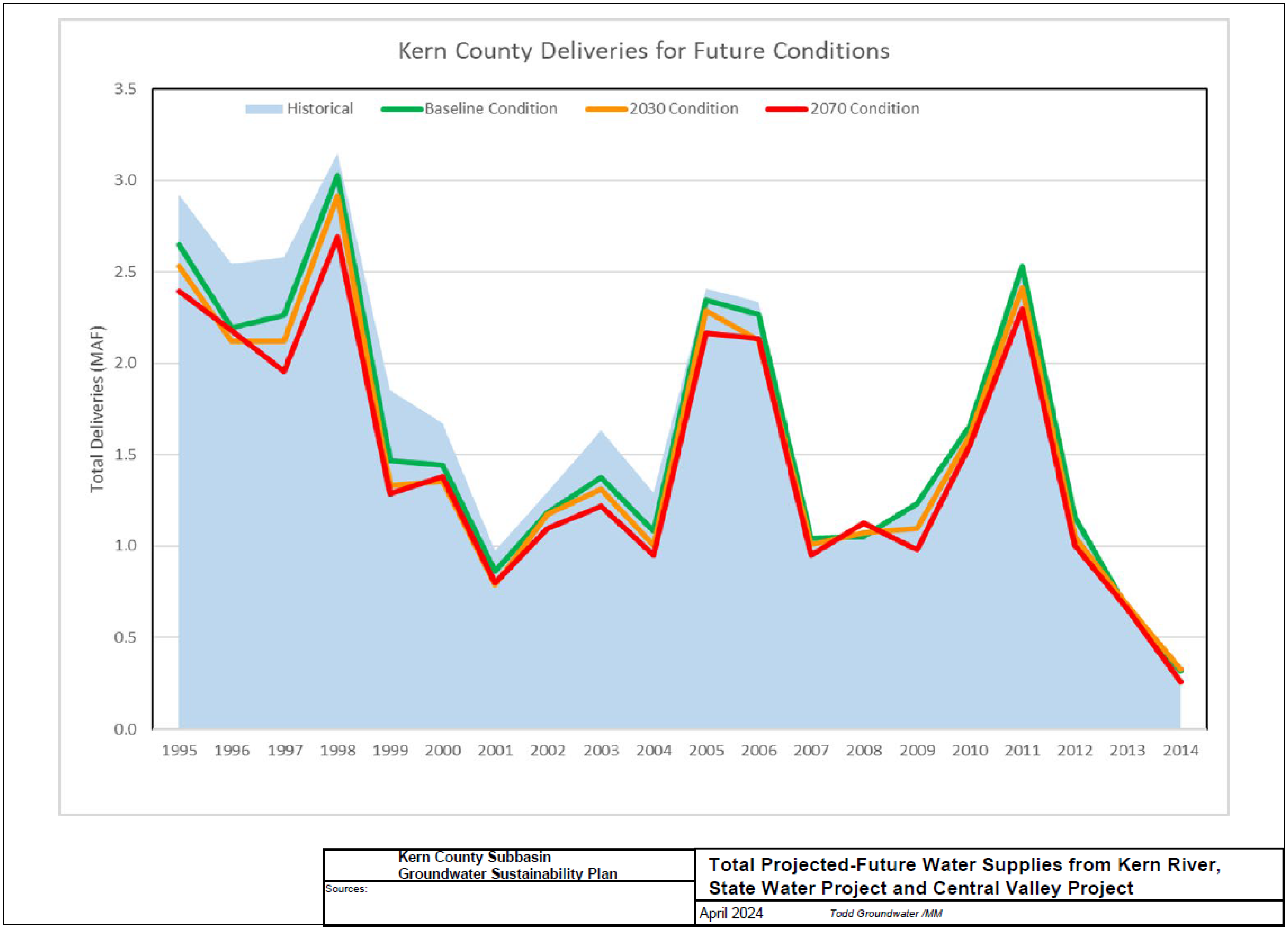


Figure 9-21. Total Projected-Future Water Supplies from Kern River, SWP, and Central Valley Project

9.5.3 Additional Surface Water Supply Adjustments

☑ **23 CCR § 354.18(c)(3)**
☑ **23 CCR § 354.18(d)(3)**

Within the Subbasin, water users engage in complex real-time water trading and wheeling activities to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. It would be difficult to project future surface water deliveries in the Subbasin without the use of a surface water allocation model that simulates these water trading and wheeling activities. Therefore, for this modeling effort, monthly future-scenario agricultural, urban and recharge deliveries from sources originating outside the Subbasin have been estimated by adjusting historical deliveries by the ratio of (total scenario inflows)/(total historical inflows) for each month, where total inflows are the sum of CVP deliveries, SWP deliveries and Kern River at First Point. In addition, Kern River flows at First Point flows above historical flows under the 2030 Climate and 2070 Climate scenarios have been proportionally added to selected recharge deliveries. This method is deemed adequate for the Subbasin-level future scenario analyses.

Some future scenario data sets do not cover the entire historical water budget period from WY1995 through WY2014. In these cases, data from an analog historical period with similar water availability has been used to fill in the missing data. The analog years for each data type are summarized as:

- For CVP deliveries (CalSim-II data), WY1951 to WY1961 have been used as analogs for missing WY2004 to WY2014 data; these analog years have a similar distribution of water availability.
- Projected future Kern River at First Point flows for calendar years 1986, 1991, 1990, and 1961 have been used as analogs for missing calendar years 2011 through 2014; each of these analog years had a similar historical annual flow volume and monthly distribution.
- For climatic data adjustment factors, calendar years 1959 to 1961 have been used as analogs to missing calendar years 2012 to 2014.

9.5.4 Projected Water Budget Results

☑ **23 CCR § 354.18(d)(3)**

The C2VSimFG-Kern was run for three scenarios representing Baseline, 2030 Climate \and 2070 Climate conditions, both with and without the proposed SGMA projects and management actions for a total of six projected future scenarios.

C2VSimFG-Kern calculates water budget components each month of the simulation period for each future scenario. Projected future water budgets developed based on the C2VSimFG-Kern simulation results with the proposed SGMA project and management actions are then compared to results for the future scenarios without the SGMA project and management actions to assess how these changes enhance groundwater sustainability within the Subbasin.

The average annual value of each water budget component summarizes the impacts over 50 years with current water demands. The water budget results for the six Projected scenarios are presented in Appendix M (Table19 through 24), and include averages over three different periods, which include:

- **WY2021 to WY2040** – Implementation Period representing the 20-year period required by the SGMA regulations to implement SGMA projects and management actions to achieve sustainability.
- **WY2041 to WY2070** – Sustainability Period representing the 30-year hydrologic period following the Implementation Period to assess the long-term sustainability of the proposed SGMA projects and management actions with variable climatic conditions including periods with above average rainfall and extended droughts.
- **WY2021 to WY2070** – Simulation Period representing the entire 50-year projected future hydrologic conditions.

Changes to surface water diversions under the proposed SGMA projects and management actions include monthly increases or reductions to 37 model diversions and the addition of seven new diversions. Ten new groundwater pumping wells have been added to simulate a new groundwater pumping program. Agricultural land use has been converted to native vegetation in ten GSAs, and to urban land use in three GSAs. The SGMA projects and management actions included in the C2VSimFG-Kern scenarios are described in Chapter 14.

Baseline simulation results indicate that the Subbasin has an average annual overdraft over the Sustainability Period (WY2041 to WY2070) of 324,326 AFY. By implementing the proposed SGMA projects and management actions, the Subbasin is forecasted to achieve sustainability by 2040 with an estimated 42,144 AFY of annual surplus over the Sustainability Period. With adjustments to account for limitations in the simulation (discussed in Section 9.7.2), the adjusted change in storage increases to 85,578 AFY. Hydrographs of the simulated groundwater levels showing the projected future change in groundwater levels are provided in Appendix N.

Collectively, the C2VSimFG-Kern simulation results indicate that the currently proposed SGMA projects and management actions, once fully implemented, provide a reasonable approach to achieve sustainable management of the Subbasin and can be adaptively managed to meet future challenges, as necessary. A summary of each of the six projected future water budgets from C2VSimFG-Kern is provided below.

9.5.4.1 Baseline Condition Water Budgets

For the Baseline Scenario without SGMA Projects, the groundwater budget for WY2021 to WY2040 (Appendix M (Table 19)) repeats the 20-year historical hydrologic period so it provides a direct comparison of the differences between the projected future Baseline without SGMA Projects and the historical condition. The primary difference between historical conditions and the projected future Baseline is a nearly 20 percent decrease in imported surface water deliveries primarily from the SWP due to the OCAP BO. Over this period, the average groundwater pumping is 1,581,000 AFY, which includes agricultural pumping, urban pumping and exported water. This results in an additional loss of groundwater storage of about 50,000 AFY over the 50-year projected future Baseline period.

The Baseline Scenario with SGMA Projects simulates the proposed SGMA projects and management actions (Section 5.2) applied to the Baseline Scenario. No other changes were made except for the addition of the SGMA projects and management actions to provide a direct comparison of the relative benefits of about 422,000 AFY of proposed SGMA projects and management actions. The groundwater budget for the Baseline Scenario with SGMA Projects is provided in Appendix M (Table20).

Comparing the groundwater budget for WY2041 to WY2070 (Appendix M (Table20)) with the same period from the Baseline Scenario (Appendix M (Table19) provides an evaluation of groundwater conditions after the SGMA projects and management actions have been fully implemented. As a result of implementing the P/MAs, total net aquifer inflows increase about 135,400 AFY. The total net aquifer outflows decrease about 231,100 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

The change in groundwater storage for the Baseline Scenario with SGMA Projects improves by about 360,000 AFY compared to the Baseline Scenario without SGMA Projects. This change results in a net gain in groundwater in aquifer storage for WY2041 to WY2070 of about 42,100 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is shown in Figure 9-22. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070.

A comparison of the average annual water budget components for the two different Baseline Scenarios is shown in Figure 9-23. Over WY2041 to WY2070, the average groundwater pumping of 1,354,000 AFY for the Baseline Scenario with SGMA Projects (which includes agricultural pumping, urban pumping and exported water) is over 270,000 AFY less than in the Baseline Scenario.

9.5.4.2 2030 Climate Change Water Budgets

The 2030 Climate scenarios simulate how the Subbasin responds assuming hydrologic conditions representing a potentially drier climate and are based on the DWR Climate Change Guidance and Resource Guide (DWR, 2018A and 2018B). The 2030 Climate scenarios were run both with and without SGMA projects. Results for these 2030 Climate scenarios are shown in Figure 9-24.

The groundwater budget for the 2030 Climate Scenario without SGMA Projects for WY2041 to WY2070 (Appendix M (Table21)) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in aquifer inflows of about 44,700 AFY, however, the aquifer net outflows increase by about 101,200 AFY. This is mostly attributed to the climate shift to earlier rainfall making more surface water available for water banking and conjunctive use projects during the winter but less available for irrigation in the summer, resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 56,600 AFY due to the climate change impacts.

The 2030 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions (Section 5.2) applied to the 2030 climate change conditions. No other changes were made to this scenario. The groundwater budget for the 2030 Climate Scenario with SGMA Projects is provided in Appendix M (Table 22).

Comparing the groundwater budget for WY2041 to WY2070 (Appendix M (Table 21)) between the two 2030 Climate Scenarios, the total net aquifer inflows increase about 118,700 AFY due to increased water banking and conjunctive use projects and deep percolation. The total net aquifer outflows decrease about 249,300 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

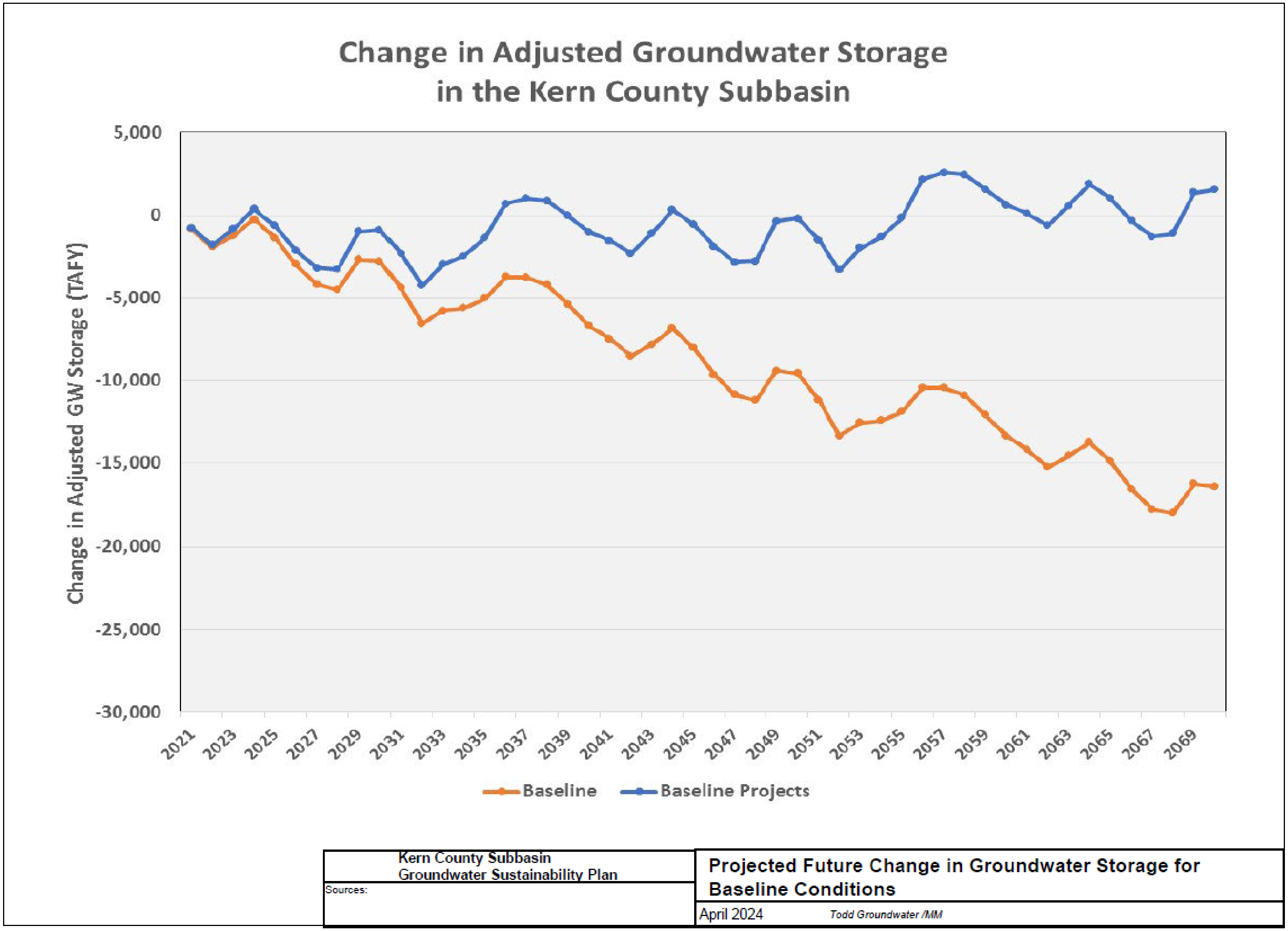
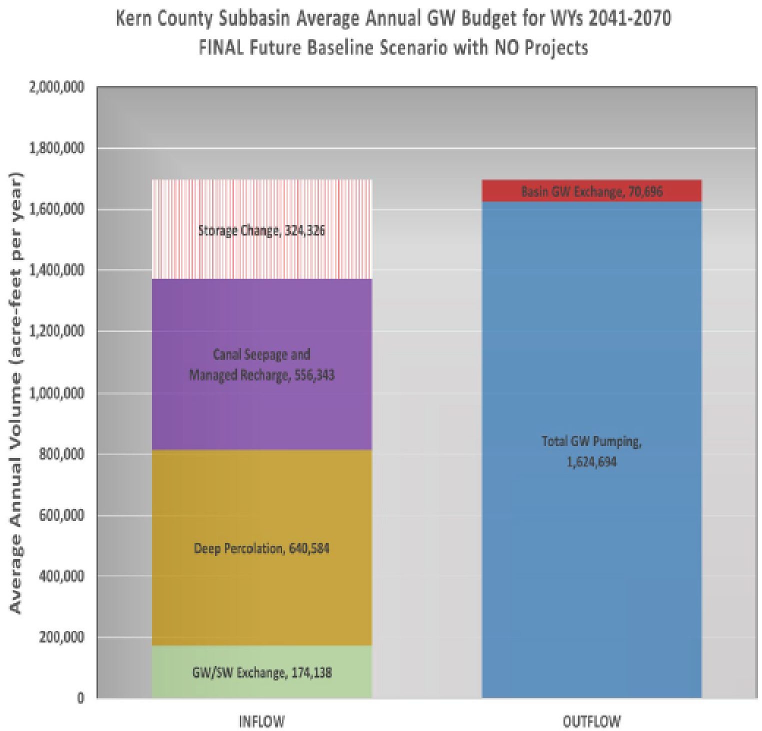
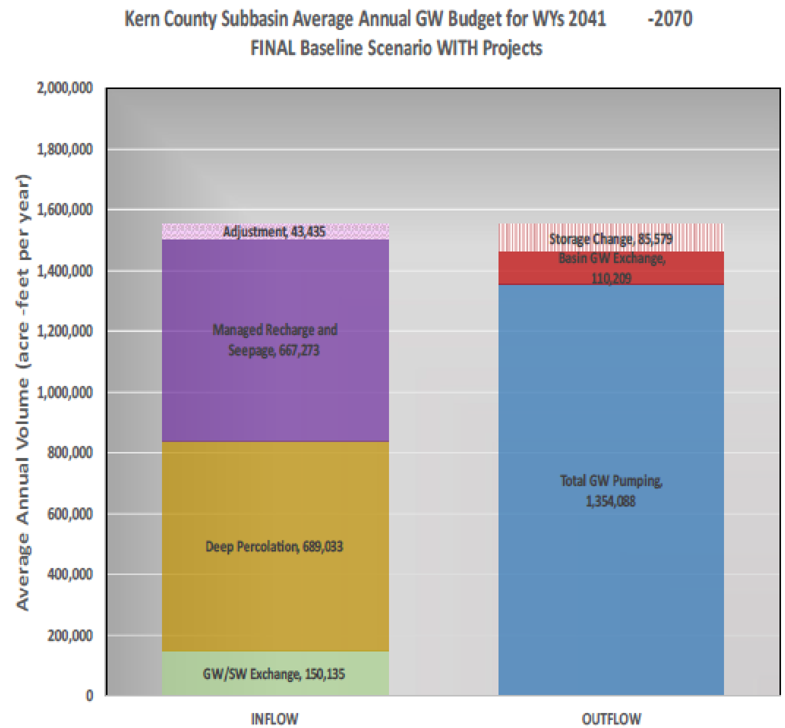


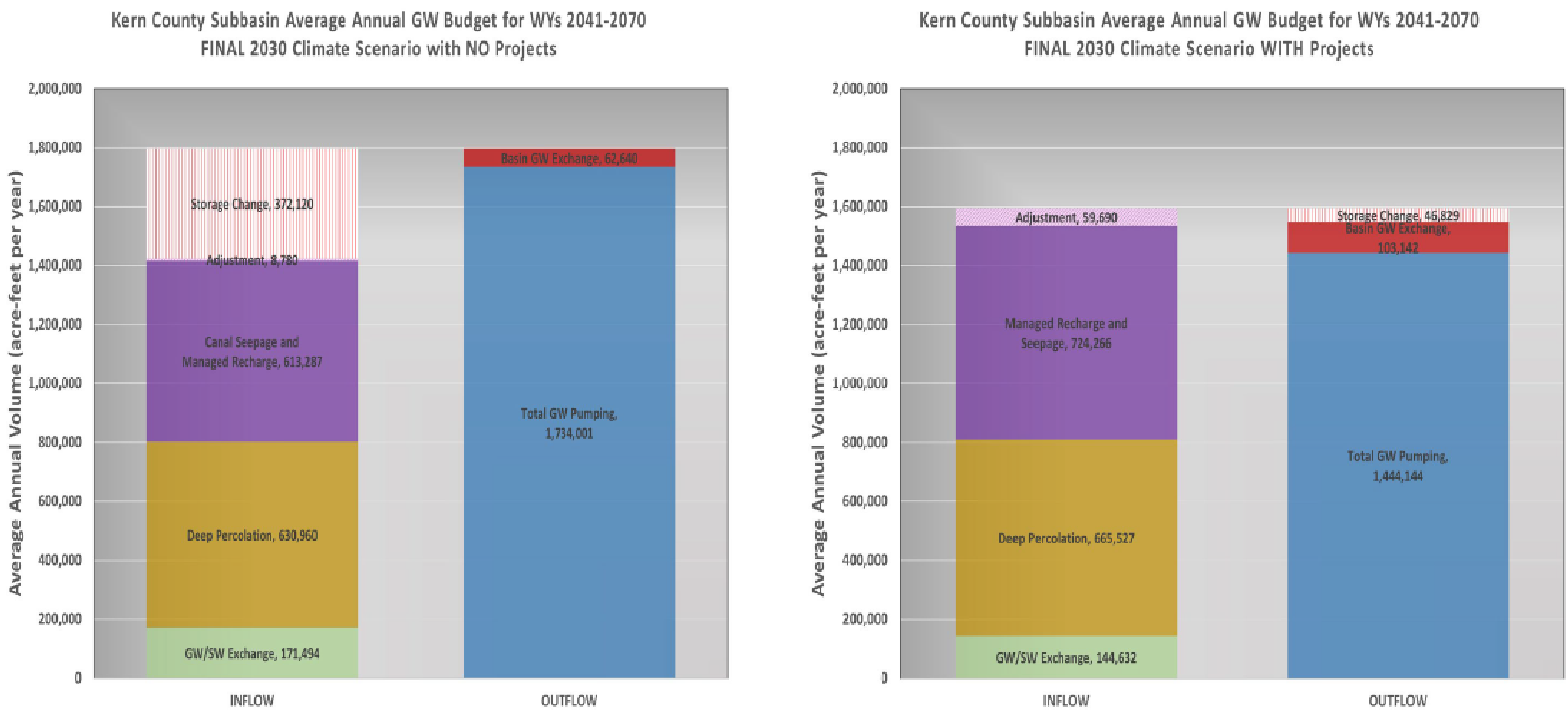
Figure 9-22. Projected-Future Change in Groundwater Storage for Baseline Conditions





Kern County Subbasin Groundwater Sustainability Plan	Baseline Projected Future Average Annual Groundwater Budget for WY2041-2070
Sources:	April 2024 *Todd Groundwater /MM*

Figure 9-23. Baseline Projected-Future Average Annual Groundwater Budget for WY2041 to 2070



Kern County Subbasin Groundwater Sustainability Plan	2030 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070
Sources:	April 2024 Todd Groundwater /MM

Figure 9-24. 2030 Climate Projected-Future Average Annual Groundwater Budget for WY2041 to 2070

This page intentionally left blank.

The change in groundwater storage for the 2030 Climate Scenario with SGMA Projects improves by about 368,000 AFY. This change results in a net decline in groundwater in aquifer storage over WY2041 to WY2070 of about 12,900 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is shown in Figure 9-27. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline Scenario with SGMA Projects.

A comparison of the average annual water budget components for the two 2030 Climate Scenarios is shown in Figure 9-24. Over this period, the average groundwater pumping of 1,444,000 AFY for the 2030 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 290,000 AFY less than in the 2030 Climate Scenario without SGMA Projects.

9.5.4.3 2070 Climate Change Water Budgets

The 2070 Scenarios simulate how the Subbasin aquifer would respond assuming hydrologic conditions representing a potentially very dry climate and are based on the DWR Climate Change Guidance (DWR, 2018A and 2018B). The 2070 Climate Change Scenarios were run both with and without SGMA Projects.

The groundwater budget for the 2070 Climate Scenario without SGMA Projects over WY2041 to WY2070 (Appendix M (Table23)) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in aquifer inflows of about 66,100 AFY, however, the net aquifer outflows increase by about 231,600 AFY. This is mostly attributed to an even greater climate shift to earlier rainfall making more surface water available for water banking and conjunctive use projects during the winter but less available for irrigation in the summer resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 165,500 AFY due to the climate change assumptions.

The 2070 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions (Section 5.2) applied to the 2070 climate change conditions. No other changes were made to this scenario. The groundwater budget for the 2070 Climate Scenario with SGMA Projects is provided in Appendix M (Table24). Comparing the groundwater budget for WY2041 to WY2070 (Appendix M (Table23)) between the two 2070 Climate Scenarios, the total net aquifer inflows increase about 106,300 AFY due to increased water banking and conjunctive use projects and deep percolation. The total net aquifer outflows decrease about 265,300 AFY due mostly to decreased groundwater pumping due to agricultural demand reduction management actions.

The change in groundwater storage for 2070 Climate Scenario with SGMA Projects improves by about 371,600 AFY. This change results in a net decline of groundwater in aquifer storage over WY2041 to WY2070 of about 118,300 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is shown in Figure 9-26. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline and 2030 Scenarios with SGMA Projects.

A comparison of the average annual water budget components for the two different 2070 Climate Scenarios is shown in Figure 9-25. Over this period, the average groundwater pumping of 1,559,000 AFY for the 2070 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 307,000 AFY less than in the 2070 Climate Scenario without SGMA Projects.

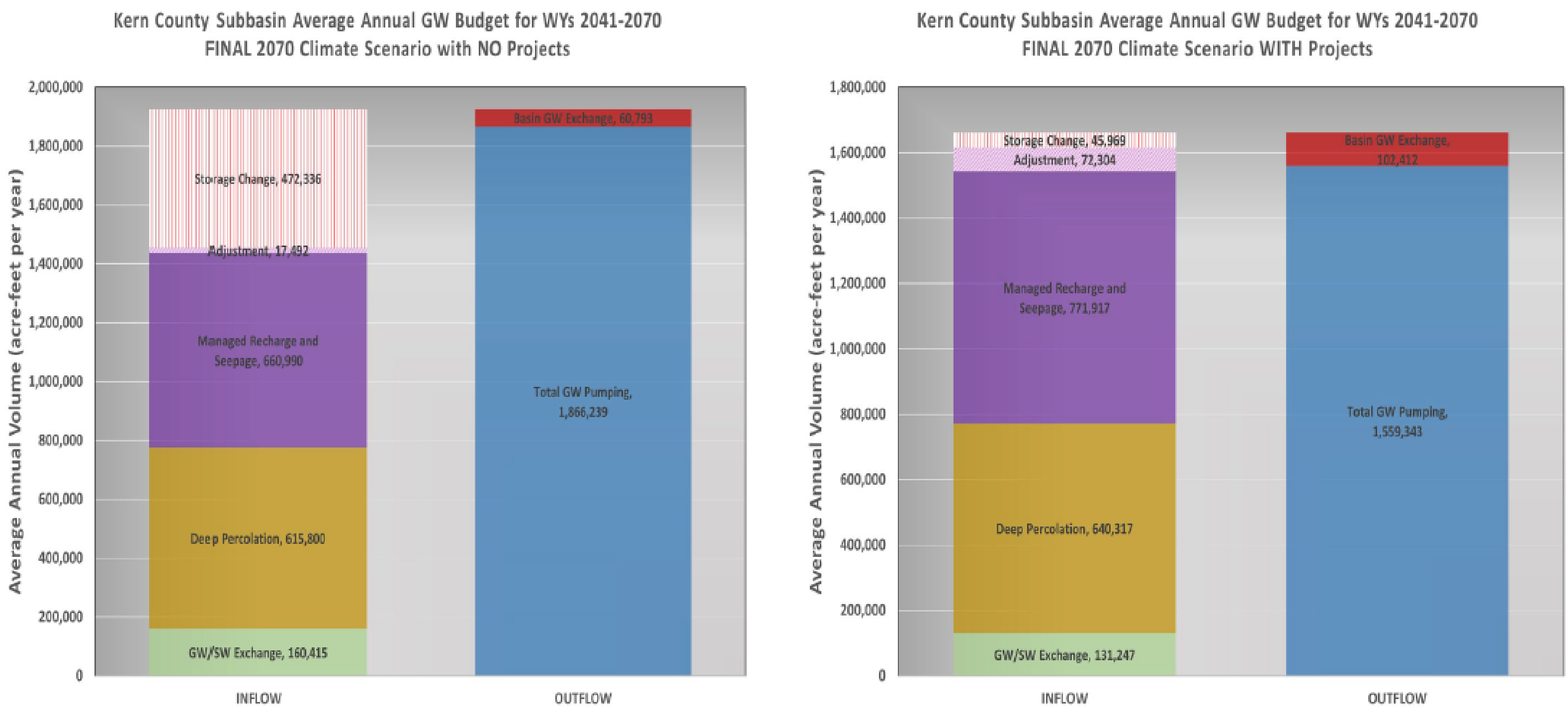
9.5.5 Change in Groundwater Storage

☑ 23 CCR § 354.18(d)(3)

Groundwater sustainability for the Subbasin was assessed using annual changes in groundwater storage. As discussed above, the decline in groundwater storage of the three future scenarios without SGMA projects and management actions is significantly mitigated by the implementation of the proposed SGMA projects and management actions. An assessment of the projected future groundwater storage change for the six projected future scenarios is summarized in Appendix M (Table 25). The results of these simulations are summarized in Table 9-7.

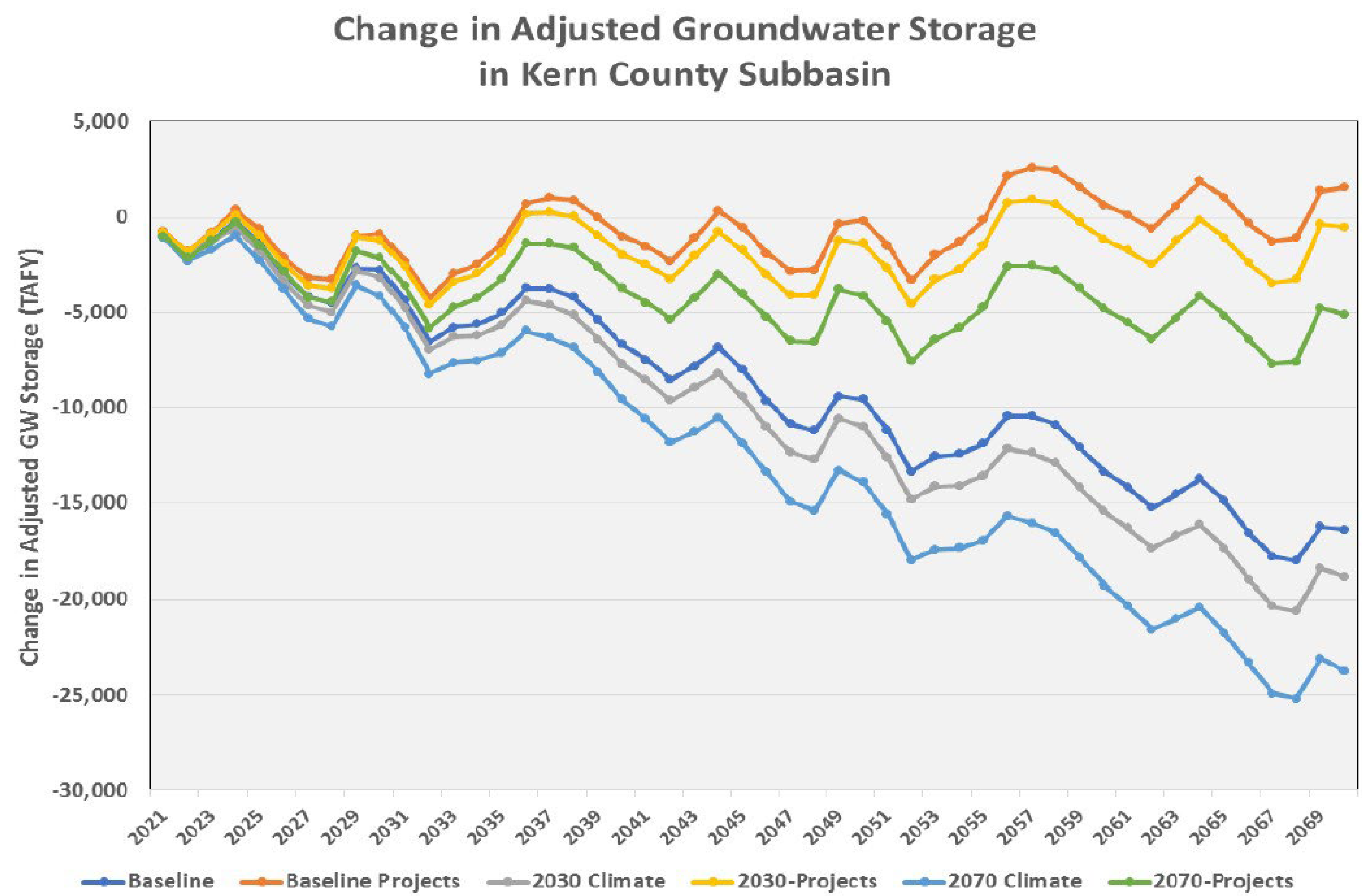
Table 9-7. Summary of Simulated Change in Groundwater Storage Results over the 2041 to 2070 Sustainability Period

C2VSimFG-Kern Model Scenario	Change in Groundwater Storage (AFY) Summary for All Model Scenarios
Historic (WYs 1995-2014)	-274,200
Current (WYs 2015-2023)	-344,019
Baseline (WYs 2040-2070)	-324,326
Baseline with Projects (WYs 2040-2070)	85,578
2030 Climate Change (WYs 2040-2070)	-372,120
2030 Climate with Projects (WYs 2040-2070)	46,829
2070 Climate Change (WYs 2040-2070)	-472,336
2070 Climate with Projects (WYs 2040-2070)	-45,969



Kern County Subbasin Groundwater Sustainability Plan	**2070 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070**
Sources:	April 2024 *Todd Groundwater /MM*

Figure 9-25. 2070 Climate Change Projected-Future Average Annual Groundwater Budget for WY2041 to 2070



Kern County Subbasin Groundwater Sustainability Plan	Projected Future Change in Groundwater Storage for All Conditions
Sources:	April 2024 Todd Groundwater /MM

Figure 9-26. Projected-Future Change in Groundwater Storage for all Conditions

These adjustments resulted in an overall improvement in the change in groundwater storage for the projected future water budgets. For the scenarios that include the SGMA Projects, the change in groundwater storage improves by 43,400 AFY (Baseline), 59,700 AFY (2030 Climate), and 72,300 AFY (2070 Climate). As a result of these adjustments, the adjusted change in groundwater storage for the three scenarios with SGMA Projects varied as follows:

- The Baseline Scenario with SGMA Projects changes from an increase of 42,100 AFY to an increase of 85,600 AFY.
- The 2030 Climate Scenario with SGMA Projects changes from a decline of 12,900 AFY to an increase of 46,800 AFY.
- The 2070 Climate Scenario with SGMA Projects changes from a decline of 118,000 AFY to a decline of 46,000 AFY.

These adjustments indicate areas of future improvement for C2VSimFG--Kern. Future updates to the model will address how to better simulate these conditions directly to limit the use of post-simulation adjustments.

9.6 Sustainability Assessment

☑ **23 CCR § 354.18(d)(3)**

As defined by SGMA, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Although the SGMA regulations require that a single value of sustainable yield must be calculated basin-wide, it should be noted that the sustainable yield can be changed with implementation of recharge projects, variations in climate, or changes in stream flow conditions. For the projected future scenarios, both the climate and the managed water supply operations are significantly affected which would lead to a change in the sustainable yield for the Subbasin.

9.6.1 Sustainability Assessment

For the sustainability assessment, the sustainable yield was recalculated using the method described above, and the results are presented in Appendix M (Table 26). Without the SGMA projects and management actions, the percentage by which the total groundwater pumping exceeds the sustainable yield provides context to compare the significance of the level of groundwater pumping for the Subbasin. For the scenarios without SGMA projects and management actions, the groundwater pumping exceeds the sustainable yield on the order of 25 percent to 34 percent Appendix M (Table 26). However, with the proposed SGMA projects and management actions, the groundwater pumping is less than the sustainable yield of the Subbasin for the Baseline and 2030 climate scenarios and is within 3 percent of the sustainable yield for the 2070 Climate Scenario Appendix M (Table 23). This assessment indicates that the proposed SGMA projects and management actions for the Subbasin are of sufficient magnitude that, if fully implemented, would lead to groundwater sustainability for the Subbasin after WY2040.

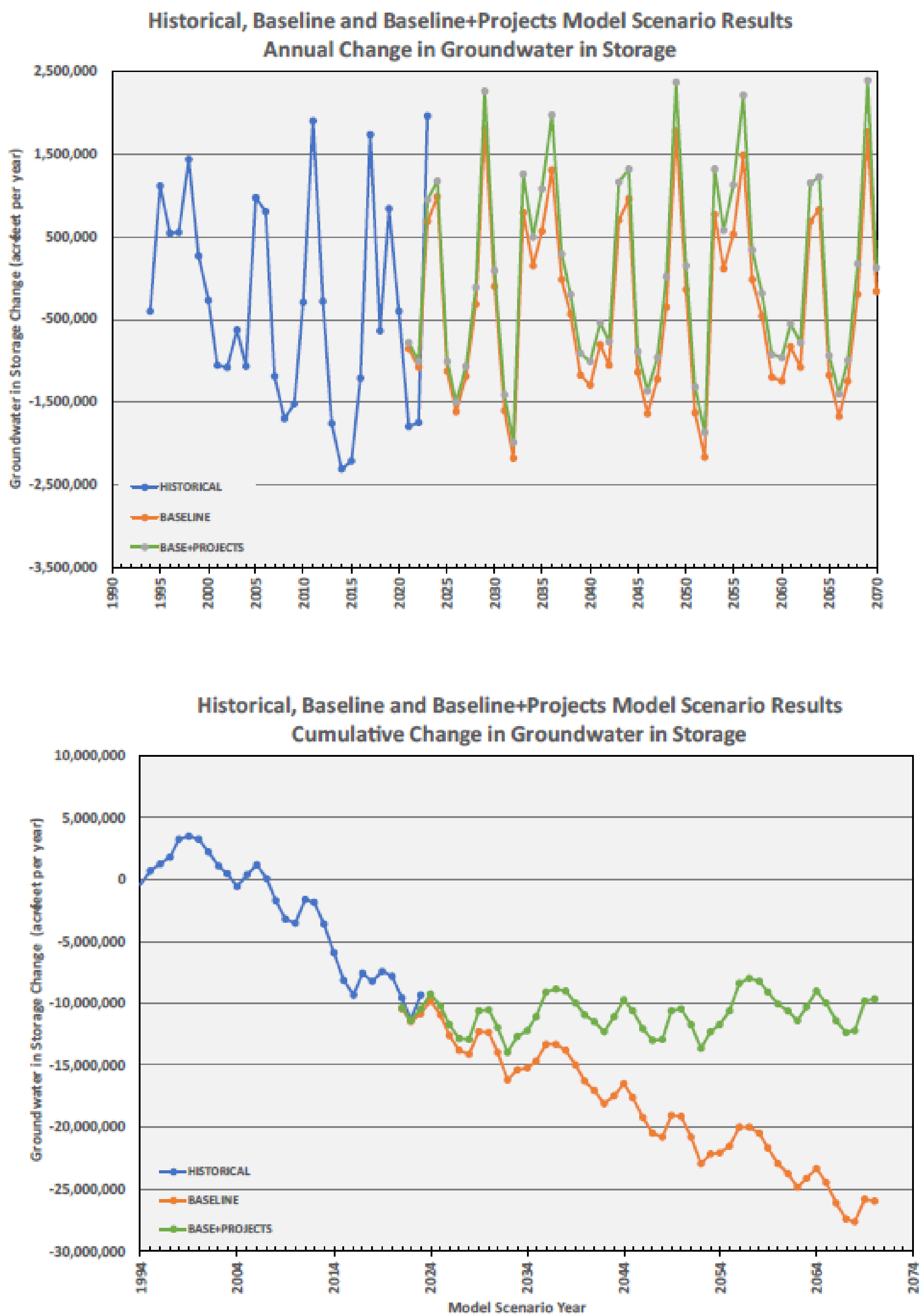
9.6.2 GSP Implementation Progress To-Date

A comparison of the updated C2VSimFG-Kern model results through WY2023 to the baseline condition provides a means to assess progress towards sustainability. Figure 9-27 compares the change in stored surface water and groundwater in storage from historical and current C2VSimFG-Kern simulation to the Projected-Future Baseline Scenarios. The Baseline Scenarios include a separate run for with and without implementation of the Project and Management Actions (P/MAs). The P/MAs are based on an original set of P/MAs that were designed to meet the Projected-Future deficit that includes a representative distribution of demand reduction and supply augmentation P/MAs (Figure 9-17). The demand reduction P/MAs provide a base level of improvement that is further enhanced with the utilization of water banking and conjunctive use during wet years. The Baseline Scenarios represent a minimum volumetric benefit of P/MAs necessary to achieve sustainability. As presented in Section 14, the Subbasin GSAs have continued to develop additional P/MAs that exceed this total.

The comparison on Figure 9-27 shows that the historical variability in change in stored surface water and groundwater in storage is reflected in the Baseline Scenario. For the Projected-Future Scenarios, the scenario with P/MAs run shows change in storage incrementally higher than the scenario without P/MAs. This shows that the high total volumes are a relatively small percentage of the overall water budget suggesting that this level of improvement is attainable.

The historical and current simulation has been extended to WY2023 which covers three years of GSP implementation. The second graph on Figure 9-27 shows the cumulative change in storage. The Baseline Scenario without P/MAs shows a general condition of the declines from WY1995 to WY2020. The Baseline Scenario with P/MAs shows that implementing P/MAs results in a change in the slope of the cumulative change in storage such that there is a slight positive increase in storage over the period from WY2041 to WY2070. The WY2023 historical and current simulation indicates that the Subbasin is generally on track with the sustainability plan at this early stage of implementation. This short-term assessment indicates that the Subbasin GSP implementation is currently on track.

This is a preliminary assessment of factors contributing to change of groundwater in storage estimates. The Subbasin GSAs are currently coordinating on several Subbasin-wide management actions to improve the ability to determine ET crop demand, upgrade the C2VSimFG-Kern model and conduct a Basin Study to address data gaps and better calculate water budgets.



Kern County Subbasin Groundwater Sustainability Plan	Comparison of Historical to Projected Future Change in Groundwater in Storage
Sources: California Data Exchange Center (CDEC, 2023) City of Bakersfield, Updated Kern River Indices by WY (received 2/15/2023)	May 2024 *Todd Groundwater/MM*

Figure 9-27. Comparison of Historical to Projected Future- Change in Groundwater in Storage

9.7 Conclusions

☑ **23 CCR § 354.18(a)**

This brief summary provides an overview of the findings and conclusions of the modeling results for the Subbasin using C2VSimFG-Kern.

9.7.1 Findings of the C2VSimFG-Kern Application and Results

The Subbasin-wide update of C2VSimFG-Kern incorporates data from many local agencies. Each participating agency provided data for their jurisdiction for use in improving the model. This included managed water supply data (e.g., surface water deliveries, land use, irrigation demand, return flows, and water banking), stream and groundwater monitoring data, geologic data, and other relevant data. This information was compiled and used to improve C2VSimFG-Kern performance in the Subbasin.

The historical water budget analysis indicates that the Subbasin was in a state of overdraft equivalent to the long-term decline in groundwater storage from WY1995 to WY2014 of 274,200 AFY. Projected Future simulations indicate that the proposed SGMA projects and management actions in the Kern County GSPs are sufficient for the Subbasin to achieve sustainability under Baseline and 2030 Climate Change conditions.

C2VSimFG-Kern is used to evaluate the change in groundwater in storage for projected future conditions using a baseline condition that projects current water supply, water demand and land use over a 50-year period based on historical hydrology. The baseline was adapted following DWR climate change guidance to develop 2030 and 2070 climate change simulations. The proposed SGMA projects and management actions were compiled from all the Subbasin GSAs. The total projects total about 421,000 AFY after implementation. This assessment indicates that the proposed SGMA projects and management actions for the Subbasin are of sufficient magnitude that, if fully implemented, would lead to groundwater sustainability for the Subbasin after WY2040.

The historical C2VSimFG-Kern performs well in the Subbasin, producing simulated water budget components and groundwater levels that generally match historical values compiled by local agencies. C2VSimFG-Kern simulated groundwater levels provide a reasonable statistical approximation of observed groundwater levels in the Subbasin that show significant improvement relative to C2VSimFG--Beta. Therefore, C2VSimFG-Kern is well suited as a planning tool to estimate the impacts of the proposed SGMA projects and management actions on groundwater conditions in the Subbasin.

The C2VSimFG-Kern model development and the water budget analysis were designed to fulfill the GSP requirement for a coordinated subbasin-wide water budget analysis, while also providing information required to fulfill other GSP requirements. The

C2VSimFG-Kern model was provided to DWR so the Subbasin revisions can be incorporated into their master version of the C2VSim model.

9.7.2 Limitations and Uncertainty of C2VSimFG-Kern

The C2VSimFG-Kern performs well in most parts of the Subbasin, producing simulated water budget components that generally match historical values compiled by local agencies. C2VSimFG-Kern simulated groundwater levels provide a reasonable approximation of observed groundwater levels in the central part of the Subbasin. Additional discussion of the validation and performance of C2VSimFG-Kern is provided in Appendix N. The model is well suited in most parts of the Subbasin to estimating the impacts of management actions on Subbasin groundwater storage.

The C2VSimFG-Kern update was limited in scope, and some model components do not perform well. These components do not reduce model capabilities with respect to GSP development but limit the usefulness of the model for other types of studies. Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. The Subbasin portion of the C2VSimFG-Kern is not calibrated, and although the land surface water budget components are generally accurate, groundwater conditions and stream flows are poorly simulated in much of the Subbasin. Some rejected recharge occurs in the Kern Fan area in very wet years, but this is not significant as it is a very small volume. The model layering along the Subbasin margins is not consistent with the current Subbasin hydrogeological conceptual model that affects the ability to accurately simulate groundwater elevations in these areas.

The C2VSimFG-Kern is a reliable and defensible tool to support planning future groundwater conditions and estimating the potential hydrological impacts of future climate conditions and management actions at the Subbasin level. It is currently the best available quantitative tool for assessing projected future groundwater conditions under SGMA. DWR recommends updating and refining models used in GSPs to incorporate new data including that in annual GSP updates. Refining Subbasin hydrologic modelling tools to replicate district-level historical conditions will provide a reliable means of assessing future effects of management actions at the district level for future GSP development.

9.7.3 Applicability of C2VSimFG-Kern Simulation Results

Based on the model validation, C2VSimFG-Kern provides a useful planning tool to evaluate potential future trends in groundwater in the Subbasin. The model validation demonstrated the capability of C2VSimFG-Kern to reasonably simulate the groundwater elevations and trends in most areas during the period from WY1995 through WY2015 based on the comparison to measured data.

The ability to reasonably simulate historical conditions provides confidence that C2VSimFG-Kern can be used to simulate potential future conditions. The model has the capability to simulate the most beneficial application of water projects that would provide the long-term benefit to the area. For the future case scenarios, the general practice is to evaluate model results with respect to long-term trends. Therefore, as a planning tool, it is most beneficial to run the model in relation to a base case and to evaluate the relative difference between the model scenario and the base case. The base case would assume a selected set of climatic, hydrologic, and pumping conditions. Commonly, the calibration base period is assumed to repeat; however, any number of variations can be constructed.

It is important to note that in some cases the model results may vary from those measured in individual wells due to the geologic complexity of the Subbasin. However, the model is capable of evaluating the impacts of changes in pumping and water use practices in the Subbasin that are useful for SMGA planning purposes.

The conclusions and recommendations presented herein are professional opinions based on the C2VSimFG-Kern revisions and simulations as described herein. The findings and professional opinions presented in this letter are presented within the limits prescribed by the client contract, in accordance with generally accepted professional engineering, geologic and modeling practices, to support development of GSPs within the Subbasin. There is no other warranty, either expressed or implied, regarding the conclusions, recommendations, and opinions presented in this report.

10. MANAGEMENT AREAS

§ 354.20. *Management Areas*
(a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.

☑ 23 CCR § 354.20(a)

For the purpose of the Sustainable Groundwater Management Act (SGMA) compliance, the Kern County Subbasin (Subbasin) is divided into Groundwater Sustainability Agencies (GSAs) which provide coverage for the entirety of the Subbasin including both districted lands and non-districted "white lands". There is no need to create management areas below the GSA level. The two exceptions are:

- Eastside Water Management Area (EWMA), a non-profit corporation governed by a seven-member Board of Directors, that is working to become a public agency and serve as the GSA for land within its boundaries. Until EWMA can serve as its own GSA, it is treated as a separate management area within the Kern Non-Districted Lands Authority.
- 7th Standard Annex was historically non-districted and was annexed into the Shafter-Wasco Irrigation District (SWID) in 2019 for the sole purpose of providing SGMA coverage. Per the landowner agreement, 7th Standard Annex does not share SWID's surface water supply benefits. Consequently, it is treated as a separate management area within the SWID GSA.

10.1 Description and Justification

§ 354.20. *Management Areas*
(b) A basin that includes one or more management areas shall describe the following in the Plan:
(1) The reason for the creation of each management area.

☑ 23 CCR § 354.20(b)(1)
☑ 23 CCR § 354.20(c)

The Kern Subbasin has 20 GSAs that mostly serve as the management areas. The two GSAs with separate management area are highlighted in Section 5.2.1 (Jurisdictional Boundaries) and the introduction to this chapter. Data and methodologies and Sustainable Management Criteria are the same across all management areas of the Subbasin. The reason for creating separate management areas is to implement area-specific Projects and Management Actions (P/MAs) that are tied to the checkbook water budget for planning purposes (refer to Chapter 14 and Appendix S).

10.2 Minimum Thresholds and Measurable Objectives

§ 354.20. *Management Areas*
(b) A basin that includes one or more management areas shall describe the following in the Plan:
(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.

☑ 23 CCR § 354.20(b)(2)

The Sustainable Management Criteria (SMCs) developed for the Subbasin, including the rationale for their selection, are described in detail in Chapter 13 *Sustainable Management Criteria.*

10.3 Monitoring

§ 354.20. *Management Areas*
(b) A basin that includes one or more management areas shall describe the following in the Plan:
(3) The level of monitoring and analysis appropriate for each management area.

☑ 23 CCR § 354.20(b)(3)

Monitoring networks for each applicable Sustainability Indicator within the Subbasin, including a discussion of the monitoring frequency appropriate to assess conditions related to SMCs, are described in detail in Chapter 15 *Monitoring Network*.

10.4 Hydrogeological Conceptual Model Areas

§ 354.20. *Management Areas*
(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

☑ 23 CCR § 354.20(c)

For the purposes of this Plan, the Subbasin has been divided into five Hydrogeological Conceptual Model (HCM) Areas with each area comprised of contiguous lands having similar hydrogeologic attributes. These areas, which aid in understanding how the complex hydrogeology of the Subbasin applies to various components of the Plan, are presented in Chapters 6 and 7 *Introduction to Basin Setting* and *Hydrogeological Conceptual Model* and help inform the formulation of the various projects and management actions (P/MAs) developed by the GSAs.

10.5 Projects and Management Actions

§ 354.20. *Management Areas*
(c) if a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

☑ 23 CCR § 354.20(c)

Each GSA is responsible for development and implementation of a suite of P/MAs sufficient for that GSA to attain sustainability within its jurisdiction and to thereby fulfill its obligations to the Subbasin for achieving sustainability. P/MAs to be implemented by each GSA are presented in Appendix S; the sum of P/MAs and expected benefits to the Subbasin are presented in Chapter 14, *Projects and Management Actions*.

This page intentionally left blank.

11. INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

***§ 354.22.** Introduction to Sustainable Management Criteria*
This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

☑ 23 CCR § 354.22

The Sustainable Groundwater Management Act (SGMA) legislation defines "Sustainability Goal" as "the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield" (California Water Code [CWC] § 10721(u)). SGMA requires Groundwater Sustainability Plans (GSPs) to develop and implement plans to meet the Sustainability Goal (CWC § 10727(a)) and requires that the plans include Measurable Objectives (MOs) and Interim Milestones (IMs) in increments of five years to achieve the Sustainability Goal within 20 years of the implementation of the 2020 GSPs (CWC § 10727.2(b)(1)).

The SGMA legislation and California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 define terms related to achievement of the Sustainability Goal, including:

- Undesirable Result (UR) – "one or more of the following effects caused by groundwater conditions occurring throughout the basin:

  (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

  (2) Significant and unreasonable reduction of groundwater storage.

  (3) Significant and unreasonable seawater intrusion.

  (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.

(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." (CWC § 10721(x));

- Minimum Threshold (MT) – "a numeric value for each sustainability indicator used to define undesirable results" (23 CCR § 351(t));
- Measurable Objective (MO) – "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR § 351(s)); and
- Interim Milestone (IM) – "a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan" (23 CCR § 351(q))

Collectively, the Sustainability Goal, URs, MTs, MOs, and IMs are referred to herein as Sustainable Management Criteria (SMCs). The Kern County Subbasin's (Subbasin's) approach to developing the SMCs applies a methodology that is a) common for all Subbasin areas, b) consistent with the SGMA regulations, c) relies on consistent data across the Subbasin, and d) would not unreasonably impact beneficial users and uses of groundwater. Sections 12 and 13 of this Plan describe the Sustainability Goal, URs, MTs, and MOs and IMs developed in coordination and collaboration with all Subbasin Groundwater Sustainability Agencies (GSAs).

11.1 Summary of Sustainable Management Criteria

Table 11-1 summarizes the SMCs for each applicable Sustainability Indicator established for the Subbasin.

Table 11-1. Current Status of Groundwater Conditions for Each Sustainability Indicator

Sustainability Indicator	UR Criteria	Minimum Threshold	Measurable Objective
Chronic Lowering of Groundwater Levels	At least one of the following occurs within the Subbasin: 1. More than 15 drinking water wells are reported as dry in any given year. If 15 drinking water wells were impacted every year, no more than 255 drinking water wells cumulatively would be impacted by 2040. 2. The MTs for Chronic Lowering of Groundwater Levels are exceeded in at least 25 percent of the RMW-WLs over a single year (i.e., two consecutive seasonal measurements).	The RMW-WL-specific MTs are set as the lower of the following: 1. Groundwater level in 2030 if the regional trend is extended from the 2015 low (the MO), or 2. Groundwater level that allows for operational flexibility below the 2015 low, based on an RMW-WL-specific record of groundwater level fluctuations	The 2015 low groundwater elevation
Reduction of Groundwater Storage	A cumulative reduction in usable groundwater storage of 9.3 MAF in the Primary Principal Alluvial Aquifer relative to the baseline (WY 2015) total usable groundwater storage volume.	MTs for Chronic Lowering of Groundwater Levels used as a proxy	MOs for Chronic Lowering of Groundwater Levels used as a proxy
Seawater Intrusion	Groundwater conditions in the Subbasin show that Seawater Intrusion is not present and is not anticipated to be present in the future, and therefore, the Sustainability Indicator is not applicable.		
Degraded Water Quality	MTs for a groundwater quality COC are exceeded in three RMW-WQs in an HCM area based the average of confirmed seasonal samples and can be attributed based on a technical analysis to groundwater management actions (e.g. groundwater level changes).	The greater concentration of: 1. The applicable health-based screening standard, or 2. The maximum pre-2015 baseline concentration at each RMW-WQ. For wells with insufficient pre-2015 data, 2010-2023 data is used determine maximum baseline concentration at each RMW-WQ. For wells with insufficient 2010-2023 data, the MT is set as the 90th percentile 2010-2023 baseline concentration in the applicable HCM area.	The greater concentration of: 1. The applicable health-based screening standard, or 2. The median pre-2015 baseline concentration at each RMW-WQ For wells with insufficient pre-2015 data, 2010-2023 data is used to determine median baseline concentration at each RMW-WQ. For wells with insufficient 2010-2023 data, the MO is set as the 90th percentile 2010-2023 baseline concentration in the applicable HCM area.

Sustainability Indicator	UR Criteria	Minimum Threshold	Measurable Objective
Land Subsidence	MT extent of subsidence is exceeded at any RMS-LS or as measured using InSAR data published annually by DWR averaged across an HCM area. Note: not all Subbasin subsidence is caused by GSA-related activities. Non-GSA subsidence is outside of GSA authority.	MTs are established along critical infrastructure as a rate and extent based on specific impacts to critical infrastructure or as an observed or allowable rate of subsidence, as determined by the Subbasin's risk-based approach (Section 13.5.2.1). Additionally, MTs are set for the Subbasin as the maximum average historical rate of subsidence in each HCM area from 2015-2023.	50 percent of the MT rate and MT extent.
Depletions of Interconnected Surface Waters	Groundwater conditions in the Subbasin show that there are a few areas with potential Interconnected Surface Waters. However, the connection is likely transient, short-lived, and involves shallow or perched groundwater that is not part of the principal aquifer systems (see Section 8.6). Therefore, the Sustainability Indicator is not applicable to the Subbasin.		

Abbreviations:

COC = Constituent of Concern
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
HCM = Hydrogeologic Conceptual Model
InSAR = Interferometric Synthetic Aperture Radar
MAF = million acre-feet
MO = Measurable Objective
MT = Minimum Threshold
RMS-LS = Representative Monitoring Site for Land Subsidence
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WQ = Representative Monitoring Well for Degraded Water Quality
WY = Water Year

12. SUSTAINABILITY GOAL

***§ 354.24**. Sustainability Goal*
Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

☑ 23 CCR § 354.24

The sustainability goal for the Kern County Subbasin is to implement its Groundwater Sustainability Plans (GSPs) to achieve sustainable groundwater management within the 20-year implementation schedule. Achieving the sustainability goal will be demonstrated by eliminating chronic lowering of groundwater levels caused by overdraft conditions and avoiding Undesirable Results for groundwater levels, groundwater storage, land subsidence, and groundwater quality. This goal will be accomplished through the following objectives:

- Implement the Subbasin Community Engagement Plan.
- Eliminate long-term groundwater overdraft and attain sustainability through conjunctive use, water banking, and demand management programs.
- Continuously evaluate groundwater conditions avoid undesirable results.
- Maintain long-term sustainability of water resources available to the Subbasin.
- Maintain a comprehensive database of beneficial uses and users to inform on the efficacy of groundwater management policies and programs.

This page intentionally left blank.

13. SUSTAINABLE MANAGEMENT CRITERIA

As discussed in Section 11, the Kern County Subbasin (Subbasin) developed Sustainable Management Criteria (SMCs) consistent with the Sustainable Groundwater Management Act (SGMA) and in coordination with all Subbasin Groundwater Sustainability Agencies (GSAs). The Subbasin's SMCs development process is proactive in identifying and managing the occurrence of Undesirable Results (URs) to beneficial users and utilizes consistent data and methodologies across the Subbasin. This section details the development processes of the URs, Minimum Thresholds (MTs), Measurable Objectives (MO) and Interim Milestones (IMs) for each Sustainability Indicator, and presents the final SMCs, where applicable.

13.1 Chronic Lowering of Groundwater Levels

13.1.1 Undesirable Results for Chronic Lowering of Groundwater Levels

§ 354.26. *Undesirable Results*

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

- *(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*
- *(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*
- *(3) 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.*

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

Per SGMA, URs for the Chronic Lowering of Groundwater Levels are defined as a "*chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon*" (California Water Code [CWC] § 10721(x)(1)). However, it is important to note that SGMA also states that "...overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (CWC § 10721(x)(1)).

The Subbasin-wide UR for Chronic Lowering of Groundwater Levels is defined as follows:

> *The point at which significant and unreasonable impacts over the planning and implementation horizon, as determined by depth/elevation of water, affect the reasonable and beneficial use of, and access to, groundwater by overlying users.*

This definition requires translation to quantify "*significant and unreasonable impacts*". The general process that was followed is consistent with requirements of California Code of Regulations Title 23 (23 CCR) § 354.26-30 which includes an identification of beneficial uses and users and an assessment of impacts to beneficial uses and users through a suite of well impacts analyses.

13.1.1.1 Identification of Beneficial Users

As discussed in Section 1.2.1, a Subbasin-wide well inventory was conducted to better understand the distribution of beneficial groundwater uses and users in the Subbasin. Based on the well inventory, there are approximately 7,227 groundwater production wells in the Subbasin and the beneficial uses and users that could be impacted by Chronic Lowering of Groundwater Levels include:

- **Agricultural users:** The primary use of groundwater from the Primary Alluvial Principal Aquifer is for agricultural purposes, including pumping from private wells and pumping from public agency wells for recovery and delivery of previously stored surface water or in-lieu recharge. The primary use of groundwater from the Santa Margarita and Olcese Principal Aquifers is for agricultural purposes. There are approximately 4,291 agricultural wells.
- **Domestic and small community users:** There are approximately 2,541 domestic and small community wells used for drinking water supplies.
- **Municipal and public water systems:** There are approximately 298 public supply wells. Groundwater is pumped for municipal use in the communities of Bakersfield, Buttonwillow, Greenfield, Arvin, East Niles, Lamont, Taft, Oildale, Shafter, Wasco, McFarland, Delano, and Mettler.
- **Industrial users:** There are approximately 97 industrial wells primarily used to supply food processing and cold storage facilities.

Per CWC §106.3(a), all drinking water users of groundwater are considered beneficial users with a human right to "safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." As such, the Subbasin GSAs have identified drinking water users, defined herein as domestic, municipal, public supply, and small community wells, as the most sensitive beneficial users.

13.1.1.2 Potential Effects of Undesirable Results on Beneficial Users

☑ **23 CCR § 354.26(b)(3)**

The primary potential effect of URs caused by Chronic Lowering of Groundwater Levels on beneficial uses and users of groundwater in the Subbasin include:

- Groundwater well dewatering: Excessive well dewatering can be detrimental to groundwater-dependent drinking water users and could result in the loss of water supply and a need for supplemental supplies. Partial well dewatering can also lead to increased maintenance costs (e.g., well rehabilitation/ redevelopment/deepening and pump lowering) and reduced well lifespan due to biofouling and plugging of well casings and screens. A well impact analysis was conducted to assess which, if any, wells would be potentially dewatered if groundwater levels in the Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) were to decline to the established MTs (see Section 13.1.2.4).
- Increased pumping lift: Increased pumping lift results in more energy use per unit volume of groundwater pumped and corresponding higher pumping costs, as well as increased wear and tear on well pump motors and reduced well efficiency.
- The relationship to potentially correlated Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, and Degraded Water Quality. The degree of correlation will continue to be explored as part of Plan implementation.

13.1.1.3 Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Potential causes of URs due to Chronic Lowering of Groundwater Levels in the Subbasin could include increased pumping and/or reduced recharge. Since the primary use of groundwater in the Subbasin is for agricultural purposes, increased groundwater pumping from the principal aquifers could occur if water use per acre on irrigated land increases or if new land is put into agricultural production. Additionally, increased pumping could occur if groundwater demand increases to supplement a shortage in imported surface water. Reduced recharge could occur due to increased agricultural irrigation efficiency, reduced surface water imports and banking, reduced groundwater inflows from adjacent areas, or due to climate change that results in decreased precipitation, decreased natural surface water inflows, and increased evapotranspiration (ET).

13.1.1.4 Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**
☑ **23 CCR § 354.26(c)**

Per Section 354.26(b)(2) of the Groundwater Sustainability Plan (GSP) Emergency Regulations, the description of URs must include the criteria used to define when and where the effects of groundwater conditions cause URs, based on a quantitative description of the combination of MT exceedances that cause significant and unreasonable effects in the Subbasin.

Given this requirement, the Subbasin established a quantitative UR definition that would be triggered if either of the following two conditions is met:

(1) More than 15 drinking water wells are reported as dry in any given year. If 15 drinking water wells were impacted every year, no more than 255 drinking water wells cumulatively would be impacted by 2040.

(2) The MTs for Chronic Lowering of Groundwater Levels are exceeded in at least 25 percent of the RMW-WLs over a single year (i.e., two consecutive seasonal measurements).

To quantify avoiding "significant and unreasonable" dewatering of drinking water wells, the GSAs assessed how many drinking water wells have historically been impacted, and how many are reasonable and economical to mitigate in the future. Furthermore, a suite of well impacts analyses was conducted to assess whether there would be "significant and unreasonable" impact to drinking water supply based on a range of potential and anticipated drinking water well and depletion of supply impacts.

The first UR criterion requiring more than 15 drinking water wells to be reported dry in any given year is justified based on the following rationale:

- The maximum number of drinking water wells that have been reported to the California Department of Water Resources (DWR) as being dewatered in any given year since 2015 is 10 wells, with a cumulative total of 38 wells.
- Since 2010, a total of 50 wells (47 drinking water wells and 3 agricultural wells) have already been mitigated through existing well mitigation programs within the Subbasin, including pump lowering, well replacement, or connection to a public supply.
- The Subbasin GSAs have determined that it is economically feasible to fund a $1 million per year Well Mitigation Program (see Section 16.2.1.1), which could provide sufficient funds to mitigate an average of 15 drinking water wells per year, or a total of 255 wells through 2040. The existing active well mitigation programs in the Subbasin have mitigated 50 dry wells for a total of $1.151

million, averaging $23,000 per mitigated well. Therefore, the Subbasin GSAs' plan to fund a $1 million per year Well Mitigation Program at an average cost of $66,000 per mitigated well is anticipated to provide sufficient funds for future mitigation.

- The most-likely distribution of drinking water well impacts, as estimated through application of the *C2VSimFG-Kern Projected-Future Baseline 2030 Climate Change* scenario, indicates that there will be fewer dewatered drinking water wells than the proposed UR definition. Specifically, the model projects that up to 77 drinking water wells will be dewatered by 2040 under climate change with no Projects and Management Actions (P/MAs), estimated based on typical volumes to be equivalent to a 1.2 percent loss of drinking water supply by volume.

The second UR criterion requiring that MTs are exceeded in at least 25 percent of RMW-WLs over two consecutive seasonal measurements is justified based on the following rationale:

- The well impact analysis shows that an average of 103 drinking water wells could be impacted at the proposed UR criterion of 25 percent of RMW-WLs (see Section 13.1.2.4), which falls within the reasonable scope (less than 255 wells) for the GSAs to address through mitigation.
- The C2VSimFG-Kern model results indicate that there are no instances where more than 25 percent of the RMW-WLs have MT exceedances over two consecutive seasonal measurements from 2020 through 2070 based on the *Projected-Future "With Project"* scenario suggesting that the Subbasin GSAs have sufficiently designed P/MAs to improve the Subbasin conditions to avoid URs.
- The Subbasin GSAs are developing a coordinated and comprehensive Well Mitigation Program to address domestic and small community wells impacted by groundwater level declines (see Section 16.2.1.1).
- The component of the criteria requiring two consecutive seasonal measurements of MT exceedances provides for confirmation that the chronic lowering of groundwater levels is not due to seasonal variation, consistent with the definition of URs for this Sustainability Indicator in CWC § 10721(x)(1).

As discussed in Section 14, the GSAs will strive through the implementation of P/MAs to manage water levels toward the MOs, which are in all cases set above the MTs.

13.1.2 Minimum Threshold for Chronic Lowering of Groundwater Levels

§ 354.28. *Minimum Thresholds*

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4

(4) Minimum thresholds for each sustainability indicator shall be defined as follows:

(c) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.

(B) Potential effects on other sustainability indicators.

Chronic Lowering of Groundwater Levels is arguably the most fundamental Sustainability Indicator, as it influences several other key Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, and in certain ways, Degraded Water Quality. Groundwater levels are also the most readily available and measurable metrics of groundwater conditions, which allows for a systematic, data-driven approach to develop MTs.

The MT is defined as "...*a numeric value for each sustainability indicator used to define undesirable results"* (23 CCR § 351(t)). Consistent with the GSP Emergency Regulations (23 CCR § 354.28I), the MTs for Chronic Lowering of Groundwater Levels considers the rate of groundwater elevation decline based on historical trends, water year types, projected water use, potential impacts to beneficial uses and users, and the relationship to other Sustainability Indicators. Specifically, the information and criteria relied on to establish the MTs for Chronic Lowering of Groundwater Levels include:

- Available historical groundwater level data for each RMW-WL;

- Regional trends, based on average groundwater level trends within each Hydrogeological Conceptual Model (HCM) Area (see Section 7.3) representing conditions under recent (post-2009) imported water supply reliability and drought conditions;
- Operational flexibility, based on the historical range in groundwater levels representing the long-term variability of groundwater conditions and operations at or near each RMW-WL; and,
- RMW-WL proximity to sensitive beneficial users in areas where water quality concentrations are influenced by groundwater levels (see Section 13.1.2.2).

This information was used to develop MTs that account for historical trends and water level fluctuations to ensure sufficient groundwater supply through variable hydrologic conditions and projected water uses. The Subbasin GSAs initially considered 11 different methods to set the MTs and systematically assessed these methods against potential well impacts, groundwater gradients, margin of operational flexibility, and other local considerations. As detailed in **Appendix P**, 11 potential alternative methods were iteratively refined, reassessed against anticipated well impacts and the proposed UR definition, and eliminated until a final, Subbasin-wide MT methodology was agreed upon by the GSAs.

The RMW-WL-specific MTs are set as the lower of the following:

(1) Trend Dominated: Groundwater level in 2030 if the regional trend is extended from the 2015 low (the MO), or

(2) Range Dominated: Groundwater level that allows for operational flexibility below the 2015 low (MO), based on an RMW-WL-specific record of groundwater level fluctuations.

Both methodologies are described in detail below.

13.1.2.1 Minimum Threshold Development

☑ **23 CCR § 354.28(b)(1)**
☑ **23 CCR § 354.28(c)(1)(A)**
☑ **23 CCR § 354.28(c)(1)(B)**

The Subbasin's approach to developing the Chronic Lowering of Groundwater Levels SMCs applies a method that is consistent with the SGMA regulations, relies on consistent data and methodologies across the Subbasin, and would not unreasonably impact beneficial uses and users of groundwater.

The following steps translate the above conceptual approach into a numeric MT value at each RMW-WL, as demonstrated in Figure 13-1 and detailed further below:

- Step 1: Extend the regional trend from the 2015 low (MO) forward to 2030
- Step 2: Subtract 25 percent of the RMW-WL-specific groundwater level range from the 2015 low (MO)
- Step 3: Select the MT as the lower of either Step 1 or Step 2 value

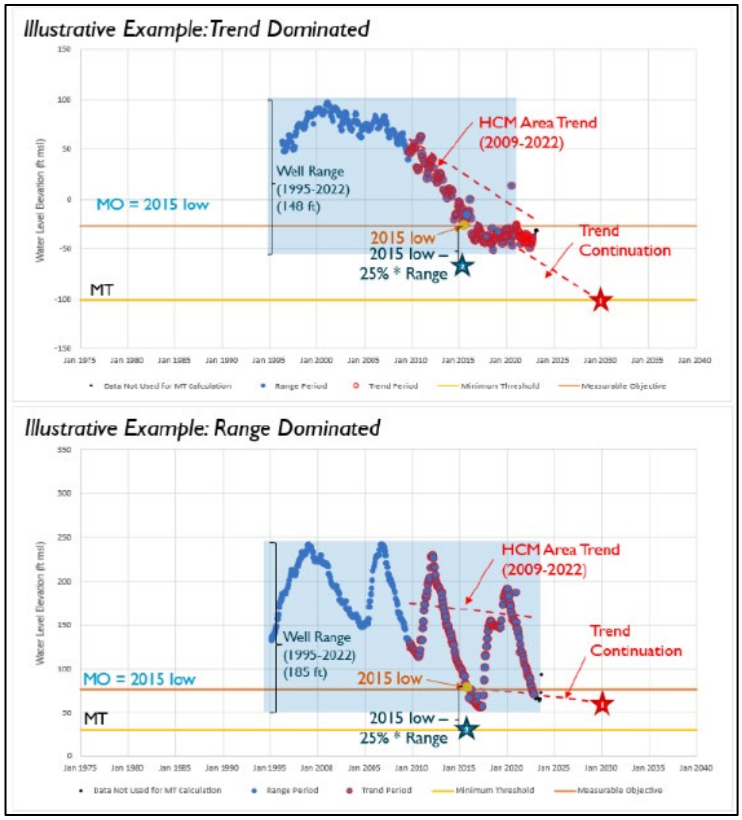


Figure 13-1. Illustrative Example of MT Approach

<u>Step 1: Regional Trend Extension</u>

Consistent with 23 CCR § 354.28(c) "...*groundwater elevation decline based on historical trends*", for each HCM Area, selected monitoring sites with recent declining trends in groundwater levels were averaged to calculate the regional trend.[1] Specifically, a linear trend was calculated using available static water level data over the period Water Year (WY) 2009 to 2022[2] for each selected monitoring site.[3]

The WY 2009 to 2022 period was selected for the following reasons:

- This period reflects the effects of changes to State Water Project (SWP) and Central Valley Project (CVP) deliveries resulting from Delta-related federal District Court rulings and initial implementation of the San Joaquin River Restoration Program; and
- The period includes the recent significant droughts, and therefore allows the trend to incorporate the possibility of another long-term drought in the future (e.g., potentially exacerbated by climate change).

[1] 200 monitoring sites distributed throughout the Subbasin were selected based on location and data availability, among other factors. Out of these selected monitoring sites, wells with recent declining trends in groundwater levels were used to calculate the regional trend for each HCM Area.
[2] Data from 2008-10-01 (WY 2009) to 2022-11-15 (WY 2022) was used for the linear trend calculation.
[3] In some instances, identified questionable data were removed for purposes of developing the trends, and some selected monitoring sites with limited data were supplemented by surrogate data from nearby wells, consistent with the 2022 GSP(s).

Some monitoring sites were identified as representing various aquifer depth profiles. Specifically:

- Within the East Margin HCM Area, two principal aquifer units have been identified, including: (1) the unconsolidated continental deposits, including the Kern River and Tulare formations (Primary Alluvial Principal Aquifer), and (2) the deeper confined units, including the Santa Margarita Formation, Olcese Sands, Pyramid Hills, and Vedder Formation (Santa Margarita Principal Aquifer; Section 7.2.10). The monitoring sites within this HCM Area were designated between the two principal aquifer units based on well completion depth and the depth of inferred geologic formations.
- There are seven multi-completion monitoring sites within the Kern River Fan HCM Area. The "-M" completion was identified as the most representative of the primary principal aquifer in this area and were used in the following regional trend analyses.

Figure 13-2 and Table 13-1 summarize the HCM Area averages and groundwater level trends from WY 2009 to 2022.

The regional trend was assigned to each RMW-WL based on its location within an HCM Area and multiplied by 14 years (i.e., to extend the trend from WY 2016 to WY 2030).[4] The resultant groundwater level decline (in feet) was subtracted from the 2015 low value to calculate the 2030 projected groundwater level at each RMW-WL. The end point of 2030 was selected for the following reasons:

- This length of time is considered reasonable and necessary to implement the various P/MAs that may be required to reverse declining groundwater level trends, in consideration of the potential regulatory, environmental, logistical, engineering, socioeconomic and other challenges that the various P/MAs may entail, as well as the time that such measures would likely take to manifest in observed groundwater level conditions; and
- This length of time is half the duration of the SGMA implementation period (i.e., through 2040), suggesting that by the halfway point, the Subbasin should be on a trajectory toward achieving the Sustainability Goal.

[4] The annual regional trend for each HCM was multiplied by 14 years to calculate the projected groundwater level decline that would occur through 2030 using the 2015 low value as a baseline. Because the 2015 low values are representative of Fall 2015 water levels, the period used to extend the trend is WY 2016 through WY 2030, or 14 years.

Step 2: RMW-WL-specific Groundwater Level Range

Variability in groundwater levels is accounted for by calculating the operational groundwater level range as the product of the observed groundwater level range in each RMW-WL over a long-term historical period and a "range percentage." This variability factor acknowledges the fact that different RMW-WLs across the Subbasin have experienced different amounts of groundwater level variability due to local operations and conditions.

The period for groundwater level range determination is defined as WY 1995 to 2022[5] for the following reasons:

- The period includes a mix of wet and dry years and so variability in groundwater levels during this time should be reflective of variable climate, groundwater use, and natural and active groundwater recharge, and surface water storage and recovery;
- This period includes the historical and current water budget period of interest defined by the GSAs, and therefore water budget and model results are available for this period; and
- The full range in historical groundwater level fluctuations was multiplied by 25 percent as a conservative allowance for future groundwater level fluctuations within a RMW-WL. Therefore, for each RMW-WL, 25 percent of the RMW-WL-specific groundwater level fluctuation was subtracted from the 2015 low groundwater level.

Table 13-1. Regional Groundwater Level Trends

HCM Area	Average Trend (feet/year)[1]
North Basin HCM Area	-7.0
Kern River Fan HCM Area	-3.1
South Basin HCM Area	-5.4
Western Fold Belt HCM Area	N/A[2]
East Margin HCM Area – Primary Alluvial Principal Aquifer	-7.2
East Margin HCM Area – Santa Margarita and Olcese Principal Aquifers	-6.6

Notes:

1. Average trend (feet/year) values represent the average regional groundwater level trend in each HCM area of the Kern Subbasin from WY 2009 through WY 2022 and include all activities (i.e., GSA and non-GSA).
2. There is insufficient historical groundwater level data from monitoring wells located in the Western Fold Belt HCM Area to calculate a trend. Principal water supply is imported surface water in this HCM Area.

---

[5] Data from 1994-10-01 (WY1995) to 2022-11-15 (WY2022) was used for the range determination.

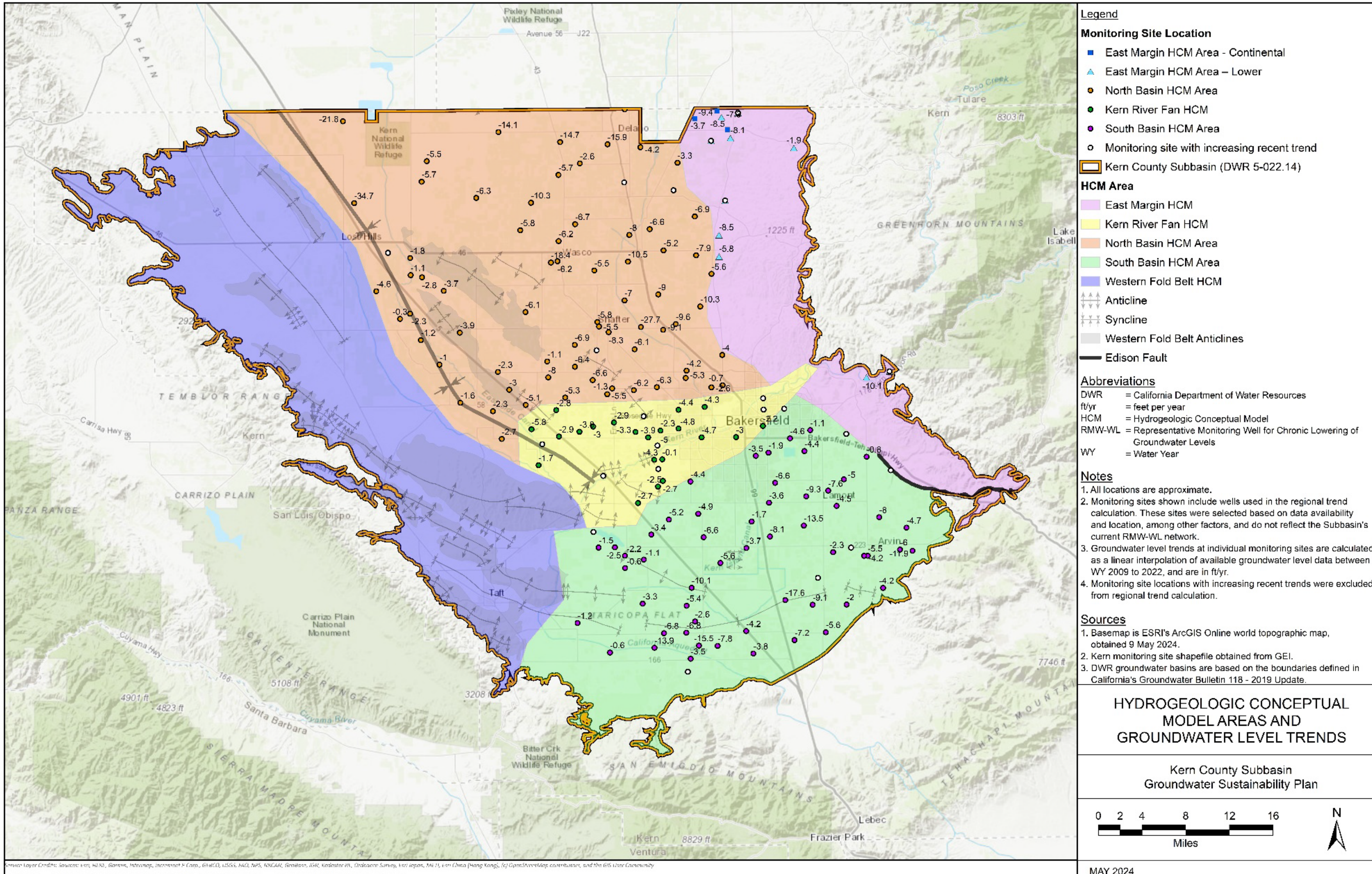


Figure 13-2. Hydrogeologic Conceptual Model Areas and Groundwater Level Trends

This page intentionally left blank.

Step 3: MT Selection

The MT value is selected as the lower groundwater level calculated under Step 1 and Step 2. The final MTs for Chronic Lowering of Groundwater Levels for the Subbasin by HCM Area for both the Primary Alluvial Principal Aquifer and Santa Margarita and Olcese Principal Aquifers are shown in Table 13-2 and mapped in Figure 13-3 and Figure 13-4, respectively. Additionally, Appendix Q contains hydrographs that plot historical groundwater levels, the MT, and the MO at each RMW-WL. A discussion of how these MTs will avoid significant and unreasonable impacts is provided in Section 13.1.1.4 above.

This page intentionally left blank.

Table 13-2. SMCs for Chronic Lowering of Groundwater Levels by RMW-WL

Local Site ID	RMW ID	HCM	GSA	Aquifer	Latitude	Longitude	MT (ft msl)	MO (ft msl)	IMs (ft msl)				MO Estimation Method
									2025	2030	2035	2040	
29S29E33N001M	RMW-001	South Basin	AEWSD	Primary Principal Alluvial	35.356255	-118.874879	219	294	257	238	266	294	2015 Low
30S29E11N001M	RMW-002	South Basin	AEWSD	Primary Principal Alluvial	35.325731	-118.842352	302	378	340	321	349	378	2015 Low
30S30E19E001M	RMW-003	South Basin	AEWSD	Primary Principal Alluvial	35.307301	-118.803495	497	573	535	516	545	573	2015 Low
30S29E29A001M	RMW-004	South Basin	AEWSD	Primary Principal Alluvial	35.296069	-118.879708	22	98	60	41	70	98	2015 Low
31S29E05E001M	RMW-005	South Basin	AEWSD	Primary Principal Alluvial	35.260883	-118.891984	14	90	52	33	62	90	Linear interpolation between November 2013 and November 2019
31S29E12M001M	RMW-006	South Basin	AEWSD	Primary Principal Alluvial	35.245303	-118.823158	-9	66	28	10	38	66	2015 Low
31S30E17K001M	RMW-007	South Basin	AEWSD	Primary Principal Alluvial	35.230887	-118.779148	5	81	43	24	52	81	Average of March 2014 and November 2016
31S29E34A001M	RMW-008	South Basin	AEWSD	Primary Principal Alluvial	35.194234	-118.842512	-46	30	-8	-27	1	30	2015 Low
31S30E30J001M	RMW-009	South Basin	AEWSD	Primary Principal Alluvial	35.201876	-118.790198	86	162	124	105	134	162	2015 Low
ACSD Well #14	RMW-010	South Basin	AEWSD	Primary Principal Alluvial	35.194193	-118.848387	-52	24	-14	-33	-4	24	2015 Low
32S29E12P001M	RMW-011	South Basin	AEWSD	Primary Principal Alluvial	35.151308	-118.818396	-12	64	26	7	36	64	2015 Low
32S29E20L001M	RMW-012R	South Basin	AEWSD	Primary Principal Alluvial	35.12900369	-118.8876795	4	79	42	23	51	79	2015 Low
32S28E23H001M	RMW-013	South Basin	AEWSD	Primary Principal Alluvial	35.130145	-118.932551	53	129	91	72	100	129	2015 Low
32S29E31N001M	RMW-014	South Basin	AEWSD	Primary Principal Alluvial	35.093374	-118.911887	4	80	42	23	51	80	2015 Low
12N20W36G001S	RMW-015	South Basin	AEWSD	Primary Principal Alluvial	35.083407	-118.962552	41	116	79	60	88	116	2015 Low
11N20W05J001S	RMW-016	South Basin	AEWSD	Primary Principal Alluvial	35.066173	-119.029415	0	75	37	18	47	75	2015 Low
DMW01	RMW-105	North Basin	BVWSD	Primary Principal Alluvial	35.60135	-119.61765	62	160	111	86	123	160	2015 Low
DMW02	RMW-106	North Basin	BVWSD	Primary Principal Alluvial	35.57164	-119.58081	54	152	103	78	115	152	2015 Low
DMW04	RMW-107	North Basin	BVWSD	Primary Principal Alluvial	35.51369	-119.59844	119	218	169	144	181	218	2015 Low
DMW05	RMW-108	North Basin	BVWSD	Primary Principal Alluvial	35.48532	-119.56483	111	210	160	136	173	210	2015 Low
DMW06	RMW-109	North Basin	BVWSD	Primary Principal Alluvial	35.45265	-119.5346	88	187	137	113	150	187	2015 Low
DMW07	RMW-110	North Basin	BVWSD	Primary Principal Alluvial	35.40209	-119.5011	57	155	106	81	118	155	2015 Low
DMW08	RMW-111	North Basin	BVWSD	Primary Principal Alluvial	35.39058	-119.44817	46	145	95	71	108	145	2015 Low
DMW10a	RMW-112a	North Basin	BVWSD	Primary Principal Alluvial	35.35362	-119.43412	18	116	67	43	80	116	2015 Low
DMW12b	RMW-113b	Kern River Fan	BVWSD	Primary Principal Alluvial	35.31847	-119.37473	24	66	45	35	50	66	2015 Low
Well 12H	RMW-167	North Basin	CWD	Primary Principal Alluvial	35.59541	-119.11595	22	120	71	46	83	120	2015 Low
Well 4R	RMW-168	North Basin	CWD	Primary Principal Alluvial	35.6023	-119.169	-33	65	16	-9	28	65	Average of February 2011 and October 2020
Well 28L	RMW-169	North Basin	CWD	Primary Principal Alluvial	35.462763	-119.074941	17	115	66	41	78	115	2015 Low
Well 24R	RMW-170	North Basin	CWD	Primary Principal Alluvial	35.64694	-119.11746	-37	61	12	-13	24	61	2015 Low
Well 11M	RMW-171	North Basin	CWD	Primary Principal Alluvial	35.5044	-119.1502	-81	17	-32	-57	-20	17	2015 Low
Well 6C	RMW-172	North Basin	CWD	Primary Principal Alluvial	35.52744	-119.10998	-73	25	-24	-49	-12	25	2015 Low
Well 33C	RMW-173	North Basin	CWD	Primary Principal Alluvial	35.54391	-119.17809	-123	-25	-74	-99	-62	-25	October 2016
EWMA #21	RMW-185	East Margin	EWMA	Santa Margarita and Olcese Principal	35.593428	-119.078767	1	95	48	24	59	95	2015 Low estimated (Spring 2015 minus seasonal fluctuation)
EWMA #30	RMW-187	East Margin	EWMA	Santa Margarita and Olcese Principal	35.667733	-119.067811	-169	-75	-122	-146	-110	-75	2015 Low
EWMA #41	RMW-189	North Basin	EWMA	Primary Principal Alluvial	35.570531	-119.091094	42	140	91	66	103	140	Fall 2013
EWMA #23	RMW-278	East Margin	EWMA	Santa Margarita and Olcese Principal	35.621978	-119.078483	-6	88	41	18	53	88	2015 Low estimated (Spring 2015 minus seasonal fluctuation)
EWMA #04	RMW-283	East Margin	EWMA	Santa Margarita and Olcese Principal	35.784003	-119.045589	-113	-19	-66	-90	-54	-19	July 2017
EWMA #49	RMW-288	East Margin	EWMA	Santa Margarita and Olcese Principal	35.736472	-118.954953	308	403	355	332	367	403	February 2022
EWMA #11	RMW-296	East Margin	EWMA	Santa Margarita and Olcese Principal	35.713365	-119.036082	-107	-13	-60	-84	-48	-13	2015 Low from nearby well

Local Site ID	RMW ID	HCM	GSA	Aquifer	Latitude	Longitude	MT (ft msl)	MO (ft msl)	IMs (ft msl)				MO Estimation Method
									2025	2030	2035	2040	
Cameo Old Well #13	RMW-297	East Margin	EWMA	Santa Margarita and Olcese Principal	35.740417	-119.031822	-107	-13	-60	-84	-48	-13	2015 Low from nearby well
Poso Well #1	RMW-298	East Margin	EWMA	Santa Margarita and Olcese Principal	35.548049	-119.076429	-69	25	-22	-46	-10	25	2015 Low from nearby well
HMWD #20	RMW-114	South Basin	HMWD	Primary Principal Alluvial	35.22944	-119.28645	27	103	65	46	75	103	2015 Low
HMWD #28	RMW-115	South Basin	HMWD	Primary Principal Alluvial	35.2086	-119.27828	-41	35	-3	-22	7	35	2015 Low
HMWD #27	RMW-116	South Basin	HMWD	Primary Principal Alluvial	35.20876	-119.25197	-48	28	-10	-29	0	28	2015 Low
HMWD #26	RMW-117	South Basin	HMWD	Primary Principal Alluvial	35.19757	-119.23575	-79	-3	-41	-60	-31	-3	2015 Low
HMWD #18	RMW-118	South Basin	HMWD	Primary Principal Alluvial	35.1811	-119.23581	1	77	39	20	49	77	2015 Low
RMW-017	RMW-017	North Basin	KRGSA	Primary Principal Alluvial	35.420895	-119.181743	6	105	56	31	68	105	2015 Low
RMW-018	RMW-018	North Basin	KRGSA	Primary Principal Alluvial	35.432778	-119.134811	-33	66	17	-8	29	66	2015 Low
RMW-019R	RMW-019R	North Basin	KRGSA	Primary Principal Alluvial	35.419936	-119.093097	101	199	150	125	162	199	2015 Low
RMW-020	RMW-020	Kern River Fan	KRGSA	Primary Principal Alluvial	35.404844	-119.00925	280	322	301	290	306	322	2015 Low
RMW-021	RMW-021	Kern River Fan	KRGSA	Primary Principal Alluvial	35.389808	-119.008747	162	204	183	172	188	204	Average of June 2014 and February 2016
RMW-025	RMW-025	Kern River Fan	KRGSA	Primary Principal Alluvial	35.353686	-119.109828	107	150	128	118	134	150	2015 Low
RMW-026	RMW-026	South Basin	KRGSA	Primary Principal Alluvial	35.35125	-118.96633	71	146	109	90	118	146	2015 Low
RMW-029	RMW-029	Kern River Fan	KRGSA	Primary Principal Alluvial	35.324712	-119.18704	-33	46	7	-13	16	46	2015 Low
RMW-030	RMW-030	South Basin	KRGSA	Primary Principal Alluvial	35.33418	-118.94313	62	138	100	81	109	138	2015 Low
RMW-031	RMW-031	Kern River Fan	KRGSA	Primary Principal Alluvial	35.296439	-119.173357	69	113	91	80	97	113	2015 Low
RMW-032	RMW-032	South Basin	KRGSA	Primary Principal Alluvial	35.295346	-119.128495	61	136	98	79	108	136	2015 Low
RMW-034	RMW-034	South Basin	KRGSA	Primary Principal Alluvial	35.274	-118.94114	64	140	102	83	112	140	Spatial Interpolation
RMW-035R	RMW-035R	South Basin	KRGSA	Primary Principal Alluvial	35.24508	-119.16403	23	99	61	42	70	99	2015 Low
RMW-037	RMW-037	South Basin	KRGSA	Primary Principal Alluvial	35.2254	-119.192763	-8	68	30	11	40	68	2015 Low
RMW-038	RMW-038	South Basin	KRGSA	Primary Principal Alluvial	35.221162	-119.107937	28	104	66	47	75	104	2015 Low
RMW-040	RMW-040	South Basin	KRGSA	Primary Principal Alluvial	35.206242	-119.038881	38	114	76	57	85	114	Average of April 2010 and April 2020
RMW-041	RMW-041	South Basin	KRGSA	Primary Principal Alluvial	35.199567	-118.898542	30	105	68	49	77	105	2015 Low
RMW-042	RMW-042	South Basin	KRGSA	Primary Principal Alluvial	35.192165	-119.205224	-9	67	29	10	39	67	2015 Low
RMW-192	RMW-192	South Basin	KRGSA	Primary Principal Alluvial	35.22126	-119.00047	43	118	81	62	90	118	2015 Low
RMW-193	RMW-193	South Basin	KRGSA	Primary Principal Alluvial	35.2053	-118.86934	62	138	100	81	110	138	2015 Low
RMW-195	RMW-195	South Basin	KRGSA	Primary Principal Alluvial	35.25245	-119.116462	44	120	82	63	92	120	2015 Low
RMW-196	RMW-196	South Basin	KRGSA	Primary Principal Alluvial	35.241412	-119.030045	21	97	59	40	69	97	2015 Low
RMW-197	RMW-197	South Basin	KRGSA	Primary Principal Alluvial	35.16573	-118.92356	-37	39	1	-18	10	39	2015 Low
RMW-200	RMW-200	South Basin	KRGSA	Primary Principal Alluvial	35.15416	-119.12814	30	106	68	49	77	106	Average of April 2010 and October 2019
RMW-201	RMW-201	Kern River Fan	KRGSA	Primary Principal Alluvial	35.394086	-119.104328	110	152	131	120	136	152	2015 Low
RMW-202	RMW-202	South Basin	KRGSA	Primary Principal Alluvial	35.266228	-119.001478	29	105	67	48	77	105	2015 Low
RMW-209	RMW-209	North Basin	KRGSA	Primary Principal Alluvial	35.422603	-119.074837	82	180	131	106	143	180	2015 Low
RMW-210	RMW-210	South Basin	KRGSA	Primary Principal Alluvial	35.390685	-118.97516	116	192	154	135	164	192	February 2016
RMW-211	RMW-211	Kern River Fan	KRGSA	Primary Principal Alluvial	35.368129	-119.010147	143	185	164	153	169	185	2015 Low
RMW-212	RMW-212	South Basin	KRGSA	Primary Principal Alluvial	35.361806	-118.933408	99	175	137	118	147	175	2015 Low
RMW-213	RMW-213	Kern River Fan	KRGSA	Primary Principal Alluvial	35.353632	-119.053869	126	168	147	136	152	168	February 2016
RMW-214	RMW-214	South Basin	KRGSA	Primary Principal Alluvial	35.328591	-119.022108	71	147	109	90	119	147	2015 Low
RMW-215	RMW-215	South Basin	KRGSA	Primary Principal Alluvial	35.332508	-119.001569	62	138	100	81	110	138	2015 Low
RMW-216	RMW-216	South Basin	KRGSA	Primary Principal Alluvial	35.292436	-118.991139	8	84	46	27	56	84	April 2016

Local Site ID	RMW ID	HCM	GSA	Aquifer	Latitude	Longitude	MT (ft msl)	MO (ft msl)	IMs (ft msl)				MO Estimation Method
									2025	2030	2035	2040	
RMW-217	RMW-217	South Basin	KRGSA	Primary Principal Alluvial	35.28125	-118.90542	9	85	47	28	57	85	2015 Low
RMW-218	RMW-218	South Basin	KRGSA	Primary Principal Alluvial	35.18677	-119.081213	83	159	121	102	130	159	2015 Low
RMW-219	RMW-219	South Basin	KRGSA	Primary Principal Alluvial	35.235366	-118.945542	35	111	73	54	83	111	2015 Low
Well 4P1	RMW-175	East Margin	KTWD	Santa Margarita and Olcese Principal	35.778296	-119.0726	-112	-18	-65	-89	-53	-18	2015 Low
Well 20C1	RMW-176	East Margin	KTWD	Santa Margarita and Olcese Principal	35.7471	-119.08988	-135	-41	-88	-112	-76	-41	2015 Low
Well 15P1	RMW-177	East Margin	KTWD	Santa Margarita and Olcese Principal	35.75054	-119.05834	-107	-13	-60	-84	-49	-13	2015 Low
Well 32M1	RMW-179	East Margin	KTWD	Santa Margarita and Olcese Principal	35.794573	-119.084745	-146	-52	-99	-122	-87	-52	2015 Low
Well 12A	RMW-290	East Margin	KTWD	Primary Principal Alluvial	35.777	-119.116	58	159	109	83	121	159	2015 Low
Well 15D1	RMW-291	East Margin	KTWD	Primary Principal Alluvial	35.762	-119.063	58	159	109	83	121	159	2015 Low from nearby well
Well 4D1	RMW-292	East Margin	KTWD	Primary Principal Alluvial	35.787	-119.08	58	159	109	83	121	159	2015 Low from nearby well
BK 9 (30S/26E-16L01)	RMW-300	Kern River Fan	KWBA	Primary Principal Alluvial	35.317806	-119.29675	-93	-5	-49	-71	-38	-5	2015 Low
88-03-009R	RMW-145R	North Basin	NKWSD	Primary Principal Alluvial	35.49703	-119.170627	-24	74	25	0	37	74	Spring 2016
88-09-009	RMW-146	North Basin	NKWSD	Primary Principal Alluvial	35.536413	-119.233014	-103	-5	-54	-79	-42	-5	2015 Low
88-21-005	RMW-147	North Basin	NKWSD	Primary Principal Alluvial	35.587778	-119.226935	-62	36	-13	-38	-1	36	2015 Low
88-29-014	RMW-148	North Basin	NKWSD	Primary Principal Alluvial	35.623163	-119.224495	-173	-75	-124	-148	-112	-75	2015 Low
99-00-003	RMW-149	North Basin	NKWSD	Primary Principal Alluvial	35.442406	-119.133177	-38	61	11	-13	24	61	2015 Low
99-00-081	RMW-150	North Basin	NKWSD	Primary Principal Alluvial	35.57636	-119.281784	-111	-12	-62	-86	-49	-12	2015 Low
99-22-084	RMW-151	North Basin	NKWSD	Primary Principal Alluvial	35.638001	-119.31244	-147	-49	-98	-123	-86	-49	2015 Low
Shafter Well 18	RMW-271	North Basin	NKWSD	Primary Principal Alluvial	35.500964	-119.206717	-48	51	1	-23	14	51	Spatial Interpolation
3361-62	RMW-284	North Basin	NKWSD	Primary Principal Alluvial	35.4714	-119.2174	-36	62	13	-12	25	62	Spring 2016
DW097	RMW-285	North Basin	NKWSD	Primary Principal Alluvial	35.4172	-119.219	-8	91	42	17	54	91	2015 Low
Well #4	RMW-043	East Margin	Olcese	Santa Margarita and Olcese Principal	35.430995	-118.841056	305	399	352	329	364	399	Spring 2016
Canyon View Ranch	RMW-044	East Margin	Olcese	Santa Margarita and Olcese Principal	35.438639	-118.803472	432	527	479	456	491	527	2015 Low
30S/26E-04D003M	RMW-045	Kern River Fan	Pioneer	Primary Principal Alluvial	35.35427	-119.19655	-46	15	-16	-31	-8	15	2015 Low
30S/26E-10P004M	RMW-048	Kern River Fan	Pioneer	Primary Principal Alluvial	35.32503	-119.17385	-51	29	-11	-31	-1	29	2015 Low
30S/26E-15N003M	RMW-049	Kern River Fan	Pioneer	Primary Principal Alluvial	35.31229	-119.18052	-36	29	-4	-20	4	29	2015 Low
30S/26E-04J003M	RMW-259	Kern River Fan	Pioneer	Primary Principal Alluvial	35.3434	-119.18163	-142	-46	-94	-118	-82	-46	2015 Low
30S/26E-04J002M	RMW-289	Kern River Fan	Pioneer	Primary Principal Alluvial	35.3434	-119.18163	-5	62	29	12	37	62	2015 Low
Bushnell	RMW-050	North Basin	RRBWSD	Primary Principal Alluvial	35.434919	-119.358003	-125	-27	-76	-101	-64	-27	2015 Low
L.R. Stout	RMW-052	North Basin	RRBWSD	Primary Principal Alluvial	35.43092	-119.28588	-57	41	-8	-32	4	41	2015 Low
RBG School	RMW-053	North Basin	RRBWSD	Primary Principal Alluvial	35.4197	-119.25437	-32	67	17	-7	30	67	Spatial Interpolation
P. Enns Domestic	RMW-054	North Basin	RRBWSD	Primary Principal Alluvial	35.41209	-119.262342	-30	68	19	-6	31	68	2015 Low
Section 18	RMW-055	North Basin	RRBWSD	Primary Principal Alluvial	35.408092	-119.330726	-69	30	-20	-44	-7	30	2015 Low
Blacco HQ	RMW-056	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.39146	-119.34535	5	47	26	15	31	47	2015 Low
Cauzza	RMW-057	North Basin	RRBWSD	Primary Principal Alluvial	35.39859	-119.39481	-62	36	-13	-37	-1	36	2015 Low
Parsons	RMW-058	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.36631	-119.38591	-19	23	2	-9	7	23	2015 Low estimated from surrogate data
West I-5	RMW-059	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.35642	-119.34122	4	46	25	14	30	46	2015 Low
Virgil Bussell	RMW-060	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.362585	-119.307951	13	58	35	24	41	58	2015 Low
27N Mayer	RMW-061a	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.3693	-119.28563	15	62	38	26	44	62	2015 Low
25M Enos	RMW-062a	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.374433	-119.251718	31	77	54	42	60	77	2015 Low
Chet Reed	RMW-063	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.39065	-119.14686	116	158	137	126	142	158	2015 Low

Local Site ID	RMW ID	HCM	GSA	Aquifer	Latitude	Longitude	MT (ft msl)	MO (ft msl)	IMs (ft msl)				MO Estimation Method
									2025	2030	2035	2040	
Home Place	RMW-064	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.382422	-119.20354	67	109	88	78	94	109	2015 Low
31H Greeley	RMW-065a	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.361718	-119.217063	7	69	38	22	46	69	2015 Low
Harvest Ranch	RMW-066	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.36336	-119.17655	59	105	82	71	88	105	2015 Low
35H RRBWSD Shop	RMW-067a	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.36585	-119.147041	73	116	95	84	100	116	2015 Low
32N Triple	RMW-068a	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.26735	-119.21383	76	118	97	86	102	118	2015 Low
28J Triple	RMW-069b	Kern River Fan	RRBWSD	Primary Principal Alluvial	35.28892	-119.18136	102	145	123	113	129	145	2015 Low
SSJMUD 8	RMW-157	North Basin	SSJMUD	Primary Principal Alluvial	35.74702	-119.336	-169	-70	-120	-144	-107	-70	2015 Low
SSJMUD 14	RMW-158	North Basin	SSJMUD	Primary Principal Alluvial	35.73948	-119.2052	-95	4	-45	-70	-33	4	2015 Low
SSJMUD 23	RMW-159	North Basin	SSJMUD	Primary Principal Alluvial	35.7185	-119.3042	-125	-26	-76	-100	-63	-26	2015 Low
SSJMUD 53	RMW-160	North Basin	SSJMUD	Primary Principal Alluvial	35.63068	-119.1912	-64	34	-15	-40	-3	34	2015 Low
SSJMUD 59	RMW-161	North Basin	SSJMUD	Primary Principal Alluvial	35.682	-119.1517	-112	-14	-63	-88	-51	-14	2015 Low
SSJMUD 62	RMW-162	North Basin	SSJMUD	Primary Principal Alluvial	35.71837	-119.1449	2	100	51	26	63	100	2015 Low
SSJMUD 42	RMW-163	North Basin	SSJMUD	Primary Principal Alluvial	35.69295	-119.232	-109	-11	-60	-85	-48	-11	2015 Low
Delano 30	RMW-252	North Basin	SSJMUD	Primary Principal Alluvial	35.78979	-119.23024	-29	70	20	-4	33	70	Average of July 2013 and July 2016
Delano 34	RMW-281	North Basin	SSJMUD	Primary Principal Alluvial	35.74363	-119.25874	-24	74	25	0	37	74	Spatial Interpolation
Shafter Well 15	RMW-204	North Basin	SWID	Primary Principal Alluvial	35.470462	-119.279183	-102	-4	-53	-78	-41	-4	2015 Low
Shafter Well 7	RMW-205	North Basin	SWID	Primary Principal Alluvial	35.507996	-119.277661	-89	10	-39	-64	-27	10	Spatial Interpolation
Superior Mutual Well 1	RMW-248	North Basin	SWID	Primary Principal Alluvial	35.444649	-119.253808	-74	24	-25	-50	-13	24	2015 Low
28S/24E-35C	RMW-249	North Basin	SWID	Primary Principal Alluvial	35.4561	-119.3595	-90	8	-41	-66	-29	8	2015 Low
Shafter Well 12	RMW-254	North Basin	SWID	Primary Principal Alluvial	35.50201	-119.2748	-90	9	-40	-65	-28	9	Spatial Interpolation
Wasco 12	RMW-256	North Basin	SWID	Primary Principal Alluvial	35.61569	-119.339678	-188	-90	-139	-164	-127	-90	2015 Low
Shafter Well 14	RMW-257	North Basin	SWID	Primary Principal Alluvial	35.494288	-119.259271	-85	13	-36	-61	-24	13	Spatial Interpolation
Wasco 8A	RMW-263	North Basin	SWID	Primary Principal Alluvial	35.58739	-119.3523	-148	-50	-99	-124	-87	-50	Spatial Interpolation
28S25E19G	RMW-269	North Basin	SWID	Primary Principal Alluvial	35.4779	-119.3145	-74	24	-25	-50	-13	24	2015 Low
Wasco 11	RMW-276	North Basin	SWID	Primary Principal Alluvial	35.5891	-119.3417	-172	-74	-123	-148	-111	-74	2015 Low
S-2	RMW-119	North Basin	SWSD	Primary Principal Alluvial	35.568704	-119.562328	-124	-25	-74	-99	-62	-25	2015 Low
S-4	RMW-121	North Basin	SWSD	Primary Principal Alluvial	35.520514	-119.582118	-90	9	-40	-65	-28	9	2015 Low
S-5	RMW-122	North Basin	SWSD	Primary Principal Alluvial	35.550636	-119.527138	-157	-59	-108	-133	-96	-59	2015 Low
S-6	RMW-123	North Basin	SWSD	Primary Principal Alluvial	35.703571	-119.339174	-175	-76	-125	-150	-113	-76	2015 Low
S-8A Cluster 1 of 2	RMW-126	North Basin	SWSD	Primary Principal Alluvial	35.630484	-119.402125	-168	-70	-119	-143	-107	-70	2015 Low
S-9A Cluster 1 of 2	RMW-128	North Basin	SWSD	Primary Principal Alluvial	35.521942	-119.394311	-127	-29	-78	-102	-66	-29	2015 Low
S-11	RMW-130	North Basin	SWSD	Primary Principal Alluvial	35.695554	-119.562279	-207	-108	-158	-182	-145	-108	2015 Low
S-12	RMW-131	North Basin	SWSD	Primary Principal Alluvial	35.722805	-119.553797	-219	-121	-170	-195	-158	-121	2015 Low
S-13A Cluster 1 of 2	RMW-132	North Basin	SWSD	Primary Principal Alluvial	35.760891	-119.436645	-203	-104	-154	-178	-141	-104	Spatial Interpolation
S-14B Cluster 2 of 2	RMW-135	North Basin	SWSD	Primary Principal Alluvial	35.666848	-119.384129	-173	-75	-124	-149	-112	-75	2015 Low
26S-23E-15A1	RMW-137	North Basin	SWSD	Primary Principal Alluvial	35.673653	-119.473336	-209	-110	-159	-184	-147	-110	2015 Low
948L02 Cluster1 of 2	RMW-139	North Basin	SWSD	Primary Principal Alluvial	35.41889	-119.421573	-139	-41	-90	-115	-78	-41	2015 Low
S-1	RMW-277	North Basin	SWSD	Primary Principal Alluvial	35.59441	-119.58141	87	185	136	111	148	185	2015 Low
28/23/16/G	RMW-286	North Basin	SWSD	Primary Principal Alluvial	35.49503	-119.50134	-124	-26	-75	-100	-63	-26	2015 Low
28/23/36/R	RMW-287	North Basin	SWSD	Primary Principal Alluvial	35.44265	-119.43983	-95	3	-46	-71	-34	3	2015 Low
Caratan Well (RMS-1)	RMW-070	South Basin	TCWD	Primary Principal Alluvial	35.200176	-118.769774	20	96	58	39	67	96	November 2019

Local Site ID	RMW ID	HCM	GSA	Aquifer	Latitude	Longitude	MT (ft msl)	MO (ft msl)	IMs (ft msl)				MO Estimation Method
									2025	2030	2035	2040	
7106-63	RMW-203	North Basin	WDWA	Primary Principal Alluvial	35.55051	-119.63684	-47	51	2	-23	14	51	March 2020
7108-66	RMW-275	North Basin	WDWA	Primary Principal Alluvial	35.77623	-119.69017	-100	-2	-51	-76	-39	-2	March 2021
S#14	RMW-279	North Basin	WDWA	Primary Principal Alluvial	35.667499	-119.672443	119	218	168	144	181	218	November 2020
Berenda Mesa #3	RMW-299	Western Fold Belt	WDWA	Primary Principal Alluvial	35.63651	-119.9487	281	363	322	302	332	363	Linear interpolation between May 2009 and May 2023
WKWD 23M-M	RMW-085b	Kern River Fan	WKWD	Primary Principal Alluvial	35.30373	-119.26992	-9	40	15	3	21	40	2015 Low
NWM1-M	RMW-266	Kern River Fan	WKWD	Primary Principal Alluvial	35.346363	-119.368446	21	63	42	32	47	63	2015 Low
7-01	RMW-293	Kern River Fan	WKWD	Primary Principal Alluvial	35.29734	-119.29722	-78	-9	-44	-61	-35	-9	2015 Low
North Ag	RMW-294	Kern River Fan	WKWD	Primary Principal Alluvial	35.34743	-119.35931	21	63	42	32	47	63	2015 Low
South Ag	RMW-295	Kern River Fan	WKWD	Primary Principal Alluvial	35.33333	-119.35928	20	62	41	31	46	62	2015 Low
32S26E20G001M	RMW-094	South Basin	WRMWSD	Primary Principal Alluvial	35.13376	-119.207679	-6	69	31	13	41	69	2015 Low
32S27E30N001M	RMW-095	South Basin	WRMWSD	Primary Principal Alluvial	35.109479	-119.123197	155	230	193	174	202	230	2015 Low
32S27E35R001M	RMW-097	South Basin	WRMWSD	Primary Principal Alluvial	35.096023	-119.04069	62	138	100	81	109	138	2015 Low
32S26E24K001M	RMW-231	South Basin	WRMWSD	Primary Principal Alluvial	35.130445	-119.136596	-15	61	23	4	33	61	2015 Low
11N22W01D001S	RMW-232	South Basin	WRMWSD	Primary Principal Alluvial	35.074957	-119.189203	48	124	86	67	95	124	2015 Low
11N22W06H001S	RMW-233	South Basin	WRMWSD	Primary Principal Alluvial	35.069237	-119.261172	192	267	230	211	239	267	2015 Low
11N21W16E001S	RMW-234	South Basin	WRMWSD	Primary Principal Alluvial	35.042829	-119.135542	-112	-9	-60	-86	-47	-9	2015 Low
12N21W34N001S	RMW-235R	South Basin	WRMWSD	Primary Principal Alluvial	35.077426	-119.117207	-38	68	15	-11	28	68	2015 Low
11N21W09C001S	RMW-236	South Basin	WRMWSD	Primary Principal Alluvial	35.0601	-119.130881	-53	23	-15	-34	-5	23	2015 Low
32S26E34P001M	RMW-237	South Basin	WRMWSD	Primary Principal Alluvial	35.094297	-119.173551	110	186	148	129	158	186	2015 Low
32S26E36P002M	RMW-238	South Basin	WRMWSD	Primary Principal Alluvial	35.09466	-119.13748	10	85	48	29	57	85	2015 Low
32S25E29Q001M	RMW-239	South Basin	WRMWSD	Primary Principal Alluvial	35.108763	-119.313135	158	234	196	177	206	234	Spatial Interpolation
32S28E16P001M	RMW-240	South Basin	WRMWSD	Primary Principal Alluvial	35.136678	-118.976775	74	150	112	93	122	150	Linear interpolation between February 2002 and November 2019
12N21W35Q001S	RMW-258	South Basin	WRMWSD	Primary Principal Alluvial	35.07685	-119.087138	19	95	57	38	67	95	2015 Low

Abbreviations:

AEWSD = Arvin GSA
BVWSD = Buena Vista Water Storage District GSA
CWD = Cawelo Water District GSA
EWMA = Eastside Water Management Area
ft msl = feet above mean sea level
GSA = Groundwater Sustainability Agency
HCM = Hydrogeologic Conceptual Model
HMWD = Henry Miller Water District GSA
ID = Identification
IM = Interim Milestone
KRGSA = Kern River GSA
KTWD = Kern-Tulare Water District
KWBA = Kern Water Bank Authority
MO = Measurable Objective
MT = Minimum Threshold
NKWSD = Southern San Joaquin Municipal Utility District GSA
RMW = Representative Monitoring Well
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RRBWSD = Rosedale-Rio Bravo Water Storage District GSA
SMC = Sustainable Management Criteria
SSJMUD = Southern San Joaquin Municipal Utility District GSA
SWID = Shafter-Wasco Irrigation District GSA
SWSD = Semitropic Water Storage District GSA
TCWD = Tejon-Castac Water District
WDWA = Westside District Water Authority GSA
WKWD = West Kern Water District GSA
WRMWSD = Wheeler Ridge-Maricopa GSA

This page intentionally left blank.

13.1.2.2 Relationship with Other Sustainability Indicators

The MTs for Chronic Lowering of Groundwater Levels were designed to ensure that they are sufficiently protective of URs defined for all other relevant Sustainability Indicators to the Subbasin. The specific relationships between Chronic Lowering of Groundwater Levels and other applicable Sustainability Indicators are discussed below.

- Chronic Lowering of Groundwater Levels and **Reduction in Groundwater Storage** are directly, if not linearly, related. As described in Section 13.2.1, if water levels in all Primary Alluvial Principal Aquifer RMW-WLs were to exceed MTs, a 4 to 10 percent decline in total usable groundwater storage would occur relative to the baseline. Because the URs for Chronic Lowering of Groundwater Levels are defined to occur when 25 percent of RMW-WLs exceed their MTs, the SMCs for Chronic Lowering of Groundwater Levels will not result in a significant loss in storage and are, therefore, sufficiently protective of Reduction of Groundwater storage in the Subbasin.
- A trending analysis between Chronic Lowering of Groundwater Levels and **Degraded Water Quality** shows no correlation for the majority of the Subbasin. However, in some localized areas of the Subbasin, a direct correlation has been observed between Chronic Lowering of Groundwater Levels and Degraded Water Quality. The relationship between water levels and water quality for each Constituent of Concern (COC) is described in detail in Section 8.6.1. Representative Monitoring Wells for Degraded Water Quality (RMW-WQs) have been selected in areas where a correlation has been observed to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities and/or to ensure beneficial users are protected.
- Historical **Land Subsidence** has been attributed to Chronic Lowering of Groundwater Levels, in part due to groundwater extractions from the Subbasin. The Subbasin GSAs assessed whether groundwater level declines to proposed MTs would cause significant and unreasonable effects due to Land Subsidence A preliminary approach (Table 13-3) is used to evaluate Chronic Lowering of Groundwater Level MTs in relation to Land Subsidence MTs because a calibrated model (1-dimensional or numerical) with land subsidence simulation capabilities is not currently available to project future subsidence within the Subbasin. This approach is described as follows:

  The average historical groundwater level decline (Column B) in relation to the average historical cumulative subsidence for each HCM area (Column C) was compared over the period from 2015 to 2023 to establish a groundwater level decline to subsidence ratio by HCM area.

  This ratio is then applied to the future projected groundwater level declines at the MTs by HCM area (to project the resulting land subsidence Columns D and E) and compared to the Land Subsidence MTs (extent; Column F) to check if the proposed Chronic Lowering of Groundwater Level MTs result in exceedances of the Land Subsidence MTs. If not exceeded, the Chronic Lowering of Groundwater Level MTs were considered to be agreeable with the Land Subsidence MTs.

As shown in Table 13-3, along all critical infrastructure and for each HCM area, the projected average cumulative extent of subsidence at Chronic Lowering of Groundwater Level MTs is less than the Land Subsidence MTs, which are considered protective of the functionality of critical infrastructure provided implementation of P/MAs as described below in Section 13.5. As such, this analysis demonstrates that MTs for Chronic Lowering of Groundwater Levels are sufficiently protective of impacts due to Land Subsidence. However, as discussed in Section 8.7, there are many causes of subsidence in the Subbasin that may contribute to potential URs, but that are outside of the authorities of a GSA to control (i.e., non-GSA-related).

Table 13-3. Projected Subsidence and Groundwater Level Minimum Thresholds

HCM Area	Average Groundwater Level Decline (feet/year)(1),(2)		(C) Average Subsidence Rate 2015-2023 (feet/year) (5)	Projected Subsidence (2024-2040) at Groundwater Level MTs(6)		(F) Subsidence MT Extent (feet)
	(A) Decline to Groundwater Level MT (3)	(B) Decline from 2015-2023 (4)		(D) Rate (feet/year)	(E) Extent (feet)	
North Basin	-7.0	-5.7	0.059	0.072	0.50	0.85
Kern River Fan	-3.8	-2.8	0.022	0.029	0.20	0.27
South Basin	-5.4	-6.1	0.037	0.033	0.23	0.48
Western Fold Belt	N/A(7)	N/A(7)	0.008	N/A(7)	N/A(7)	0.1
East Margin	-7.0	-6.5	0.006	0.007	0.05	0.14

Notes:

1. Trend is calculated using monitoring wells with declining trends.
2. For the East Margin HCM Area, the trend is calculated by averaging data from the Primary Alluvial Principal Aquifer and the Santa Margarita and Olcese Principal Aquifers. In all other HCM areas, the trend is based solely on data from the Primary Alluvial Principal Aquifer.
3. The groundwater level decline to the MT is calculated as the average difference between the MO and MT, divided by 14 years.
4. The subsidence MTs are based on land subsidence that occurred over the 2015 to 2023 time period.
5. Average subsidence by HCM Area for Oct 2015 through Sept 2023 based on InSAR data downloaded from the DWR website.
6. Projected subsidence at groundwater level MTs are calculated by projecting a subsidence rate associated with the rate of decline in groundwater levels at the MT based on the observed subsidence and groundwater level declines over the 2015-2023 time period.
7. There is insufficient historical groundwater level data from monitoring wells located in the Western Fold Belt HCM Area to calculate a trend. Principal water supply is imported surface water in this HCM Area.

13.1.2.3 Consideration of Adjacent Basins

In consideration of adjacent subbasins, the Chronic Lowering of Groundwater Level MTs were compared along the southern boundary with the White Wolf Subbasin (Primary Alluvial Principal Aquifer) and to the north with the Tulare Lake Subbasin (Primary Alluvial Principal Aquifer) and the Tule Subbasin (Primary Alluvial Principal Aquifer and Santa Margarita Principal Aquifer). No adjacent basins overly the Olcese Principal Aquifer.

The MTs in the White Wolf Subbasin were developed using a similar methodology as the Subbasin and range from approximately 60 feet to 140 feet higher than the existing Subbasin MTs along the southern boundary, which maintains the historic cross-boundary flow direction from White Wolf Subbasin toward the Subbasin. The Santa Margarita Aquifer is not considered a principal aquifer in the White Wolf Subbasin; therefore no comparison was made.

The Tule and Tulare Lake Subbasins are in the process of revising their SMCs and therefore a complete comparison of MTs could not be made at this time. Based on the currently available information, the revised MTs in the Tule and Tulare Lake Subbasins will remain designated by aquifer (Upper, Lower, Composite, and Santa Margarita Formation). In discussion with the Tulare Lake Subbasin representatives, the preliminary revised approach sets MOs as the 2015 low groundwater elevation at representative monitoring sites, which is the same methodology used in the Subbasin (see Section 13.1.3.10). As such, if both subbasins work toward sustainable conditions with their MOs, the groundwater gradient should remain the same as observed in 2015.

Furthermore, groundwater level gradients along the Subbasin boundaries were evaluated to assess potential impacts to adjacent basins. Figure 13-5 shows groundwater levels under the Subbasin's MTs relative to actual Fall 2015 Low groundwater levels. Water levels under the MTs do not differ significantly from actual Fall 2015 water levels; therefore, it is not expected that the MTs will substantially alter groundwater level gradients beyond those experienced in 2015.

Subbasin GSAs have and will continue to coordinate development of SMCs and ongoing Plan implementation in the Subbasin through common District membership in the White Wolf GSA (i.e. Arvin-Edison Water Storage District, Wheeler Ridge-Maricopa Water Storage District, and Tejon-Castac Water District) to minimize any impacts on the adjacent White Wolf Subbasin's ability to achieve its Sustainability Goal. The Subbasin GSAs will also continue to engage with the Tulare Lake Subbasin and the Tule Subbasin through their respective Plan revision processes. Additionally, Subbasin GSAs will continue to coordinate with the Tule Subbasin due to their jurisdictional overlap with the Tule Subbasin (i.e. Kern-Tulare Water District GSA).

13.1.2.4 Impact to Beneficial Users

As identified in Section 1.2.1, the primary beneficial uses and users of groundwater in the Subbasin as identified by the Subbasin well inventory include agricultural users, industrial users, domestic well owners, small community wells, and municipal well operators. The MTs were developed to prevent significant and unreasonable impacts to these uses and groups of groundwater users and are justified by the well impact analyses presented below.

Well Impact Analyses

One factor to consider when setting MTs for Chronic Lowering of Groundwater Levels is the potential for dewatering of wells or well screens. Through the Subbasin's Well Mitigation Program (Section 16.2.1.1), the GSAs have determined it is reasonable to potentially mitigate an average of 15 drinking water wells per year over the next 17 years (i.e., a total of 255 wells through 2040). The well impact analysis was conducted to estimate the number of drinking wells that would be impacted under the proposed MTs, and whether this number is within the reasonable scope for the GSAs to address through mitigation. A well impacts analysis for all well types, including agricultural and industrial wells, is detailed in **Appendix R**.

The GSAs' well inventory was used to estimate the total number of drinking water wells in the Subbasin. It is estimated that there are 2,501 domestic wells, 298 municipal/public supply wells, and 41 small community wells (2,840 total drinking water wells) within the Subbasin. However, many of these wells may have already been impacted prior to 2015, which would be considered a "pre-SGMA" condition that would be outside of the purview of the GSAs to remedy (CWC § 10727.2(b)(4)).

In consideration of these factors, the following screening process was employed on the GSA well inventory to establish a subset of wells to use in the well impact analysis for planning purposes. It should be noted that the screening process described below is used only for estimating the number of drinking water wells expected to be impacted and will not be used for determining eligibility under the Well Mitigation Program.

1. Remove wells that were already dewatered at 2015 low water levels (MOs) and were assumed to have remained dewatered following 2015[6] – removed 1,115 wells.

   As discussed in Section 13.1.3.10, the MOs are set at the 2015 low groundwater elevation. To estimate if wells were already impacted at the MOs, 2015 low groundwater levels (MOs) were spatially interpolated between all RMW-WLs in

[6] Removal of wells that were already dewatered in 2015 reflects the fact that SGMA does not require GSPs to address URs that occurred before and have not been corrected by January 1, 2015 (CWC § 10727.2(b)(4)).

the Primary Alluvial Principal Aquifer to create a surface representing these MOs. This surface was compared with 80 percent of the total completed depth of each well. A well was considered “dewatered” if the interpolated 2015 low depth to groundwater was below 80 percent of the total well depth. These wells were removed from the planning dataset, as they would have been affected by groundwater conditions prior to 2015.

2. Remove wells that will be older than 70 years by 2040 – removed 248 wells

   A typical lifespan of an agricultural well is approximately 50 years, and even shorter for domestic wells (Rodríguez-Flores et al., 2023). Therefore, wells over 70 years old by 2040 are considered likely to have been abandoned or replaced during the SGMA implementation period. Use of 1970 (i.e., 70 years old by 2040) as the threshold for a typical well lifespan is consistent with screening conducted as part of the Community Water Center’s Drinking Water Tool: https://drinkingwatertool.communitywatercenter.org/.

Following this screening process, a total of 1,477 drinking water wells were considered for this well impact analysis (1,262 domestic wells, 181 municipal/public supply wells, and 34 small community wells). Construction records for these wells were compared to the spatially interpolated MT values (as a depth below ground surface) across the Subbasin. A well was considered “dewatered” if the interpolated MT depth to groundwater was below 80 percent of the total well depth.

It is recognized that a wide range of well impacts may occur based on the various potential combinations of RMW-WLs that could exceed MTs. As such, the well impact analysis considered the following five scenarios, three of which consider the criteria for URs (i.e., 25 percent of RMW-WLs reaching MTs).

- *Scenario – 1 - Worst Case*: The worst-case well impacts scenario is defined as the number of drinking water wells that would be impacted if all RMW-WLs reach their MTs. To evaluate this scenario, depths of wells within the Subbasin were compared to the spatially interpolated MT groundwater depth at each well location. Impacts under this scenario are shown in Figure 13-6.
- *Scenario – 2 - High-End Bracketed Results*: This scenario evaluates the upper range of potential well impacts that would occur under the 25 percent threshold for URs. For this analysis, each impacted drinking water well from Scenario #1 was assigned to the nearest RMW-WL. The 25 percent of RMW-WLs with the *highest* density of impacted drinking water wells were identified, and impacted wells assigned to these RMW-WLs were counted. Results from this scenario are shown in Figure 13-7.
- *Scenario – 3 - Low-End Bracketed Results:* Similar to Scenario #2, this scenario evaluates the lower range of potential well impacts that would occur under the 25 percent threshold for URs. In this scenario, the 25 percent of RMW-WLs with the

lowest density of impacted drinking water wells were identified, and impacted wells assigned to these RMW-WLs were counted. Results from this scenario are shown in Figure 13-8.

- *Scenario – 4 - Stochastic Prediction*: This scenario evaluates the average number of well impacts that would occur under the 25 percent threshold for URs using stochastic predictive modeling. This analysis considered 5,000 random combinations of the 25 percent of RMW-WLs that exceed MTs to determine a distribution of drinking water well impacts. A histogram of the range of well impacts is shown in Figure 13-9, and average well impacts are shown in Table 13-4.
- *Scenario #5 – Modeled Projected Future Conditions:* This scenario evaluates the well impacts that would occur under projected future 2030 climate change conditions and projected future conditions with implementation of P/MAs as estimated through application of the *C2VSimFG-Kern Projected-Future Baseline 2030 Climate Change* scenario. This scenario is considered the most likely well impacts analysis since the groundwater flow model represents spatially variable groundwater conditions across the Subbasin. The 2030 climate analysis represents the number of drinking water wells that would be dewatered if conditions were to persist without any P/MAs under 2030 climate change. The P/MA analysis represents the number of wells that would be dewatered if GSAs were to implement the P/MAs described in Section 14. The 2030 climate scenario results are shown in Figure 13-10, and the P/MA results are shown in Figure 13-11.

The results of the drinking water well impact analysis for each scenario is shown in Table 13-4 below. For completeness, an expanded well impacts analysis that includes all production well types are shown in **Appendix R**.

The results in Table 13-4 show that in the worst-case scenario, a maximum of 409 drinking water wells are expected to be dewatered if all RMW-WLs were to decline to the MTs. However, when the 25 percent UR definition is considered, an average of 103 drinking water wells are expected to be dewatered, which is within the scope and budget of the Well Mitigation Program. The "most likely" scenario is represented by the modeled projected conditions as it represents a spatial projection of groundwater conditions across the Subbasin. These results show that under modeled projected future conditions without implementation of P/MAs, a total of 77 drinking water wells are simulated to be dewatered, which is well within the scope and budget of the Well Mitigation Program. Furthermore, the GSAs have adopted a policy to address MT exceedances observed in any individual RMW-WL as they occur (Section 16.2.1), which provides additional assurance against creating URs.

Table 13-4. Drinking Water Well Impact Analysis Results

Scenario	Estimated Dewatered Drinking Water Well Count	Estimated Depletion of Supply (AFY)	Percentage of Total Estimated Urban[1] Water Supply
#1: Worst Case	409	16,618	10%
#2: High-End Bracketed[7]	327	9,563	5.9%
#3: Low-End Bracketed	0	0	0%
#4: Stochastic Prediction	103	3,572	2.2%
#5: Modeled Projected Future Conditions[8]	2030 Climate Scenario: 77 P/MA Scenario: 13	2,387 9	1.2% <0.01%

Notes:

1. The "urban" water supply estimates reported in the Subbasin's WY 2022 Annual Report includes groundwater extractions for all urban uses including residential, commercial, municipal, industrial, food processing, oilfield use, landscaping and other uses.

Reported WY 2022 pumping volumes and well counts from the Subbasin well inventory were used to estimate an average annual pumping rate of 0.71 acre-feet (AF) per well for domestic and small community wells and 1,167 AF per well for public supply wells. Based on these average pumping values and the number of impacted wells presented in Table 13-4, it was determined that on average (i.e., under Scenario #4), 103 impacted drinking water wells (99 domestic wells, 1 small community well, and 3 public supply wells) would result in a potential impact of 3,572 acre-feet per year (AFY) of drinking water supply, which is approximately 2.2 percent of the Subbasin's total urban water use. Additionally, under the "most likely" distribution of RMW-WL exceedances (Scenario #5), 77 impacted drinking water wells (75 domestic wells and 2 public supply wells) would result in a potential impact of 2,387 AFY of supply, or 1.2 percent of the Subbasin's total urban water use.

Given the Subbasin GSAs are developing a coordinated and comprehensive Well Mitigation Program to address domestic and small community wells impacted by groundwater level declines, this depletion of supply is not considered to be significant and unreasonable, and the proposed MTs were determined to be sufficiently protective of all groundwater pumpers, including drinking water wells users.

---

7 The Subbasin's RMW-WL monitoring network contains 185 RMW-WLs, of which 14 are not considered to be screened in the Primary Alluvial Principal Aquifer. The High-End and Low-End Bracketed scenarios only consider RMW-WLs screened in the Primary Alluvial Principal Aquifer, as these wells were considered representative of shallower domestic wells. Therefore, the 43 RMW-WLs, representing 25% of the 171 RMW-WL subset, with the highest and lowest densities were identified in for the High-End and Low-End Bracketed scenarios, respectively.

8 Scenario #5 utilized modeled data for the projected groundwater level change between 2020 and 2040 under both a baseline 2030 climate change scenario and a 2030 climate change scenario with the implementation of P/MAs.

13.1.2.5 State, Federal, and Local Standards

☑ **23 CCR § 354.28(b)(5)**

There are no state, federal, or local standards pertaining to groundwater levels in the Kern Subbasin.

13.1.2.6 Measurement of Minimum Thresholds

☑ **23 CCR § 354.28(b)(6)**

Groundwater levels will be measured in the Subbasin's RMW-WLs semiannually using the monitoring protocols outlined in Section 15.3.1.

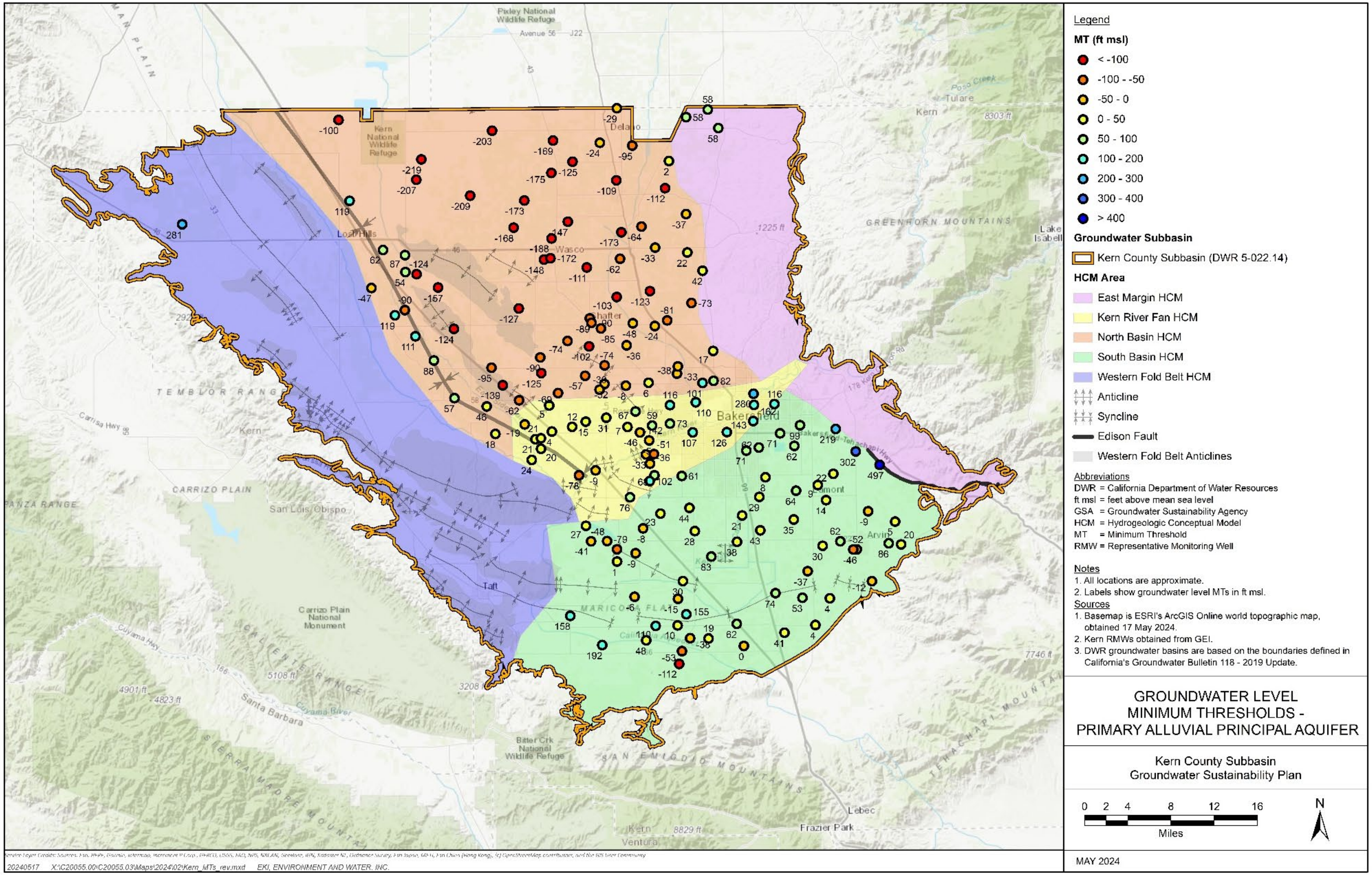


Figure 13-3. Groundwater Level Minimum Thresholds – Primary Alluvial Principal Aquifer

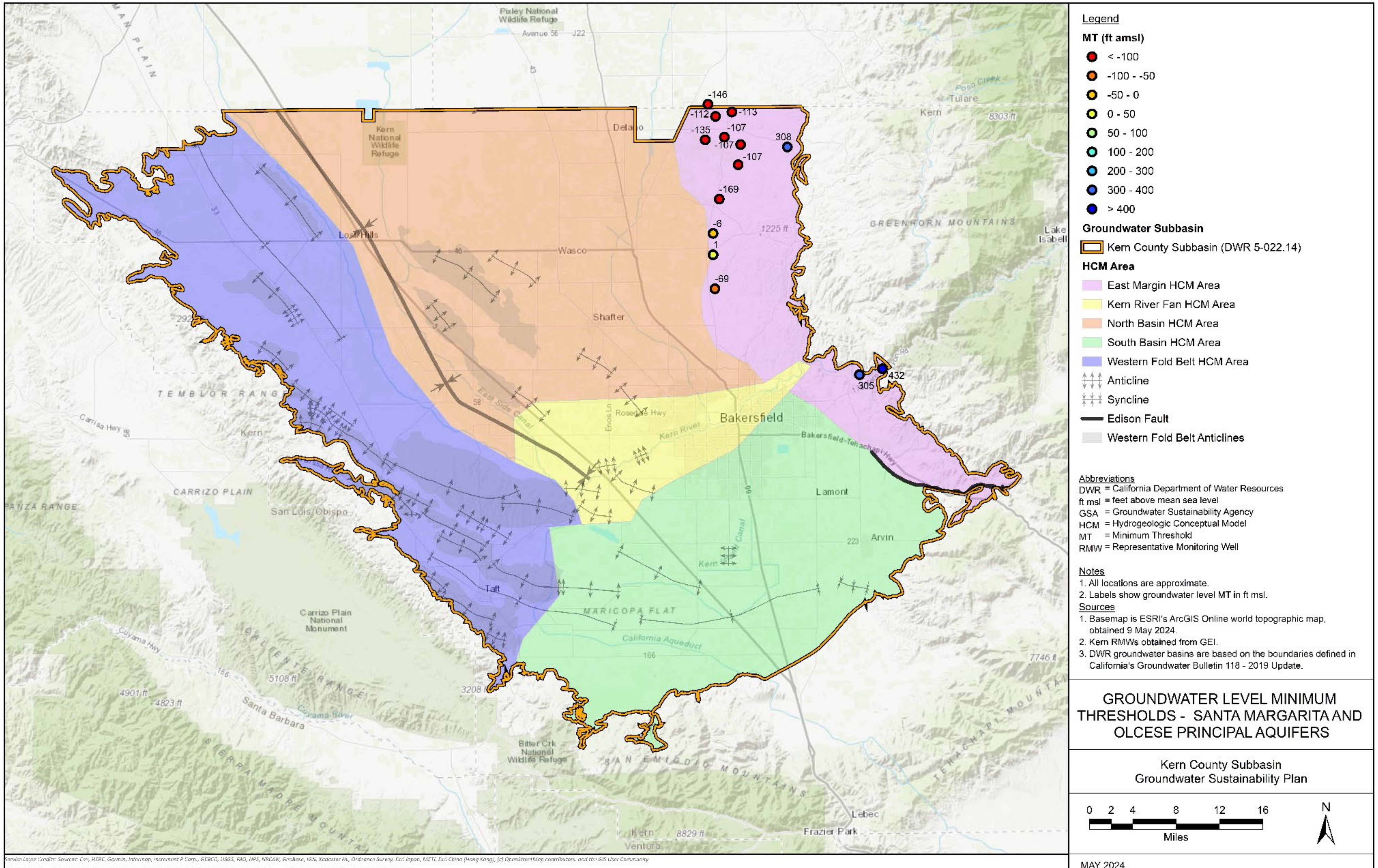


Figure 13-4. Groundwater Level Minimum Thresholds – Santa Margarita and Olcese Principal Aquifers

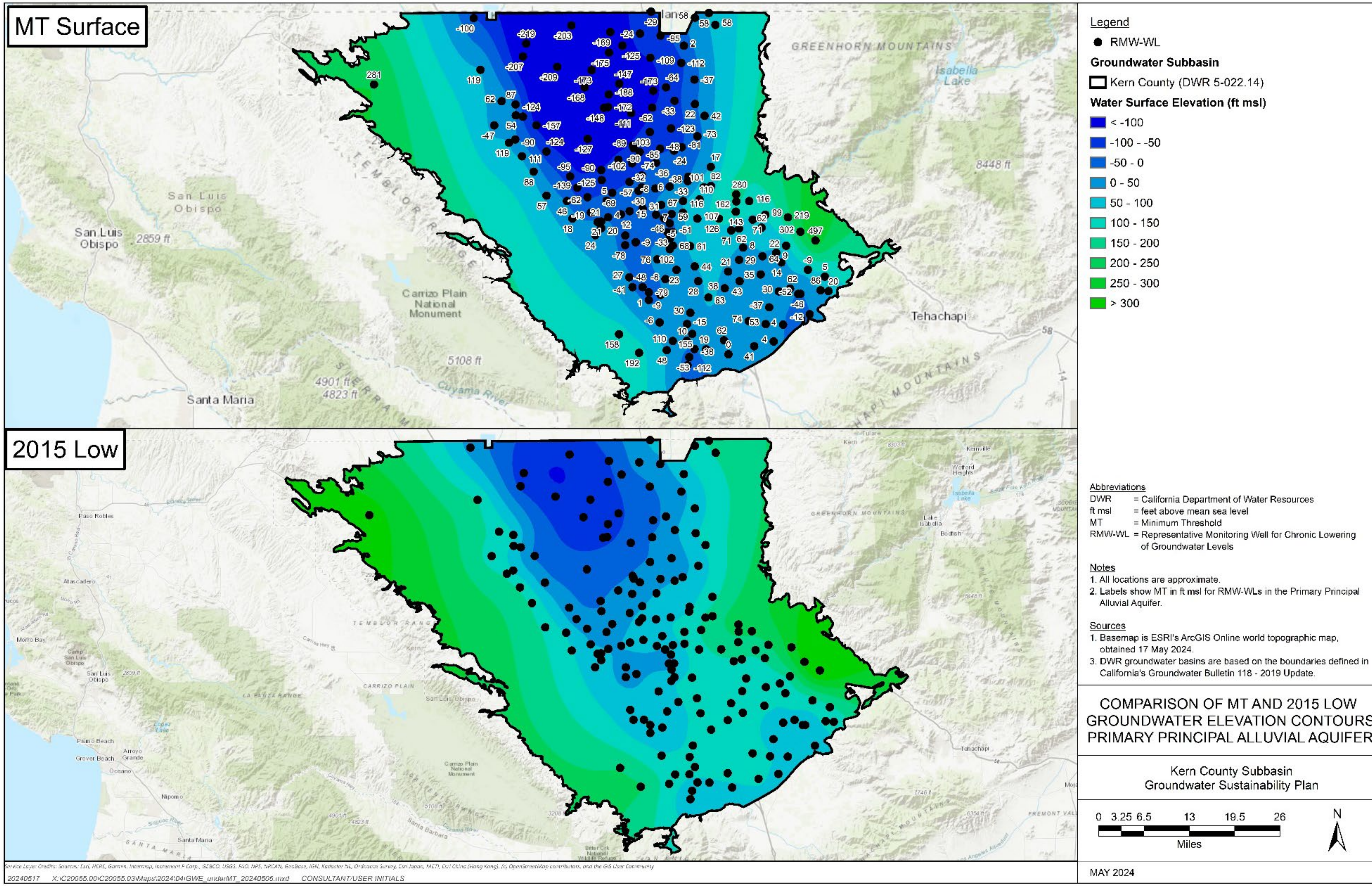


Figure 13-5. Comparison of MT and 2015 Low Groundwater Elevation Contours – Primary Principal Alluvial Aquifer

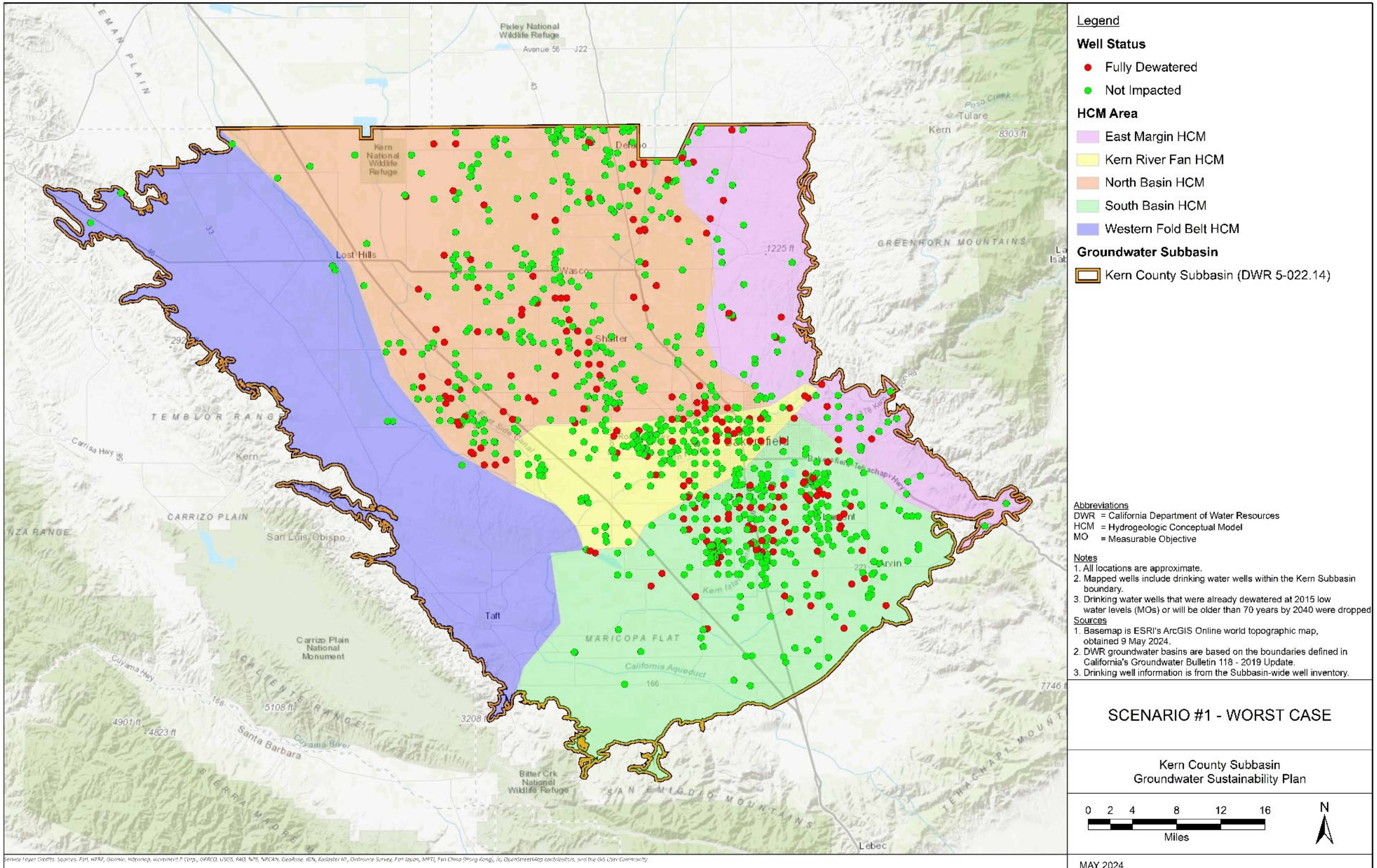


Figure 13-6. Scenario #1 – Worst Case

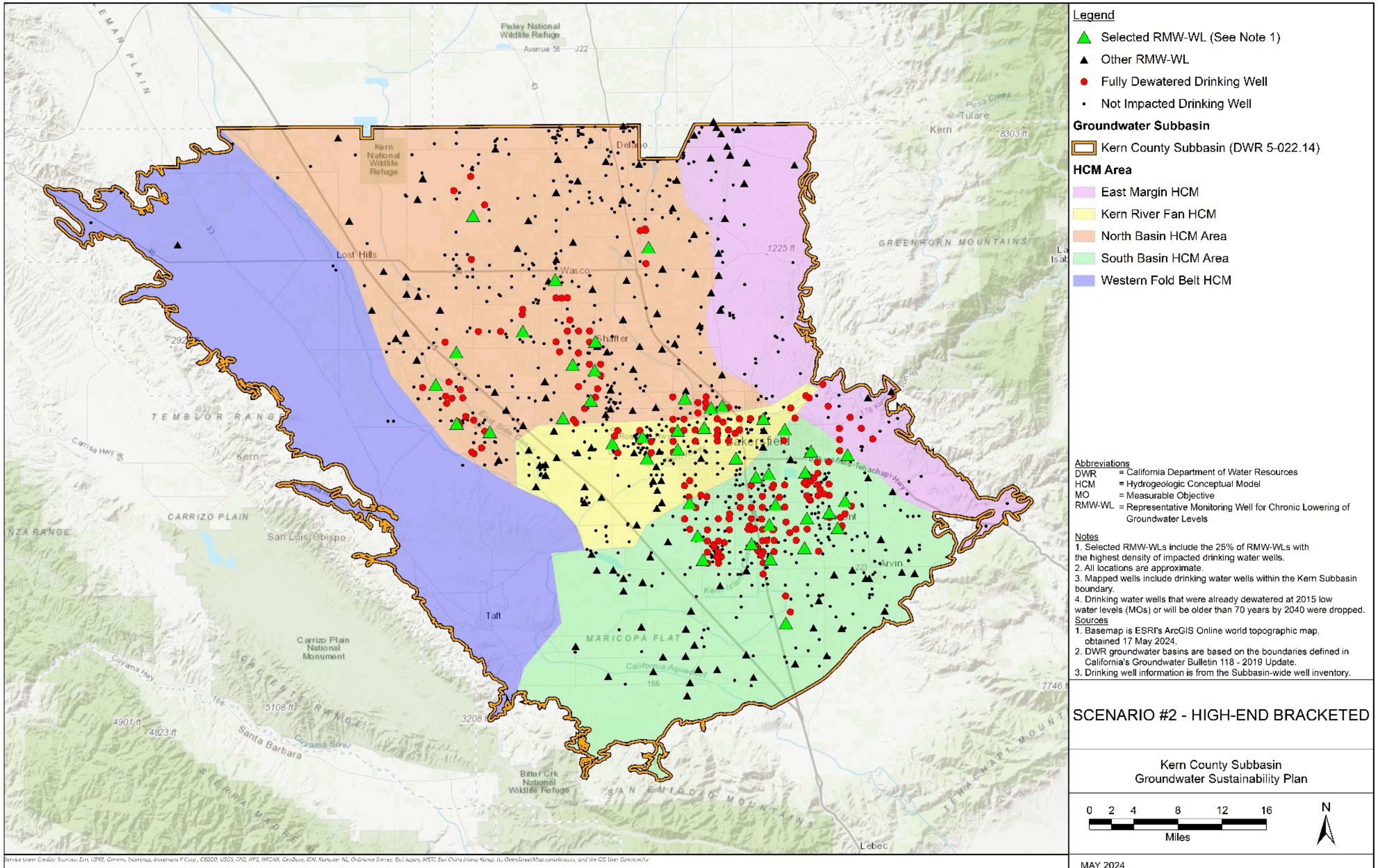


Figure 13-7. Scenario #2 – High-End Bracketed

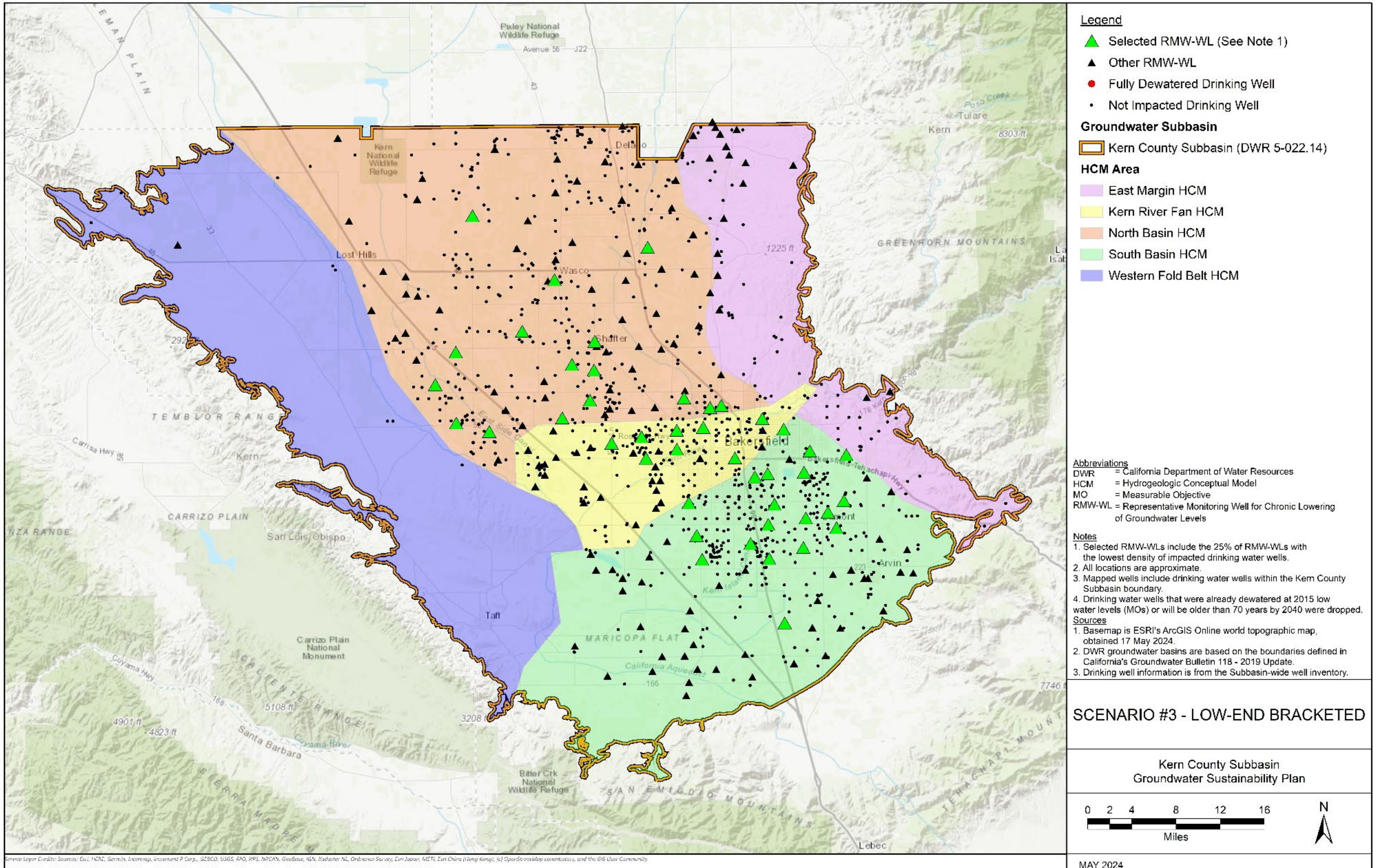


Figure 13-8. Scenario #3 – Low-End Bracketed

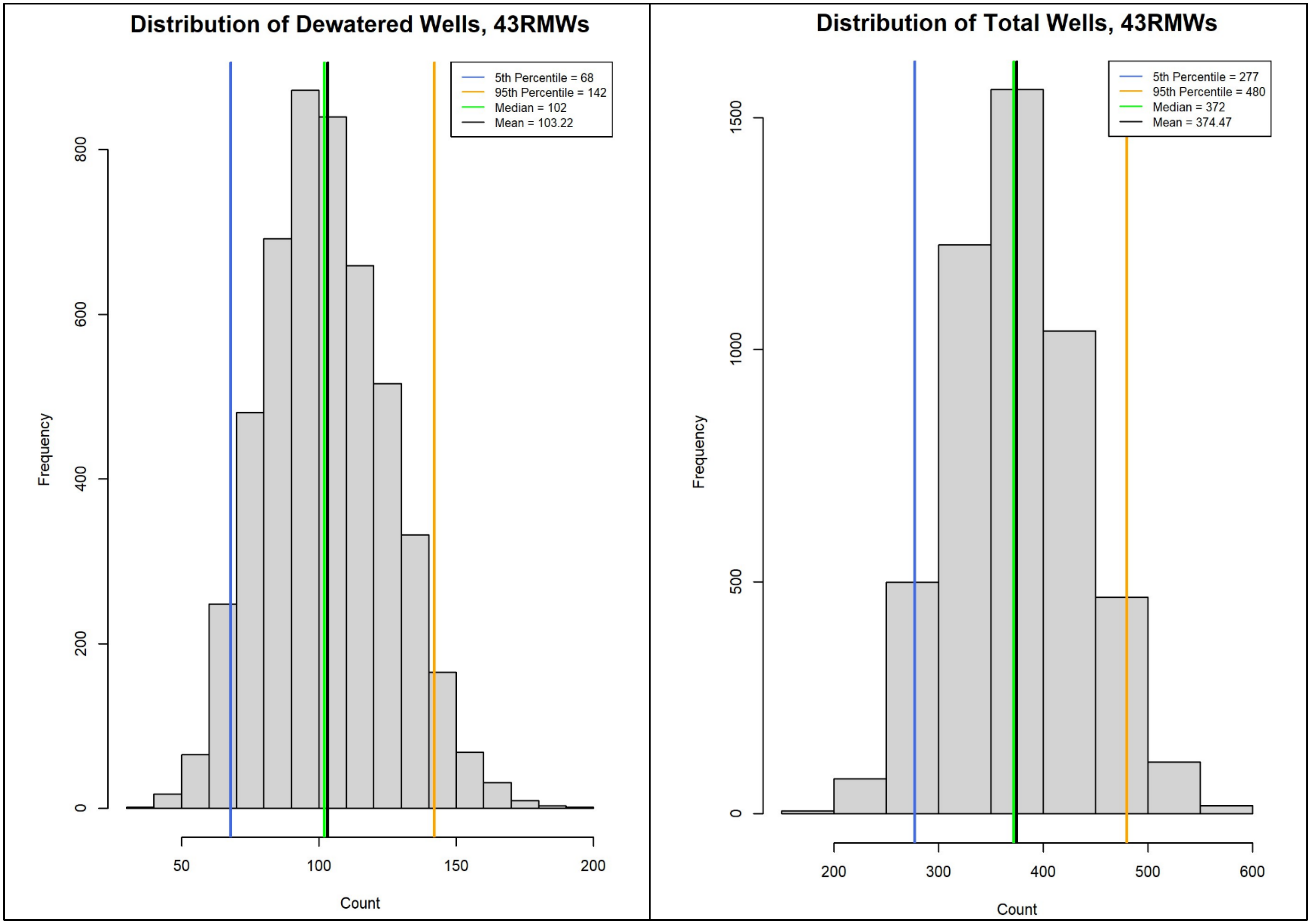


Figure 13-9 . Scenario #4 - Stochastic Prediction

This page intentionally left blank.

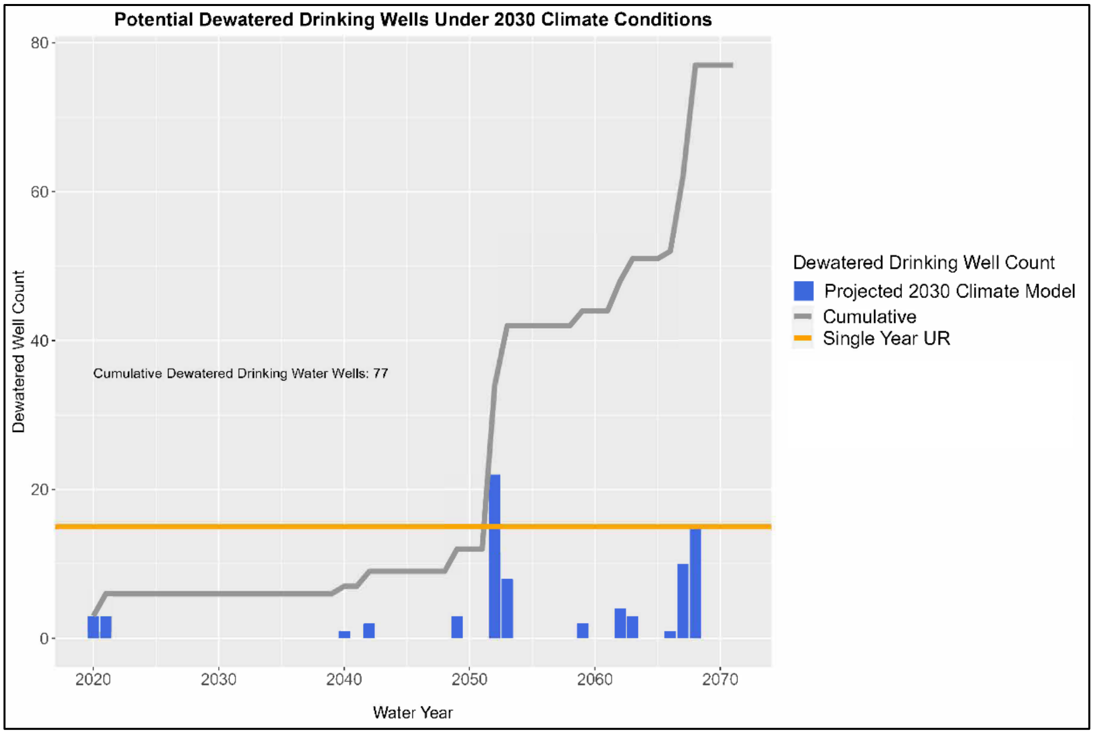


Figure 13-10. Scenario #5 – Potential Dewatered Drinking Wells Under Modeled Projected Future 2030 Climate Conditions

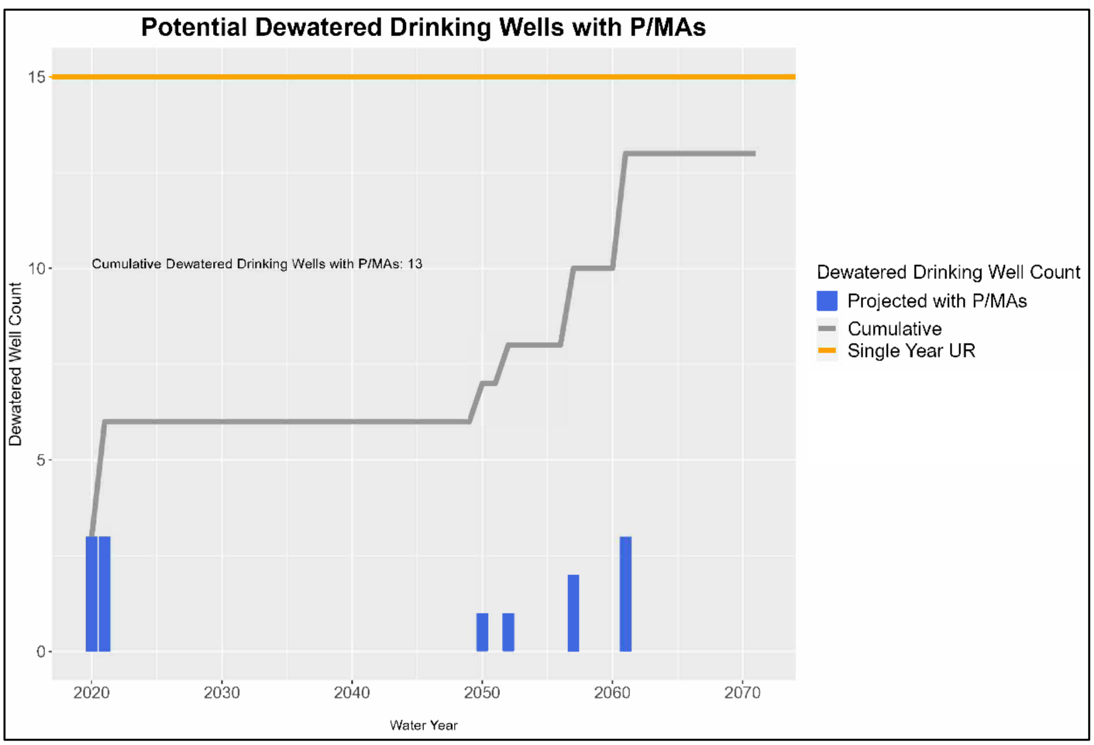


Figure 13-11. Scenario #5 – Potential Dewatered Drinking Wells Under Modeled Projected Future Conditions with P/MAs

13.1.3 Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels

***§ 354.30.** Measurable Objectives*

(a) Each Agency shall establish measurable objectives, including interim milestones 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.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives 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.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(e) 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 interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

(f) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(e)**

13.1.3.1 Measurable Objective Development

The MOs are defined as "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR § 351(s)). The MOs for Chronic Lowering of Groundwater Levels are set at the "2015 low" groundwater level at each RMW-WL. This is defined as the lowest groundwater level measurement observed in an RMW-WL during calendar year 2015, when available. In the instances where no 2015 measurement is available, one of the following methods was used to estimate the "2015 low", at the discretion of the GSAs:

1. The closest temporal measurement;
2. A spatial interpolation of the Fall 2015 groundwater level at the RMW-WL;
3. An average or linear interpolation between two bookend temporal measurements; or

4. Surrogate Fall 2015 groundwater level data from a nearby well.

Table 13-2 provides the MOs at each RMW-WL and documents the "2015 low" groundwater level estimation method, if applicable. The final MOs are shown in Figure 13-12 and Figure 13-13 for the Primary Alluvial Principal Aquifer and Santa Margarita and Olcese principal aquifers, respectively.

This page intentionally left blank.

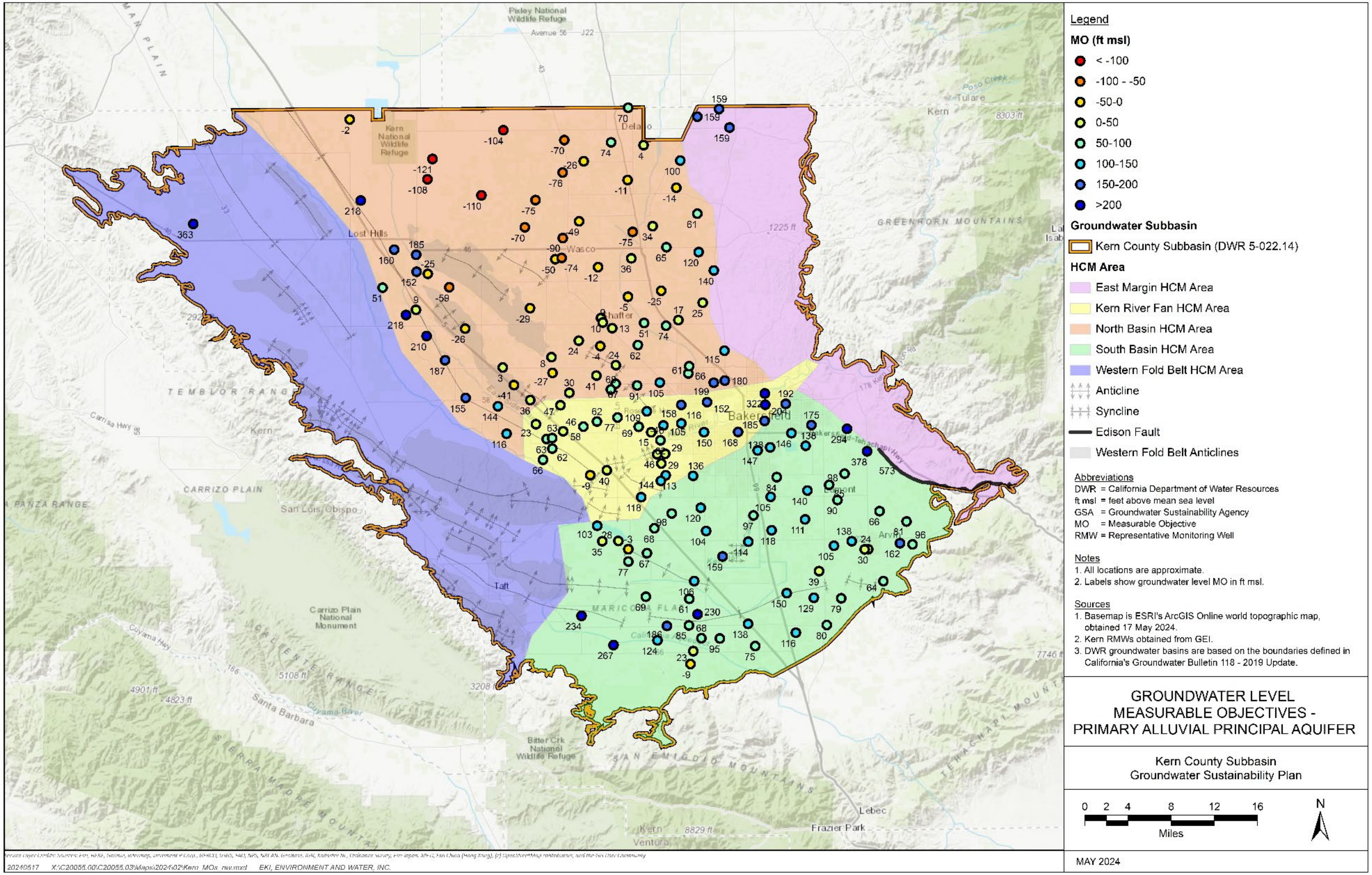


Figure 13-12. Groundwater Level Measurable Objectives – Primary Alluvial Principal Aquifer

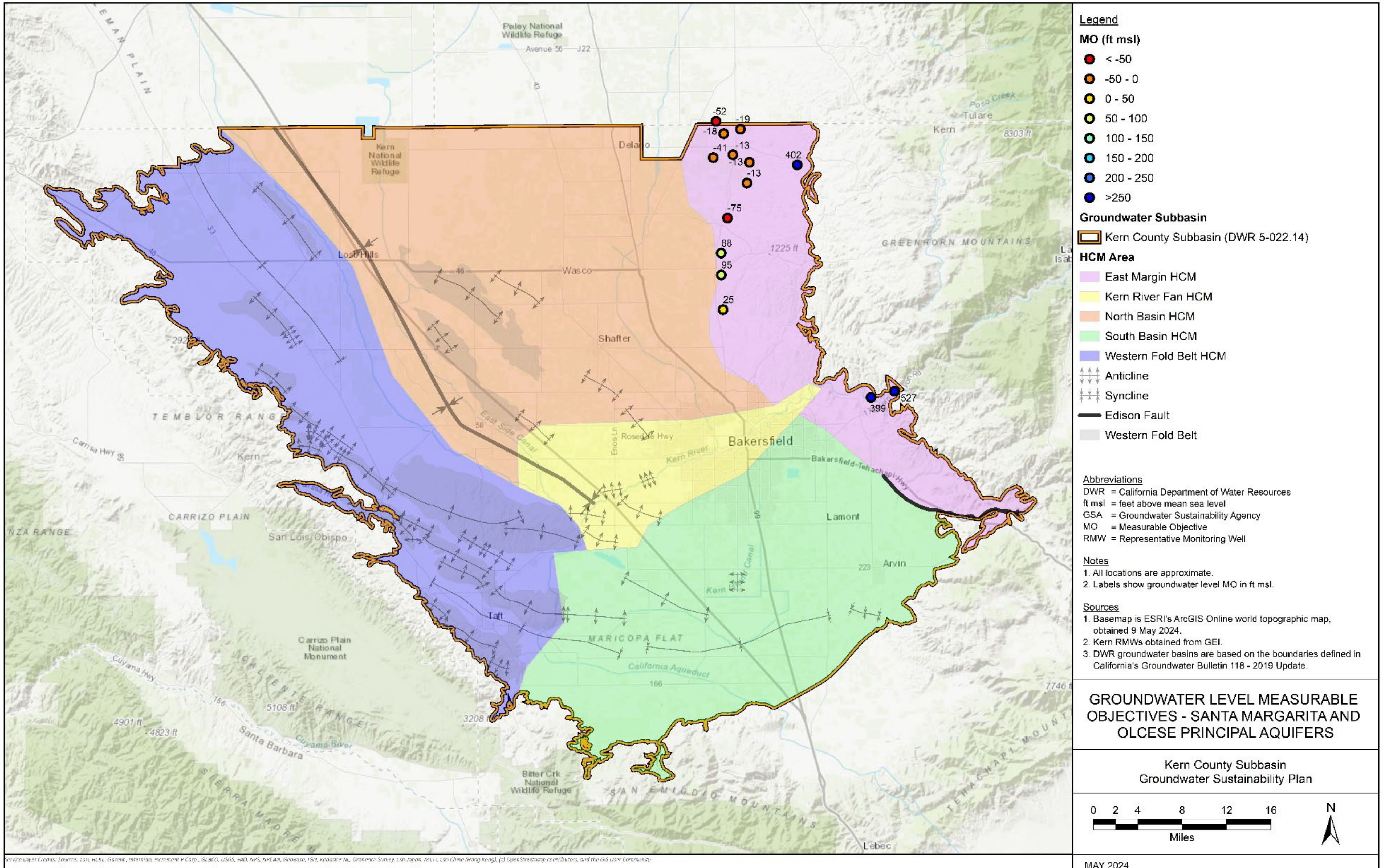


Figure 13-13. Groundwater Level Measurable Objectives – Santa Margarita and Olcese Principal Aquifers

13.1.3.2 Interim Milestones (IM) Development

The IMs are defined as “a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan” (23 CCR § 351(q)). The IMs must consider the time required to implement P/MAs and the resultant time for which observed changes to the groundwater system will occur. The IMs for Chronic Lowering of Groundwater Levels are defined based on a trajectory for groundwater levels informed by recent groundwater level trends, the MTs, and the MOs. This trajectory assumes a continuation of the recent regional groundwater level trends for the first five-year period (2020 through 2025), a slowing from that trend over the second five-year period (2025 to 2030), a recovery to the five-year IM in the third five-year period (2030 to 2035), and recovery towards the MO over the fourth (last) five-year period (2035 to 2040). Specifically, the trajectory for Chronic Lowering of Groundwater Levels IMs is demonstrated in Figure 13-14 and is calculated as follows:

- 2025 IM = half the vertical distance between the MT and the MO ($\frac{MO+MT}{2}$)
- 2030 IM = half the vertical distance between the MT and the 2025-IM ($\frac{MT+2025\ IM}{2}$)
- 2035 IM = half the vertical distance between the 2030-IM and the MO ($\frac{2030\ IM+MO}{2}$)
- 2040 IM = MO

Table 13-2 provides the IMs at each RMW-WL.

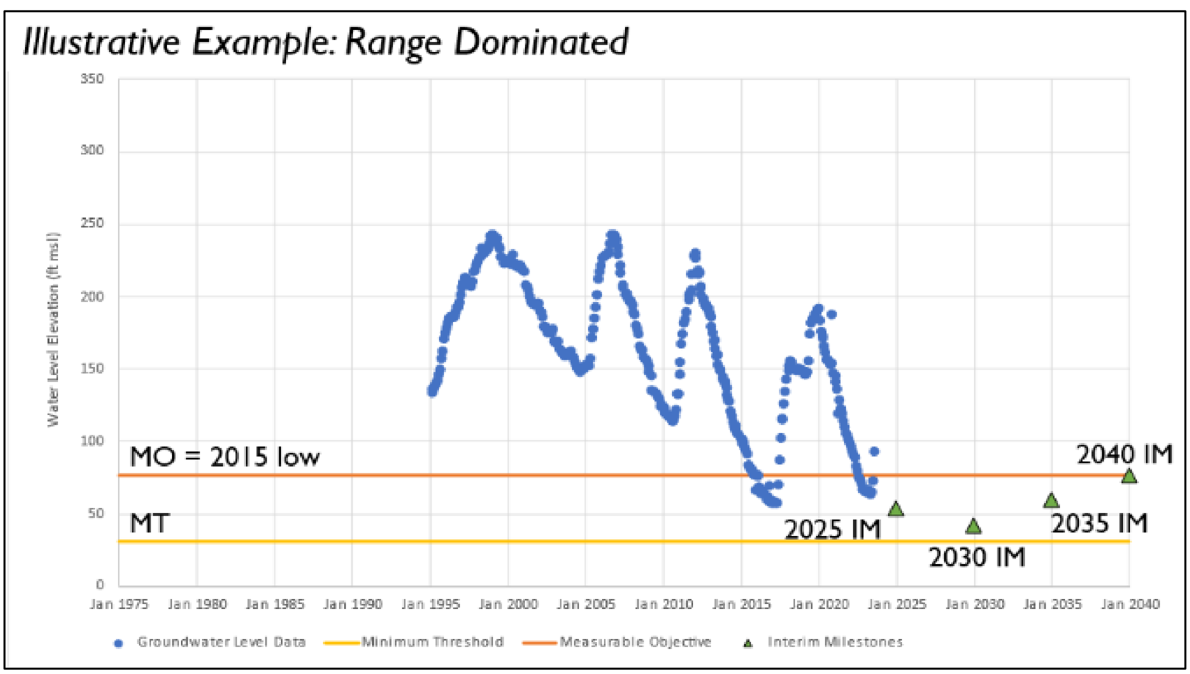


Figure 13-14. Illustrative Example of IM Approach

13.2 Reduction of Groundwater Storage

13.2.1 Undesirable Results for Reduction of Groundwater Storage

Per SGMA, a UR for the Reduction of Groundwater Storage means a "significant and unreasonable reduction of groundwater storage" (CWC § 10721(x)(1)) and is defined herein as follows:

> *The point at which significant and unreasonable impacts, as determined by the amount of groundwater in the basin, affect the reasonable and beneficial use of, and access to, groundwater by overlying users over an extended drought period.*

13.2.1.1 Identification of Beneficial Users

The beneficial users for the Reduction of Groundwater Storage Sustainability Indicator are the same as those for Chronic Lowering of Groundwater Levels described in Section 13.1.1.1.

13.2.1.2 Potential Effects of Undesirable Results on Beneficial Users

☑ **23 CCR § 354.26(b)(3)**

The primary potential effect of URs caused by Reduction of Groundwater Storage on beneficial uses and users of groundwater in the Subbasin would be reduced groundwater supply reliability. The effect would be most significant during periods of reduced surface water supply availability due to, for example, natural drought conditions, regulatory restrictions, natural disasters, or other causes. However, as discussed in Section 13.2.2, there is significant usable groundwater storage within the Subbasin and these effects are unlikely to occur over the GSP planning and implementation horizon.

13.2.1.3 Potential Causes of Undesirable Results

☑ **23 CCR § 354.26(b)(1)**

Reduction of Groundwater Storage is directly correlated to Chronic Lowering of Groundwater Levels. Therefore, the potential causes of URs due to Reduction of Groundwater Storage are generally the same as the potential causes listed above for URs due to Chronic Lowering of Groundwater Levels (i.e., increased groundwater pumping and reduced recharge).

13.2.1.4 Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**
☑ **23 CCR § 354.26(c)**

As discussed in Section 13.1.3, MOs for Chronic Lowering of Groundwater Levels are set to the “2015 low” groundwater elevations at each RMW-WL. These MOs are set to achieve operational conditions that allow the Subbasin to maintain a net zero long-term average change in groundwater in storage. The MT for Chronic Lowering of Groundwater Levels is set at a depth below the MO for operational flexibility that provides a reasonable margin between the MT and MO that will accommodate droughts, climate change, conjunctive use operations, water banking, or other groundwater management activities commensurate with levels of uncertainty (23 CCR §354.30(c)). The volume of groundwater within the interval between MT and MO groundwater levels (9.3 million acre-feet [MAF]) represents the operational flexibility of groundwater storage.

The criteria used to define a UR is a cumulative reduction in usable groundwater storage in the Primary Principal Alluvial Aquifer of more than 9.3 MAF relative to the baseline total usable groundwater storage volume. The total useable storage represents the volume of groundwater in storage within the lateral and vertical extent of the Primary Alluvial Principal Aquifer where active pumping wells are located and therefore is considered to be the volume of water able to be extracted by existing wells in the Subbasin. As discussed above, MOs for Chronic Lowering of Groundwater levels are set to maintain 2015 (i.e., SGMA baseline) groundwater levels in the Subbasin; therefore, total usable storage at MO groundwater levels is the SGMA baseline total usable storage. A 9.3 MAF reduction in usable storage is not unreasonable given the large size of the basin and total usable storage estimates, and it is similar to the storage change observed during recent multi-year droughts without unreasonable dewatering of wells (discussed below).

The baseline total usable storage was calculated using aquifer properties derived from the Subbasin groundwater flow model[9], the depth at which active wells are pumping (“total usable depth”; discussed below), and MO groundwater elevations. Given that the total usable depth varies throughout the Subbasin and is difficult to estimate in some areas of the Subbasin where there is a low density of active pumping wells, a sensitivity analysis was conducted assuming total usable depths of 1,000, 1,500, 2,000, 2,500, and 3,000 feet to develop a range for the Subbasin’s calculated baseline total usable storage (Section 8.2.2). As shown in Table 8-1, the Subbasin’s baseline total usable storage may range from 90,000,000 to 260,000,000 AF. The total usable storage calculated from this groundwater level analysis was validated against the model estimate of total usable storage, demonstrating a direct correlation between groundwater levels and groundwater storage in the Subbasin.

[9] A specific yield of 0.075 was used for upper portions of the Subbasin and a specific storage of $4.3x10^{-5}$ was used for lower portions of the Subbasin.

The change in storage between the MO and MT groundwater levels (9.3 MAF) was calculated by spatially interpolating MTs and MOs at Primary Alluvial Principal Aquifer RMW-WL across the Subbasin and compared to the baseline total usable storage. This analysis shows that if groundwater levels decline from the MOs to the MTs, the reduction of storage would range from 4-10 percent of the estimated range of total usable storage[10]. 9.3 MAF allows for a future four-year drought and is not unreasonable for a multi-year drought period for the Subbasin's Primary Alluvial Principal Aquifer based on the estimated change in storage during the 2012-2016 drought (-7.7 MAF). Additionally, it is estimated that at WY 2022 pumping rates (a critically dry year), the 90-96 percent of storage remaining would be enough to support Subbasin-wide pumping for a minimum of 25 years. This comparison demonstrates that the operational flexibility groundwater storage is small relative to the Total Useable Storage (Figure 13-15). Therefore, URs related to Reduction of Groundwater Storage are not anticipated to occur at Chronic Lowering of Groundwater Level MTs.

Because of the direct correlation between groundwater elevation and groundwater storage volume, groundwater levels are used as proxy to measure conditions for this Sustainability Indicator.

[10] Excludes certain areas of the Eastern Margin and Western Fold Belt HCM areas where there is not RMW-WL coverage.

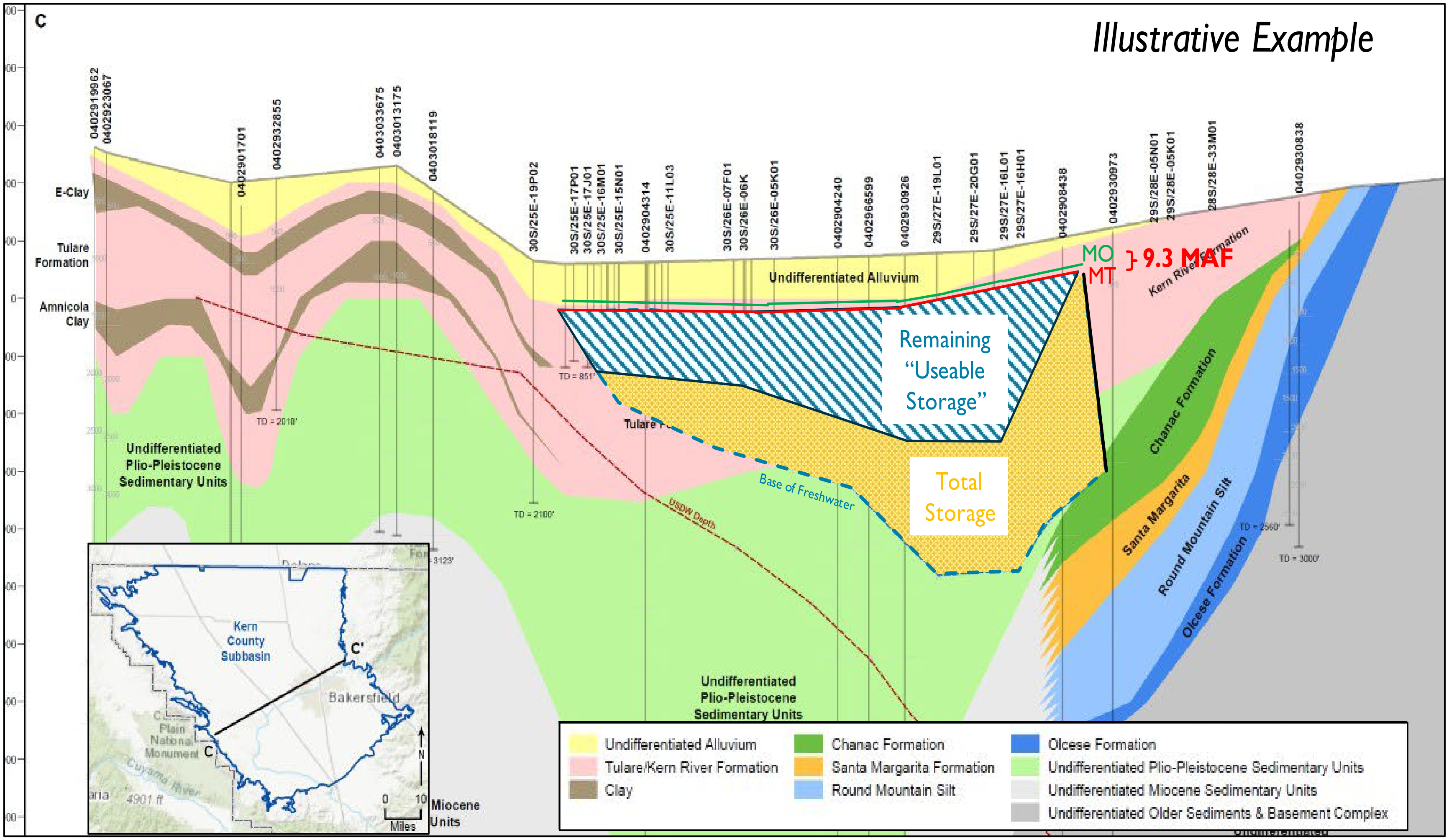


Figure 13-15. Illustrative Example of Reduction of Groundwater Storage SMCs

This page intentionally left blank.

13.2.2 . Minimum Threshold for Reduction of Groundwater Storage

> ***§ 354.28.*** *Minimum Thresholds*
> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> *a. Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.*
> *(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.*

As discussed above, the UR definition for Reduction of Groundwater Storage equates to a volumetric decrease in storage amounting to a reduction in 9.3 MAF (4 to 10%) of usable storage over the planning and implementation horizon, and the criteria for the URs are tied to the UR criteria for Chronic Lowering of Groundwater Levels. It is logical to tie these two Sustainability Indicators together, as the amount of groundwater in storage is directly, if not linearly, related to groundwater levels. Because of the close relationship between these two Sustainability Indicators, and because the MTs for Chronic Lowering of Groundwater Levels are protective of the beneficial uses and users of groundwater (discussed below), the MTs for Chronic Lowering of Groundwater Levels are used as a proxy for the Reduction of Groundwater Storage Sustainability Indicator (refer to Table 13-2 for MTs for Chronic Lowering of Groundwater Levels).

13.2.2.1 Use of Groundwater Levels as a Proxy

> ☑ **23 CCR § 354.28(b)(1)**
> ☑ **23 CCR § 354.28(c)(2)**
> ☑ **23 CCR § 354.28(d)**

The URs for Reduction of Groundwater Storage are defined to occur when there is a 9.3 MAF (4 to 10%) decline in total usable groundwater storage relative to the baseline. As discussed above, this decline in usable storage is not considered to be unreasonable and is calculated by assuming that all Primary Alluvial Principal Aquifer RMW-WLs exceed MTs. However, URs for Chronic Lowering of Groundwater Levels are defined to occur when 25 percent of RMW-WLs exceed their MTs, which would correspond to a lower decline in storage than the UR criteria for Reduction of Groundwater Storage.

The calculation of a 4 to 10 percent reduction in usable storage at the proposed MTs and the more stringent UR criteria for Chronic Lowering of Groundwater Levels demonstrate that SMCs for Chronic Lowering of Groundwater Levels are sufficiently protective of Reduction of Groundwater storage in the Subbasin and serve as a reasonable proxy.

13.2.3 Measurable Objective and Interim Milestones for Reduction of Groundwater Storage

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(d)**

As discussed in Section 13.2.2.1, because of the close relationship between the Reduction of Groundwater Storage and Chronic Lowering of Groundwater Levels Sustainability Indicators, the MOs and IMs for Chronic Lowering of Groundwater Levels serve as a proxy for Reduction of Groundwater Storage, and it is not necessary to set unique MO or IMs for Reduction of Groundwater Storage. Furthermore, since the baseline for the total usable groundwater storage is based on the WY 2015 value, and MOs for Chronic Lowering of Groundwater Levels are set at the 2015 low groundwater elevation, there should be minimal to no change in groundwater storage at the MOs compared to baseline conditions. Finally, as stated above, the MOs for Chronic Lowering of Groundwater Levels provide an adequate margin of operational flexibility. Refer to Table 13-2 for MOs and IMs for Chronic Lowering of Groundwater Levels.

13.3 Degraded Water Quality

13.3.1 Undesirable Results for Degraded Water Quality

The SGMA defines an UR for Degraded Water Quality as "significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies" (CWC § 10721(x)).

The Subbasin-wide definition of URs for Degraded Water Quality is defined as follows:

> *The point at which significant and unreasonable impacts occur over the planning and implementation horizon, as caused by water management actions, that affect the reasonable and beneficial use of, and access to groundwater by overlying users.*

The Subbasin's approach to Degraded Water Quality reflects the fact that SGMA does not require GSPs to address degraded water quality URs that occurred before and have not been corrected by January 1, 2015 (CWC § 10727.2(b)(4)) and that "...*sustainable groundwater management" means the <u>management and use of groundwater</u> in a manner that can be maintained during the planning and implementation horizon without causing undesirable results*." (CWC §10721(v)) (emphasis added). Consistent with these regulations, the Subbasin GSAs have defined "water management actions" as GSA actions related to groundwater recharge or extraction within the Subbasin. As such, the URs definition appropriately focuses on whether water quality conditions have degraded as a result of water management actions since the enactment of SGMA on January 1, 2015.

The regulatory oversight authority for drinking water quality rests with the State Water Resources Control Boards (SWRCB) Division of Drinking Water (DDW), and therefore general measures to address drinking water quality served to the public are generally beyond the purview of the SGMA, except where directly impacted as a result of groundwater management within the GSA's control. Those regulatory oversight and enforcement actions have and will occur on their own mandated timelines and in accordance with DDW permitting, reporting and enforcement processes. Water quality issues related to wastes discharged below the root zone from irrigated agricultural lands (e.g., nitrate) are also regulated separately under the Central Valley Regional Water Quality Control Board's (CVRWQCB's) Irrigated Lands Regulatory Program (ILRP). Additionally, the CVRWQCB's Basin Plan and stakeholder led Central Valley Salinity Alternative for Long-Term Sustainability (CV-SALTS) programs address groundwater quality degradation from all permitted dischargers (ILRP, dairies, food processors, wineries, wastewater treatment plants, industrial, etc.) through the Nitrate and Salt Control programs. The Subbasin GSAs are actively coordinating with these entities and programs in the collection, sharing and analysis of applicable data (Section 14.2.3, P/MA KSB-2).

13.3.1.1 Identification of Beneficial Users

Subbasin GSAs have identified domestic and small community well owners as the most vulnerable beneficial users for the Degraded Water Quality sustainability indicator. The SMCs for Degraded Water Quality are designed to prioritize protection of the most vulnerable beneficial users, which are inherently protective of all other beneficial users. As mentioned in Section 13.1.1.1 above, based on the Subbasin well inventory, there are 2,541 domestic and small community wells.

It is acknowledged that other beneficial users, particularly municipal or public systems, may also be potentially impacted by Degraded Water Quality. However, by prioritizing the protection of the most vulnerable groundwater users, the Degraded Water Quality SMCs are inherently designed to ensure the protection of all beneficial users in the Subbasin. The MTs for Degraded Water Quality are set at state and federal drinking water standards or pre-SGMA baseline conditions, which are sufficiently protective for all drinking water systems. Other beneficial uses of groundwater, such as for agricultural irrigation or industrial use, require lower water quality standards and would also be sufficiently protected by drinking water quality standards. Furthermore, the Subbasin Plan establishes a water quality monitoring network with sufficient Subbasin-wide coverage to monitor impacts to all Subbasin beneficial users (see Section 15.2.4).

13.3.1.2 Potential Effects of Undesirable Results on Beneficial Users

☑ 23 CCR § 354.26(b)(3)

The potential effects of URs caused by Degraded Water Quality on beneficial uses and users of groundwater may include:

- Increased costs to treat groundwater to drinking water standards if it is to be used as a potable supply source;
- Increased costs to blend relatively poor-quality groundwater with higher quality sources for drinking water users, agricultural users, and industrial users; and,
- Potential reduction in the usable volume of groundwater in the Subbasin if large areas are impaired to the point that they cannot be used to support beneficial uses and users.

13.3.1.3 Potential Causes of Undesirable Results

☑ 23 CCR § 354.26(b)(1)

The URs due to Degraded Water Quality are the result of increases in concentrations of constituents of concern (COCs) in groundwater. These increases in concentration can occur through a variety of processes, some of which are causatively related to groundwater management activities and under the purview of the GSAs, and some of which are not.

- Lateral migration from adjacent areas with poorer quality groundwater;
- Leaching from internal sources such as fine-grained, clay-rich interbeds;
- Upward vertical flow (upconing) of poor water quality from deeper zones below the bottom of the freshwater interface;
- Recharge from managed recharge projects;
- Seepage from various natural and man-made channels;
- Seepage from various non-GSA activities;
- Irrigation system backflow into wells and flow through well gravel pack and screens from one formation to another;
- Deep percolation of excess applied irrigation water and other water applied for cultural practices (e.g., for soil leaching); and
- Natural occurrence and prevalence from geologic formations. It is noted that wells screened in portions of the Subbasin with naturally degraded water quality are not within the purview of the GSAs to remedy as part of the Well Mitigation Program.

13.3.1.4 Criteria Used to Define Undesirable Results

☑ **23 CCR § 354.26(b)(2)**

Under SGMA, the regulatory authority granted to GSAs includes the management of the quantity, location, and timing of groundwater pumping to prevent URs, namely the "significant and unreasonable" impacts to beneficial users. As discussed above, to be considered a "significant and unreasonable" impact, water quality would need to be degraded beyond state and federal regulatory drinking water standards or pre-existing baseline concentrations as a result of water management actions.

Several COCs for the Subbasin are identified in Section 8.4.1 based on data from the SWRCB's Groundwater Ambient Monitoring and Assessment (GAMA) Program from 2010 through 2023. Several criteria were utilized by the Subbasin GSAs to systematically assess which COCs warranted the development of SMCs based on a consistent assessment of existing groundwater conditions, the relationship between groundwater management (i.e., extraction, recharge, or groundwater level changes) and the state and federal water quality regulations. The Subbasin GSAs then only developed SMCs for those COCs that met all of the following criteria. This process notwithstanding, the GSAs are committed to continue to monitor and otherwise evaluate water quality and the COCs as part of on-going SGMA implementation.

- *Existing Health-Based Standard:* A COC meets this criterion if it has an existing state or federal health-based regulatory standard. For this process, health-based regulatory standards include Maximum Contaminant Levels (MCLs), Health-Based Screening Levels (HBSLs), Secondary Maximum Contaminant Levels (SMCLs), United States Environmental Protection Agency (USEPA) Health Advisory Levels, and Notification Levels (NLs). SMCs were not developed for COCs that do not have existing health-based regulatory standards. Emerging constituents will be reevaluated in the next periodic evaluation if new health-based regulatory standards are established.
- *Post-SGMA Exceedance of Health-Based Standard*: A COC meets this criterion if, based on GAMA data from 2015 through 2023, at least 5 percent of wells sampled Subbasin-wide exceed the most stringent health-based standard for the COC, as reported in Section 8.4.1. SMCs were not developed for COCs that had reported exceedances in less than 5 percent of sampled wells.
- *Potential to Impact Beneficial Users:* A COC meets this criterion if it is both prevalent throughout the Subbasin and concentrations are or have the potential to be exacerbated by groundwater management actions taken by the GSAs (e.g., lateral migration from adjacent areas with poorer quality groundwater). A COC is considered to be prevalent throughout the Subbasin if post-SGMA (i.e., 2015-2023) median concentrations exceed the health-based screening standard in any HCM area, as presented in Section 8.4.1. A COC would have the potential to be

exacerbated by groundwater management actions if concentrations are affected by groundwater level changes. Section 8.4.1 presents an analysis of the relationship between groundwater levels and concentrations of each COC. A COC was considered to have high potential to impact beneficial users if both criteria were met, moderate potential if one of these criteria was met, and low potential if neither of these criteria were met. SMCs were not developed for COCs with low potential to impact beneficial users.

The results of the screening process for each identified COC are identified in Table 13-5. The COCs applicable for the development of Degraded Water Quality SMCs are arsenic, total nitrate/nitrite (as N), nitrate, nitrite[11], total dissolved solids (TDS), 1,2,3-Trichloropropane (1,2,3-TCP), and uranium. Detailed analysis of the available water quality information for each COC is presented in Section 8.4.1.

Table 13-5. Criteria for Developing Degraded Water Quality SMCs

Constituent of Concern	Existing Health-Based Standard	% of Wells Exceeding Health-Based Standard	Potential to Impact Beneficial Users	SMC Developed
Arsenic	10 ppb	22.4%	High	Yes
Nitrate (as N)	10 ppm	14.9%	Moderate	Yes
Nitrate + Nitrite (as N)	10 ppm	24.9%	Moderate	Yes
Nitrite (as N)	1 ppm	1.8%[11]	Moderate	Yes
Total Dissolved Solids	1,000 ppm	11.7%	Moderate	Yes
1,2,3-Trichloropropane (1,2,3-TCP)	5 ppt	44.5%	Moderate	Yes
Uranium	20 pCi/L	7.2%	Moderate	Yes
1,2 Dibromoethane (EDB)	20 ppt	0.7%	Low	No
1,2,-Dibromo-3-chloropropane (DBCP)	200 ppt	2.0%	Low	No
Benzene	1 ppb	0.5%	Low	No
Gross Alpha	15 pCi/L	5.1%	Low	No
Perfluorooctanoic acid (PFOA)	4 ppt	14.8%	N/A[1]	No[1]
Perfluorooctanoic sulfonate (PFOS)	4 ppt	6.9%	N/A[1]	No[1]
Selenium	50 ppb	0.9%	Low	No

[1] In April 2024, the USEPA announced the Final MCLs for PFOA and PFOS of 4 ppt. Per the USEPA's final rule, public water systems have three years (by 2027) to complete initial monitoring and five years (by 2029) to implement solutions. Due to limited existing data at a Subbasin scale, SMCs for PFOA and PFOS are not set at this time. Subbasin GSAs will use emerging data from public water systems to conduct an initial assessment of Subbasin conditions. SMCs for PFOA and PFOS will be informed by data collected during Plan implementation and will be evaluated as part of the first Periodic Evaluation.

[11] As discussed in Section 8.4.1, nitrite is primarily non-detect in the Subbasin. Median concentrations and exceedance locations of total nitrate/nitrite (as N) are similar to the prevalence of nitrate. SMCs were established for individual nitrate species because they contribute to the total nitrate/nitrite (as N).

Based on the significant and unreasonable effects described above, the criteria for URs for Degraded Water Quality for the applicable COCs are as follows:

> *URs for Degraded Water Quality are defined to occur within the Subbasin if and when MTs for a groundwater quality COC are exceeded in three (3) RMW-WQs in an HCM area based on the average of confirmed seasonal sample results and can be attributed based on a technical analysis to groundwater management actions (e.g. groundwater level changes)*.

The component of the UR criteria requiring MT exceedances in three RMW-WQs in an HCM area was selected to ensure that an MT exceedance is not a localized issue and represents a degradation of groundwater conditions occurring in a greater portion of the Basin. The occurrence of a single MT exceedance would trigger the Subbasin's MT Exceedance Policy (see Section 16.2.1), which requires: (1) collection of a confirmation sample to ensure the first measurement is not erroneous, and (2) investigation of whether a degradation of water quality is occurring as a result of groundwater management actions. An investigation would include statistical and/or spatial analyses between water levels and water quality to determine causation, depending on the availability of data. For example, in an RMW-WQ that has at least five sampling points with water level data that temporally overlaps with WQ data, a granger causality test between water levels and water quality could be conducted.

As discussed in Section 13.3.2, MTs for arsenic, total nitrate/nitrite (as N), nitrate, nitrite, TDS, 1,2,3-TCP, and uranium are established at the Subbasin's RMW-WQs. Additionally, the Subbasin has developed a framework for a Well Mitigation Program (Section 16.2.1.1) and entered into partnerships to provide emergency and long-term solutions to restore access to water for domestic and small community wells impacted by Degraded Water Quality.

13.3.2 Minimum Threshold for Degraded Water Quality

> ***§ 354.28.*** *Minimum Thresholds*
> *(6) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> (5) *Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.*

The GSP Emergency Regulations (23 CCR § 354.28(c)) state that the MT for Degraded Water Quality shall be the "degradation of water, including the migration of contaminant plumes that impair water supplies or other indicators of water quality as determined by the Agency that may lead to undesirable results". The GSP Emergency Regulations further state that the MT "shall be based on the number of supply wells, a volume of water, or a location of an iso-contour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin", and that "the Agency shall consider local, state, and federal water quality standards applicable to the basin." This language indicates that MTs for Degraded Water Quality can reasonably be based on concentrations of water quality COCs, as quantified by sampling measurements at the RMW-WQs.

13.3.2.1 Minimum Threshold Development

☑ **23 CCR § 354.28(b)(1)**
☑ **23 CCR § 354.28(c)(4)**

As discussed above in Section 13.3.1, the process for developing SMCs for the COCs identified within the Subbasin considers the regulatory authority granted to GSAs to effect sustainable groundwater management under SGMA, which includes the management of the quantity, location, and timing of groundwater pumping and recharge. As outlined in Section 13.3.1.4, COCs were screened to consider risks to vulnerable drinking water beneficial users based on health-based regulatory standards or in instances where risks are expected to be exacerbated by groundwater management actions (i.e., extractions or recharge). Because of the limited purview of GSAs with respect to water quality, and the rightful emphasis on those constituents that may be related to groundwater management activities, the COCs currently applicable within the Subbasin and for which the Subbasin are setting SMCs are arsenic, total nitrate/nitrite (as N), nitrate, nitrite[10], TDS, 1,2,3-TCP, and uranium.

MTs for Degraded Water Quality are set at the Subbasin's RMW-WQs. The MTs are tied to regulatory water quality standards – namely, the CCR Title 22 Drinking Water Standards, as applicable to each COC. The MT is set as the greater concentration of (1) the applicable health-based screening standard (Table 13-6) or (2) the maximum 2010 – 2014 baseline concentration at each RMW-WQ[12]. For wells with insufficient 2010 – 2014 data, 2010-2023 data is used to determine maximum baseline concentration at each RMW-WQ. For wells with insufficient 2010-2023 data, the MT is set as the 90th percentile 2010-2023 baseline concentration in the applicable HCM area.

It is an appropriate goal to try to maintain concentrations of each COC at or below regulatory drinking water quality standards, or for wells that were already impacted before the SGMA effective date, to try and maintain concentrations at their pre-SGMA

---

[12] Non-detect measurements for 1,2,3-TCP collected prior to 2018 were not included in the 2010-2014 baseline calculation because the detection level for purposes of reporting (DLR) was established in December 2017. Therefore, pre-2018 non-detect measurements may not represent results below the 1,2,3-TCP DLR of 0.005 µg/L.

baseline levels. Use of a baseline condition acknowledges that “the plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015” (CWC § 10727.2(b)(4)).

Final MTs for Degraded Water Quality in each RMW-WQ are shown in Table 13-7. Additionally, **Appendix S** contains chemographs that plot historical water quality concentrations, the MT, and the MO at each RMW-WQ.

Table 13-6. Drinking Water Standards for COCs

Constituent of Concern	Health-Based Standard	Value
Arsenic	CA MCL	10 µg/L
Nitrate	CA MCL	10 mg/L
Nitrite	CA MCL	1 mg/L
Total Dissolved Solids	CA SMCL - Upper	1,000 mg/L
1,2,3-Trichloropropane (1,2,3-TCP)	CA MCL	0.005 µg/L
Uranium	CA MCL	20 pCi/L

This page intentionally left blank.

Table 13-7. SMCs for Degraded Water Quality

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
7th Standard Annex	North Basin	Superior Mutual Well 1, CA1503209_001_001	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	57	57	57	57	57
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Arvin GSA	East Margin	Murray Family Farms Well 2, AGC100012326-KRWCA00025, CA1503565_002_002	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Arvin GSA	South Basin	RMW-004 (30S29E29A001M)	Nitrate	mg/L	21.4	22.2	22.2	22.2	22.2	22.2
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	16	16	16	16	16	16
			TCP	ng/L	277	277	277	277	277	277
			TDS	mg/L	1000	1000	880	880	880	880
			Uranium	pCi/L	20	20	20	20	20	20
Arvin GSA	South Basin	RMW-010 (ACSD Well #14), CA1510001_022_022, USGS-351140118505401	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	77	77	77	77	77
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Arvin GSA	South Basin	RMW-001 (29S29E33N001M)	Nitrate	mg/L	11	11	11	11	11	11
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	16	16	16	16	16	16
			TCP	ng/L	277	277	277	277	277	277

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Arvin GSA	South Basin	RMW-224 (31S29E10K001M)	Nitrate	mg/L	16.6	25	25	25	25	25
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	33	33	33	33	33	33
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
BVWSD GSA	North Basin	RMW-107 (28S22E10D002M), AGC100012323-BVCWD00002	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	10	10	10	10	10	10
			Arsenic	ug/L	46	46	46	46	46	46
			TCP	ng/L	7	7	7	7	7	7
			TDS	mg/L	1967	1967	1967	1967	1967	1967
			Uranium	pCi/L	28	28	28	28	28	28
BVWSD GSA	North Basin	RMW-110 (DMW 07)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	11	11	11	11	11	11
			TCP	ng/L	7	7	7	7	7	7
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	28	28	28	28	28	28
BVWSD GSA	Kern River Fan	RMW-113b (DMW12b)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	3	3	3	3	3	3
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	8	8	8	8	8	8
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
CWD GSA	North Basin	RMW-172 (6C), AGC100012324-CAWDC00009	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			TCP	ng/L	189	189	189	189	189	189
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
CWD GSA	North Basin	RMW-169 (28L)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	270	270	270	270	270	270
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
EWMA	East Margin	RMW-288 (EWMA #49)	Nitrate	mg/L	13	13	13	13	13	13
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
EWMA	East Margin	RMW-189 (EWMA #41)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
EWMA	East Margin	RMW-185 (EWMA #21)	Nitrate	mg/L	13	13	13	13	13	13
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
HMWD GSA	South Basin	HMWD #23	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			Arsenic	ug/L	59	59	59	59	59	59
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KNDLA GSA	East Margin	Uplands of the Kern W2? Placeholder for final decision	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	South Basin	East Niles #23 (ENCSD), CA1510006_032_032	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	South Basin	Lamont #12, CA1510012_006_006	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	11	12	12	12	12	12
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	South Basin	AGC100012326-KRWCA00069	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	52	52	52	52	52	52
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	Kern River Fan	CBK L201, CA1510031_028_028	Nitrate	mg/L	10	10	10	10	10	10

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	9	14	14	14	14	14
			TDS	mg/L	100	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	Kern River Fan	RMW-021 (CWS)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	Kern River Fan	CBK 41-01, CA1510031_098_098	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	27	27	27	27	27
			TCP	ng/L	24	37	37	37	37	37
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	South Basin	RMW-025 (30S/27E-05D001) (ID4) - CBK-23 for WQ	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KRGSA	Kern River Fan	RMW-211 (CWS)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
KRGSA	Kern River Fan	Greenfield Taft Well, CA1510024_004_004	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	11	13	13	13	13	13
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KTWD GSA	East Margin	Well 12A2	Nitrate	mg/L	13	13	13	13	13	13
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KTWD GSA	East Margin	Well 4D1, AGC100012326-KRWCA00004	Nitrate	mg/L	10	11	11	11	11	11
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
KWB GSA	Kern River Fan	Kern Water Bank BK 9 (30S/26E-16L01)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
NKWSD GSA	North Basin	RMW-271 (Shafter Well 18), CA1510019_023_023	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	145	259	259	259	259	259
			TDS	mg/L	1005	1100	1100	1100	1100	1100

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			Uranium	pCi/L	23	23	23	23	23	23
NKWSD GSA	North Basin	RMW-148 (88-29-014)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Olcese Water District GSA	East Margin	RMW-043 (Olcese #4)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
Pioneer GSA	Kern River Fan	RMW-049 (30S26E15N003M)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	14	29	29	29	29	29
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
RRBWSD GSA	Kern River Fan	RMW-062a (25M Enos), AGC100012326-KRWCA00021	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
RRBWSD GSA	Kern River Fan	RMW-065a (31H Greeley), AGC100012326-KRWCA00029	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
RRBWSD GSA	Kern River Fan	RMW-067a (35H RRBWSD Shop)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	52	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
RRBWSD GSA	Kern River Fan	Frito Lay #1, CA1502615_001_001	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SSJMUD GSA	North Basin	RMW-252 (Delano 30), CA1510005_036_036	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	13	32	32	32	32	32
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SSJMUD GSA	North Basin	RMW-281 (Delano 34), CA1510005_047_047	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	28	28	28	28	28	28
SSJMUD GSA	North Basin	RMW-159 (SSJMUD 23), AGC100012326-KRWCA00030	Nitrate	mg/L	15	17	17	17	17	17
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	30	30	30	30	30	30

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			TCP	ng/L	198	198	198	198	198	198
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SWID GSA	North Basin	RMW-256 (Wasco 12), CA1510021_017_017	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	31	50	50	50	50	50
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SWID GSA	North Basin	RMW-257 (Shafter 14), CA1510019_009_009	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	200	363	363	363	363	363
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SWSD GSA	North Basin	Primex Farm Water System Well 4, CA1503521_004_004	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	11	11	11	11	11
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
SWSD GSA	North Basin	Lost Hills Utility District Well 3, CA1510046_006_006	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	46	46	46	46	46	46
			TCP	ng/L	7	7	7	7	7	7
			TDS	mg/L	1967	1967	1967	1967	1967	1967
			Uranium	pCi/L	28	28	28	28	28	28
TCWD GSA	South Basin	RMW-070, Caratan Well	Nitrate	mg/L	11	11	11	11	11	11
			Nitrite	mg/L	1	1	1	1	1	1

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			Arsenic	ug/L	16	16	16	16	16	16
			TCP	ng/L	277	277	277	277	277	277
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
WDWA GSA	Western Fold	Berenda Mesa #3	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	143	143	143	143	143	143
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	9072	9072	9072	9072	9072	9072
			Uranium	pCi/L	20	20	20	20	20	20
WDWA GSA	Western Fold	RMW-275 (7108-66)	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	21	21	21	21	21	21
			TCP	ng/L	5	52	52	52	52	52
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	24	24	24	24	24	24
WKWD GSA	Kern River Fan	Well 7-02, CA1510022_015_015	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	5	5	5	5	5	5
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
WRMWSD GSA	South Basin	11N/21W-08A01	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	10	10	10	10	10	10
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
WRMWSD GSA	South Basin	32S/28E-16P02	Nitrate	mg/L	22	22	22	22	22	22

GSA	HCM Area	Well ID	Constituent	Units	MO	MT	IM			
							2025	2030	2035	2040
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	33	33	33	33	33	33
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
WRMWSD GSA	South Basin	32S/25E-36R01	Nitrate	mg/L	22	22	22	22	22	22
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	33	33	33	33	33	33
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	1000	1000	1000	1000	1000	1000
			Uranium	pCi/L	20	20	20	20	20	20
WRMWSD GSA	South Basin	32S/26E-14J02	Nitrate	mg/L	10	10	10	10	10	10
			Nitrite	mg/L	1	1	1	1	1	1
			Arsenic	ug/L	43	55	55	55	55	55
			TCP	ng/L	300	300	300	300	300	300
			TDS	mg/L	720	3700	3700	3700	3700	3700
			Uranium	pCi/L	20	20	20	20	20	20

Abbreviations:

BVWSD = Buena Vista Water Storage District GSA
CWD = Cawelo Water District
EWMA = Eastside Water Management Area
ft msl = feet above mean sea level
GSA = Groundwater Sustainability Agency
HMWD = Henry Miller Water District GSA
IM = Interim Milestone
KNDLA= Kern Non-Districted Land Authority
KRGSA = Kern River GSA
KTWD = Kern-Tulare Water District
KWB = Kern Water Bank
mg/L = milligrams per liter
ng/L = nanogramers per liter
MO = Measurable Objective
MT = Minimum Threshold
NKWSD = North Kern Water Storage District
pCi/L = picocuries per liter
RMW = Representative Monitoring Well
RRBWSD = Rosedale-Rio Bravo Water Storage District GSA
SSJMUD = Southern San Joaquin Municipal Utility District
SWID = Shafter-Wasco Irrigation District
SWSD = Semitropic Water Storage District
TDS = total dissolved solids
TCP = 1,2,3-trichloropropane
ug/L = micrograms per liter
WDWA = Westside District Water Authority
WRMWSD = Wheeler-Ridge Maricopa Water Storage District

This page intentionally left blank.

13.3.2.2 Relationship with Other Sustainability Indicators

☑ **23 CCR § 354.28(b)(2)**

The MTs for Degraded Water Quality were designed to ensure that they are sufficiently protective of URs defined for all other relevant Sustainability Indicators to the Subbasin. The specific relationships between Degraded Water Quality and other applicable Sustainability Indicators are discussed below.

- A direct correlation has been observed between **Degraded Water Quality** and **Chronic Lowering of Groundwater Levels** (and **Reduction of Groundwater Storage**, by proxy) in some areas of the Subbasin. The relationship between water levels and water quality for each COC is described in detail in Section 8.4.1. RMW-WQs have been selected in areas where a correlation has been observed between groundwater levels and water quality to facilitate ongoing monitoring and reporting in these areas potentially affected by groundwater management activities and to protect beneficial users.
- **Land Subsidence** has been predicted to increase arsenic concentrations due to release from clay minerals (Smith et al., 2018). However, this has not been observed in most of the Central Valley, including the Subbasin (Haugen et al., 2021). Concentrations of arsenic were plotted against annual Interferometric Synthetic Aperture Radar (InSAR) subsidence rates at two RMW-WQs in the North Basin HCM Area near the northern Subbasin boundary. Arsenic concentration trends in these RMW-WQs showed weak and opposite correlations with subsidence, supporting the finding that a correlation between arsenic concentrations and subsidence has not been observed in the Subbasin (Figure 13-16). Potential increases in arsenic due subsidence will be monitored and managed per the SMCs established for Degraded Water Quality. There has been no observed correlation between Land Subsidence and other water quality COCs in the Subbasin; however, RMW-WQs have been selected in areas with historical subsidence to continue to monitor the potential relationship between subsidence and arsenic.

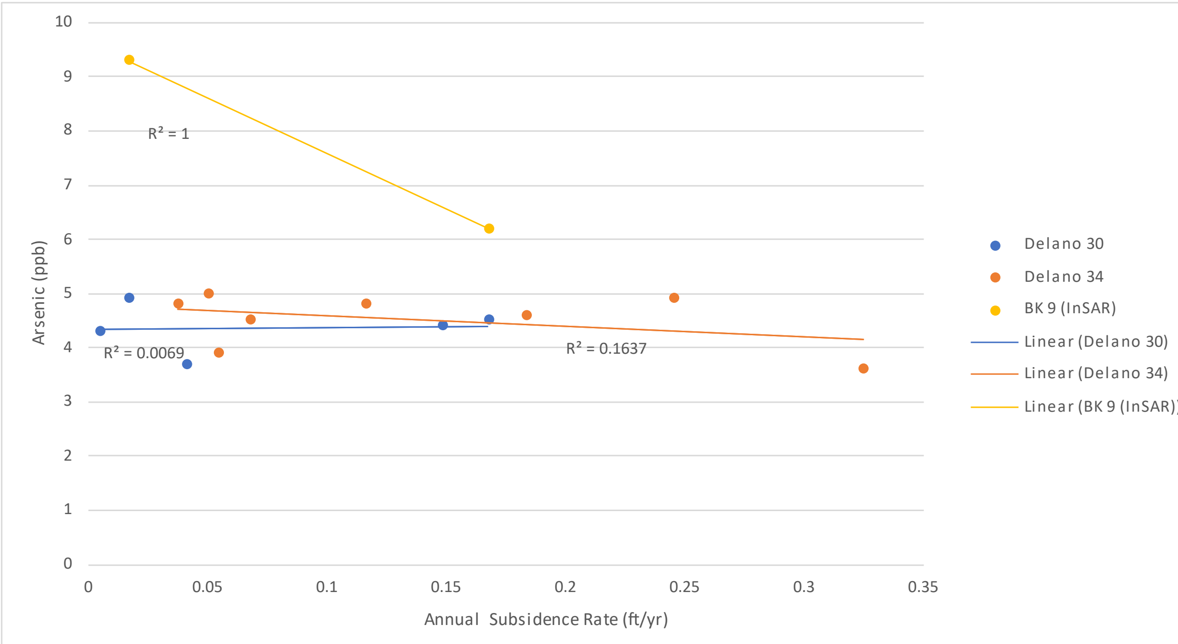


Figure 13-16. Arsenic Concentrations vs. Annual Subsidence Rates

13.3.2.3 Consideration of Adjacent Basins

☑ **23 CCR § 354.28(b)(3)**

The MTs for Degraded Water Quality are not expected to impact adjacent basins' ability to achieve their Sustainability Goals, as MTs are set based on regulatory thresholds or pre-SGMA concentrations. Groundwater flow exits the Subbasin across the northern Subbasin boundary (Figure 8-1). All adjacent basins (the Tule, Tulare Lake, and White Wolf Subbasins) have similarly committed to preventing further groundwater quality degradation beyond MCLs or pre-SGMA baseline conditions.

Additionally, the Chronic Lowering of Groundwater Levels MTs are not expected to cause significant changes to existing local groundwater gradients (Section 13.1.2.3) and are thus anticipated to be protective in terms of preventing migration of poor-quality water from or into the Subbasin.

13.3.2.4 Impact to Beneficial Users

☑ **23 CCR § 354.28(b)(4)**

Primary MCLs are regulatory thresholds based on criteria for drinking water quality, which is the most sensitive beneficial use. As such, the MT for Degraded Water Quality considers the most vulnerable beneficial uses and users of groundwater.

Furthermore, the Chronic Lowering of Groundwater Levels MTs generally maintain existing local groundwater gradients and are thus anticipated to be protective in terms of preventing migration of poor-quality water within the Subbasin. As described in Section

15.2.1, three sentinel wells exist in areas of groundwater flow from the Western Fold Belt HCM area into the adjacent down gradient North Basin HCM Area. These wells will monitor for transition in groundwater level and quality.

13.3.2.5 State, Federal, and Local Standards

☑ **23 CCR § 354.29(b)(5)**

The State of California and the USEPA set primary MCLs for constituents that may pose potential human health risks. State, federal, and local entities have greater authority to enforce water quality standards, especially for anthropogenic-derived pollutant constituents. For example, drinking water supplies from public water systems are regulated to primary MCLs set by the USEPA and SWRCB Division of Drinking Water. Water quality issues related to waste discharge into the groundwater aquifer are regulated separately via the CVRWQB's Basin Planning process and the issuance of Waste Discharge Requirements.

Given the limited regulatory authority of GSAs with respect to water quality, it is not appropriate to consider setting the MTs lower than the MCLs. Therefore, the MTs for Degraded Water Quality are set at the COC's respective MCLs and SMCLs. It should be noted that monitoring for these and other water quality parameters will continue to be conducted at all water quality monitoring well locations, as discussed in Section 15.3.3.

13.3.2.6 Measurement of Minimum Thresholds

☑ **23 CCR § 354.24**

Compliance with the Degraded Water Quality MTs will be based on monitoring data collected semi-annually for the Subbasin's RMW-WQs with established SMCs in accordance with the monitoring protocols described in Section 15.3.3 and in the Coordination Agreement.

13.3.3 Measurable Objective and Interim Milestones for Degraded Water Quality

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(e)**

As with the MTs, the MOs for Degraded Water Quality are defined at RMW-WQs in the Subbasin for key COCs: arsenic, total nitrate/nitrite (as N), nitrate, nitrite[10], TDS, 1,2,3-TCP, and uranium. Similar to the MTs, the MOs for Degraded Water Quality are set as the greater concentration of (1) the applicable health-based screening standard (Table

13-6) or (2) the median 2010 to 2014 baseline concentration at each RMW-WQ[13]. For wells with insufficient 2010 to 2014 data, 2010 to 2023 data is used to determine median baseline concentration at each RMW-WQ. For wells with insufficient 2010 to 2023 data, the MO is set as the 90th percentile 2010 to 2023 baseline concentration in the applicable HCM area. MOs for Degraded Water Quality in each RMW-WQ are shown in Table 13-7.

The MOs are set in recognition that per the State's Antidegradation Policy (Resolution No. 68-16), further degradation would pose an unacceptable risk to the Subbasin's drinking water users.

The IMs for Degraded Water Quality are set at the same value as the MTs for each RMW-WQ, in line with the Subbasin's commitment to not allow further degradation of water quality beyond existing regulatory thresholds or, in areas that are naturally or otherwise degraded before the SGMA effective date, beyond their pre-SGMA baseline levels. The IMs and MOs for Degraded Water Quality are shown by RMW-WQ in Table 13-7.

13.4 Seawater Intrusion

§ 354.28. *Undesirable Results*
(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.
§ 354.28. *Minimum Thresholds*
(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

- *(3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:*
  - *(A) Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.*
  - *(B) A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.*

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

---

[13] Non-detect measurements for 1,2,3-TCP collected prior to 2018 were not included in the 2010-2014 baseline calculation because the detection level for purposes of reporting (DLR) was established in December 2017. Therefore, pre-2018 non-detect measurements may not represent the 1,2,3-TCP DLR of 0.005 µg/L.

☑ **23 CCR § 354.26(d)**
☑ **23 CCR § 354.28(c)(3)**
☑ **23 CCR § 354.28(e)**

The GSP Emergency Regulations state that “An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators” (23 CCR § 354.26(d)). Because the **Subbasin is not located near any saline water bodies, seawater intrusion is not present and not likely to occur**, and the Seawater Intrusion Sustainability Indicator is not applicable. Therefore, no SMCs for this Sustainability Indicator are defined in the Subbasin.

13.5 Land Subsidence

As discussed in Section 8.5.2, Land Subsidence in the Subbasin is driven by several factors, including subsidence that is caused by activities within the authorities of GSAs to control (“GSA-related” subsidence) and causes of subsidence that are outside GSA authorities to control (“non-GSA” subsidence). “GSA-related” causes of land subsidence are defined herein to include groundwater pumping for agricultural and municipal and industrial (M&I) uses, which causes the depressurization of aquifers and aquitards due to lowering of groundwater levels and leads to compaction of compressible strata and lowering of the ground surface. “Non-GSA” causes of land subsidence are defined herein to include expansive soil types susceptible to hydro-compaction that can affect infrastructure integrity, oil, and gas extraction (Section 8.5.2), age of critical infrastructure, historical geotechnical deficiencies (e.g., lack of pre-construction hydro-compaction on the Aqueduct) and subsidence caused by natural processes such as faulting (Section 7.1.6.5).

13.5.1 Undesirable Results for Land Subsidence

SGMA defines an UR for Land Subsidence as “significant and unreasonable land subsidence that substantially interferes with surface land uses” (CWC § 10721(x)).

The Subbasin-wide UR for Land Subsidence is defined as follows:

> *The point at which the amount of subsidence, if caused by GSA-related Subbasin groundwater extractions, creates a significant and unreasonable impact (requiring either retrofitting or replacement to a point that is economically unfeasible to the beneficial users) to surface land uses or critical infrastructure. A significant loss in functionality that could be mitigated through retrofitting and is considered economically feasible to the beneficial users would not be considered undesirable.*

13.5.1.1 Identification of Beneficial Users

23 CCR § 354.26(b)(3) states that the description of URs should include: "P*otential 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*." Beneficial users of groundwater that could experience potential URs caused by Land Subsidence include all groundwater production wells in the Subbasin, as described in Section 13.1.1.1. Although critical infrastructure is not defined as a beneficial user in CWC § 10723.2, it is still considered as a land use and property interest in the development of SMCs for Land Subsidence. Specifically, this Plan considers infrastructure used for water conveyance, transportation, flood control, and the interstate gas distribution pipelines to be land use and property interests that could be affected by URs for Land Subsidence. These infrastructure types are categorized based on their subsidence vulnerability and impacts to beneficial users and only a subset of these infrastructure types have local SMCs established, as presented in Section 13.5.2.4.

In order to identify and classify infrastructure in the Subbasin potentially affected by land subsidence, the Subbasin has adopted three classifications for critical infrastructure, Regional Critical Infrastructure, GSA Area Critical Infrastructure, and other infrastructure which are defined as follows.

Regional Critical Infrastructure is defined as infrastructure located within the Subbasin that serves multiple areas of the Subbasin and whose loss of significant functionality due to subsidence, if caused by GSA-related Subbasin groundwater extractions, would have significant impacts to beneficial users. The Subbasin has collectively determined that the only infrastructure that meets the definition for Regional Critical Infrastructure are the California Aqueduct and the Friant-Kern Canal.

GSA Area Critical Infrastructure is defined as infrastructure located within a particular GSA whose loss of significant functionality due to subsidence if caused by GSA-related Subbasin groundwater extractions would have significant impacts to beneficial users within that GSA. Each Subbasin GSA has identified their respective GSA Area Critical Infrastructure.

Other infrastructure is defined as other water supply, water conveyance, water treatment, transportation, or interstate gas distribution pipelines not included under Regional Critical Infrastructure or GSA Area Critical Infrastructure.

Using the above classifications, the Subbasin GSAs identified Regional and GSA Area Critical Infrastructure that could be significantly and unreasonably affected by land subsidence within their jurisdictions where applicable. Figure 13-17 through Figure 13-19 show all identified critical infrastructure within the Subbasin that could be potentially impacted by subsidence. As shown on Figure 13-17, Regional Critical Infrastructure includes the Friant-Kern Canal (FKC) and the California Aqueduct

(Aqueduct). As shown on Figure 13-18, GSA Area Critical Infrastructure includes the Calloway Canal, Lerdo Canal, Beardsley Canal, Cross Valley Canal, Kern River Canal, Arvin-Edison Water Storage District Canal, Olcese Canal, Interstate-5 (I-5), and Highway 99. Other infrastructure, as shown on Figure 13-19, includes wells, railroads, interstate gas pipelines, county roadways, and other locally identified water facilities, and as these were determined to have minimal subsidence-related risks (see Section 13.5.2.4).

This page intentionally left blank.

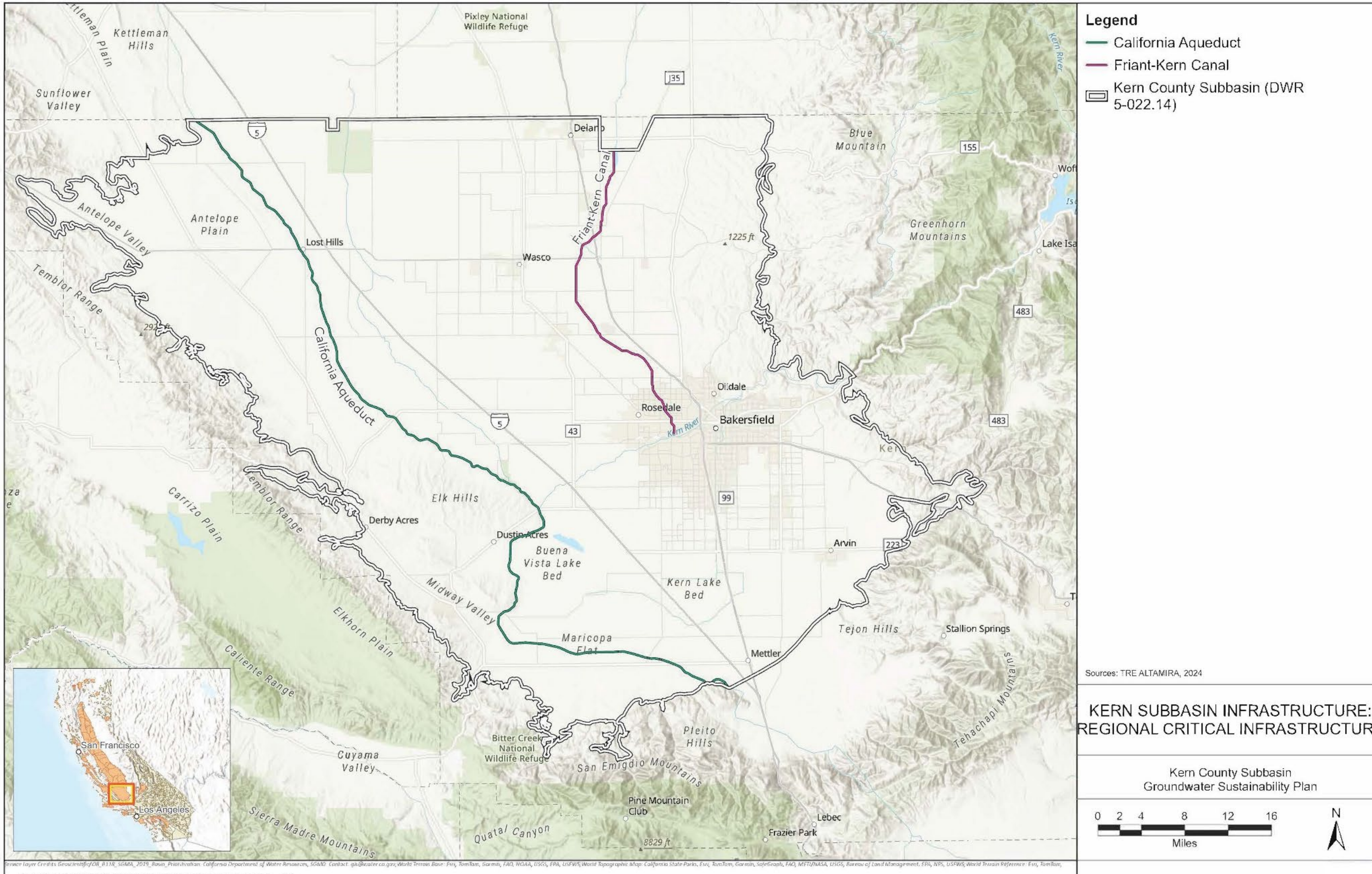


Figure 13-17. Kern Subbasin Infrastructure: Regional Critical Infrastructure

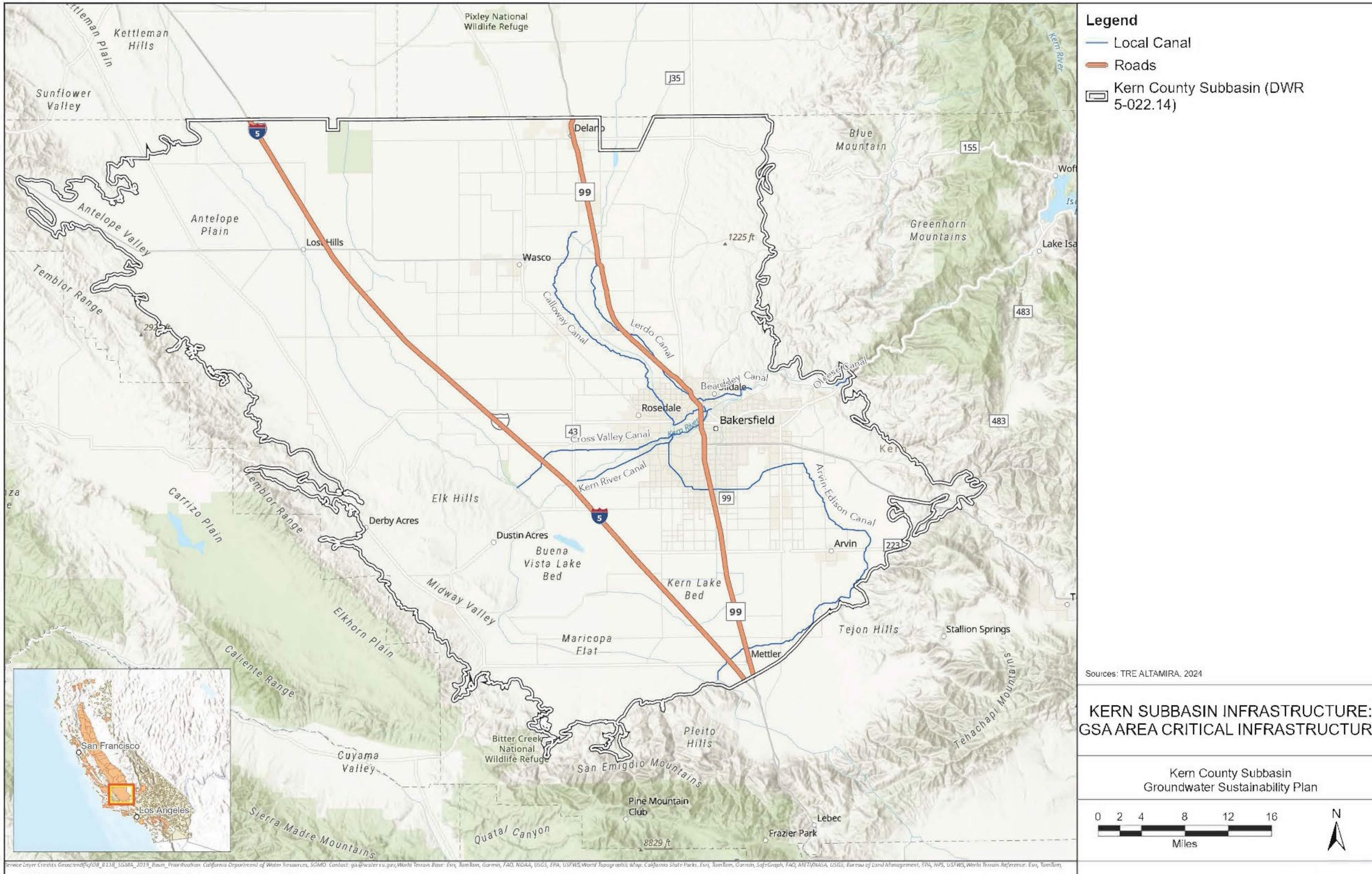


Figure 13-18. Kern Subbasin Infrastructure: GSA Area Critical Infrastructure

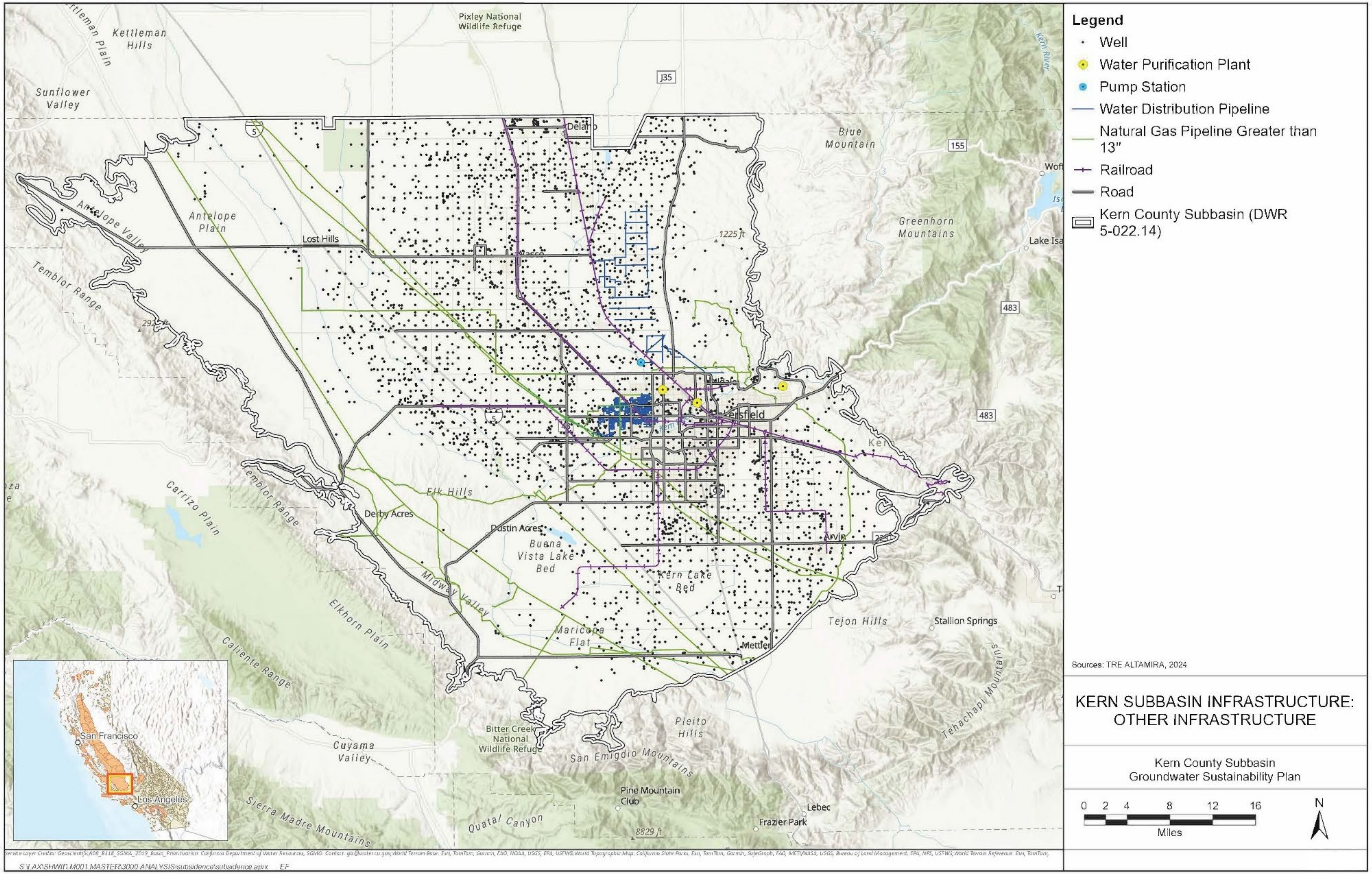


Figure 13-19. Kern Subbasin Infrastructure: Other Infrastructure

This page intentionally left blank.

13.5.1.2 Potential Effects of Undesirable Results on Beneficial Users

☑ 23 CCR § 354.26(b)(3)

Potential effects of URs caused by Land Subsidence on beneficial uses and users of groundwater and the Regional and GSA Area Critical Infrastructure include, but are not limited to, potentially altering the land surface in ways that could damage well casings, gravity-driven water conveyance infrastructure (i.e., lined and unlined canals), and other linear infrastructure (e.g., transportation and utilities). These impacts may result in loss of surface water delivery capacity, increase flooding risk, disrupt essential services such as domestic water supply, cause property damage, and jeopardize public safety for beneficial users.

13.5.1.3 Potential Causes of Undesirable Results

☑ 23 CCR § 354.26(b)(1)

Land subsidence can be caused by several mechanisms, but the mechanism most relevant to sustainable groundwater management activities under the authority of GSAs is the depressurization of aquifers and aquitards due to lowering of groundwater levels from increased groundwater pumping or reduced recharge, leading to compaction of compressible strata and lowering of the ground surface. Therefore, the potential GSA-related causes of URs due to Land Subsidence are increased pumping and/or reduced recharge in areas underlain by compressible strata.

Other non-GSA causes of land subsidence include hydro-compaction of expansive soils, oil and gas activities, age of infrastructure, natural geologic processes (e.g., faulting), and residual subsidence attributable to non-GSA or pre-SGMA (prior to January 2015) activities.

13.5.1.4 Criteria Used to Define Undesirable Results

☑ 23 CCR § 354.26(b)(2)

In consideration of the risk-based approach described below, the criteria for URs caused by Land Subsidence are as follows:

> *URs for Land Subsidence are defined to occur within the Subbasin if and when the MT extent of subsidence is exceeded at any of the Subbasin's Representative Monitoring Sites for Land Subsidence (RMS-LS) or as measured using InSAR data published annually by DWR averaged across an HCM area.*

These criteria for URs are justified because an exceedance of the MT extent of GSA-related subsidence at any RMS-LS could interfere with the functionality of critical infrastructure and require significant mitigation to avoid impacts to beneficial users. Only the exceedance of the MT extent of subsidence triggers a UR. Per the Subbasin's MT exceedance policy (Section 16.2.1), exceedance of the MT subsidence rate in any one year would trigger monitoring, and exceedance of the MT rate over two years would trigger investigation and potential initiation of P/MAs.

13.5.2 Minimum Threshold for Land Subsidence

§ 354.28. *Minimum Thresholds*

(b) Minimum thresholds for each sustainability indicator shall be defined as follows:

1. *Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:*
   - *Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.*
   - *Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.*

MTs for Land Subsidence are defined herein as levels of land subsidence that, if they occurred, would result in URs to surface land uses and Regional and GSA Area Critical Infrastructure, which is identified in Section 13.5.1.1. The MTs defined below are in terms of total vertical extent of land subsidence (in feet) from 2024-2040, as well as a corresponding average annual rate of subsidence (in feet per year) measured quarterly and reported annually to align with the Annual Report cycle. These MTs also inform the MOs and IMs defined in Section 13.5.3.

13.5.2.1 Minimum Threshold Development

☑ **23 CCR § 354.28(b)(1)**
☑ **23 CCR § 354.28(c)(5)**

A coordinated approach was developed by the Subbasin to identify and evaluate potential subsidence impacts that substantially interfere with surface land uses and are caused by GSA groundwater extractions within the Subbasin. This process is outlined below and shown in Figure 13-20.

<u>Step #1: Identify areas with historical land subsidence or potential for future land subsidence</u>

Section 8.5 documents the spatial extent and magnitude of historical subsidence in the Subbasin and identifies areas susceptible to future subsidence. Most of the Subbasin has potential for future subsidence, except along the western and eastern margins of the Subbasin and at alluvial fans where coarser sediment types have less potential for subsidence.

MTs are set for the entire Subbasin as the maximum observed average subsidence rate in each HCM area from 2015 to 2023 as determined by InSAR data published by DWR (Figure 8-49). Separate SMCs are established in areas susceptible to future land subsidence, as discussed below.

Step #2: Identify areas of the Subbasin where Agricultural and M&I pumping (i.e., GSA-related causes) occur and potentially contribute to subsidence

Agricultural and M&I pumping primarily occur in the central portion of the Subbasin, as shown in Figure 8-59. Subsidence in other portions of the Subbasin is primarily driven by non-GSA causes.

For areas where subsidence has been attributed to non-GSA causes and that are outside of the vicinity of Regional Critical Infrastructure, the MT rates are set as the observed average subsidence rate in each HCM area from 2015 to 2023 and the MT extent is set as the cumulative amount of subsidence at that rate from 2024 to 2040[14]. As such, the Subbasin will continue to monitor and report subsidence in these areas, with the recognition that the GSAs will likely need to coordinate with multiple entities that are influenced by land subsidence from non-GSA causes. If non-GSA causes of subsidence are contributing to subsidence along critical infrastructure, the GSAs will work collaboratively with the relevant regulatory agency (e.g., DWR's California Aqueduct Subsidence Program [CASP]) to provide data from the GSA demonstrating the lack of GSA activities contributing to subsidence in the area.

[14] For example, if an HCM area has an average rate of subsidence of 0.05 ft/year from 2015 through 2023, then the MT rate for that HCM area would be 0.05 ft/year of average annual subsidence and the MT extent would be 0.05 ft/year x 16 years = 0.8 ft of average cumulative subsidence through 2040.

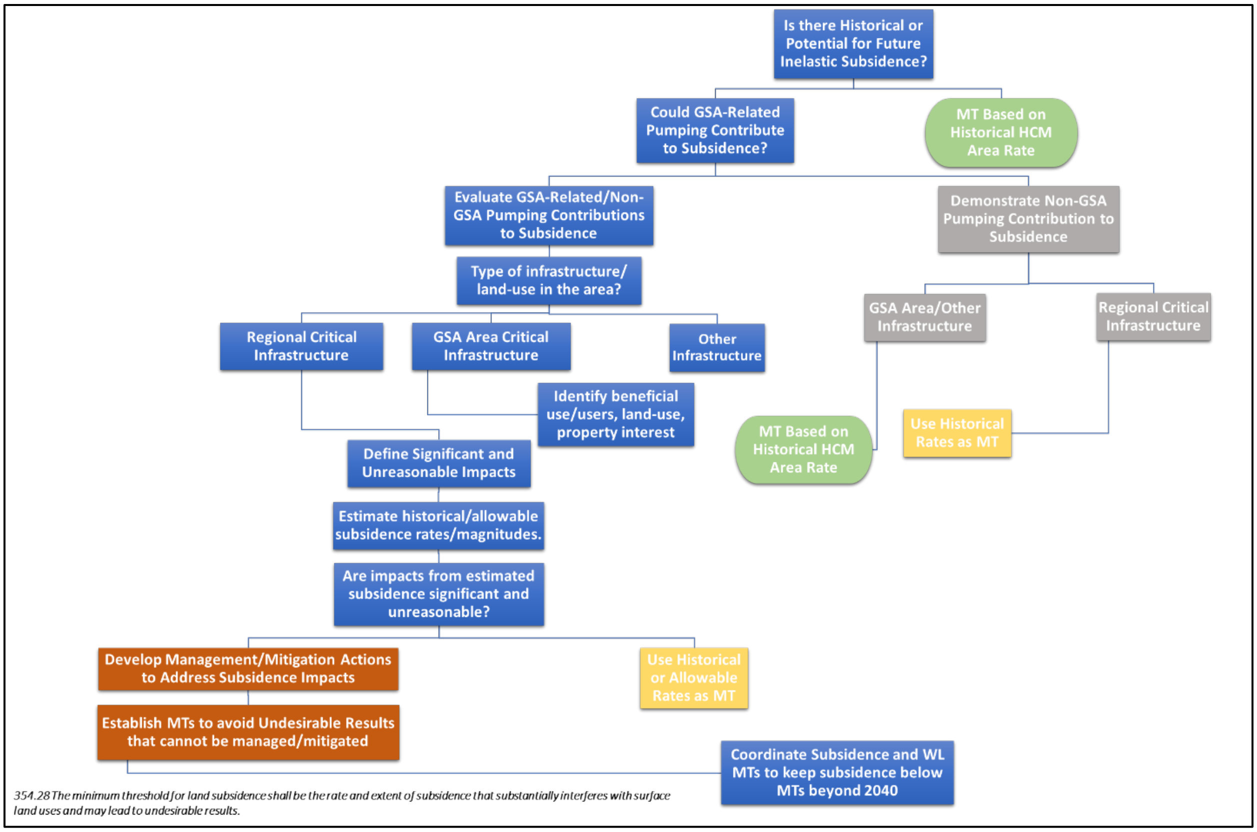


Figure 13-20. Approach to Develop SMCs for Land Subsidence

<u>Step #3: Classify the potential for subsidence due to GSA-related activities to cause significant and unreasonable impacts</u>

For areas of the Subbasin with agricultural or M&I pumping (i.e., GSA-related subsidence), subsidence potential was classified into four categories (High, Moderate, Low, and Minimal) based on the historical cumulative subsidence extent from 2015 to 2023 as reported by InSAR data:

- **High:** Greater than 3 feet
- **Moderate:** 1 to 3 feet
- **Low:** 0.33 to 1 foot
- **Minimal:** Less than 0.33 feet

As discussed in Section 8.5.1.3, areas with high subsidence potential do not exist within the Subbasin but exist north of the Subbasin in Tule and Tulare Lake Subbasins (Figure 8-50). As shown in Figure 13-21, areas with moderate subsidence potential (i.e., 1 to 3 feet from 2015 to 2023) primarily exist along the northern boundary of the Subbasin and are likely associated with higher rates of subsidence documented north of the Subbasin. Other isolated areas of moderate subsidence potential have been identified within the Subbasin, some of which may be associated with non-GSA factors.

Areas with low subsidence potential (0.33 to 1 foot from 2015 to 2023) generally are concomitant with the moderate subsidence areas and are in areas of higher groundwater extraction per square mile (see Figure 13-21). Areas with minimal subsidence potential (i.e., less than 0.33 feet from 2015 to 2023) cover the majority of the Subbasin and are associated with groundwater extractions ranging from 100 to greater than 2,000 AF per square mile (see Figure 13-21).

This page intentionally left blank.

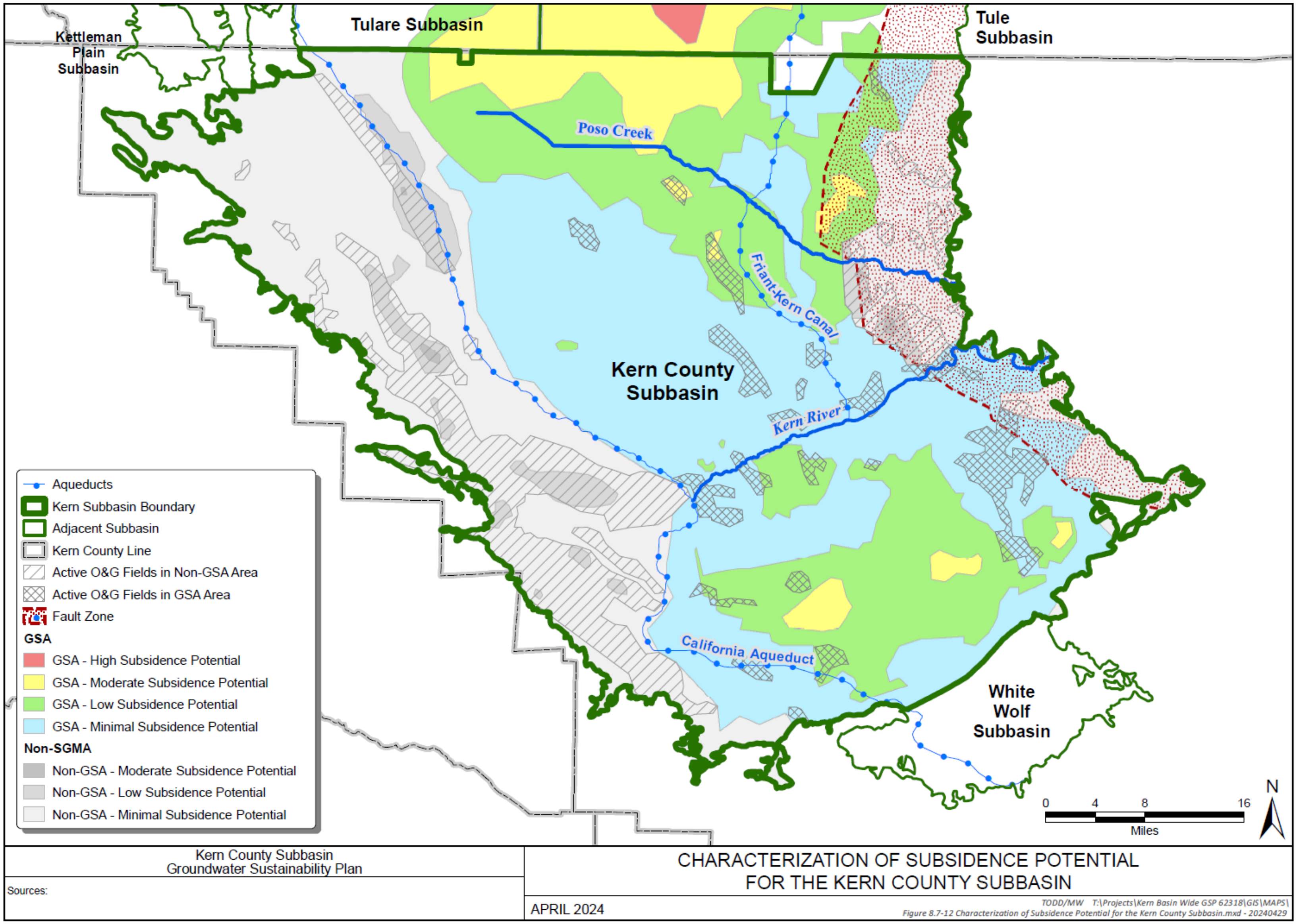


Figure 13-21. Characterizing Land Subsidence Potential

This page intentionally left blank.

Step #4: Project Future Rates and Extents of Subsidence to Assess Potential Significant and Unreasonable Impacts on Infrastructure

Historical (2015 – 2023) rates and extent of subsidence (as obtained from InSAR, GPS, extensometer, and benchmark data) are not known to have caused significant and unreasonable impacts within the Kern Subbasin. Note, that the historical subsidence observed in the Kern Subbasin includes GSA-related, non-GSA related, and residual (due to pre-2015 activities) subsidence (Section 8.5.2). This Subbasin Plan proposes stabilizing water levels by 2030 (Section 13.1.3.2), hence future rates and extents of subsidence are likely expected to be less than historical in areas where GSA-related activities will stop chronic lowering of groundwater levels, effectively minimizing subsidence beyond 2030. However, residual (due to pre-2030 activities) and non-GSA related subsidence may continue beyond 2030. As such, a conservative approach was taken to estimate the maximum future potential subsidence by extrapolating historical (2015 to 2023) rates of subsidence from 2024 to 2040. Figure 13-22 shows the historical (2015 to 2023) extent of subsidence based on the InSAR data. Figure 13-23 shows the historical rate and cumulative subsidence averaged for each HCM area. Figure 13-23 also reports the maximum cumulative subsidence within each HCM area. As can be seen the maximum extent of subsidence observed from 2015 to 2023 in the Kern Subbasin was 2.37 feet at the northern boundary of the subbasin, correlated with much higher subsidence rates observed north of the Kern Subbasin.

The historical rates of subsidence were extrapolated forward through 2040 to estimate a conservative maximum extent of future subsidence (actual subsidence in the Kern Subbasin is expected to be less than these amounts as water levels are expected to stabilize by 2030). Figure 13-24 and Figure 13-25 shows the spatial distribution and HCM area averages for the maximum amount of subsidence (conservatively) estimated from 2024 to 2040. As can be seen the estimated maximum amount of subsidence in the Kern Subbasin from 2024 to 2040 is 4.41 feet at the northern boundary of the Kern Subbasin, associated with the historically high rates of subsidence seen in areas north of the Kern Subbasin boundary. The average amount of future subsidence for any given HCM area ranges from 0.1 ft to 0.85 feet (Figure 13-25).

This page intentionally left blank.

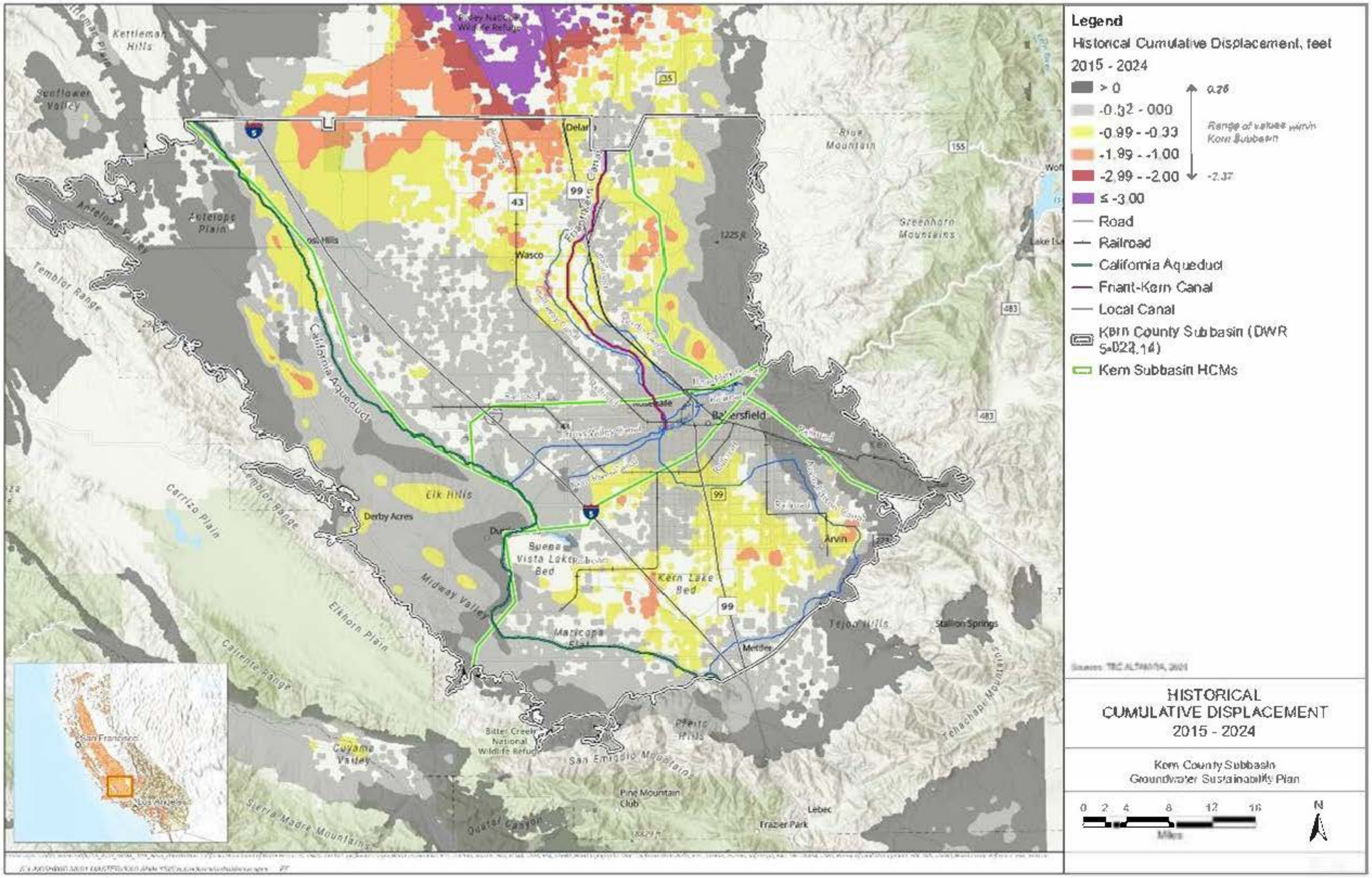


Figure 13-22. Historical (2015 – 2023) Subsidence Extents15

---

15 Inclusive of GSA-related, non-GSA, and residual subsidence as observed based on InSAR data from 2015 to 2023.

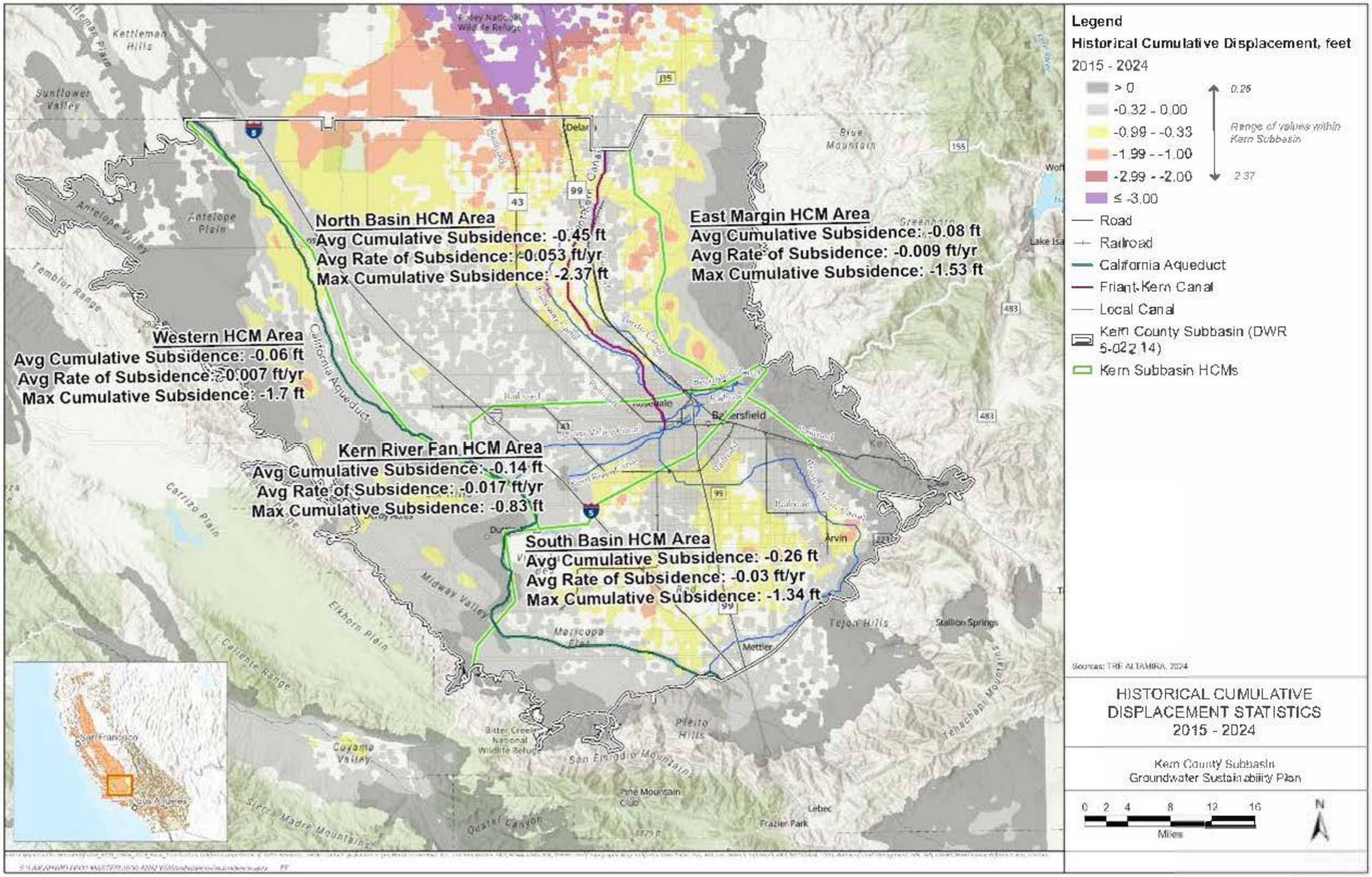


Figure 13-23. Historical (2015 – 2023) Rate, Average, and Maximum Subsidence Extents[17] for each HCM area

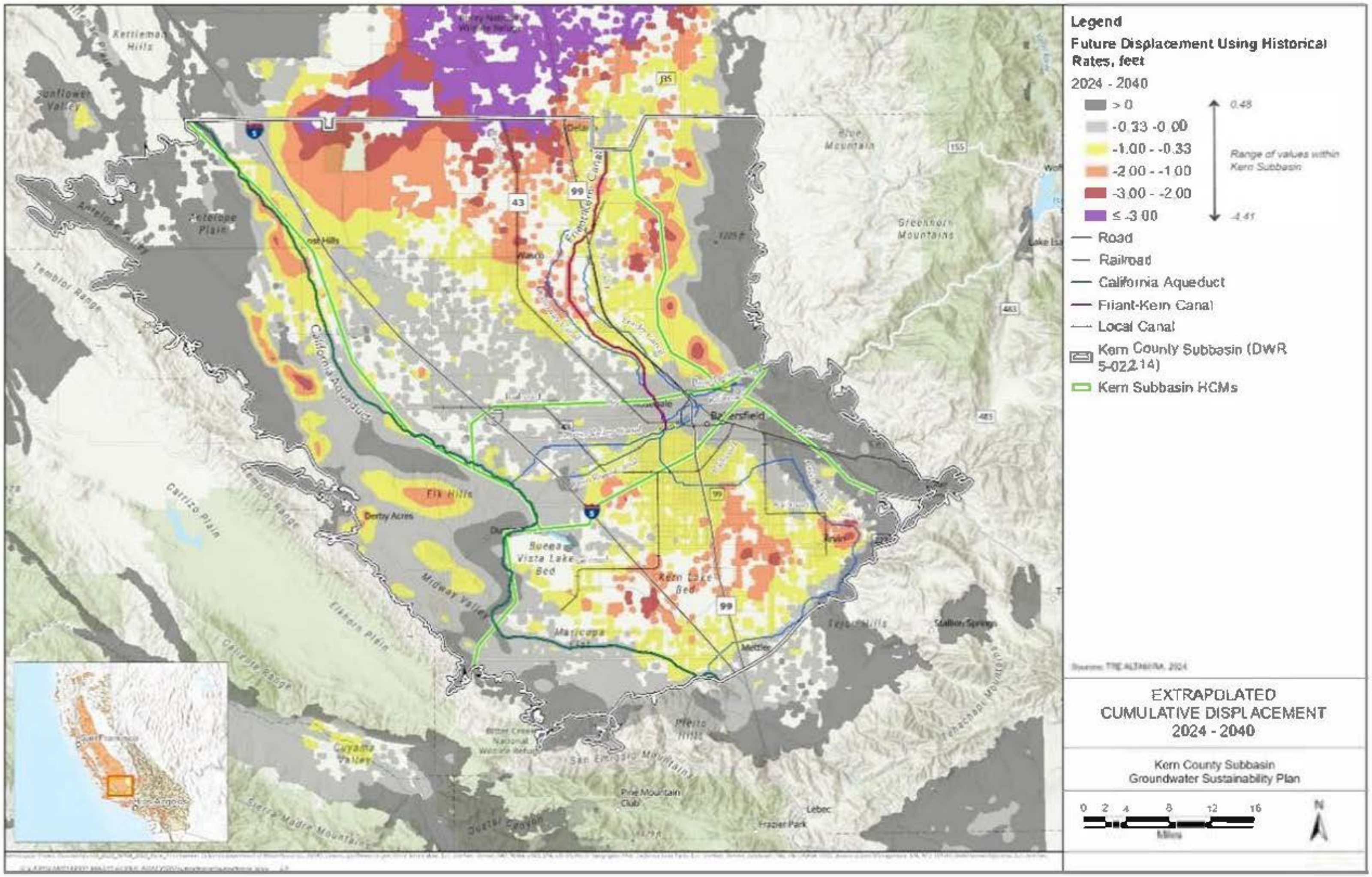


Figure 13-24. Conservative Estimates of Maximum Future (2024 – 2040) Subsidence Extents[16]

[16] Inclusive of GSA-related, non-GSA, and residual (from pre-2030 activities) subsidence. Future estimates are based on 2015 – 2023 rates of subsidence extrapolated through 2040.

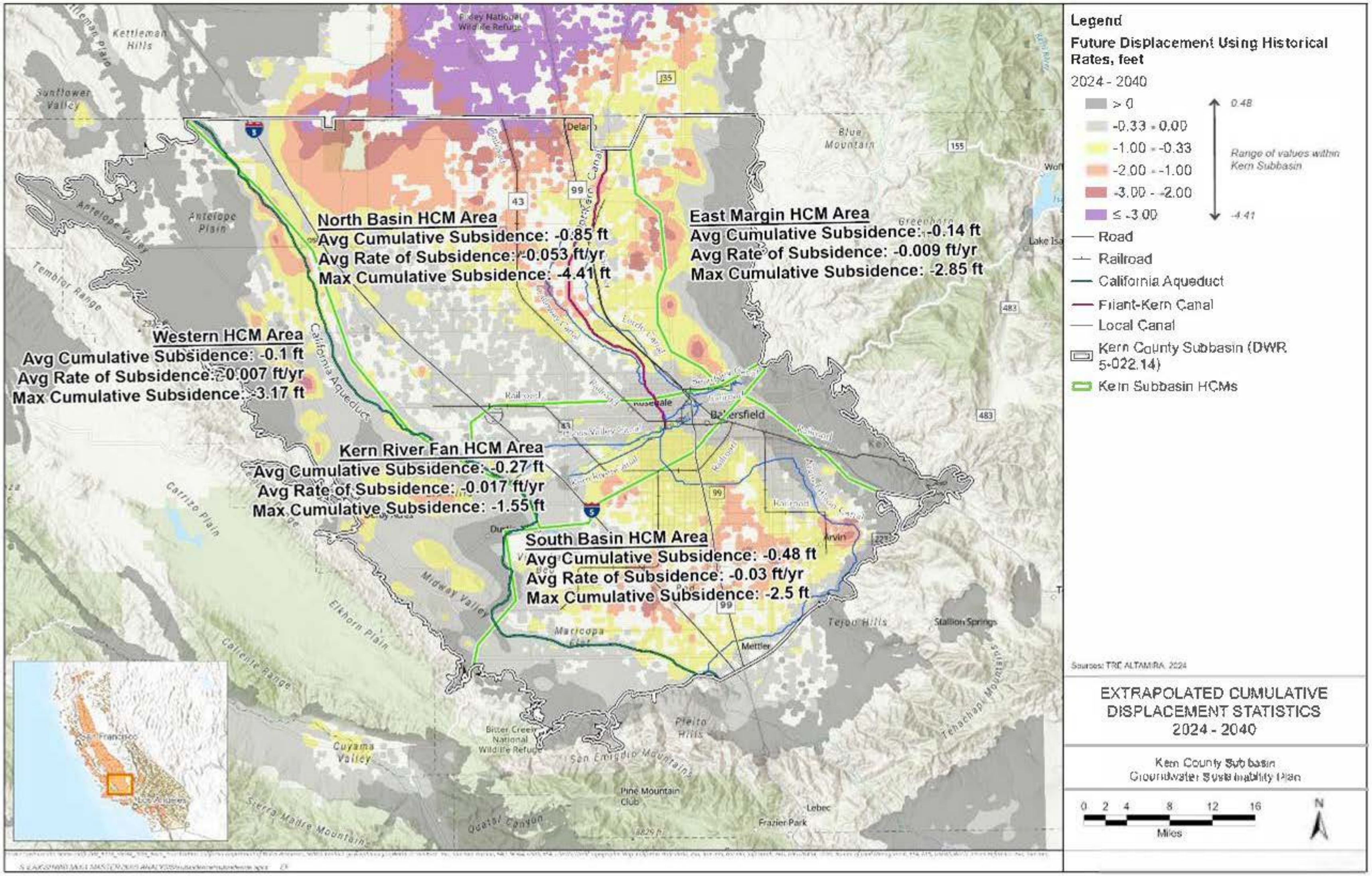


Figure 13-25. Conservative Estimates of Maximum Future (2024 – 2040) Rate, Average, and Maximum Subsidence Extents for each HCM area[18]

Infrastructure can be impacted by both absolute subsidence extent as well as differential subsidence, where different parts of the infrastructure subside at different rates leading to issues like buckling and fissures along roads, rupture of pipelines, etc. Potential for future differential subsidence was ascertained by calculating the change in slope along Regional Critical Infrastructure, GSA Area Critical Infrastructure, and selected other infrastructure from 2024 to 2040, based on the 2023 and projected 2040 subsidence extent maps (Figure 13-22 and Figure 13-24). Some other infrastructure (interstate gas pipelines, and other local water supply, conveyance, and treatment facilities) were not included in the differential subsidence analysis, as GSAs do not have access to the necessary information to assess Subbasin-wide subsidence impacts on these other infrastructure. Current and projected rates of differential subsidence across the Subbasin are low and are not expected to cause Undesirable Results along other infrastructure. During Plan implementation, the GSAs will continue to engage with beneficial users of these other infrastructure to assess potential for subsidence-related impacts.

Figure 13-26 and Figure 13-27 show cumulative subsidence and the change in slope (reported as change in vertical feet over 1000 horizontal feet) along critical infrastructure assessed for potential impacts. As can be seen, for most of the critical infrastructure, the change in slope is less than 0.1 feet/1000 feet (less than 0.01%), which is a negligible amount well within the uncertainty of the InSAR data. The maximum change in slope is 0.33 feet/1000 feet (0.033 %), in a small area to the southeast.

This page intentionally left blank.

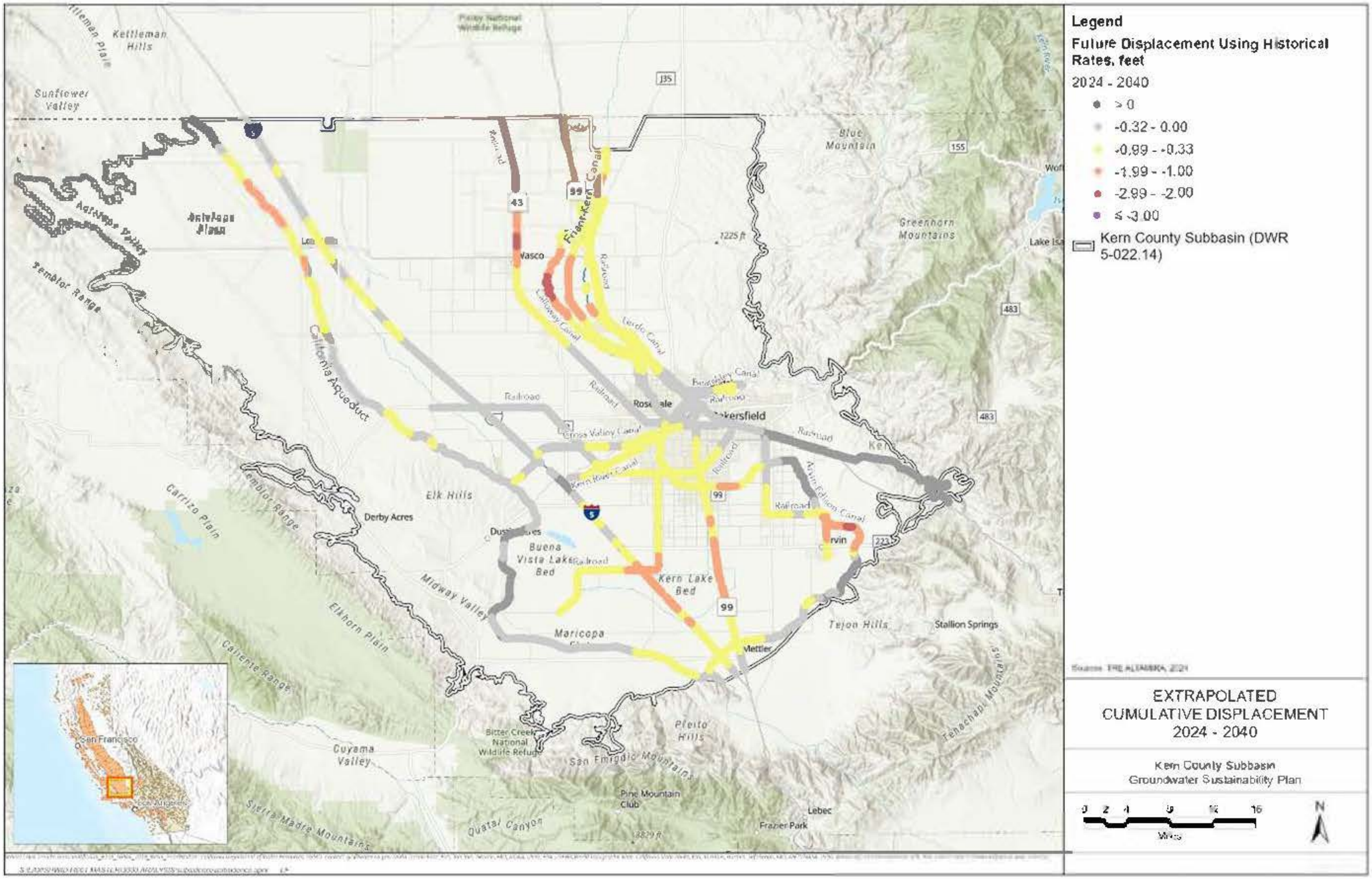


Figure 13-26. Conservative Estimates of Maximum Future (2024 – 2040) Cumulative Subsidence along Critical Infrastructure

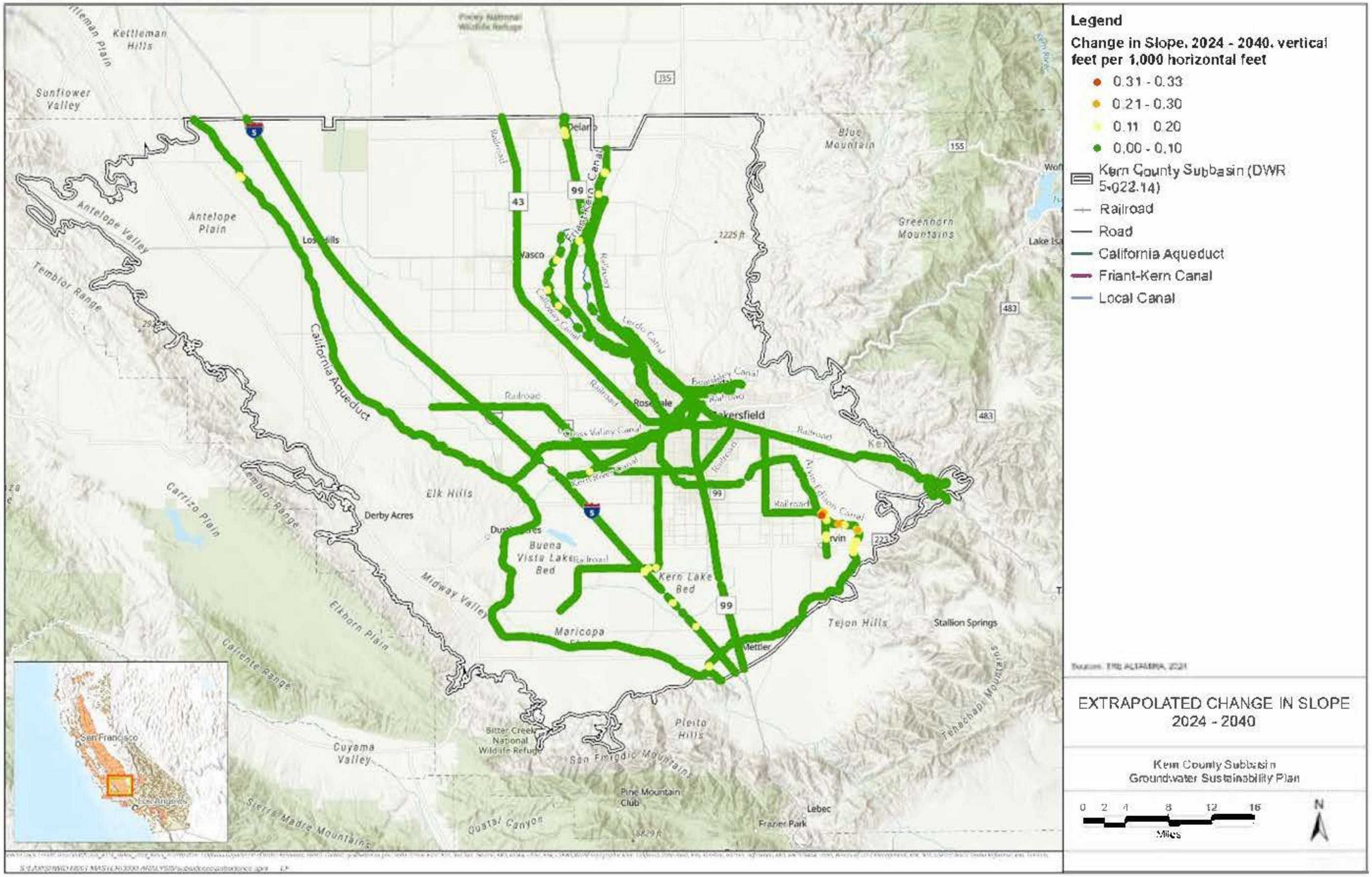


Figure 13-27. Change in Slope (vertical feet per 1000 horizontal feet) along Critical Infrastructure from 2024 – 2040 based on Projected Subsidence Extent

These conservative estimates of maximum future subsidence and change in slope were then assessed for potential impacts on infrastructure within the Kern Subbasin to develop risk-based subsidence SMCs as described below.

Step #5: Develop Risk-Based SMCs

A risk-based approach to develop SMCs for Land Subsidence is shown in Table 13-8. The risk-based SMCs consider both the subsidence potential identified in Step #3 and the vulnerability of surface land uses to impacts caused by subsidence (i.e., Risk = Subsidence Potential * Vulnerability). The vulnerability ranking is depicted by the cell color in Table 13-8 and has the same categories (i.e., High, Moderate, Low, and Minimal) as subsidence potential. Gravity-driven infrastructure is highly susceptible to subsidence because flooding and loss of conveyance capacity may result from low rates of subsidence, whereas other types of infrastructure can tolerate moderate to even high rates of regional subsidence without experiencing URs.

As shown in Table 13-8, SMCs and/or proposed monitoring were developed using the risk-based framework based on infrastructure type (i.e., Regional Critical Infrastructure, GSA Area Critical Infrastructure, or other infrastructure). For Regional Critical Infrastructure, MTs are proposed based on the observed and allowable rates of subsidence. For GSA Area Critical Infrastructure, MTs are proposed for infrastructure with low to high potential and vulnerability to subsidence. For all other infrastructure and areas of the Subbasin with minimal subsidence potential (Step #3), the Subbasin has set SMCs based on the historical rate of subsidence by HCM area. MTs set for all Regional and GSA Area Critical Infrastructure, and HCM areas are further discussed below.

Table 13-8. Subsidence Potential, Vulnerability and Risk to Infrastructure

Subsidence Cause	Subsidence Potential	Regional Critical Infrastructure[1]	GSA Area Critical Infrastructure[1]	Other Infrastructure[1]
Activities Within GSA Authority (GSA-Related)	High[3]	N/A[3]	N/A[3]	N/A[3]
	Moderate	Impact-Based SMC[2]	SMC Based on Historical or Allowable Rate[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]
	Low	Impact-Based or SMC Based on Historical or Allowable Rate[2]	SMC Based on Historical or Allowable Rate[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]
	Minimal	SMC Based on Historical or Allowable Rate[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]
Activities outside GSA Authority (Non-GSA)	N/A	SMC Based on Historical or Allowable Rate[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]	SMC based on Historical HCM Area Rate (Table 13-13)[2]

[1] Colored cells correspond to subsidence vulnerability. Dark orange = High vulnerability; Light orange = medium vulnerability; Yellow = Low vulnerability; No fill = Minimal vulnerability

[2] An impact-based SMC entails assessing impacts on infrastructure from future subsidence. If the impacts are found to be significant and unreasonable then mitigation and/or P/MA are proposed to avoid URs. A historical or allowable rate is chosen as the SMC if future subsidence at historical or higher allowable extent of subsidence is not likely to cause significant and unreasonable impacts to the given infrastructure.

[3] There are no areas with "High" subsidence potential within the Kern Subbasin.

This risk-based approach provides a standard guideline for GSAs to determine criteria to use when defining SMCs for Land Subsidence. The remainder of this section details the development of MTs along identified Regional and GSA Area critical infrastructure.

13.5.2.1.1 Potential Subsidence Impacts

Overall, the estimated maximum future subsidence and change in slope (Figure 13-24 through Figure 13-27) are not expected to lead to significant and unreasonable impacts, except in a section along the Friant Kern Canal (discussed in subsequent sections). The highest future subsidence extent estimated for the Kern Subbasin from 2024-2040 is 4.41 feet at the northern boundary, correlated with the much higher amounts of subsidence observed just north of the Kern Subbasin boundary. This maximum subsidence is expected to be less than that projected for this analysis, as the Tule subbasin to the north reaches sustainability and minimizes subsidence by 2040[17]. Moreover, significant and unreasonable impacts are not expected even at this amount of subsidence because a) no critical infrastructure passes through the area with the highest extent of subsidence, b) groundwater wells located in this area can tolerate this

[17] Based on the most current information obtained from Thomas Harder in March 2024, the Tule Subbasin has set their Land Subsidence Minimum Thresholds at a maximum of approximately 7 feet.

amount of subsidence as they are typically fitted with compression sections that can withstand 15 to 30 feet of subsidence (Kevin McGillicuddy, Roscoe Moss Co. 1/5/24), and c) if there are local impacts due to subsidence then these will be addressed through mitigation (Section 14.2.3, Project KSB-1) if they are impacted by GSA-related subsidence.

The rest of this section evaluates the potential impacts on regional critical infrastructure from the projected amounts of subsidence to assess if a) significant and unreasonable impacts may occur due to the estimated absolute or differential future subsidence, and b) establish SMCs to avoid any significant and unreasonable impacts to regional critical infrastructure.

Regional Critical Infrastructure

Northern California Aqueduct

The following considerations were used to establish Land Subsidence SMCs for the northern portions of the California Aqueduct, represented by Pools 23 through 30 (MP 184 to 250):

- As detailed in Section 8.5.1.5, historical subsidence has occurred along the northern portion of the Aqueduct and there is a potential for subsidence to occur in the future.
- Historical subsidence has occurred primarily as a result of non-GSA activities and conditions. Oil field activities and other non-GSA factors are well documented and extensive along the northern portion of the Aqueduct, and as such they are outside of GSA authority to manage.
- Sections of the Aqueduct that fall within the Subbasin have been identified as Regional Critical Infrastructure.

Following the decision tree (Figure 13-20) for the above considerations, MTs are set as an observed or allowable rate of subsidence. This determination is supported by the subsidence risk matrix (Table 13-8), where the northern portion of the Aqueduct was determined to have a low vulnerability ranking based on its designation as a Regional Critical Infrastructure with primarily non-GSA causes of subsidence.

The MT for Land Subsidence along the northern portion of the Aqueduct (i.e., within the 5-mile-wide CASP buffer zone) is defined as the avoidance of a permanent loss of conveyance capacity attributable to subsidence as limited by remaining concrete liner freeboard for a specific Aqueduct pool that exceeds twice the average observed rate from 2016-2022.

Using InSAR and CASP benchmark survey data from 2022, twice the average observed rate was calculated to be 0.1 feet per year for Aqueduct pools 23 through 30. This equates to an MT subsidence extent of 1.6 feet from 2024-2040. Pools 23 to 30 contain significant non-GSA activities and causes of subsidence. If an MT exceedance occurs, it would trigger the MT exceedance policy wherein an assessment of the cause would be conducted in consultation with CASP. If the exceedance is found to be related to a non-GSA cause, the exceedance will be defined as outside of GSA authority to manage and the relevant regulatory agency would be contacted.

GSA-related subsidence would likewise be assessed and addressed following the MT exceedance policy, including implementation of focused PMAs as appropriate. Table 13-9 provides the SMCs for the northern Aqueduct.

Table 13-9. Northern Aqueduct SMCs

Pools 26 – 30 (MP 184.82 – 250.99)						
Aqueduct Pool/ Mile Post (MP)	**Pool Classification**	**MT Rate (feet/year)**	**MO Rate (feet/year)**	**IMs 2025/2030/2035 (feet)**	**IM Rates 2025/2030/2035 (feet/year)**	**MT Extent (2024-2040) (feet)**
Pool 23 (MP 184.82 to 197.05)	AOI 2 Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 24 (MP 197.05 to 207.94)	AOI 2 Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 25 (MP 207.94 to 217.79)	AOI 2 Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 26 (MP 217.79 to 224.92	Monitor/ Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 27 (MP 217.79 to 231.73)	Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 28 (MP 231.73 to 238.11)	Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 29 (MP 238.11 to 244.54)	Monitor/Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6
Pool 30 (MP 244.54 to 250.99)	Monitor/ Report to CASP	0.05 to 0.1	0.05	0.4/0.64/0.72	0.013 to 0.025/ 0.025 to 0.05/ 0.038 to 0.075	0.8 to 1.6

Notes:

1. The Northern Aqueduct has significant non-GSA activities present in the 5-mile-wide Aqueduct "buffer zone". For example, Area of Interest (AOI) 2 is adjacent to the Lost Hills Oil Field. Exceedances of an SMC would trigger the Subbasin SMC exceedance policy wherein an assessment of the cause of the exceedance would be conducted in consultation with CASP. If found to be related to a non-GSA cause (e.g., Aqueduct pre-construction geotechnical deficiencies, expanding soils, oil activities, natural processes (faulting, compaction) and age of infrastructure), the exceedance would be defined as outside of GSA authority.
2. MT extent is defined as the cumulative amount of vertical subsidence (in feet) that would occur from 2024-2040 at the MT rate.

The above methodology for developing MTs, recognizing the baseline subsidence rate as calculated from the latest CASP survey data, is supported by the findings of the Kern Groundwater Authority Subsidence Study and Lawrence Livermore Study.

As discussed above, potential for future GSA-related differential subsidence was ascertained by calculating the change in slope from 2024 to 2040. As shown in Figure 13-27, the change in slope along the majority of the Northern Aqueduct is less than 0.1 feet/1000 feet (less than 0.01%), which is a negligible amount well within the uncertainty of the InSAR data, with a very small segment with a change in slope between 0.1 feet/1000 feet and 0.2 feet/1000 feet (less than 0.02%). Therefore, the GSA-related differential subsidence risk for the Northern Aqueduct is minimal.

Southern Aqueduct

The following considerations were used to establish Land Subsidence SMCs for the southern portions of the California Aqueduct, represented by Pools 31 through 35:

- As detailed in Section 8.5.1.5, historical subsidence has occurred along the southern portion of the Aqueduct and there is a potential for subsidence to occur in the future.
- Historical subsidence has occurred as a result of both GSA and non-GSA pumping displacement.
- Sections of the California Aqueduct that fall within the Subbasin have been identified as Regional Critical Infrastructure.
- Because of the nature of the soils and anticipated potential for hydro-compaction, the southern Aqueduct pools were built with excess freeboard and have a buffer to accommodate subsidence without negatively influencing conveyance capacity. As such, it is not anticipated that future impacts from subsidence will be significant and unreasonable.

Following the decision tree (Figure 13-20) for the above considerations, MTs are set as an observed or allowable rate of subsidence. This determination is supported by the subsidence risk matrix (Table 13-8), where the southern portion of the Aqueduct was determined to have a medium vulnerability ranking based on its designation as a Regional Critical Infrastructure with low subsidence potential. Consequently, setting the MTs as the allowable rate of subsidence is sufficient to avoid URs for the southern portion of the Aqueduct.

CASP benchmark survey data from 1969 to 1978 show that initial design freeboard of the southern pools ranged from 5.5 feet in the west to 8.5 feet in the east.[18] The 2017 California Aqueduct Subsidence Study published by CASP does not suggest that operational impacts have occurred within the southern pools since this time (DWR, 2017b). To maintain sufficient functional capacity, CASP has a minimum freeboard requirement of 2.5 feet within the southern pools. Therefore, URs based on a "significant loss in functionality" are defined for the Aqueduct's southern pools as available freeboard falling below the 2.5 feet minimum design freeboard.

InSAR data and yearly benchmark surveys completed by CASP were used to assess recent (i.e., post-2015) subsidence in the southern pools. InSAR data show that over the 2015-2021 period, cumulative subsidence within the southern portion of the Aqueduct ranged from less than 0.08 feet to 0.6 feet. Similarly, yearly benchmark surveys suggest that from 2016 to2023, cumulative subsidence ranged from 0.2 to 0.75 feet. Both InSAR and survey data indicate that the southern pools currently have a significant buffer between the 2.5 feet minimum freeboard requirement and recent pool elevations.

As shown in Figure 13-28, the MTs based on the allowable extent of subsidence are set as 75 percent of the difference between the reported 2016 freeboard and the 2.5 feet minimum freeboard requirement for each benchmark location in the southern portion of the Aqueduct. MTs at each survey benchmark on the southern portion of the Aqueduct are included in Table 13-10.

[18] DWR notes in its recent California Aqueduct Subsidence Study that as much as 9 feet of land subsidence occurred as a result of hydro-compaction from pre-consolidation ponding activities during Aqueduct construction within the southern pools (DWR, 2017b). The considerable additional freeboard that was constructed throughout these portions is attributable to the potential of additional subsidence after construction.

Table 13-10. Southern Aqueduct SMCs by Survey Benchmark

Pool	Milepost	Latitude	Longitude	Minimum Thresholds		Measurable Objectives		Interim Milestones Extent (ft)				Interim Milestones Rate (ft/yr)			
				Extent (2024-2040) (ft)	Rate (ft/yr)	Extent (2024-2040) (ft)	Rate (ft/yr)	2025	2030	2035	2040	2025	2030	2035	2040
31	**254.5**	35.122641	-119.376350	1.62	1.08	0.81	0.54	0.41	0.65	0.73	0.81	0.27	0.54	0.81	1.08
	254.85	35.117658	-119.376832	1.26	0.84	0.63	0.42	0.31	0.50	0.57	0.63	0.21	0.42	0.63	0.84
	255	35.115378	-119.377052	1.37	0.91	0.68	0.46	0.34	0.55	0.62	0.68	0.23	0.46	0.68	0.91
	255.36	35.110513	-119.375308	1.47	0.98	0.74	0.49	0.37	0.59	0.66	0.74	0.25	0.49	0.74	0.98
	256.11	35.101410	-119.368590	1.88	1.25	0.94	0.63	0.47	0.75	0.85	0.94	0.31	0.63	0.94	1.25
	256.14	35.101048	-119.368318	1.82	1.21	0.91	0.61	0.46	0.73	0.82	0.91	0.30	0.61	0.91	1.21
32	**256.56**	35.095790	-119.364353	0.74	0.49	0.37	0.25	0.18	0.29	0.33	0.37	0.12	0.25	0.37	0.49
	257	35.090683	-119.359751	1.91	1.27	0.96	0.64	0.48	0.76	0.86	0.96	0.32	0.64	0.96	1.27
	257.48	35.088159	-119.352287	1.28	0.85	0.64	0.43	0.32	0.51	0.58	0.64	0.21	0.43	0.64	0.85
	257.63	35.088191	-119.349607	0.87	0.58	0.44	0.29	0.22	0.35	0.39	0.44	0.15	0.29	0.44	0.58
	258	35.088548	-119.343036	1.25	0.83	0.62	0.42	0.31	0.50	0.56	0.62	0.21	0.42	0.62	0.83
	258.5	35.089023	-119.334263	0.98	0.65	0.49	0.33	0.24	0.39	0.44	0.49	0.16	0.33	0.49	0.65
	258.59	35.089058	-119.332866	1.05	0.70	0.53	0.35	0.26	0.42	0.47	0.53	0.18	0.35	0.53	0.70
	258.61	35.089037	-119.332261	1.64	1.09	0.82	0.55	0.41	0.65	0.74	0.82	0.27	0.55	0.82	1.09
	259	35.088552	-119.325382	1.57	1.04	0.78	0.52	0.39	0.63	0.70	0.78	0.26	0.52	0.78	1.04
	259.5	35.087927	-119.316599	1.34	0.89	0.67	0.45	0.34	0.54	0.60	0.67	0.22	0.45	0.67	0.89
	259.65	35.087799	-119.314807	1.17	0.78	0.58	0.39	0.29	0.47	0.53	0.58	0.19	0.39	0.58	0.78
	260.01	35.087292	-119.307686	1.41	0.94	0.70	0.47	0.35	0.56	0.63	0.70	0.23	0.47	0.70	0.94
	260.45	35.086357	-119.299940	1.60	1.06	0.80	0.53	0.40	0.64	0.72	0.80	0.27	0.53	0.80	1.06
	260.5	35.086198	-119.299083	1.43	0.96	0.72	0.48	0.36	0.57	0.64	0.72	0.24	0.48	0.72	0.96
	261	35.084594	-119.290483	1.57	1.05	0.79	0.52	0.39	0.63	0.71	0.79	0.26	0.52	0.79	1.05
	261.47	35.083087	-119.282402	1.56	1.04	0.78	0.52	0.39	0.62	0.70	0.78	0.26	0.52	0.78	1.04
	261.72	35.082200	-119.278915	1.60	1.07	0.80	0.53	0.40	0.64	0.72	0.80	0.27	0.53	0.80	1.07
33	**262**	35.080538	-119.273511	2.90	1.93	1.45	0.97	0.73	1.16	1.31	1.45	0.48	0.97	1.45	1.93

Pool	Milepost	Latitude	Longitude	Minimum Thresholds		Measurable Objectives		Interim Milestones Extent (ft)				Interim Milestones Rate (ft/yr)			
				Extent (2024-2040) (ft)	Rate (ft/yr)	Extent (2024-2040) (ft)	Rate (ft/yr)	2025	2030	2035	2040	2025	2030	2035	2040
	262.5	35.077374	-119.265583	3.20	2.13	1.60	1.07	0.80	1.28	1.44	1.60	0.53	1.07	1.60	2.13
	262.61	35.076695	-119.263880	3.16	2.10	1.58	1.05	0.79	1.26	1.42	1.58	0.53	1.05	1.58	2.10
	263	35.074741	-119.257435	3.22	2.15	1.61	1.07	0.81	1.29	1.45	1.61	0.54	1.07	1.61	2.15
	263.5	35.072964	-119.248985	3.16	2.11	1.58	1.05	0.79	1.27	1.42	1.58	0.53	1.05	1.58	2.11
	264	35.074164	-119.240320	2.75	1.83	1.37	0.92	0.69	1.10	1.24	1.37	0.46	0.92	1.37	1.83
	264.37	35.075033	-119.234400	3.14	2.09	1.57	1.05	0.79	1.26	1.41	1.57	0.52	1.05	1.57	2.09
	264.5	35.075443	-119.231614	2.94	1.96	1.47	0.98	0.73	1.17	1.32	1.47	0.49	0.98	1.47	1.96
	265	35.075594	-119.222756	3.03	2.02	1.52	1.01	0.76	1.21	1.36	1.52	0.51	1.01	1.52	2.02
	265.5	35.075592	-119.213961	3.05	2.03	1.53	1.02	0.76	1.22	1.37	1.53	0.51	1.02	1.53	2.03
	266	35.075590	-119.205129	2.98	1.99	1.49	0.99	0.75	1.19	1.34	1.49	0.50	0.99	1.49	1.99
	266.5	35.075587	-119.196285	2.94	1.96	1.47	0.98	0.73	1.18	1.32	1.47	0.49	0.98	1.47	1.96
	266.91	35.075620	-119.189152	2.95	1.97	1.48	0.98	0.74	1.18	1.33	1.48	0.49	0.98	1.48	1.97
	267.14	35.075797	-119.185046	2.95	1.97	1.48	0.98	0.74	1.18	1.33	1.48	0.49	0.98	1.48	1.97
34	**268**	35.075437	-119.169912	2.88	1.92	1.44	0.96	0.72	1.15	1.30	1.44	0.48	0.96	1.44	1.92
	268.5	35.073695	-119.161340	2.83	1.89	1.41	0.94	0.71	1.13	1.27	1.41	0.47	0.94	1.41	1.89
	268.94	35.072002	-119.154023	2.74	1.83	1.37	0.91	0.69	1.10	1.23	1.37	0.46	0.91	1.37	1.83
	269.3	35.070431	-119.147864	2.60	1.74	1.30	0.87	0.65	1.04	1.17	1.30	0.43	0.87	1.30	1.74
	269.66	35.068873	-119.141757	2.46	1.64	1.23	0.82	0.62	0.99	1.11	1.23	0.41	0.82	1.23	1.64
	270	35.067646	-119.135945	2.22	1.48	1.11	0.74	0.55	0.89	1.00	1.11	0.37	0.74	1.11	1.48
	270.5	35.066398	-119.127343	2.42	1.62	1.21	0.81	0.61	0.97	1.09	1.21	0.40	0.81	1.21	1.62
	271	35.065946	-119.118545	2.60	1.74	1.30	0.87	0.65	1.04	1.17	1.30	0.43	0.87	1.30	1.74
35	**271.5**	35.064355	-119.109919	2.94	1.96	1.47	0.98	0.74	1.18	1.32	1.47	0.49	0.98	1.47	1.96
	272	35.062034	-119.101556	3.18	2.12	1.59	1.06	0.79	1.27	1.43	1.59	0.53	1.06	1.59	2.12
	272.39	35.060028	-119.095241	3.83	2.55	1.91	1.28	0.96	1.53	1.72	1.91	0.64	1.28	1.91	2.55
	273	35.056536	-119.085221	3.58	2.39	1.79	1.19	0.90	1.43	1.61	1.79	0.60	1.19	1.79	2.39

Pool	Milepost	Latitude	Longitude	Minimum Thresholds		Measurable Objectives		Interim Milestones Extent (ft)				Interim Milestones Rate (ft/yr)			
				Extent (2024-2040) (ft)	Rate (ft/yr)	Extent (2024-2040) (ft)	Rate (ft/yr)	2025	2030	2035	2040	2025	2030	2035	2040
	273.09	35.056016	-119.083726	3.58	2.39	1.79	1.19	0.90	1.43	1.61	1.79	0.60	1.19	1.79	2.39
	273.75	35.049560	-119.075208	3.78	2.52	1.89	1.26	0.94	1.51	1.70	1.89	0.63	1.26	1.89	2.52
	274.04	35.047080	-119.071496	3.38	2.25	1.69	1.13	0.85	1.35	1.52	1.69	0.56	1.13	1.69	2.25
	274.5	35.043908	-119.064174	2.68	1.79	1.34	0.89	0.67	1.07	1.21	1.34	0.45	0.89	1.34	1.79
	275	35.040705	-119.056384	2.51	1.67	1.26	0.84	0.63	1.00	1.13	1.26	0.42	0.84	1.26	1.67
	275.5	35.037885	-119.048264	2.86	1.91	1.43	0.95	0.71	1.14	1.29	1.43	0.48	0.95	1.43	1.91
	275.56	35.037601	-119.047444	1.93	1.29	0.96	0.64	0.48	0.77	0.87	0.96	0.32	0.64	0.96	1.29
	276	35.034147	-119.040737	3.41	2.28	1.71	1.14	0.85	1.37	1.54	1.71	0.57	1.14	1.71	2.28
	276.09	35.033464	-119.039691	3.47	2.32	1.74	1.16	0.87	1.39	1.56	1.74	0.58	1.16	1.74	2.32
	276.5	35.033343	-119.032649	3.94	2.63	1.97	1.31	0.99	1.58	1.77	1.97	0.66	1.31	1.97	2.63
	276.71	35.034244	-119.029503	3.59	2.40	1.80	1.20	0.90	1.44	1.62	1.80	0.60	1.20	1.80	2.40
	277.13	35.037409	-119.023222	3.17	2.11	1.59	1.06	0.79	1.27	1.43	1.59	0.53	1.06	1.59	2.11
	277.5	35.037213	-119.016490	3.60	2.40	1.80	1.20	0.90	1.44	1.62	1.80	0.60	1.20	1.80	2.40
	277.6	35.036628	-119.014868	3.82	2.55	1.91	1.27	0.95	1.53	1.72	1.91	0.64	1.27	1.91	2.55
	277.7	35.035919	-119.013298	3.92	2.61	1.96	1.31	0.98	1.57	1.76	1.96	0.65	1.31	1.96	2.61
	277.8	35.035225	-119.011762	4.08	2.72	2.04	1.36	1.02	1.63	1.84	2.04	0.68	1.36	2.04	2.72
	277.9	35.034515	-119.010198	4.24	2.83	2.12	1.41	1.06	1.70	1.91	2.12	0.71	1.41	2.12	2.83
	278	35.033534	-119.008803	4.50	3.00	2.25	1.50	1.12	1.80	2.02	2.25	0.75	1.50	2.25	3.00

Notes:
(1) MT extent is defined as the cumulative amount of vertical subsidence (in feet) that would occur from 2024-2040 at the MT rate. Similarly, MO extent is defined as the cumulative amount of vertical subsidence that would occur from 2024-2040 at the MO rate.

Abbreviations

ft = feet
ft/yr = feet per year
MO = Measurable Objective
MT = Minimum Threshold
SMC = Sustainable Management Criteria

This page intentionally left blank.

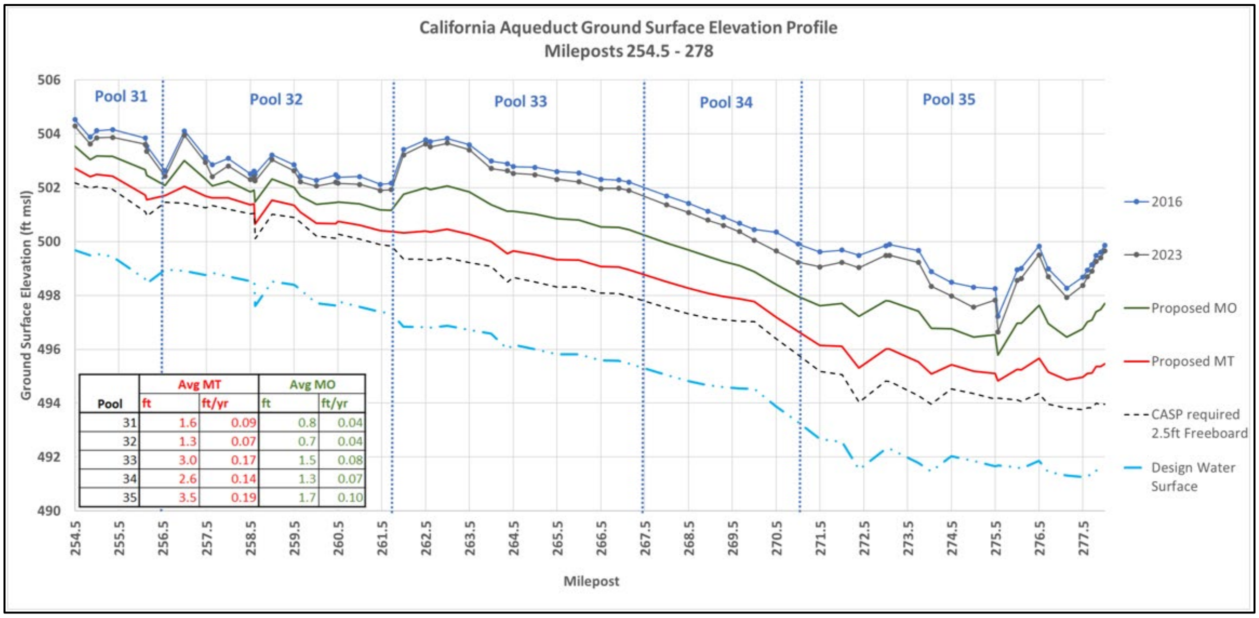


Figure 13-28. Land Subsidence SMCs on the Southern Aqueduct

As discussed above, potential for future differential subsidence was ascertained by calculating the change in slope from 2024 to 2040. As shown in Figure 13-20b, the change in slope along the Southern Aqueduct is less than 0.1 feet/1000 feet (less than 0.01%), which is a negligible amount well within the uncertainty of the InSAR data. Therefore, the future differential subsidence risk for the Southern Aqueduct is minimal.

Friant-Kern Canal (FKC)

The Friant Water Authority (FWA) position regarding subsidence along the FKC is that "any unmitigated conveyance loss due to subsidence beyond 2020 would lead to undesirable results". The proposed MT for the FKC is a 5-year annual average rate of 0.1 feet per year (ft/yr) with a maximum 3 feet of cumulative subsidence from 2015 to 2040. Beyond 2040, subsidence is to be minimized through demand reduction and other proactive measures (e.g., P/MAs). A maximum of approximately 0.4 feet of subsidence was observed along the FKC from 2015 to 2020. If the proposed MT is reached, up to an additional 2.6 feet of cumulative subsidence post-2020 could occur along the FKC.

To evaluate potential impacts from future subsidence along the FKC, the historical subsidence rate from 2015 to 2023 was forecast to 2040 using linear extrapolation to provide a conservative estimate of future subsidence (as discussed in Section 13.5.2.1.1). This approach uses a conservative "without projects" scenario, assuming consistent continued rates of subsidence equal to historical (2015 – 2023) through 2040. Figure 13-29 displays subsidence at MP 133.43 extrapolated to 2040 and indicates a total cumulative displacement of 2.7 feet since 2015 (1.6 additional feet from 2024 to 2040).

To further evaluate potential future subsidence along the FKC, a profile was developed using the historical InSAR subsidence data from 2015 to 2023 extrapolated to 2040 as shown in Figure 13-30. The subsidence forecast assumes that future subsidence occurs in areas of historical subsidence. It provides a general understanding of sections of the FKC that may require a liner raise and exceed subsidence thresholds that trigger the need for additional infrastructure improvements such as bridge replacement (e.g., approximately 1.25 feet of subsidence triggers the need for bridge replacement). Note, that with the basin moving towards sustainability and water levels stabilizing by 2030, actual rates and extents of subsidence are expected to be lower than these conservative estimates of future subsidence.

Mitigation would consist of raising the concrete liner by 3 to 6 feet and upgrading associated facilities/infrastructure such as bridge crossings, check structures, wasteways, turnouts, inlet drains, siphons/underdrains, power and telephone and various size pipelines. Mitigation is discussed below in Section 13.5.2.4.

Table 13-11 provides the SMCs for the FKC. MT extent is based on a projection of the MT rate from 2024 through 2040.

Table 13-11. FKC SMCs

MP 116.9 (County Line) - 152.13 (End FKC Kern River)						
GSA	**Mile Post**	**MT**	**MO**	**IMs**	**IMs**	**MT Extent**
		Rate	**Rate**	**2025/2030/2035**	**2025/2030/2035**	**(2024-2040)**
		(feet/year)	**(feet/year)**	**(feet)**	**(feet/year)**	**(feet)**
SSJMUD	116.9 - 124.3	0.08	0.04	0.32/0.51/0.58	0.02/0.04/0.06	1.28
NKWSD	124.3 - 142.8	0.10	0.05	0.40/0.64/0.72	0.025/0.05/0.075	1.60
KRGSA	142.8 – 152.13	0.02	0.01	0.08/0.13/0.14	0.005/.01/0.015	0.32

Notes:

1. MT extent is defined as the cumulative amount of vertical subsidence (in feet) that would occur from 2024-2040 at the MT rate.

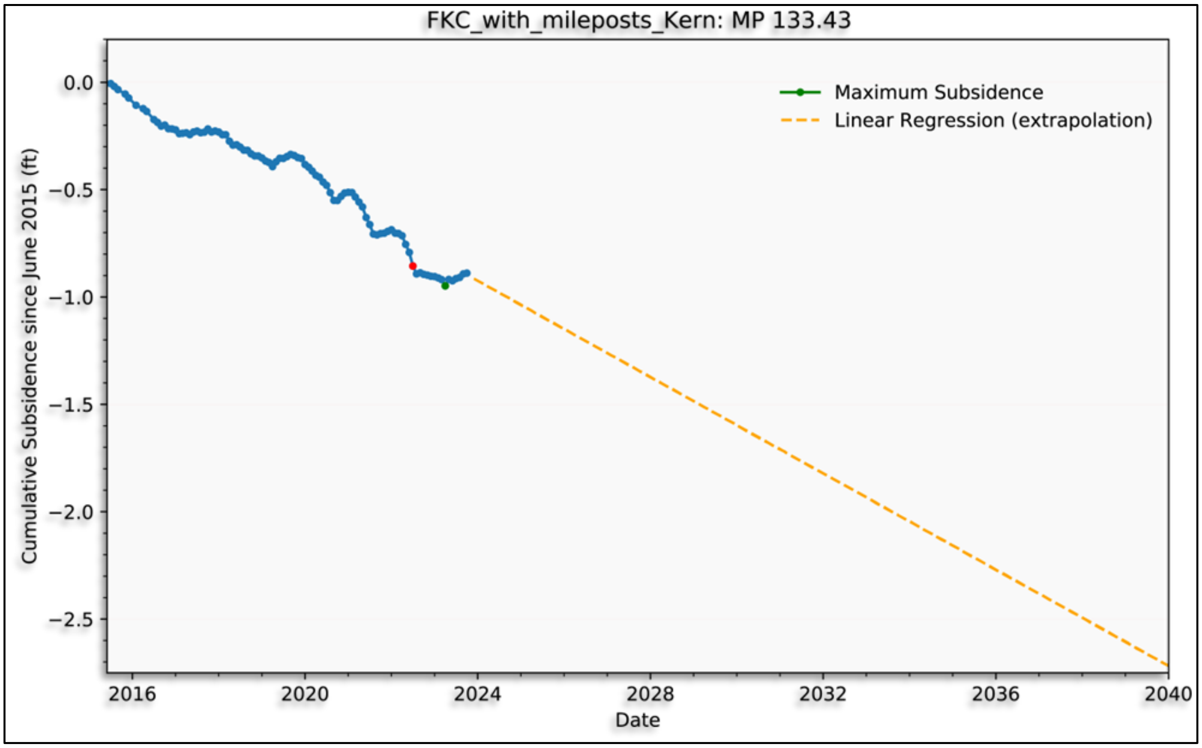


Figure 13-29. FKC Mile Post 133.43 Extrapolated Subsidence to 2040 (Based on 2015 to 2023 InSAR data)

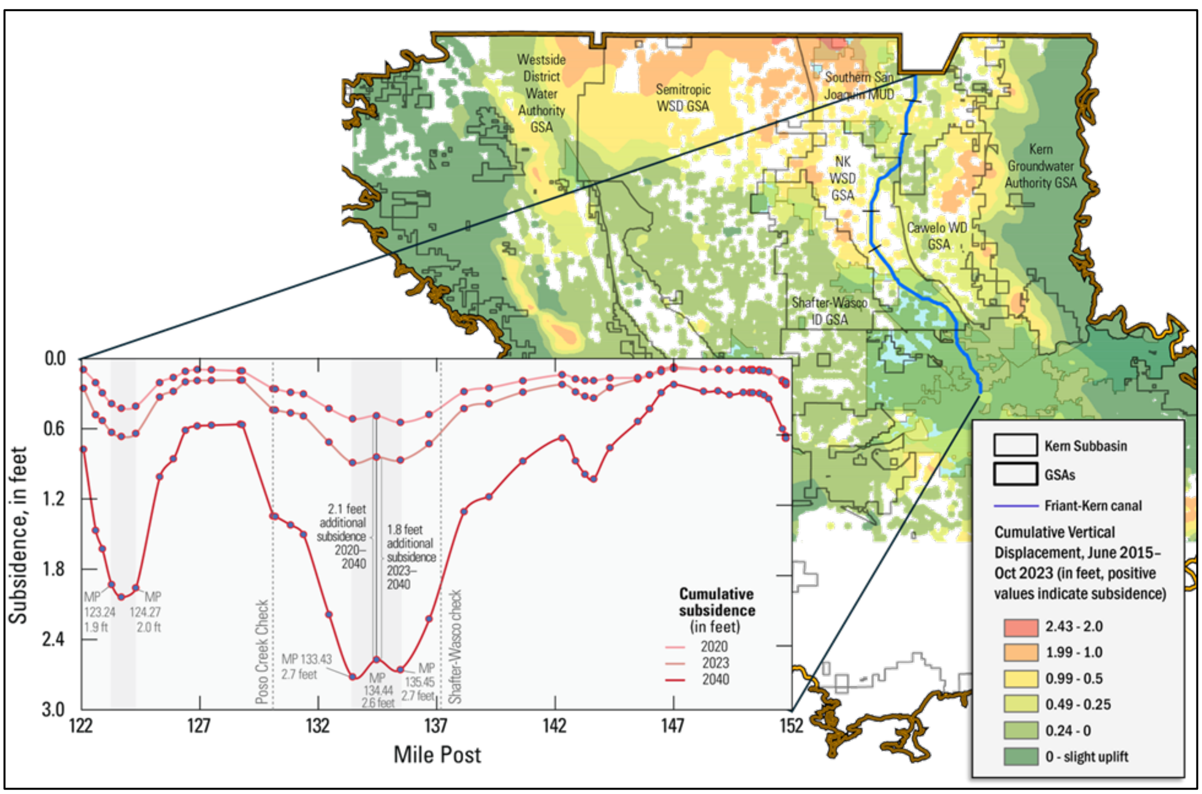


Figure 13-30. Kern Subbasin Cumulative Subsidence 2015 to 2023 and FKC Subsidence Profile Extrapolated to 2040

GSA Area Critical Infrastructure

GSA Area critical infrastructure within the Kern Subbasin includes the Calloway Canal, Lerdo Canal, Beardsley Canal, Cross Valley Canal, Kern River Canal, Arvin-Edison Water Storage District Canal, Olcese Canal, Interstate-5 (I-5), and Highway 99. Figure 13-26 and Figure 13-27 show the cumulative extent from 2024- 2040 and the change in slope for areas underlying these critical infrastructures. The amount of projected subsidence is similar to those seen under historical (2015 to 2023) conditions when no impacts on infrastructure were reported. Further, the change in slope for the majority of the infrastructure facilities is less than 0.1 feet/1000 feet (0.01%) with the highest change (close to 0.3 feet/1000 feet or 0.03%) in slope estimated in the southeast along the Arvin Edison canal. These change in slopes are not expected to lead to significant differential subsidence impacts, which cannot be addressed through retrofitting or upgrades. Nevertheless, the Arvin GSA is monitoring this area on a regular basis (annual surveys at five representative monitoring sites), and has the ability to detect, manage, and mitigate any impacts if they were to occur in this area due to future subsidence.

Other Infrastructure

The future projected 2040 subsidence is not anticipated to cause any significant and unreasonable impacts to other Infrastructure as a result of differential subsidence. For example, the High Speed Rail subsidence report (Amec, 2017) specifies a maximum acceptable change of grade of 0.1% (1 feet/1000 feet), which is almost an order of magnitude higher than the maximum estimated change of slope for other infrastructure. Hence, these amounts of subsidence are not expected to lead to significant and unreasonable impacts on these infrastructure facilities and therefore can be used as the basis for the MTs. See Section 13.5.2.4 for the discussion of potential impacts on other infrastructure.

Final Minimum Thresholds

The final MTs for Land Subsidence along all critical infrastructure are shown in Table 13-12. MTs for all other areas of the Subbasin are set as the average historical subsidence rates and extents in each HCM area from 2024-2040 as described in Section 13.5.2.1 (Table 13-13). Land subsidence rates and extents will be compared against MTs annually both locally along Critical Infrastructure (Table 13-12) and regionally averaging the InSAR displacement across each HCM area (Table 13-13).

It is important to note that the MTs are only set for the SGMA implementation period, after which the rate and extent of residual subsidence due to GSA-related activities would be minimal as the Kern Subbasin proposes to stabilize water levels (no chronic lowering of water levels) beyond 2030. The MOs are set at half the rate and extent of the MTs for the given HCM area. Given that water levels are expected to stabilize 10 years before the MT extrapolation period, future subsidence is expected to be closer to the MOs rather than the MTs by 2040. However, it is difficult to accurately predict future subsidence given that residual and non-GSA subsidence may continue beyond 2030.

This page intentionally left blank.

Table 13-12. Subsidence SMC Matrix

Infrastructure	Critical Infrastructure Type[1]	GSA	Maximum Historical Cumulative (ft) Subsidence (InSar: 2015 - 2023)	Maximum Historical Rates (ft/yr) of Subsidence (InSar: 2015 - 2023)	Subsidence Cause	Subsidence Potential[2]	Impacts from Historical Subsidence	Potential Impacts from Future Subsidence	Pumping Vulnerability[3]	SMC Approach[4]	MT rate (ft/yr)	MT 2024-2040 extent (ft)[5]	MO rate (ft/yr)	MO 2024-2040 extent (ft)	IMs extent (ft)			IMs rate (ft/yr)		
															2025	2030	2035	2025	2030	2035
Friant Kern Canal	Regional	SSJMUD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Loss of Conveyance Capacity	Medium	Impact Based SMC	See Table 13-11									
	Regional	NKWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	Loss of freeboard; possible loss of conveyance	Loss of Conveyance Capacity	Medium	Impact Based SMC	See Table 13-11									
	Regional	KRGSA	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	None	Low	Impact Based SMC	See Table 13-11									
California Aqueduct	Regional	BVWSD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	Loss of freeboard; possible loss of conveyance	Loss of Conveyance Capacity	Low	Historical/Allowable Rate SMC	See Table 13-9									
	Regional	HMWD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	None	Low	Historical/Allowable Rate SMC	See Table 13-9									
	Regional	WKWD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	Loss of freeboard; loss of conveyance	Loss of freeboard, Possible Loss of Conveyance	Low	Historical/Allowable Rate SMC	See Table 13-9									
	Regional	SWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	Non-GSA	Low	Loss of freeboard; loss of conveyance	Loss of freeboard, Possible Loss of Conveyance	Low	Historical/Allowable Rate SMC	See Table 13-9									
	Regional	WDWA	0.33 to 1 ft	0.04 to 0.12 ft/yr	Non-GSA	Low	Loss of freeboard; loss of conveyance	Loss of freeboard, Possible Loss of Conveyance	Low	Historical/Allowable Rate SMC	See Table 13-9									
	Regional	WRMWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	Loss of freeboard	Loss of freeboard, Possible Loss of Conveyance	Medium	Impact Based SMC	See Table 13-10									
Calloway Canal	GSA Area	KRGSA	<0.33 ft	< 0.04 ft/yr	GSA	Minimal	None	Minimal ; Low	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	NKWSD	1 to 3 ft	0.12 to 0.37 ft/yr	GSA	Moderate	None	Moderate	Medium	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	SWID	1 to 3 ft	0.12 to 0.37 ft/yr	GSA	Moderate	None	Minimal ; Low	Medium	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
Lerdo Canal	GSA Area	CWD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal ; Low	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09

Infrastructure	Critical Infrastructure Type[1]	GSA	Maximum Historical Cumulative (ft) Subsidence (InSar: 2015 - 2023)	Maximum Historical Rates (ft/yr) of Subsidence (InSar: 2015 - 2023)	Subsidence Cause	Subsidence Potential[2]	Impacts from Historical Subsidence	Potential Impacts from Future Subsidence	Pumping Vulnerability[3]	SMC Approach[4]	MT rate (ft/yr)	MT 2024-2040 extent (ft)[5]	MO rate (ft/yr)	MO 2024-2040 extent (ft)	IMs extent (ft)			IMs rate (ft/yr)		
															2025	2030	2035	2025	2030	2035
	GSA Area	NKWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal ; Low	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	KRGSA	<0.33 ft	< 0.04 ft/yr	GSA	Minimal	None	Minimal ; Low	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
Beardsley Canal	GSA Area	CWD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal ; Low	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	KRGSA	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal ; Low	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
Cross Valley Canal	GSA Area	KRGSA	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	KWB	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	Pioneer	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	RRBWSD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
Kern River Canal	GSA Area	KRGSA	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.04	0.68	0.02	0.34	0.17	0.27	0.31	0.01	0.02	0.03
	GSA Area	KWB	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.04	0.68	0.02	0.34	0.17	0.27	0.31	0.01	0.02	0.03
	GSA Area	Pioneer	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.04	0.68	0.02	0.34	0.17	0.27	0.31	0.01	0.02	0.03
AEWSD Canal	GSA Area	AEWSD	1 to 3 ft	0.12 to 0.37 ft/yr	GSA	Moderate	None	Possible loss of freeboard	Medium	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
Olcese Canal	GSA Area	OWD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
I-5	GSA Area	AEWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	BVWSD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-13									
	GSA Area	KRGSA	1 to 3 ft	0.12 to 0.37 ft/yr	GSA	Moderate	None	Minimal, Low, Moderate	Medium	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	KWB	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-12									
	GSA Area	RRBWSD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-12									
	GSA Area	SWSD	<0.33 ft	<0.04 ft/yr	GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-12									

Infrastructure	Critical Infrastructure Type[1]	GSA	Maximum Historical Cumulative (ft) Subsidence (InSar: 2015 - 2023)	Maximum Historical Rates (ft/yr) of Subsidence (InSar: 2015 - 2023)	Subsidence Cause	Subsidence Potential[2]	Impacts from Historical Subsidence	Potential Impacts from Future Subsidence	Pumping Vulnerability[3]	SMC Approach[4]	MT rate (ft/yr)	MT 2024-2040 extent (ft)[5]	MO rate (ft/yr)	MO 2024-2040 extent (ft)	IMs extent (ft)			IMs rate (ft/yr)		
															2025	2030	2035	2025	2030	2035
	GSA Area	WDWA	<0.33 ft	<0.04 ft/yr	Non-GSA	Minimal	None	Minimal	Minimal	HCM Area Average	HCM Area Average, see Table 13-12									
	GSA Area	WRMWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
Hwy 99	GSA Area	AEWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	CWD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	KRGSA	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	NKWSD	0.33 to 1 ft	0.04 to 0.12 ft/yr	GSA	Low	None	Minimal	Low	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09
	GSA Area	SSJMUD	1 to 3 ft	0.12 to 0.37 ft/yr	GSA	Moderate	None	Minimal	Medium	Historical/Allowable Rate SMC	0.12	2.04	0.06	1	0.51	0.82	0.92	0.03	0.06	0.09

Notes:
(1) Green rows indicate regional Infrastructure. MO/MT rates for regional infrastructure were derived based on benchmark data. Northern Aqueduct rates utilized benchmark and InSAR data (Whitepaper). Yellow rows indicate MA Infrastructure. MA MO/MT Rates were derived from historical (2015-2023) InSAR data.
(2) Step 3 as outlined in Section 13.5.2.1. See Figure 13-21.
(3) Step 5 as outlined in Section 13.5.2.1. See Table 13-8.
(4) Risk-based SMC approach as described in Section 13.5.2.1. See Table 13-8.
(5) MT extent is defined as the cumulative amount of vertical subsidence (in feet) that would occur from 2024-2040 at the MT rate. Similarly, MO extent is defined as the cumulative amount of vertical subsidence that would occur from 2024-2040 at the MO rate.

Abbreviations
AEWSD = Arvin GSA
BVWSD = Buena Vista Water Storage District GSA
CWD = Cawelo Water District GSA
ft = feet
ft/yr = feet per year
GSA = Groundwater Sustainability Agency
HMWD = Henry Miller Water District GSA
IM = Interim Milestone
KRGSA = Kern River GSA
KWB = Kern Water Bank GSA
MO = Measurable Objective
MT = Minimum Threshold
NKWSD = North Kern Water Storage District GSA
OWD = Olcese Water District GSA
RRBWSD = Rosedale-Rio Bravo Water Storage District GSA
SMC = Sustainable Management Criteria
SSJMUD = Southern San Joaquin Municipal Utility District GSA
SWID = Shafter-Wasco Irrigation District GSA
SWSD = Semitropic Water Storage District GSA
WDWA = Westside District Water Authority GSA
WKWD = West Kern Water District GSA
WRMWSD = Wheeler Ridge-Maricopa GSA

This page intentionally left blank.

Table 13-13. Land Subsidence SMCs by HCM Area

HCM Area	**Average (across HCM Area)** Subsidence Rate and Extents (ft)[1]			
	Minimum Threshold (rate ft/yr, 2024-2040 extent ft)[2]	**Measurable Objective** (rate ft/yr, 2024-2040 extent ft)[3]	**Interim Milestones 2025 / 2030 / 2035 (extent ft)**	**Interim Milestones 2025 / 2030 / 2035 (**Rate ft/year)
North Basin HCM Area	0.05 ft/yr, 0.85 ft	0.03 ft/yr, 0.43 ft	0.21 / 0.34 / 0.38	0.013 / 0.025 / 0.038
Kern River Fan HCM Area	0.02 ft/yr, 0.27 ft	0.01 ft/yr, 0.14 ft	0.07 / 0.11 / 0.12	0.005 / 0.01 / 0.015
South Basin HCM Area	0.03 ft/yr, 0.48 ft	0.02 ft/yr, 0.24 ft	0.12 / 0.19 / 0.22	0.008 / 0.015 / 0.023
Western Fold Belt HCM Area	0.01 ft/yr, 0.10 ft	0.01 ft/yr, 0.05 ft	0.03 / 0.04 / 0.05	0.003 / 0.005 / 0.008
East Margin HCM Area	0.01 ft/yr, 0.14 ft	0.01 ft/yr, 0.07 ft	0.04 / 0.06 / 0.06	0.003 / 0.005 / 0.008

Notes:

1. Subsidence MTs include subsidence from both GSA-related and non-GSA causes. Values have been rounded to the second decimal digit.
2. MT extent is defined as the cumulative amount of vertical subsidence (in feet) that would occur from 2024-2040 at the MT rate.
3. MO extent is defined as the cumulative amount of vertical subsidence that would occur from 2024-2040 at the MO rate

This page intentionally left blank..

13.5.2.2 Relationship with Other Sustainability Indicators

☑ **23 CCR § 354.28(b)(2)**

The MTs for Land Subsidence were designed to ensure that they are sufficiently protective of URs defined for all other relevant Sustainability Indicators to the Subbasin. The specific relationships between Land Subsidence and other applicable Sustainability Indicators are discussed below:

- Historic land subsidence has been attributed to **Chronic Lowering of Groundwater Levels**. The Subbasin GSAs are integrating subsidence into the Subbasin's groundwater flow model as part of Plan implementation; results of which will be used to ensure that MTs for Land Subsidence are protective of MTs set for Chronic Lowering of Groundwater Levels. As demonstrated in Section 13.1.2.2, subsidence associated with groundwater level declines to Chronic Lowering of Groundwater Level MTs is not projected to exceed the established Land Subsidence MTs. Furthermore, the glide path trajectory for Chronic Lowering of Groundwater Level IMs (Section 13.1.3.2) shows increasing groundwater levels after 2030. This increase provides a 10-year buffer to address residual subsidence that may occur between 2030 and 2040 due to preceding groundwater level declines.
- A potential effect of URs due to Land Subsidence is a **Reduction of Groundwater Storage** due to compaction of fine-grained subsurface layers during groundwater pumping. As discussed in Section 13.2, the Chronic Lowering of Groundwater Levels MTs are used as a proxy for Reduction of Groundwater Storage and were demonstrated to be protective of URs due to Reduction of Groundwater Storage. Chronic Lowering of Groundwater Level SMCs are also protective of URs due to Land Subsidence. Through the correlation with Chronic Lowering of Groundwater Level SMCs, it is reasonable to conclude that Land Subsidence MTs will not cause an unreasonable Reduction of Groundwater Storage.
- Studies suggest that consolidation of subsurface layers with high clay content may liberate arsenic and **degrade groundwater quality** (Smith et al., 2018). However, this has not been observed in most of the Central Valley, including the Subbasin (Haugen et al., 2021). Concentrations of arsenic were plotted against annual InSAR subsidence rates at two RMW-WQs in the North Basin HCM Area near the northern Subbasin boundary. Arsenic concentration trends in these RMW-WQs showed weak and opposite correlations with subsidence, supporting the finding that a correlation between arsenic and subsidence has not been observed in the Subbasin. Potential increases in arsenic due to subsidence will be monitored and managed per the SMCs established for Degraded Water

Quality. There has been no observed correlation between Land Subsidence and other water quality COCs in the Subbasin.

- No direct correlation has been discerned between Depletions of Interconnected Surface Waters and Land Subsidence.

13.5.2.3 Consideration of Adjacent Basins

☑ 23 CCR § 354.28(b)(3)

The MTs for Land Subsidence have been developed through a coordinated, Subbasin-wide effort and in consideration of the use of infrastructure outside of the Subbasin. The maximum extent of recent subsidence is along the northern boundary and is influenced by the higher rates of subsidence north of the Subbasin boundary. The methods used to develop MTs for Land Subsidence are generally consistent with adjacent basins. Further, MT extents in the Kern Subbasin are much lower and more protective than MT extents in the adjacent northern Tule and Tulare Lake subbasins. Therefore, implementation of the Plan would not prevent neighboring subbasins from achieving their Land Subsidence sustainability goal(s). Although Land Subsidence MTs in the adjacent southern White Wolf Subbasin are currently set using groundwater levels as a proxy, Subbasin GSAs are actively collaborating with the White Wolf GSA to ensure consistency as the White Wolf GSA develops Land Subsidence SMCs.

13.5.2.4 Impact to Beneficial Users

☑ 23 CCR § 354.28(b)(4)

As discussed above, the MTs for Land Subsidence are designed to maintain the functionality of Regional and GSA Area Critical Infrastructure and avoid URs to surface land uses.

Northern Aqueduct

The MT for Land Subsidence for the Northern Aqueduct is established based on the avoidance of a permanent loss of conveyance capacity associated with GSA-related subsidence as limited by remaining concrete liner freeboard for specific Aqueduct pools (Pools 23 to 30). It is typical that major infrastructure designs incorporate assumptions for natural settling, subsidence of any type, service life, repair and replacement cycles, among other considerations, and MTs aim to maintain the functional capacity of the Northern Aqueduct. However, since data indicates that subsidence within the 5-mile-wide CASP buffer zone along the northern Aqueduct is influenced by various non-GSA activities and conditions some subsidence and its affects will likely be outside the GSA authority to manage.

The methodology for developing MOs and MTs recognizes a baseline subsidence rate as calculated from DWR InSAR, CASP survey data, and is supported by the findings of the Kern Groundwater Authority Subsidence Study and Lawrence Livermore Study.

Southern Aqueduct

The 2017 California Aqueduct Subsidence Study published by CASP does not suggest that operational impacts or loss in conveyance capacity have occurred within the southern pools since 2017. To maintain sufficient functional capacity, CASP has a minimum freeboard requirement within the southern pools of 2.5 feet above the design water surface. As shown in Figure 13-28 above, the Southern Aqueduct MTs would maintain more than CASP's required 2.5 feet minimum freeboard above the design water surface, maintain the general elevation change to minimize impacts to gravity-driven conveyance, and therefore maintain the functionality of the Aqueduct between pools 31 and 35. Subbasin GSAs have been in close coordination with the CASP team regarding this MT approach, and have adjusted the Southern Aqueduct MTs to be set at 67 individual benchmark locations (MP 254.5 through 278) instead of on an average pool level (see Table 13-10).

FKC

As stated previously, FWA has concluded that "any unmitigated conveyance loss due to subsidence beyond 2020 would lead to undesirable results." As shown above in Figure 13-29, InSAR data documents that post-2020 subsidence has occurred along the FKC.

The following preliminary analysis of post-2020 subsidence impacts is based on evaluating the freeboard, which is the minimum distance required from the top of the canal lining to the water surface elevation to convey flow as documented in FWA's FKC HEC-RAS model. The required minimum freeboard varies along the FKC profile.

Output from the FWA's FKC HEC-RAS model was used to perform preliminary evaluation of sections of the Lower Reach impacted by post-2020 subsidence. Based on review of the proposed 2,500 cfs water surface elevation, 2018 water surface elevation documented in the HEC-RAS model and the 2018 top of lining elevation, the following sections of the FKC with subsidence impacts resulting in loss of conveyance capacity were identified:

- MP 122.85 to MP125.29: 2.44 miles (12,883 ft)
- MP 130.05 to MP 137.2: 7.15 miles (37,752 ft)

These sections of the FKC identified to be impacted by post-2020 subsidence will not have enough remaining freeboard to convey flows if subsidence were to continue at historical rates. Based on preliminary analysis, about 10 miles of liner raise and associated infrastructure improvements is likely attributable to the conservative estimate of post-2020 subsidence. This analysis is preliminary and will be refined as additional subsidence and surveying data becomes available. The Subbasin is currently working with FWA as documented in the Kern Subbasin Progress Report on Friant-Kern Canal Lower Reach Subsidence Mitigation Studies and Request for Letter of Support from FWA dated April 30, 2024 to further analyze and finalize subsidence projections, finalize cost amounts, and conduct an attribution analysis to ultimately determine a cost allocation, and determine how future mitigation will fit into FWA's future efforts with regards to capacity restoration projects along the FKC.

Several Subbasin GSAs have initiated and funded a P/MA to model subsidence along the lower reach of the FKC, with the intent to develop an attribution analysis. This attribution analysis would then be used in discussions to attribute the mitigation costs to GSAs based on the relative impact of each GSAs operations on subsidence at the FKC.

GSA Area Critical Infrastructure

As shown in Table 13-12, the MTs defined herein are based on subsidence rates that have historically occurred and have been managed by Subbasin GSAs through ongoing maintenance and improvements to facilities (e.g., adding additional freeboard to canals, as necessary). Subbasin GSAs could feasibility continue to manage/mitigate further subsidence if it were to occur at similar or lower rates. A summary of potential impacts to GSA Area Critical Infrastructure is provided below:

- **Calloway Canal**: The Calloway Canal experienced a cumulative subsidence extent ranging from less than 0.33 feet to 1.0 feet from 2015 to 2023 and has not had any subsidence-related impacts to date. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along the Calloway Canal is less than 0.2 vertical feet per 1,000 horizontal feet (feet per 1,000 feet). The local GSAs have communicated that the projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.
- **Lerdo Canal**: The Lerdo Canal experienced a cumulative subsidence extent ranging from less than 0.33 feet to 1.0 feet from 2015 to 2023 and has not had any subsidence-related impacts to date. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along the Lerdo Canal is less than 0.1 feet per 1,000 feet. The local GSAs have communicated that the projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.
- **Beardsley Canal**: The Beardsley Canal experienced a cumulative subsidence extent of less than 0.33 feet from 2015 to 2023 and has not had any subsidence-related impacts to date. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along the Beardsley Canal is less than 0.1 feet per 1,000 feet. The local

GSAs have communicated that the projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.

- **Cross Valley Canal**: The Cross Valley Canal experienced a cumulative subsidence extent of less than 0.33 feet from 2015 to 2023 and has not had any subsidence-related impacts to date. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along the Cross Valley Canal is less than 0.1 feet per 1,000 feet. The local GSAs have communicated that the projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.
- **Kern River Canal**: The Kern River Canal, which has both lined and unlined sections, experienced a cumulative subsidence extent of 0.33 to 1.0 feet from 2015 to 2023 and has not had any subsidence-related impacts to date. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent is less than 0.1 feet per 1,000 feet along most of the Kern River Canal and is between 0.1 and 0.2 feet per 1,000 feet in a few short sections. The local GSAs have communicated that the projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.
- **AEWSD Canal**: The AEWSD Canal experienced a cumulative subsidence extent ranging from less than 0.33 to over 1.0 feet from 2015 to 2023 and has shown minimal subsidence-related impacts to date, with the greater subsidence impacts occurring in the northern portion of the canal. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent is less than 0.1 feet per 1,000 feet along most of the AEWSD, but up to 0.33 feet per 1,000 feet in the northern portion of the canal. Five RMS-LS were selected as the most representative locations for which to monitor ground surface elevations as they are each situated directly proximate to the AEWSD Canal, and in some instances adjacent to areas with historical subsidence and therefore greater change in slope estimates. The RMS-LS have been surveyed annually for ground surface elevations since 2018. Arvin GSA plans to complete surveys on an annual basis, or more frequently as needed. AEWSD has indicated that it can continue to manage and mitigate further subsidence if it were to occur at similar or lower rates. As such, SMCs based on historical rates are considered to be sufficiently protective of beneficial uses and users of the AEWSD Canal.
- **Olcese Canal**: The Olcese Canal experienced a cumulative subsidence extent of less than 0.33 feet from 2015 to 2023 and has not shown any subsidence-related impacts to date. Two RMS-LS were selected directly proximate to the Olcese Canal to allow the Olcese GSA to monitor any future subsidence.

- **I-5**: I-5 has experienced a cumulative subsidence extent ranging from less than 0.33 feet to over 1.0 feet from 2015 to 2023, and no historic land subsidence-induced impacts have been documented. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along I-5 is less than 0.1 vertical feet per 1,000 horizontal feet, except in some small sections of the roadway. A change in grade of 0.01 percent is reasonable for roadways. Therefore, this projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.

- **Highway 99**: Highway 99 has experienced a cumulative subsidence extent ranging from 0.33 to over 1.0 feet from 2015 to 2023, and no historic land subsidence-induced impacts have been documented. Based on the change-in-slope analysis (Figure 13-27), the estimated change of slope based on the 2024-2040 projected subsidence extent along Highway 99 is less than 0.1 vertical feet per 1,000 horizontal feet, except in some small sections of the roadway. A change in grade of 0.01 percent is reasonable for roadways. Therefore, this projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts.

Other Infrastructure

Other infrastructure in the Subbasin have the potential to be impacted by URs caused by Land Subsidence (i.e., both vertical and lateral deformation). Other infrastructure are largely managed, monitored, and maintained by other appropriate state and federal agencies (e.g., CalTrans, California Public Utilities Commission, etc.). In addition to specific MTs established for Regional and GSA Area Critical Infrastructure, MTs for Land Subsidence were developed for the entire Subbasin based on the average historical subsidence rate in each HCM Area (Table 13-13). Given that other infrastructure, not including those identified as Regional or GSA Area Critical Infrastructure, have no known historical subsidence-related impacts, these Subbasin-wide MTs are anticipated to provide sufficient protection against adverse impacts caused by GSA-related activities in the Subbasin.

The various other types of infrastructure considered are discussed below.

- **Railroads:** Several railroads traverse the Subbasin. Based on the change-in-slope analysis above (Figure 13-27), the maximum estimated change of slope along railroads is 0.2 feet per 1,000 feet. The High Speed Rail subsidence report (Amec, 2017) specifies a maximum acceptable change of grade of 0.1 percent (1 feet per 1,000 feet), which is much higher than the maximum estimated change of slope (0.3 feet per 1000 feet).

- **Interstate oil and gas pipelines:** Several interstate oil and gas pipelines run through the Subbasin and are considered other infrastructure that could be impacted by land subsidence. The GSAs do not have access to the necessary information to assess subbasin-wide subsidence impacts on interstate gas pipelines. However, a study by the California Energy Commission concluded that "more than three times the maximum observed rates of subsidence in the 2015 to 2017 period would have been required to cause yielding in local pipelines due to high subsidence. The maximum subsidence during 2015 to 2017 was about 2 feet and occurred in the Southeastern part of San Joaquin Valley" (California Energy Commission, 2023). Based on this study, it was determined that recent subsidence rates in the Subbasin (discussed in Section 8.5.1) are significantly less than the extent of subsidence that would be required to impact regional oil and gas pipelines. Subbasin GSAs will continue to engage with oil and gas entities during Plan implementation.
- **Water conveyance facilities:** water distribution pipelines and associated facilities (e.g., pump stations) and local gravity-driven canals are critical for conveyance and provision of surface water supplies and can be damaged from land subsidence. Several canals were classified as Regional and GSA Area Critical Infrastructure above. Other water conveyance facilities have not experienced known impacts due to land subsidence at historical rates in the Subbasin and therefore will be monitored and managed under the Subbasin-wide SMCs in Table 13-13.
- **Water and wastewater treatment plants:** There are several water and wastewater treatment plants in the Subbasin in or near the Cities of Bakersfield, Delano, and McFarland that would significantly impact water users if they were impacted by land subsidence. These facilities have not experienced known impacts due to land subsidence at historical rates in the Subbasin and therefore will be monitored and managed under the Subbasin-wide SMCs in Table 13-13.
- **Domestic, agricultural, and other wells:** Damage to water well casings could impact the beneficial use of groundwater. If the well could be reasonably modified or its function in not impeded, then the impact to a well could be considered minimal. The GSAs have not observed damage to groundwater production wells caused by subsidence in the past. Most deep wells in the central basin (at depths where clay compaction is expected to be occurring) have been fitted with compression sections that can withstand several (15 to 30) feet of subsidence (Kevin McGillicuddy, Roscoe Moss Co. 1/5/24). As such, these wells are not expected to be impacted even under the conservative estimate of maximum future subsidence.
- **Buildings and county roadways:** There are several buildings and roadways that would have significant impacts on land use if land subsidence occurred.

Historical land subsidence around the Subbasin's major urban centers, including the City of Bakersfield, has been relatively low, and impacts caused by subsidence to buildings and county roadways are not known to have occurred. Furthermore, the change in slope analysis conducted along county roadways suggests that the maximum estimated change of slope is 0.1 feet per 1,000 feet. A change in grade of 0.01 percent is reasonable for roadways. Therefore, this projected amount of subsidence at the MTs is not expected to lead to significant and unreasonable impacts and, therefore, will be monitored and managed under the Subbasin-wide SMCs in Table 13-13.

- **Flood control structures:** Within the Subbasin, several flood control structures (i.e., levees) are present along local streams such as the Kern River and Caliente Creek. These structures are managed by agencies with which the GSAs have coordinated during the Plan development process. There have been no documented historical impacts on flood control structures attributed to GSA-related subsidence. Furthermore, there was minimal flooding in the Kern Subbasin in 2023, which was a historically wet year (with significant flooding in other parts of the San Joaquin Valley). During Plan implementation, the GSAs are committed to ongoing coordination with flood management agencies to proactively address any potential future impacts to flood control structures caused by GSA-related subsidence. For example, several public agencies are participating in the update of the California Office of Emergency Services (Cal OES) Hazard Mitigation Plan. This plan assesses potential vulnerabilities to infrastructure, including subsidence, and outlines strategies to effectively mitigate these risks.

13.5.2.5 State, Federal, and Local Standards

☑ 23 CCR § 354.28(b)(5)

There are no state, federal, or local standards pertaining to land subsidence in the Subbasin.

13.5.2.6 Measurement of Minimum Thresholds

☑ 23 CCR § 354.28(b)(6)

The GSAs have established RMS-LS along all Regional Critical Infrastructure and some GSA Area Critical Infrastructure. A 5-mile buffer zone was established in consultation with CASP and FWA for all Regional Critical Infrastructure, and a 1-mile buffer zone was established for all GSA Area Critical Infrastructure.

The cause, rate and total cumulative extent of subsidence will be monitored and updated annually at the Subbasin's RMS-LS. Additionally, MTs for Land Subsidence will be monitored for the entire Subbasin using InSAR data published by DWR, whereby the annual displacement, as reported by InSAR data, will be averaged across each HCM Area and compared to the Land Subsidence SMCs in Table 13-13 in the Annual Report. The hierarchy of methodologies for monitoring subsidence is:

1. InSAR (direct measurement), downloaded from DWR
2. InSAR time series at consistent locations
3. CASP and FWA benchmark surveys
    a. CASP typically conducts benchmark surveys annually and will provide data upon request. The Subbasin GSAs will request and utilize this benchmark data to assess compliance with SMCs established along the California Aqueduct.
4. Global Positioning System (GPS)
5. Other land-based methods (e.g. extensometers, third party benchmark surveys, third party benchmark surveys, etc.)

Figure 15-11 and Figure 15-12 shows the InSAR coverage and the subsidence monitoring network for the Subbasin, respectively.

Subsidence data will be collected from all of the above on an annual basis. For Critical infrastructure both the InSAR and monitoring network data will be evaluated against the local MTs/MOs for representative monitoring sites along the infrastructure. InSAR data will also be tabulated and analyzed at the HCM Area scale to compare against the HCM Area average MTs and MOs. Note, that there will likely be variability in subsidence values within the HCM Area. If local values exceed the range of subsidence estimated in the projected subsidence extent (Figure 13-24), then the GSAs will investigate the cause of and impact from subsidence and can set more stringent local MTs to be protective of any potential significant and unreasonable impacts in the future.

The representative monitoring network for Land Subsidence will be monitored in accordance with the monitoring protocols outlined in Section 15.3.4.

13.5.3 Measurable Objective and Interim Milestones for Land Subsidence

☑ **23 CCR § 354.30(c)**
☑ **23 CCR § 354.30(e)**

The MOs defined below are in terms of total vertical extent of land subsidence (feet) from 2024 to 2040, as well as a corresponding average annual rate of subsidence (feet per year) measured quarterly and reported annually to align with the Annual Report cycle.

13.5.3.1 Measurable Objective Development

The MOs for Land Subsidence are conservatively set to 50 percent of the MT rate and MT extent from 2024 to 2040. This is roughly equivalent to the recent subsidence rates continuing through 2030 and then abating. Due to the inherent time lag of the aquitard depressurization process, there may still be some residual subsidence potential that has yet to manifest. Therefore, it is not considered reasonable to expect an immediate and complete cessation to the historical subsidence rates. These MOs would serve to stabilize and minimize the potential for additional subsidence to occur after 2040.

The final MOs for Land Subsidence are shown in Table 13-9, Table 13-10, Table 13-11, Table 13-12, and Table 13-13.

13.5.3.2 Interim Milestones Development

The IMs for Land Subsidence have been set to follow a glide path that establishes IMs in 5-year increments at 25 percent of the MT extent in 2025, 40 percent of the MT extent in 2030, and 45 percent of the MT extent in 2035. The IMs defined below are in terms of total vertical extent of land subsidence (in feet). The final IMs for Land Subsidence are shown in Table 13-9, Table 13-10, Table 13-11, Table 13-12, and Table 13-13.

An example glide path through 2040 for Milepost 270 of the Southern Aqueduct is shown below in Figure 13-31. As demonstrated in this figure, IMs are set to minimize subsidence, and establish a glide path of no additional GSA-related subsidence after 2040. As discussed in Section 13.1.3.2, the glide path trajectory for Chronic Lowering of Groundwater Level IMs shows increasing groundwater levels after 2030. This increase provides a 10-year buffer to address residual subsidence that may occur between 2030 and 2040 due to preceding groundwater level declines.

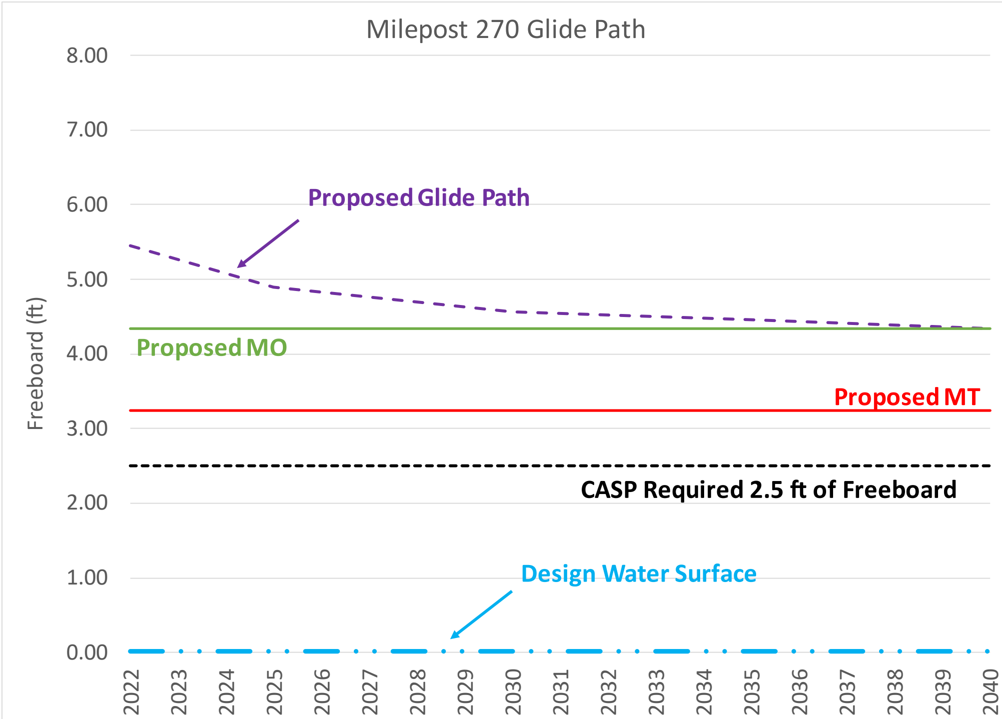


Figure 13-31. Milepost 270 Glide Path

13.6 Interconnected Surface Water

§ 354.28. *Minimum Thresholds*
(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

- *Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:*
  - *The location, quantity, and timing of depletions of interconnected surface water.*
  - *A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.*

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

☑ 23 CCR § 354.26(d)
☑ 23 CCR § 354.30(c)
☑ 23 CCR § 354.30(e)

Interconnected surface water is defined by the GSP regulations as surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (CCR 23 § 351). As described in Section 8, the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset, which maps vegetation and wetland features that could indicate dependence on groundwater, was used to assess whether surface water features in each HCM area were considered interconnected surface water. Available data and information indicate that major surface water features within the Subbasin are largely fed by surface water and are not considered interconnected surface water features due to groundwater level depths significantly below the surface water features. Furthermore, no groundwater dependent ecosystems (GDEs) were identified in any of the five HCM areas. Therefore, as described in Section 7.2.9 and Section 8.6, multiple lines of evidence (i.e., water quality data, hydro-stratigraphy, and water levels) suggest that the Primary Alluvial Principal Aquifer is hydraulically separated from the Shallow Alluvium and surface water bodies interconnected thereto, and depletion of interconnected surface water has not been observed within the Subbasin.

The GSP Emergency Regulations state that "*An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators*" (23 CCR § 354.26(d)). Because evidence suggests that depletion of interconnected surface water within the Subbasin is not present and not likely to occur, the Depletions of Interconnected Surface Water Sustainability Indicator is not applicable. Therefore, no SMCs for this Sustainability Indicator are defined in the Subbasin.

DWR is in the progress of developing new guidelines for interconnected surface water and SGMA implementation. The Basin will continue to monitor the status of these new guidelines and will adapt management of the Depletions of Interconnected Surface Water Sustainability Indicator if needed in the next five-year Plan update.

14. PROJECTS AND MANAGEMENT ACTIONS

§ 354.44. *Projects and Management Actions*

(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.

(b) Each Plan shall include a description of the projects and management actions that include the following:

(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:

(A) A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.

(B) The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.

(2) If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.

(3) A summary of the permitting and regulatory process required for each project and management action.

(4) The status of each project and management action, including a timetable for expected initiation and completion, and the accrual of expected benefits.

(5) An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.

(6) An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.

(7) A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.

(8) A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.

(9) A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.

(c) Projects and management actions shall be supported by best available science.

(d) An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.

14.1 Goals and Objectives of Projects and Management Actions

☑ **23 CCR § 354.44(a)**
☑ **23 CCR § 354.44 (b)(1)(A) and (B)**

A key component of Groundwater Sustainability Plans (GSPs) is Projects and Management Actions (P/MAs) that address any existing or potential future overdraft conditions that could cause Undesirable Results for the identified relevant Sustainability Indicators. This section presents the P/MAs that are cumulatively proposed to achieve the Kern County Subbasin's (Subbasin) Sustainability Goal. Implementation of P/MAs began in 2020 and is estimated to continue along a glide path until the estimated Subbasin deficit of 372,000 acre-feet per year (AFY) under the 2030 Climate Change Scenario is corrected. All necessary P/MAs are scheduled for implementation by the January 2040 deadline to achieve sustainability (refer to Section 9.1.4.5 Projected Water Budget Results).

The Kern Subbasin uses checkbook accounting that aligns with the numerical groundwater flow model to evaluate efficacy of Sustainable Groundwater Management Act (SGMA) implementation. Checkbook accounting uses historical surface water supply balances to estimate groundwater overdraft attributable to each Groundwater Sustainability Agency (GSA). This approach provides a deficit planning number that is compared against anticipated results of P/MAs, which enables the Subbasin to evaluate results against the current deficit and use adaptive management techniques to adjust project implementation consistent with the glide path approach.

The glide path approach allows for flexible implementation of P/MAs as needed to address future conditions throughout the 50-year GSP planning and implementation horizon (i.e., out to 2070). P/MAs presented in this section were developed with consideration of costs, benefits, and preliminary feasibility analyses; however, some P/MAs are conceptual and will require significant further evaluation (i.e., engineering, economic, environmental, legal, etc.) before implementation. Some of the P/MAs presented in this section will continue to fill data gaps and establish mitigation measures as part of Plan Implementation.

Consistent with the goals and objectives of the P/MAs explained in this section, (including the relevant Sustainability Indicators), categories of expected benefits, and the coordinated implementation glide path are presented in subsequent sections. Common Subbasin-wide P/MAs are presented in this Section. Individual GSA P/MAs are presented in Appendix S. All GSAs coordinated on common methods for P/MA development, as follows:

- Single, linear path of milestones through 2040.
- Standard P/MA categories, types, and definitions.

- Consistent format to present each P/MA and anticipated yield; and-
- Consistent analytical method to calculate each GSA's minimum target P/MA based on the Subbasin-wide projected deficit of 372,120 AFY, which is the Subbasin's groundwater reduction goal to achieve sustainability by January 2040.

At the end of Section 14.12 a description is provided for each P/MA planned by the GSA as summarized in Table 14-4 through Table 14-23. This section also explains how each P/MA addresses relevant overdraft conditions, or other Sustainability Indicators (i.e., water quality, subsidence, etc.), and describes other considerations relevant to implementation, including the following:

- Potential permitting and regulatory requirements.
- P/MA status and implementation timeline.
- Criteria for evaluating expected benefits.
- Sources of water that are relied upon.
- Legal authority required to implement the P/MAs, and
- Summary of estimated costs and the GSA's plans to meet those costs.

14.1.1 Implementation Glide Path Kern County Subbasin

☑ 23 CCR § 354.44(b)(2)

As stated above, the goals and objectives of the P/MAs presented herein are to address existing overdraft conditions that could trigger Undesirable Results as P/MAs are incrementally implemented to achieve the sustainability goal. While the exact schedule for implementation of all the individual P/MAs is not known with certainty at this time, general implementation schedules, also known as a glide path, have been developed as summarized in Table 14-1 and illustrated on Figure 14-1. This glide path is designed to address 25 percent (93,000 AFY) of the projected deficit of 372,000 AFY during each five-year milestone through 2040, which in turn will improve conditions for the relevant Sustainability Indicators based on the assumption that those conditions are directly related to the balance of supplies and demands within the Subbasin as shown in Table 14-1. The anticipated P/MA implementation schedule is forecasted to exceed the target deficit reduction by 2030 and exceed the 2040 milestone with a safety factor of 2.0, illustrating an extremely high degree of P/MA redundancy. A sensitivity analysis is illustrated on Figure 14-1 for both 50 percent and 75 percent actual realized benefits from P/MAs. Even if only 50 percent of P/MA benefits are realized, the Subbasin would still succeed in eliminating 102 percent of the projected deficit. Figure 14-2 and Figure 14-3 depicts that the Subbasin will rely on 317,000 AFY of demand reduction to mitigate the 372,000 AFY projected deficit and has identified as-needed projects available for development that would provide an additional estimated 71,000 AFY of deficit reduction capacity, bringing the total safety factor to 2.2 times the planned goal.

Table 14-1. (Glide Path – Target Deficit Reduction)

Project and Management Action Implementation Schedule (AFY)						
Kern County Subbasin Projected-Future Scenario Deficit Reduction "Glide Path" 354.44 (b)(2)		**2020**	**2025**	**2030**	**2035**	**2040**
Projected Deficit			**-372,000**			
Target Deficit Reduction (%)		0	25%	50%	75%	100%
Projected Deficit No P/MA's		**372,000**	**372,000**	**372,000**	**372,000**	**372,000**
Deficit Reduction "Glide Path" Milestones		**-372,000**	**-279,000**	**-186,000**	**-93,000**	**0**
Project and Management Action, by Type (AFY)						
Planned Demand Reduction	Land Retirement	14,965	28,091	36,384	42,603	42,603
	Demand Reduction	3,855	64,512	124,460	168,100	213,133
	Ag to Urban Conversion	1,067	8,078	15,450	22,850	30,250
	Water Conservation-Efficiency	25,099	28,690	28,690	28,690	28,690
Subtotal		**44,986**	**129,371**	**204,984**	**262,243**	**314,676**
Planned Water Supply Augmentation	Supplemental Water Recharge	35,219	53,278	81,664	84,884	84,884
	Supplemental Water Use	34,072	49,752	55,762	66,647	73,447
	Third-Party Banking	12,215	33,222	33,222	31,935	31,935
	New Local Supply	0	8,000	25,557	114,557	120,107
	Exercise of Rights	101,327	129,597	136,952	136,952	136,952
Subtotal		**182,833**	**273,849**	**333,157**	**434,975**	**447,325**
P/MA Implementation Schedule*		**227,819**	**403,220**	**538,141**	**697,218**	**762,001**
As-Needed PMA Deficit Benefits		***0***	***550***	***4,800***	***51,826***	***71,645***
Planned P/MA Deficit Reduction Schedule*		**-144,181**	**31,220**	**166,141**	**325,218**	**390,001**

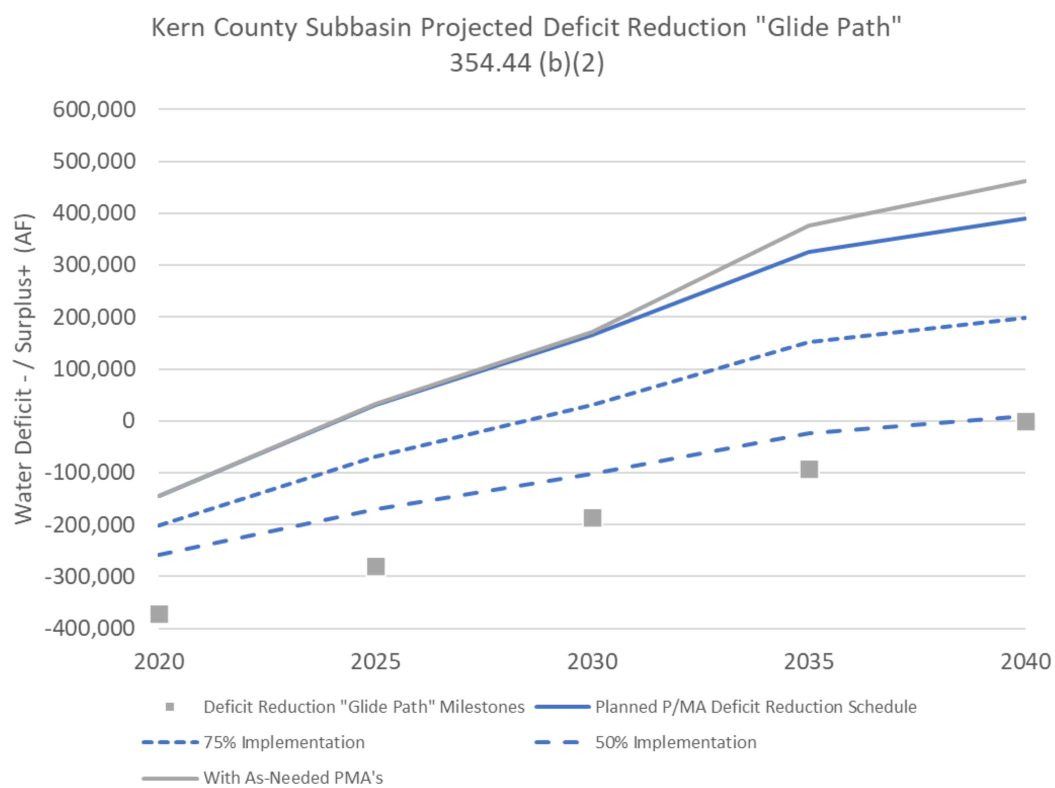


Figure 14-1. (Glide Path – P/MA Planned Deficit Reduction vs. Milestones)

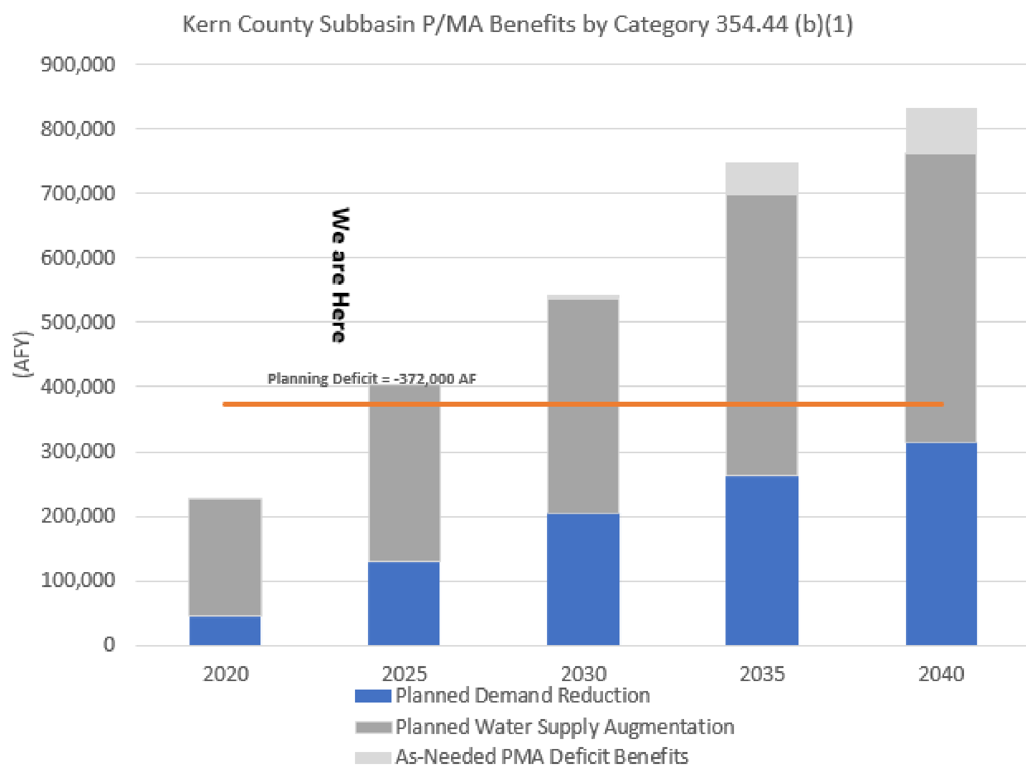


Figure 14-2. P/MA by Category

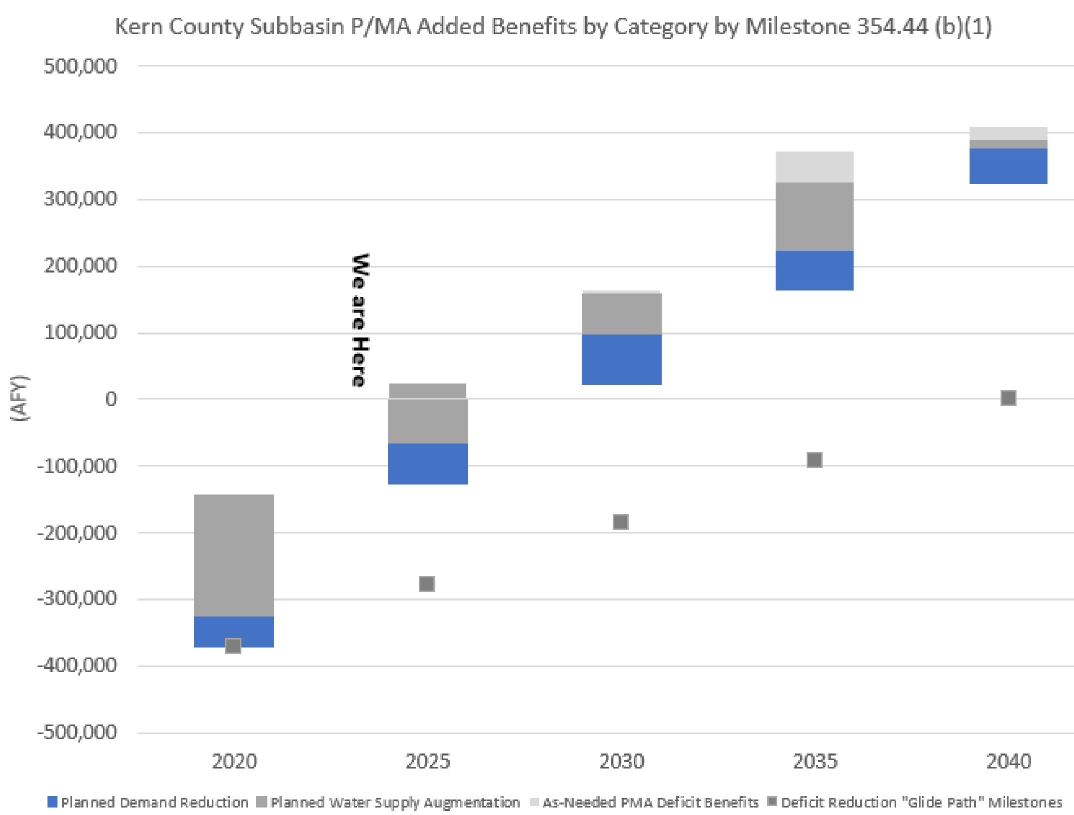


Figure 14-3. P/MA by Category with Implementation Glide Path

14.1.2 Uncertainty Associated with the Basin Setting

☑ 23 CCR § 354.44(d)

The Subbasin GSAs, as it relates to this planning document, have agreed to use a historical supply and demand analysis using a checkbook approach to determine the minimum target P/MA goal for each GSA. Minimum target P/MA goals for each GSA were calculated using this historical checkbook surface water supply and demand analysis for the 2010-2019 period, then applying an adjustment for estimated climate change which results in an increased minimum target P/MA goal above historical levels as shown below in Table 14-2. The Kern Subbasin has a reasonable level of uncertainty associated with the Basin Setting. This will be resolved as the Basin Study (P/MA KSB-4) addresses data and information gaps and recalibrates the Subbasin numerical surface water and groundwater flow model. To compensate for uncertainty, the P/MAs are proposed to be implemented incrementally to achieve this goal for each GSA Management Area, as defined in Appendix S. Progress on the implementation of the glide path will be presented annually via the Kern County Subbasin Annual Report.

The general implementation schedules, or glide path, were developed by the individual GSAs and are tabulated in Appendix S. To meet the Subbasin's Sustainability Goal, the glide path aims to address 25 percent of the projected deficit during each five-year Milestone through 2040, which in turn will improve conditions of the relevant Sustainability Indicators based on the assumption that those conditions are directly related to the balance of supplies and demands.

The Subbasin GSAs, as it relates to this planning document, have agreed to use the calculated checkbook approach to determine the minimum target P/MA goal for each individual GSA. This is for P/MA planning purposes only, as these values are not considered final, and will be revised during the Basin Study KSB-4. Minimum target P/MA goals for each GSA were calculated using this historical checkbook surface water supply and demand analysis for the 2010-2019 period, then applying an adjustment for estimated climate change which results in the increased minimum target P/MA goal above historical levels as shown below in Table 14-2. The checkbook in its current form is consistent in methodology across all GSAs. The checkbook is based on surface water inflows and outflows from each GSA; it does not specify ownership of water or differentiate between water for consumptive use, conjunctive use, or water banking for others. This will be more thoroughly addressed during the Basin Study. A subbasin adjustment was also applied to account for conditions such as Subbasin outflow and data uncertainties. A "zero" in the first column connotes a GSA with no checkbook minimum target P/MA.

The Kern Subbasin has a reasonable level of uncertainty associated with the Basin Setting. However, the Basin Study (P/MA KSB-4) will help address remaining data and information gaps and support recalibration of the Subbasin numerical surface water and groundwater flow model. Again, the estimates shown in Figure 14-2 and discussed below are for P/MA planning purposes only and will be updated in subsequent planning cycles based on the results of the Basin Study management action KSB-4 as described in Section 14.2.3.

Table 14-2. (P/MA Targets by GSA)

GSA Name	Minimum Target P/MA	Planned P/MA
Arvin GSA	34,770	60,760
Buena Vista Water Storage District GSA	0	39,610
Cawelo Water District GSA	0	35,110
Eastside Water Management Area	3,940	7,020
Henry Miller Water District GSA	1,330	3,850
Kern River GSA	0	150,433
Kern Water Bank Groundwater Sustainability Agency	0	21,762
Kern-Tulare Water District GSA	970	7,720
North Kern Water Storage District GSA	0	32,620
Olcese Water District GSA	0	0
Pioneer GSA	0	0
Rosedale-Rio Bravo Water Storage District GSA	0	18,360
Semitropic Water Storage District GSA	136,040	223,600
Kern National Wildlife Refuge	0	0
Shafter-Wasco Irrigation District GSA	22,560	29,292
7th Standard	12,260	23,153
Southern San Joaquin Municipal Utility District	33,610	33,610
Tejon-Castac Water District GSA	0	1,800
West Kern Water District GSA	0	191
Westside District Water Authority GSA	0	50,000
Wheeler Ridge-Maricopa GSA	18,910	36,330
Whitelands	20,410	20,410
Subbasin Adjustment (subbasin outflow and data uncertainty)	87,320	
Subbasin Total	**372,120**	**795,631**

Minimum target goals of the planned P/MAs for each GSA are shown by HCM Area as illustrated below on Figure 14-4 through Figure 14-8. It should be noted that the actual P/MA target is estimated for the entire GSA and repeated without adjustments specific to the HCM Area. Since the jurisdictional boundary of some GSAs span more than one HCM Area, the series of graphs targets by HCM should not be assumed the full demand reduction is allocated to that HCM.

14.1.3 P/MA Planning by HCM Area

This series of graphs shows the total minimum target P/MA (red font) by GSA and their estimated results from implementing demand reduction (light gray) and supply augmentation (blue) projects. The total estimated yield of these P/MAs are represented by the dark gray bar with the estimated AFY benefit (dark gray).

The P/MA target surplus shown in Figure 14-4 is attributed to various factors for each GSA whose jurisdictional boundary spans the Western Fold Belt Area. As described in Section 8.1.1.1, minimal groundwater pumping occurs in the Western Fold Belt HCM Area due to low recharge and poor groundwater quality that limits the ability to utilize groundwater. One factor is the checkbook approach allocates native yield and precipitation across the Subbasin, consequently, agencies that cover areas where groundwater is not suitable for the beneficial uses rely on imported surface water to support the land uses in those areas; regardless of water use, these areas are credited with native yield. The following bullet points provide information about each GSA shown in Figure 14-4

- Westside District Water Authority (WDWA) GSA is predominantly located within the northern portion of the Western Fold Belt HCM. WDWA GSA plans to contribute to reduction in the Subbasin's estimated deficit sustainability via water supply augmentation, and as needed, demand management. Details on P/MAs are provided in Section 14.6.
- West Kern Water District (WKWD) GSA is predominantly in the southern portion of the Western Fold Belt HCM. The GSA plans to contribute to reduction in the Subbasin's estimated deficit via water supply augmentation. Details on P/MAs are provided in Section 14.6.
- White Lands are un-districted lands that are managed for purposes of SGMA by the Kern Non-Districted Land Authority. These non-contiguous lands are dispersed throughout the HCM Areas. The projected minimum target P/MA is 20,410 AFY for these lands based on consumptive use estimates extrapolated from ET data; see KSB-6 for the demand reduction program that will be implemented to mitigate the projected deficit attributed to these land uses. Details on P/MAs are provided in section 14.3.
- A small portion of the Buena Vista Water Storage District (BVWSD) GSA is within the Western Fold Belt HCM. The GSA plans to contribute to reduction in the Subbasin's estimated deficit sustainability via water supply augmentation, primarily. Details on P/MAs are provided in Section 14.6.
- A small portion of the Henry-Miller Water District (HMWD) GSA is within the southern portion of the Western Fold Belt HCM. The projected minimum target P/MA is 1,300 AFY, which will be mitigated via water demand reduction. Details on P/MAs are provided in Section 14.10.

- A small portion of the Wheeler-Ridge Maricopa Water Storage District (WRMWSD) GSA is within the southern portion of the Western Fold Belt HCM. The GSA's primary means of meeting the projected minimum target P/MA of 18,900 AFY is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.10.

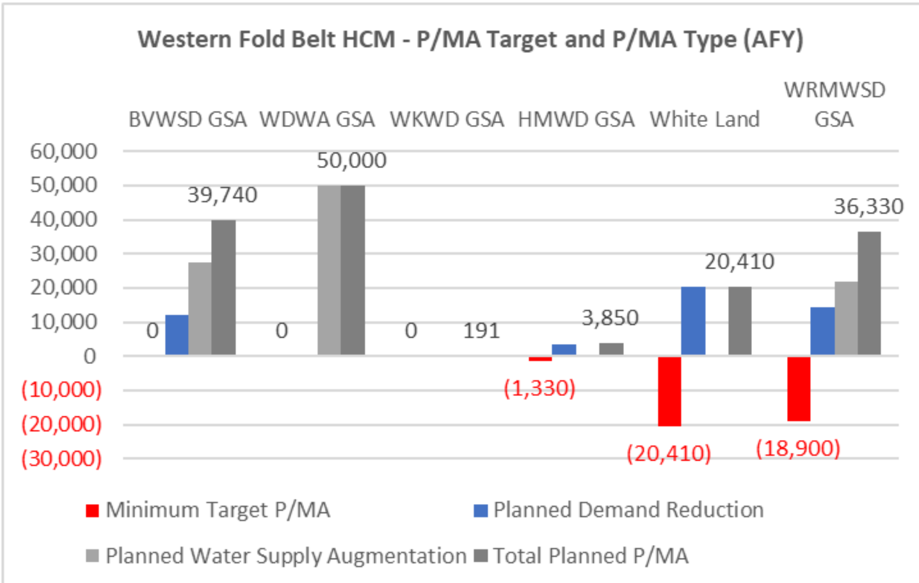


Figure 14-4. (P/MA Target by GSA in the Western Fold Belt)

Figure 14-5 shows GSAs whose jurisdictional boundary spans the North Basin HCM Area, which is predominately an agricultural area with four municipalities, rural communities, and a large area of federal and California Conservation Easement Area designated for the Kern National Wildlife Refuge, Semitropic Ridge Reserve as well as the Semitropic, Lokern, and Buttonwillow Ecological Reserves (refer to Section 5.3.1). Significant groundwater pumping occurs in the North Basin HCM. There has been a long history of conjunctive management and water banking. The following bullet points provide information about each GSA referenced for the first time in Figure 14-5.

- Semitropic Water Storage District (SWSD) GSA is completely within the northern portion of the North Basin HCM. The GSA's primary means of meeting the P/MA target of 136,040 AFY is via demand reduction. Details on P/MAs are provided in Section 14.10.

- North Kern Water Storage District (NKWSD) GSA is completely within the eastern portion of the North Basin HCM. The GSA's means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.

- Shafter-Wasco Irrigation District GSA, Shafter-Wasco Irrigation District (SWID) is completely within the central portion of the North Basin HCM. The GSA's primary means of meeting the P/MA target of 22,560 AFY is via water supply augmentation through its contract supplies. Details on P/MAs are provided in Section 14.10.

- Shafter-Wasco Irrigation District GSA, 7th Standard Annex (SWID 7th) is completely within the central portion of the North Basin HCM. The primary means of meeting the P/MA target of 12,260 AFY is via demand reduction. Details on P/MAs are provided in Section 14.10.
- Southern San Joaquin Municipal Utility District (SSJMUD) GSA is completely within the northern portion of the North Basin HCM. The GSA's primary means of meeting the P/MA target of 33,610 AFY is via water supply augmentation. Details on P/MAs are provided in Section 14.10.
- Buena Vista Water Storage District (BVWSD) GSA is predominately within the western portion of the North Basin HCM. The GSA achieves sustainability via mainly water supply augmentation. Details on P/MAs are provided in Section 14.6.
- White Lands are un-districted, un-managed lands covered by the Kern Non-Districted Land Authority. The primary means of meeting the P/MA target of 20,410 AFY is via demand reduction, refer to KSB-6.
- A portion of the Rosedale-Rio Bravo Water Storage District (RRBWSD) GSA is within the southern portion of the North Basin HCM. The GSA's means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A portion of the Cawelo Water District GSA is within the eastern portion of the North Basin HCM. The GSAs means of sustainability is via primarily water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A small portion of the Kern River GSA is within the southeastern portion of the North Basin HCM. The GSA's means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A small portion of the Westside District Water Authority GSA is within the southwestern portion of the North Basin HCM. The GSAs means of sustainability is via water supply augmentation and, as needed, demand reduction. Details on P/MAs are provided in Section 14.6.

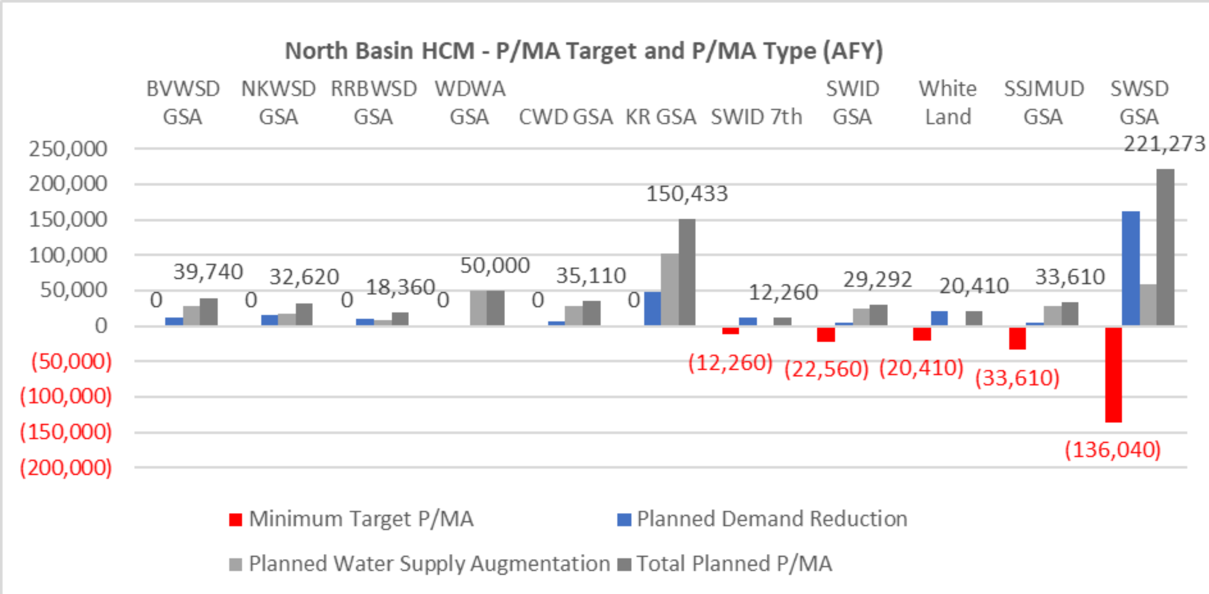


Figure 14-5. (P/MA Target by GSA in the North Basin)

Figure 14-6 shows GSAs whose jurisdictional boundary spans the Eastern Margin HCM Area. Land use is predominately native vegetation with agricultural and industrial land uses. Agricultural irrigation demand is primarily met through imported surface water, with some groundwater pumping from the Santa Margarita and Olcese Principal Aquifers. The following bullet points provide information about each GSA referenced for the first time in Figure 14-6.

- Kern-Tulare Water District GSA is <u>completely</u> within the northern portion of the East Margin HCM. The GSA's means of meeting the P/MA target of 970 AFY is via demand reduction. Details on P/MAs are provided in Section 14.10.
- Eastside Water Management Area (covered by Kern Non-Districted Land Authority) is <u>completely</u> in the northern portion of the Eastern Margin HCM. The GSA's primary means of meeting the P/MA target of 3,940 AFY is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.10.
- Tejon-Castac Water District GSA is <u>predominantly</u> within the southern portion of the East Margin HCM. The GSA's means of sustainability is via primarily water supply augmentation. Details on P/MAs are provided in Section 14.6.
- Olcese Water District GSA is <u>completely</u> within the southern portion of the East Margin HCM. The GSA's does not have a projected minimum target P/MA deficit. Details on P/MAs are provided in Section 14.6.
- A portion of the Cawelo Water District GSA is within the central portion of the East Margin HCM. The GSAs means of sustainability is via primarily water supply augmentation. Details on P/MAs are provided in Section 14.6.

- White Lands are un-districted, un-managed lands covered by the Kern Non-Districted Land Authority. These non-contiguous lands are dispersed throughout the HCM Areas. The primary means of meeting the P/MA target of 20,410 AFY is via demand reduction,
- A small portion of Arvin-Edison Water Storage District GSA is predominately in the southern portion of the Eastern Margin HCM. The GSA's primary means of sustainability to close the estimated projected deficit of 34,770 AFY is via water supply augmentation. Details on P/MAs are provided in Section 14.10.

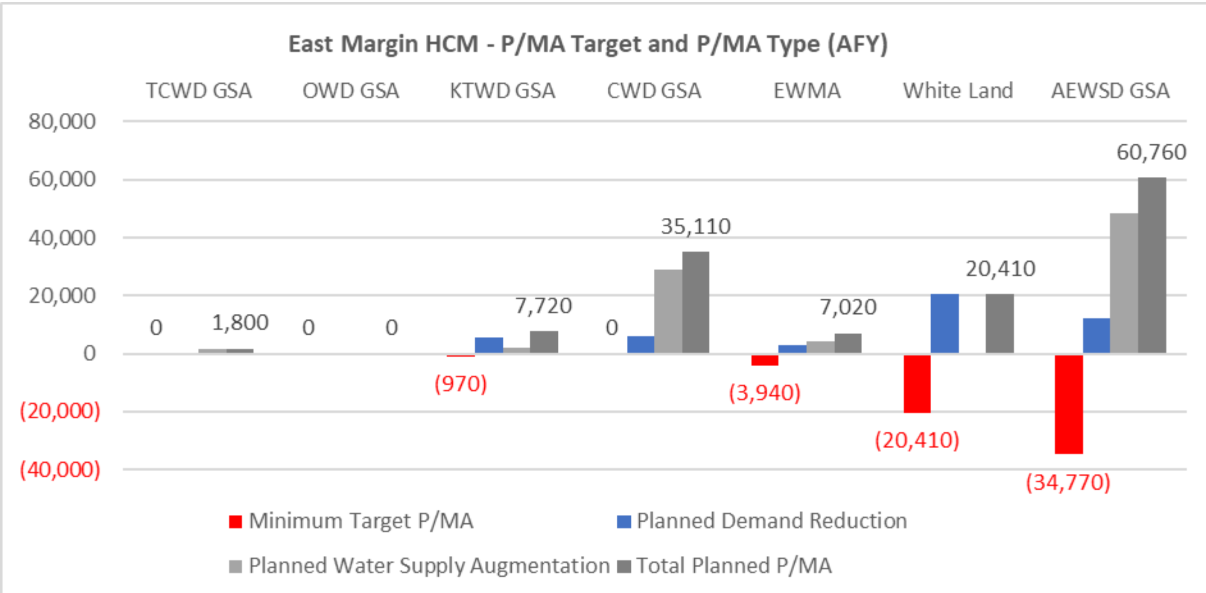


Figure 14-6. (P/MA Target by GSA in the Eastern Margin)

Figure 14-7 shows GSAs whose jurisdictional boundary spans the Kern River Fan HCM Area, which is municipal and rural communities, and water banking. These programs have been in place for several decades and were developed to help secure more reliable water supplies due to California's wet- and dry-year cycles (refer to Section 5.3.1). The following bullet points provide information about each GSA referenced for the first time in Figure 14-7.

- The Kern Water Bank GSA is completely in the western portion of the Kern River Fan HCM. The GSA does not have a projected deficit and the means of sustainability is via water supply augmentation. Details on P/MAs are provided in Section 14.6.
- The Pioneer GSA is completely in the central portion of the Kern River Fan HCM. The GSA does not have a projected minimum targe P/MA deficit. Details on P/MAs are provided in Section 14.6.
- West Kern Water District GSA groundwater pumping area is predominantly in the western portion of the Kern River Fan HCM. The GSA does not have a projected

minimum target P/MA deficit and the means of sustainability is via water supply augmentation. Details on P/MAs are provided in Section 14.6.

- A portion of the Rosedale-Rio Bravo Water Storage District GSA is within the northern portion of the Kern River Fan HCM. The GSA does not have a projected minimum target P/MA deficit and the means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A small portion of the Cawelo Water District GSA is within the central portion of the Kern River Fan HCM. The GSA does not have a projected minimum target P/MA deficit and the means of sustainability is via primarily water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A small portion of the Kern River GSA is within the northeastern portion of the Kern River Fan HCM. The GSA's does not have a projected minimum target P/MA deficit and the means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.
- A small portion of the Buena Vista Water Storage District GSA is within the western portion of the Kern River Fan Belt. The GSA does not have a projected minimum target P/MA deficit and the means of sustainability are via mainly water supply augmentation. Details on P/MAs are provided in Section 14.6.

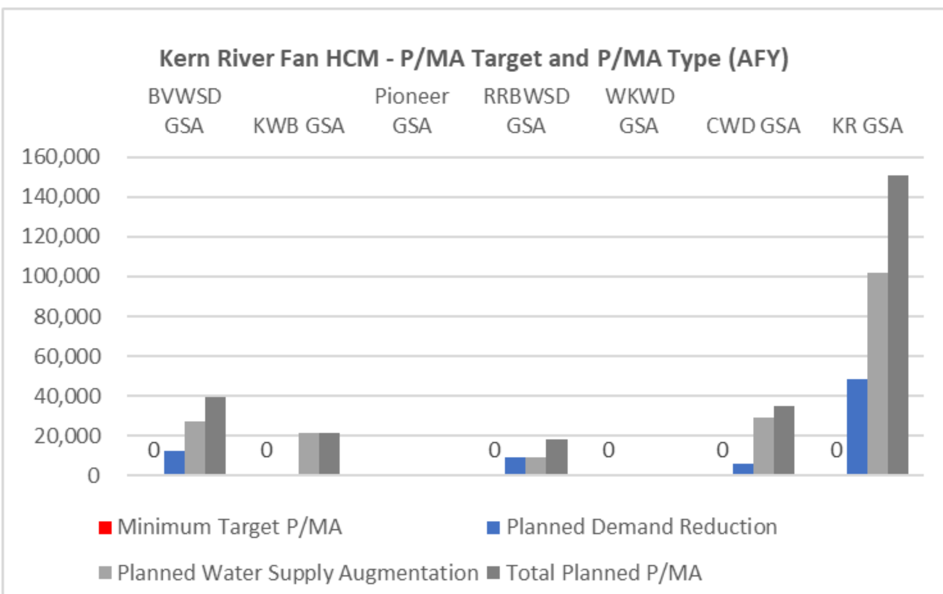


Figure 14-7. (P/MA Target by GSA in the Kern River Fan)

Figure 14-8 shows GSAs whose jurisdictional boundary spans the South Basin HCM Area. Land use is predominately agricultural with some industrial land uses. Urban land uses include the City of Arvin and unincorporated communities of Greenfield, Weedpatch, and Mettler, as well as several rural communities. Agricultural irrigation demand is primarily met through imported surface water and conjunctive use, as well as third party banking programs. All GSAs shown in Figure 14-8 also span across another HCM Area and were addressed in previous sections.

- Arvin-Edison Water Storage District GSA is predominately in the eastern portion of the South Basin HCM Areas. The GSA's primary means of meeting the P/MA target of 34,770 AFY is via water supply augmentation. Details on P/MAs are provided in Section 14.10.
- Wheeler Ridge Maricopa Water Storage District GSA is predominately within the southern portion of the Western Fold Belt. The GSA's primary means of meeting the P/MA target of 18,900 AFY is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.10.
- The Kern River GSA is predominately within the northern portion of the South Basin HCM. The GSA does not have a projected minimum target P/MA deficit and the means of sustainability is via a balance of demand reduction and water supply augmentation. Details on P/MAs are provided in Section 14.6.
- Henry-Miller Water District GSA is predominately within the northwestern portion of the South Basin Belt. The GSA's primary means of meeting the P/MA target of 1,330 AFY is via water supply augmentation. Details on P/MAs are provided in Section 14.10.
- A portion of Tejon-Castac Water District GSA is within the eastern portion of the South Basin HCM. The GSA's does not have a projected P/MA deficit and the means of sustainability is via primarily water supply augmentation. Details on P/MAs are provided in Section 14.6.
- White Lands are un-districted, un-managed lands covered by the Kern Non-Districted Land Authority. These non-contiguous lands are dispersed throughout the HCM Areas. The primary means of meeting the P/MA target of 20,410 AFY is via demand reduction, refer to KSB-6.
- A small portion of the BVWSD GSA is within the northwestern portion of the South Basin HCM. The GSA's does not have a projected P/MA deficit and the means of sustainability is via mainly water supply augmentation. Details on P/MAs are provided in Section 14.6.

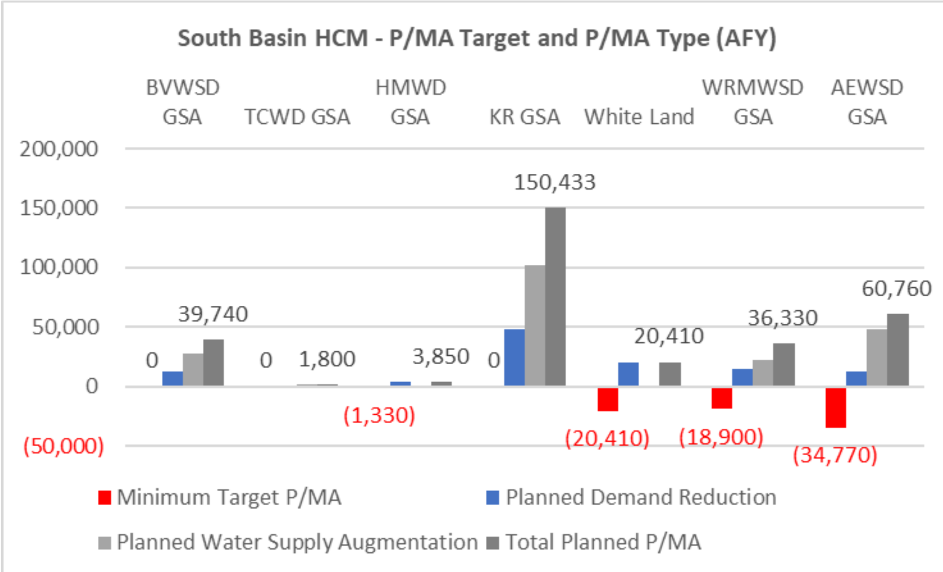


Figure 14-8. (P/MA Target by GSA in the South Basin)

14.2 List of Projects and Management Actions

☑ **23 CCR § 354.44(b)(1)**

Subbasin-wide P/MAs are labeled with “KSB-#” which represents P/MAs that all – or nearly all - GSAs are participating in to achieve the Subbasin’s Sustainability Goal. Individual GSA P/MAs are numbered with the acronym of the GSA and are detailed on Table 14-4 through Table 14-23 at the end of this Chapter.

14.2.1 Demand Reduction P/MAs

Subbasin Demand Reduction P/MAs are the primary means of implementation of a glide path that will result in closing the currently identified “deficit” of 372,120 AFY under the 2030 Climate Change Scenario by the January 2040 GSP implementation deadline. P/MAs benefits that contribute to water demand reduction of **314,767 AFY** by 2040 include:

- **Land Retirement (42,603 AFY)**: Permanent change from irrigated to non-irrigated.
- **Demand Reduction (213,133 AFY)**: Program to reduce applied groundwater including (temporary, rotational, cropping changes, and possible permanent changes).
- **Ag to Urban Conversion (30,250 AFY)**: Conversion of land from irrigated land to urban.
- **Water Conservation-Efficiency (28,690 AFY)**: Incentives to improve water use practices.

- Individual GSA P/MA details can be found in Appendix S.
- KSB-6 White Land Water Budget/Demand Management – The Subbasin is developing a governance structure and demand reduction action for Subbasin white lands (lands not within a district). As part of the implementation of KSB-6 there would be another round of public outreach to include remaining white land landowners. Previous stakeholder outreach efforts accomplished GSA management of over 150,000 acres of white lands that were absorbed via agreement with various GSAs and managed for sustainability. Approximately 7,200 acres of white lands (less than 1% of the Subbasin) remain currently using groundwater (irrigated agriculture and urban) to have management actions assigned. KSB-5 Basin Study will provide added technical data to support setting water budgets necessary to implement a linear white lands demand reduction schedule of 10 percent per year, estimated at a total of 20,410 AF over the planning period of 2030-2040. Additional details are provided in the Kern Non-District Lands Authority Joint Powers Authority governance document in Appendix D. Due to the white land's relatively small groundwater demand, implementing white land demand management in the 2025-2030 period will not preclude the Subbasin's ability to meet its sustainability goal.

14.2.2 Water Supply Augmentation P/MA's

☑ 23 CCR § 354.44(b)(9)

Subbasin Water Supply Augmentation P/MAs are the secondary means of implementation of a glide path that will result in closing the currently identified "deficit" of 372,120 AFY under the 2030 Climate Change Scenario by the January 2040 GSP implementation deadline. P/MAs that contribute to water supply augmentation of **447,325 AFY** by 2040 include:

- **Supplemental Water Recharge (84,884 AFY):** Increased recharge projects during wet years.
- **Supplemental Water Use (73,447 AFY):** Purchase imported water for current year.
- **Third-Party Banking (31,395 AFY):** Local benefit derived from third-party Banking.
- **New Local Supplies (120,107 AFY)**: Use of recycled water supplies.
- **Exercise of Rights (136,952 AFY):** Improved utilization of existing water supplies/rights (banked or surface).
- Individual GSA P/MA details can be found in Appendix S.

14.2.3 Data-Gap Filling and Mitigation Efforts

☑ **23 CCR § 354.44(b)(2)**

To address identified data-gaps, Subbasin Management Actions either currently being implemented or have been implemented that contribute to data-gap filling and mitigation efforts include:

KSB-1 Friant-Kern Canal Capacity Mitigation – The Subbasin is working to implement this project shown in more detail in Appendix T. Conveyance conditions of the Friant-Kern Canal (FKC) have been impacted by historical subsidence and will potentially be impacted by future subsidence under the proposed implementation of the Subbasin GSPs. The Friant Water Authority (FWA) position regarding subsidence along the FKC is that “any unmitigated conveyance loss due to subsidence beyond 2020 would lead to undesirable results”. Sustainable management criteria (SMCs) have been proposed for the FKC that limit subsidence to a 5-year annual average rate of 0.1 feet per year (ft/yr) with a maximum 3 feet of cumulative subsidence from 2015 to 2040. Beyond 2040, subsidence is to be minimized with zero average subsidence (including residual subsidence) attributable to groundwater pumping under GSA jurisdiction. To address post-2020 subsidence along the FKC, a mitigation program consisting of raising the sides (liner) of the canal and upgrading associated facilities/infrastructure such as bridge crossings, check structures, wasteways, turnouts, inlet drains, siphons/underdrains, power and telephone and various size pipelines is proposed. The mitigation program will be partially funded by GSAs within the Kern Subbasin, based on the relative impact of post-2020 pumping and groundwater overdraft on subsidence along the FKC. FWA is evaluating several Lower Reach Capacity Correction alternatives including achieving the original design conveyance capacity of 2,500 cubic feet per second (cfs). FWA has performed their own forecast of future subsidence in a reconnaissance-level study (Note: the FWA future subsidence forecast is less than historical rate from 2015 to 2023 used to develop the FKC subsidence minimum threshold and assumes groundwater levels stabilizing quickly during implementation of the GSPs). FWA’s position is that the Subbasin GSAs should minimize and mitigate lost conveyance capacity post-2020 due to ongoing subsidence attributable to groundwater pumping under GSA jurisdiction.

As part of this project and management action (P/MA), the Subbasin would implement the following: (1) participate in a program that monitors and tracks ongoing subsidence regionally within the Subbasin and locally along the FKC, (2) compare observed rates of subsidence to established SMCs along the FKC and take action such as pumping reductions should future observed subsidence rates exceed interim milestones and the minimum threshold, (3) collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction and evaluate the degree of post-2020 lost capacity attributable to subsidence, (4) develop an attribution analysis of post-2020 subsidence impacts using either a numerical model to perform predictive analysis or other suitable tool, and (5) develop and implement a funding mechanism based on the subsidence attribution analysis to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.

KSB-2 Coordination with Groundwater Regulatory Programs – The Subbasin will continue to coordinate with various water quality regulatory programs implemented by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program (ILRP), Safe and Affordable Funding for Equity and Resilience Program (SAFER) projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking Memorandums of Understanding (MOUs), which mandates the sampling of monitoring wells and adherence to mitigation measures to protect groundwater quality.

KSB-4 Coordination with Basin Study – The Subbasin has coordinated to perform an updated Basin Study (see Appendix U). The work will address data and information gaps and recalibrate the Subbasin model. The update will:

a. Improve the understanding of the groundwater response to the implementation of P/MAs.
b. Develop an improved determination of the input data to address data gaps for Subbasin-wide and local water budgets.
c. Incorporate locally derived hydrogeologic conceptual model data from the Subbasin Plan into the model to better represent subsurface groundwater flow within and out of the Subbasin.
d. Improve model calibration to better simulate groundwater levels with respect to minimum thresholds and measurable objectives.

KSB-5 Domestic Well Mitigation – The Subbasin has executed a Letter of Intent (see Appendix K) to fund and implement a subbasin-wide domestic and small community well mitigation program starting January 1, 2025 with Self-Help Enterprises (SHE) as follows:

a. Emergency Bottled Water – Upon notice that a domestic well user has lost access to water, SHE distributes 2 weeks' worth of bottled drinking water to the household within 24 hours.
b. Well Assessment – SHE staff conduct on-site assessments which includes review of well reports/documentation, confirming water source, checking for running water/water pressure, assessing well depth and water level, inspecting electrical and above-ground components, inspecting any existing tank systems, identifying locations for new tank system placement, and developing a site map.

c. Temporary Tanks and Hauled Water – If necessary, SHE arranges for installation of a tank system and routine delivery of hauled potable water to the site. Repair and maintenance services are provided to the system until removal.

d. Ongoing Bottled Water – SHE coordinates deliveries of ongoing bottled drinking water until a long-term solution is in place.

e. Long-Term Solutions – SHE finances, as provided by the GSAs, well repairs, well replacement, and service connections to nearby water systems (whenever feasible) to restore long-term water access to the home.

KSB-7 Well Registry – The Subbasin, as part of the 2024 GSP amendment process, developed a more accurate well inventory based on available databases and field verifications. This management action will continue to provide improvements and maintenance of the Subbasin's existing well inventory and house the well registry within the Kern County Subbasin data management system. At least annually, the Subbasin will update the system using DWR/County well permit information and well surveys. Additional details regarding the data sources and methodologies used to develop the improved well inventory can be found in Section 5.6.1.

KSB-8 Consumptive-Use Study – The Subbasin has annually contracted with either Cal Poly's Irrigation Training Research Center and/or LandIQ for monthly evapotranspiration data of the Subbasin for both planning and, in some GSAs, for groundwater extraction fee calculation purposes. The Subbasin will continue this effort and invest in improved technology and processes for improved accuracy. See proposal document in Appendix V.

14.2.4 Adaptive Management Efforts

To the extent that projects and management actions are unable to prevent Minimum Threshold Exceedances that are caused by activities under GSA authority, further actions will be evaluated and considered as directed by KSB-3 Exceedance Policy attached in Appendix W. If either the projects or management actions are unable to produce the projected benefits or other better options are found that prove more cost-effective the GSA may deviate from the actions as described above. At each 5-year planning window, each previously described P/MA benefits will be evaluated. New P/MAs may also be evaluated and included at the planning window and added if estimated benefits are unrealized. Progress on the glide path's implementation will be presented annually via the Kern County Subbasin Annual Report and inform adaptive management efforts.

Each GSA will enact projects and actions to accomplish at least a linear path to sustainability. Several projects have been identified and listed "**As Needed**" on Table 14-3 and could reduce the deficit by up to 71,645 AFY if implemented.

14.3 Circumstances for Implementation

☑ **23 CCR § 354.44(b)(1)(A)**

As discussed above, an overall P/MA implementation schedule, or preliminary glide path has been developed as a framework to guide the level of benefits that are planned to be achieved over the GSP implementation period (i.e., until 2040), and further through the SGMA planning and implementation horizon (i.e., through 2070). P/MAs will be implemented in such a way as to meet the glide path Milestones as a minimum requirement.

P/MAs have been categorized on Table 14-4 through Table 14-23 as: **Implemented**, **Functional**, **In-Process**, or **As-Needed**.

Implemented – In anticipation of SGMA, several P/MAs were initiated pre-2020 and have since been completed. Several other P/MAs were developed in response to SGMA and have since been completed and are accruing benefits.

Functional – In response to SGMA, several P/MAs had been initiated and have since been completed. Several other P/MAs were developed in response to SGMA and have since been completed but are not yet accruing benefits.

In-Process – Other P/MAs are In-Process somewhere between Feasibility and Construction/Implementation. All of the In-Process P/MAs will be implemented except for circumstances such as litigation, failed funding, failed ballot initiatives, or environmental constraints.

As-Needed – As part of the Adaptive Management efforts, several P/MAs have been identified in response to Minimum Threshold Exceedances, failed or diminished P/MA's, new opportunities, or other unforeseen issues. At each 5-year planning window, these and other P/MAs will be formally evaluated for implementation.

14.4 Public Notice Process

☑ **23 CCR § 354.44(b)(1)(B)**

Public notice requirements vary for the different P/MAs listed above. Some projects' infrastructure improvements may not require specific public noticing (other than that related to construction), whereas other management actions that involve, for example, imposition of fees by the GSA, may require public noticing pursuant to Proposition 218 or Proposition 26. In general, GSA meetings are open to the public. In some instances, the P/MAs will also each be subject to California Environmental Quality Act (CEQA) review and other permitting processes that are subject to public notice and review.

Additional stakeholder outreach efforts will be conducted prior to and during P/MA implementation, as required by law.

14.5 Overdraft Conditions

☑ 23 CCR § 354.44(b)(2)

As discussed in Section 9.1.2.4 *Overdraft Conditions*, the Subbasin has a net water budget deficit of 372,120 AFY over the historical period based on the specific budget model under the 2030 Climate Change Scenario by 2040. The P/MAs presented herein are expected to result in benefits that will address the projected deficit to avoid Undesirable Results and maintain sustainability as shown on Figure 14-1.

14.6 Permitting and Regulatory Process

☑ 23 CCR § 354.44(b)(3)

Permitting and regulatory requirements vary for the different P/MAs depending on whether they are infrastructure projects, recharge projects, demand reduction, or management actions. Detailed descriptions of permitting requirements are provided in Section 5.6. The various types of permitting and regulatory requirements (not all applicable to every P/MA) that may be applicable to P/MAs are summarized by category in the following section.

Federal

- National Environmental Policy Act (NEPA) documentation if federal grant funds are used.
- National Pollution Discharge Elimination System (NPDES) stormwater program permit (administered by the California State Water Resources Control Board).

State

- CEQA documentation, including one or more of the following: Initial Study (IS), Categorical Exemption (CE), Negative Declaration (ND), Mitigated Negative Declaration (MND), or Notice of Exemption (NOE).
- Environmental Impact Report (EIR).
- California State Water Resources Control Board permits and regulations regarding recycled water use, waste discharge, and stormwater capture for recharge.
- California Surface Mining and Reclamation Act (SMARA) regulations.
- California Division of Safety of Dams regulations.

Regional

- San Joaquin Valley Air Pollution Control District (SJVAPCD) permit and regulations.
- Power and Water Resources Pooling Authority (PWRPA).

County/Local

- Encroachment permits – Kern County, local agencies, CalTrans, and others.
- Kern County grading permit.
- Kern County well construction permit.

Specific currently identified permitting and regulatory requirements for each P/MA are listed in Table 14-4 through Table 14-23. Upon implementation of any P/MA, the regulatory and permitting requirements of the P/MA will be reexamined.

14.7 Status and Implementation Timetable

☑ 23 CCR § 354.44(b)(4)

Section 14.3 Circumstances for Implementation established categories for implementation, including implemented, functional, in-process, or as-needed. P/MAs related to water quantity will be initiated in a manner and sequence that achieves the glide path level of expected benefits shown in Table 14-4 through Table 14-23. As-needed projects are part of the Subbasin's adaptive management process that compensates for uncertainty in the checkbook accounting.

14.8 Expected Benefits

☑ 23 CCR § 354.44(b)(5)

P/MAs have expected benefits related to water quantity. Once a P/MA is implemented, there needs to be a way to evaluate, ideally to quantify, the benefits resulting from that P/MA. How P/MA benefits are evaluated/quantified depends on the P/MA type. For those P/MAs that involve direct supply augmentation, the benefit is quantified directly through the measurement of those flows. For P/MAs that involve indirect supply augmentation through, for example, increased groundwater storage, quantification of the benefit will require tracking of deliveries to said projects as compared to estimated benefits made in the planning process. For P/MAs that involve water demand reduction, the benefit will be evaluated by comparison of the observed water demand condition (e.g., irrigated acreage, consumptive use) against a hypothetical condition where the P/MA was not in place. Because it is not possible to determine with certainty what the condition without the P/MA would be like, the quantification of the benefits is inherently uncertain.

As discussed above, although the P/MAs described herein are laid out along a general timetable defined by incremental elimination of water budget deficits (i.e., the glide path), the goals and objectives of P/MA implementation are informed by a water budget outcome with the goal to ensure that Undesirable Results for relevant Sustainability Indicators are avoided by the end of the SGMA implementation period (i.e., by 2040). For this reason, ultimately the success of the collective implementation of P/MAs will be determined by whether the Sustainability Goal is achieved.

14.9 Source and Reliability of Water from Outside the Basin

☑ 23 CCR § 354.44(b)(6)

Specific sources of water utilized for water supply augmentation P/MAs can be found in Appendix S for each specific project.

14.9.1 P/MA Annual Water Benefit Estimate for Groundwater Recharge/Storage Projects

Water banking recharge projects have been designed with a very conservative water supply augmentation benefit calculation as follows:

*Annual Water Benefit = estimated infiltration rate ft/day * wetted acres * days operation in a wet year * 20 percent of years being wet * percent of stored water for third parties.*

Specific benefit calculations for water supply augmentation P/MAs can be found in Appendix S for each specific project or management action.

14.10 Legal Authority Required

☑ 23 CCR § 354.44(b)(7)

As GSAs, per California Water Code (CWC) § 10725 through 10726.8, the GSA possesses the legal authority necessary to implement the demand management P/MAs described herein. Further description of GSA authority can be found in Appendix S.

14.11 Estimated Costs and Plans to Meet Them

☑ 23 CCR § 354.44(b)(8)

Estimated costs for each P/MA in the Subbasin are presented in Table 14-3. The costs are approximate and subject to refinement. These costs include “one-time” costs and ongoing costs. The one-time costs may include capital costs associated with construction, feasibility studies, permitting, environmental (CEQA) compliance, or any other costs required to initiate a given P/MA. The ongoing costs are associated with

O&M and/or costs to otherwise continue implementing a given P/MA. It should be noted that depending on the source and nature of funding for the P/MAs, the one-time costs may or may not be incurred entirely at the beginning of the P/MA; in some instances, loans or other financing options may allow for spreading out of "one-time" costs over time.

Potential sources of funding for the various P/MAs are also presented in Table 14-4 through Table 14-23, and include but not limited to the following:

- District assessments and/or water charges.
- Grant funding from sources including DWR, United States Bureau of Reclamation (USBR), and CA WISP.

Estimated costs for the Subbasin's P/MAs by implementation status are presented in Table 14-3. The costs are approximate and subject to refinement. These costs include "one-time" costs and ongoing costs.

Table 14-3. Kern County Subbasin (P/MA Cost by Implementation Status)

Kern County Subbasin	Estimated Costs	
	One-time	Annual
Implemented	$233,144,932	$35,409,670
Functional	$6,360,000	$63,175
In-Process	$1,064,191,409	$12,994,425
As-Needed	$289,880,000	$8,998,000
Total	**$1,593,576,341**	**$57,465,270**

14.12 Management of Recharge and Groundwater Extractions

☑ 23 CCR § 354.44(b)(9)

As stated previously in Section 9 Water Budget Information, the Subbasin is in a state of approximate water supply/demand deficit of 372,120 AFY. One of the primary means by which the deficit will be addressed is through the implementation of P/MAs that reduce demand and augment supplies from additional outside sources of water, in particular during normal to wet years. Many of the projects discussed herein and shown on Table 14-4 through Table 14-23 take advantage of additional wet-year supplies that are assumed to be available as capacity increases. These P/MAs include various direct recharge projects and projects that increase storage capacity and delivery flexibility.

In addition to these supply augmentation projects, the portfolio also includes policy-based management actions aimed at demand reduction. Some of these management actions aim to reduce overall water demand through newly implemented water charges, and others are more specifically focused on reducing groundwater pumping by land retirement and imposed water budgets. Through this combination of increased recharge during wet years and demand reduction, the P/MA efforts will ensure that chronic lowering of groundwater levels and reduction in storage during drought will be offset by increases in groundwater levels and storage during other periods.

This page intentionally left blank.

Table 14-4. AEWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators: Groundwater Levels & Storage	Relevant Sustainability Indicators: Groundwater Quality	Relevant Sustainability Indicators: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process	As-Needed									Implemented		Functional	In-Process			As-Needed						
AE-1	ACSD Well #12 Construction	This project would drill a new well to replace a well that is considered at risk of contamination due to its proximity to the Brown and Bryant Superfund Site. The new well (No. 12) is being drilled concurrently with the Arsenic Mitigation Project Phase II and will allow ACSD to bring four new wells online in addition to Well No. 13 and 14 brought online in July of 2016.		✓			Underway	Public meetings, direct mail	Title 22 Drinking Water Regulations	Complete	Complete	2019-	0	0	✓					NA	None	$2,250,000	NA	ACSD
AE-2	On-Farm Recharge	The program encourages individual growers to perform on-farm recharge for individual and aggregated benefits. Water may be recharged on-farm in private basins and/or distributed through irrigation systems across irrigated acreage in excess of current crop ET.	✓			Supplemental Water Recharge	Underway	No public notice required for implementation; outreach and education will expand program.	NA	Starting in 2023, provided financial incentives to landowners to conduct on-farm recharge; 13,317 AF recharged to the Kern Subbasin in 2023.	Ongoing; implemented beginning in 2019	2023-	5300	0	✓	✓	✓			Local stormwater	None	NA	NA	Private; if required
AE-3	Emergency 1,2,3-TCP Treatment Well #12 (EPA Replacement CW-1)	The project involves the installation of emergency 1,2,3-TCP treatment at the well head. The work will include installation of a skid mounted treatment system with two granular activated carbon media vessels for removal of 1,2,3-TCP, connection to the existing well discharge piping, installation of below ground and above ground influent and effluent piping and appurtenances, electrical and controls, and modifications to the existing well site PLC programming.		✓			Underway	Public meetings, direct mail	Title 22 Drinking Water Regulations	Well #12 was completed and commissioned in May of 2021.	Completed May 2021	2021-	0	0	✓					NA	None	$1,600,000	TBD	ACSD
AE-4	Forrest Frick Pipeline / KDWD Eastside Canal Intertie	This project connects the Forrest Frick Pipeline to the KDWD Eastside Canal to send AEWSD SW supplies through KDWD to serve portions of the AEWSD GWSA with temporary water contracts, utilizing existing infrastructure (turnouts, pipelines that are both District and landowner owned). With the District's new 9(d) contract, certain provisions of Reclamation law are no longer applicable and all lands within the service area can now be served with federal water supplies.	✓	✓		Supplemental Water Use	Underway	Infrastructure improvement; no public noticing necessary	CEQA; NEPA; County encroachment permits	Deliveries began in February 2023	Construction completed in February 2023	2023-	1,900	0	✓	✓	✓			Additional wet-year imported water supplies	None	$1,000,000	TBD	AEWSD General Fund, USBR grant
AE-5	Arsenic Mitigation Project - Phase II	The purpose of the project is to bring the ACSD water system into compliance for Arsenic. All five of the ACSD active wells exceed the maximum contaminant level (MCL) of 10 ppb for Arsenic. The project was separated into two phases. Phase II involves drilling three new wells, constructing a 1.0 MG storage tank and booster pumping plant, and connecting the facilities to the existing distribution system. The original five (5) water wells will then be abandoned and destroyed in accordance with Kern County Standards.		✓			Underway	Public meetings, direct mail	Title 22 Drinking Water Regulations	Well #18 completed December 2023; all other project components complete	December 2023	2024-	0	0	✓					NA	None	$14,200,000	TBD	ACSD
AE-6	Private & Caltrans Basin Connections	This project involves the construction of pipelines to connect several on-farm private basins and Caltrans sumps near AEWSD to utilize for groundwater recharge.	✓			Supplemental Water Recharge	Grant funding	Infrastructure improvement; no public noticing necessary	Caltrans permitting; CEQA if longer pipeline connections are required	Several Cal Trans basins have been connected to AEWSD and are currently taking surface water for recharge	Ongoing	2023-	270	0	✓	✓	✓			Additional wet-year imported water supplies; Local stormwater	None	$500,000	NA	AEWSD General Fund; grants

AE-31	Exercising Existing Water Rights	The USBR, SLDMWA, FWA, and SJREC have entered into a MOU to collectively identify projects and potential actions aimed at improving drought resiliency south of the Delta, including AEWSD deliveries from the FKC. The South of Delta Drought Resiliency Framework allows participating entities to voluntairly conserve and securely store a portion of their CVP south of Delta deliveries for subsequent use with the goal of providing at least a 5% allocation to CVP south of Delta agricultural water service/repayment contracts, reducing reliance on Delta exports in drought years.	✓			Exercise of Rights	Underway	NA	NA	MOU effective March 2024	2024	2024-	2000	0			✓			Increased reliability of AEWSD's CVP supplies	Signed MOU	$0	$0	AEWSD General Funds
AE-8	AEWSD Sunset Spreading Works	The Sunset Spreading Works, approximately 150 acres, is located on the boundary between AEWSD and KDWD, adjacent to KDWD's Eastside Canal. The Project takes surface water (Federal CVP, State Water Project, or local supplies) diverted through KDWD's Eastside Canal and recharges the surface supplies as part of AEWSD's and KDWD's joint water management programs. The Project included the construction of exterior and interior dikes for a direct recharge facility, a new turnout and pump station from the KDWD Eastside Canal, and interbasin structures.	✓	✓		Supplemental Water Recharge	Underway	Infrastructure improvement; no public noticing necessary	KDWD encroachment permit; CEQA; NEPA if federal funds are used	Project construction is anticipated to be complete in Spring 2024; Early deliveries began in February 2023 using mobile temporary pumps	Spring 2024	2023-	4920	410	✓	✓	✓			Additional wet-year imported water supplies	None	$7,330,000	TBD	AEWSD General Fund (50%), KDWD (50%)
AE-9	DiGiorgio Unit In-Lieu Storage Program	The District will supply SW when available through new facilities to the GWSA to meet its water requirements with the intent of reducing District-wide GW use. However, when SW is in short supply and under agreement, the landowners could recover and return GW from their own wells to the District canal system through new pipelines once they have satisfied their own water needs.	✓	✓		Supplemental Water Use	Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; NEPA requirements if grant funds are used; PWRPA; possible Kern County encroachment permits	Phase 2a construction anticipated to be complete in Fall 2024; funded through portion of a $25M loan to AEWSD	Phase 2a completion: Fall 2024	2025-	4250	0	✓					Additional wet-year imported water supplies	None	$17,000,000	TBD	AEWSD General Fund
AE-10	Frick Unit In-Lieu Project	This project would increase the ability of the District to provide surface water supplies to the Groundwater Service Area (GWSA) to help meet crop irrigation requirements. With the Project, the District will supply surface water when available through new facilities to the GWSA to meet crop irrigation requirements with the intent of reducing District wide groundwater use.	✓	✓		Supplemental Water Use	Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; NEPA requirements if grant funds are used; PWRPA; possible Kern County encroachment permits	$2M from the IRWM Round 2 grant awarded	2025	2026-	3500	0	✓					Additional wet-year imported water supplies	None	$16,000,000	TBD	AEWSD General Fund, IRWM Grant
AE-11	Expansion of North Canal Spreading Works	The Project will convert approximately 160 acres of permanently cropped agricultural lands into additional groundwater recharge facilities as part of the District's existing North Canal Spreading Works. The Project water supply benefits include approximately 500 AFY due to the land use change (vineyards and almond orchards to basins), plus an average annual recharge benefit of 5,200 AFY (or 13,000 AF in an unconstrained year).	✓	✓		Supplemental Water Recharge	Underway	CEQA, NEPA	CEQA, NEPA	Planning and design underway; construction anticipated to begin in October 2025 and last 6 months	2025	2026-	5200	500	✓	✓	✓			Additional wet-year imported water supplies	None	$4,300,000	TBD	AEWSD General Fund; DWR grant
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	AEWSD General Fund (Study only)
AE-12	AEWSD South Canal Flood Study / Improvements	The South Canal Flood Study would review and possibly revise the FEMA floodplain in this area in order to increase the height of the canal bank to provide additional operational freeboard and accordingly reduce the potential for canal spills and subsequent flooding. The additional canal storage could allow for the caputure and use of additional floodwater in-lieu of groundwater pumping.	✓			New Local Supply	Grant funding	Infrastructure improvement; no public noticing necessary	NA	Initiated the South Canal Flood Study, including identification of potential grant funding sources	Study approx. 1 year; construction approx. 1 year	2030-	150	0		✓	✓			Local stormwater	None	$2,300,000	NA	AEWSD General Fund
AE-13	Conversion of Granite Quarry to Sycamore Ranch	The Granite Co. quarry, located upstream of the Sycamore Spreading Basins, is approaching the end of its operational life and could be converted into a balancing / detention / spreading reservoir. Excess flows in the North Canal could be pumped into the quarry reservoir, so the detained water could be recirculated for irrigation demands in-lieu of groundwater pumping and/or recharged.	✓	✓		Supplemental Water Use	To be implemented upon adoption of GSP / Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; DMR SMARA permit closure; NEPA requirements if grant funds are used	Geotechnical study complete; AEWSD and TCWD have participated in several meetings to discuss the permitting process for this project	Construction duration TBD	2030-	0	0	✓		✓			Additional wet-year imported water supplies	Property acquisition or land use agreement with quarry owner	$15,000,000	TBD	AEWSD General Fund, TCWD

AE-14	AEWSD Wasteway Basin Improvements	The primary use of the existing AEWSD Wasteway Basin is to provide emergency water storage in the event of power failure. Additionally, it works as a detention facility for the City of Bakersfield stormwater. This project would include construction of a HDPE liner along the levees, installation of recirculation pumps, and basin grading. These improvements would allow the basin to serve as a location to divert and clarify sediment.	✓			New Local Supply	Project to be implemented upon FEMA grant approval.	Infrastructure improvement; no public noticing necessary	SJVAPCD Dust Control & SWPPP; NEPA Cultural Resources	AEWSD continues to seek grant funding for this project.	Construction duration: 3 years	2040-	1550	0		✓	✓			Stormwater from Bakersfield storm sewer system	None	$2,500,000	$32,000	AEWSD General Fund
AE-15	General In-Lieu Storage Program	The In-Lieu Banking Program consists of suppling surface water to landowners that previously relied only on groundwater (GWSA). New infrastructure would have to be built to facilitate the implementation of this program.	✓	✓		Supplemental Water Use	Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; NEPA requirements if grant funds are used; PWRPA; possible Kern County encroachment permits	Imported and delivered surface water to contracted and noncontracted lands; Sandrini Unit (i.e., Tejon Expansion) under design; Development of a potential hybrid in-lieu and temporary water service contract is underway and landowner outreach for the new areas will begin soon.	2030	2030-	15000	110	✓					Additional wet-year imported water supplies	None	$10,000,000	TBD	AEWSD General Fund
AE-32	Capture of Imported Water Return Flows from White Wolf Subbasin	AEWSD has provided imported water deliveries to landowners within the White Wolf Subbasin. Return flows of imported water flow across the White Wolf Fault into Arvin GSA. Arvin GSA would capture the proportion of Subbasin inflows attributed to AEWSD's imported water return flows for distribution and use within the surface water service area.	✓			Exercise of Rights	Underway	GSA Board meetings	NA	Arvin GSA has initiated discussions and negotiations with Subbasin GSAs and White Wolf GSA	2025	2025-	4500	0						Imported water return flows	None	$0	$0	NA
AE-16	Sycamore Creek Detention & Sedimentation Basin	The proposed basin would serve to intercept sediment from Sycamore creek flows to prevent constriction where sediment deposits downstream, reduce the peak outflow, and prevent the likelihood of a canal and spreading basing breach. Detained water could be recirculated for irrigation demands or recharged for groundwater supply augmentation.	✓	✓		Supplemental Water Recharge	Grant funding	Infrastructure improvement; no public noticing necessary	County grading permit; NEPA if federal grant funds used; SMARA (potentially)	Not yet Initiated	Construction duration: approx. 2 years	1-3 years after construction	250	0		✓				Local stormwater	None	$3,000,000	$30,000	AEWSD; potential grants
AE-17	Stormwater Management and Flood Control Improvements	Potential construction of new sedimentation/detention basins, flood ditch erosion protection, Spillway Basin expansion, lengthening the South Canal's siphon under David Road or extension of the South Canal liner through designated floodplain reaches.	✓	✓		Supplemental Water Recharge	Grant funding and completion of feasibility study	Infrastructure improvement; no public noticing necessary	Permits: TBD; NEPA requirements if funds are granted	Not yet Initiated	Construction duration: approx. 1 year	1-3 years after construction	TBD	0	✓	✓				Local stormwater	None	TBD	TBD	AEWSD and partnering agencies
AE-18	Caliente Creek Habitat Mitigation and Groundwater Recharge	Restoration of agricultural lands to native vegetation to provide flood mitigation. Two alternatives are being considered, of which Alternative 1 is partial agricultural and 2 is non-agricultural.	✓			Supplemental Water Recharge; Land Retirement	Grant funding	CEQA, NEPA	CEQA; NEPA (if federal funds used); SWRCB Waste Discharge Requirements; CDFW Agreement; Determination of consistency with VFHCP	Not yet Initiated	TBD	Immediately following construction	TBD	TBD		✓				Local stormwater	None	$3,000,000	TBD	AEWSD; potential grants
AE-19	AEWSD Intake Canal / KDWD Farmer's Canal Intertie	Improvement of existing and/or construction of new interties between AEWSD Intake Canal and KDWD's Farmer's Canal to facilitate water exchanges between the two districts and Kern County partners.	✓			Supplemental Water Use	Completion of feasibility study	Infrastructure improvement; no public noticing necessary	None (CEQA exempt under 15301 and 15303)	Not yet Initiated	Construction duration: approx. 1 year	1 year after construction	4000	0			✓			Additional wet-year imported water supplies	None	$2,000,000	$20,000	AEWSD General Fund; KDWD
AE-20	AEWSD North Canal Balancing Reservoir Expansion & Discharge Pipelines	The proposed project will consist of the installation of a pipeline system that will convey flows from the four (4) wells within the AEWSD Balancing Reservoir directly to the basin discharge structure and no longer through the basin low flow channels. Infiltration and evaporation losses on well discharge flows will be eliminated and power efficiency for the wells (kwh/af) will be significantly enhanced since all water pumped will be discharged into the North Canal.	✓			Supplemental Water Recharge; Demand Reduction	Completion of feasibility study	Infrastructure improvement; no public noticing necessary	None	Not yet Initiated	Construction duration TBD	1-3 years after construction	100	40			✓			Additional wet-year imported water supplies	None	$300,000	TBD	AEWSD; potential grants

AE-21	AEWSD Lateral Capacity Improvement Projects	Increase delivery capacity of the AEWSD N-55 lateral system. Some examples of the actions considered for this project are: replacement of lateral system and landowner pipelines, renovation of storage tanks, construction of pump stations, etc.	✓			Supplemental Water Use	Grant funding/Completion of feasibility study	Infrastructure improvement; no public noticing necessary	Permits: TBD; NEPA requirements if funds are granted	Not yet Initiated	Construction duration TBD	TBD	1000	0			✓			Additional wet-year imported water supplies	None	$15,000,000	TBD	AEWSD General Fund
AE-22	AEWSD South Canal Balancing Reservoir	Creation of a reservoir to allow water storage for flow mismatches in the AEWSD canal system during operation or emergencies. Depending on the location, this reservoir would increase storage capacity by ~500 AF.	✓			Supplemental Water Use	Grant funding, South County flooding response	Infrastructure improvement; no public noticing necessary	TBD	Not yet Initiated	Construction duration TBD	TBD	500	190			✓			Additional wet-year imported water supplies	None	$5,000,000	$5,000	AEWSD General Fund
AE-23	Reclamation of Oilfield Produced Water	Reclaiming water from oil production facilities for irrigation purposes is currently an untapped water source in AEWSD. After treatment and cooling, produced water could be pumped into AEWSD facilities to serve irrigation demands in-lieu of groundwater pumping.	✓	✓		New Local Supply	To be implemented upon adoption of GSP / agreement with partnering oil field	Public meetings	TBD	Not yet Initiated	TBD	1 year after agreement	1000	0						Oil field produced water	None	TBD	TBD	AEWSD and partnering oilfield
AE-24	Wastewater Reclamation with City of Arvin & Bakersfield	Reclaiming water from Cities of Arvin and Bakersfield wastewater treatment facilities for irrigation purposes is currently an untapped water source in AEWSD. After wastewater treatment, the effluent could be pumped into AEWSD facilities to serve irrigation demands in-lieu of groundwater pumping.	✓			New Local Supply	To be implemented upon adoption of GSP / agreement with City of Arvin and City of Bakersfield	Public meetings	City encroachment permits; SWRCB Waste Discharge Requirements	Not yet Initiated	TBD	1 year after agreement	10000	0						Wastewater from Cities of Arvin and Bakersfield	None	TBD	TBD	AEWSD and partnering cities
P/MA Number	**P/MA Name**	**Summary Description**	**Relevant Sustainability Indicators Affected**			**Overdraft Correction Description Category**	**Circumstances for Implementation**	**Public Noticing Process**	**Permitting and Regulatory Process Requirements**	**Status**	**Timetable for Completion**	**Timetable for Accrual of Expected Benefits**	**Expected Benefits**							**Source(s) of Water**	**Legal Authority Required**	**Estimated Costs**		
													Primary (AFY)		**Secondary**									
			Groundwater Levels & Storage	**Groundwater Quality**	**Land Subsidence**								**Water Supply Augmentation**	**Demand Reduction**	**Water Quality Improvement**	**Flood Control**	**Water Management Flexibility or Efficiency**	**Mitigation Programs**	**Data Gap Filling/ Monitoring**			**One-time Costs**	**Ongoing Costs (per year)**	**Potential Funding Source(s)**
Management Actions	Implemented	Functional	In-Process		As-Needed							Implemented		Functional	In-Process			As-Needed						
AE-25	Groundwater Extraction Quanticiation Method	Application of a new policy to specify an approved method to quantify the individual and aggregated groundwater extractions for the required SGMA annual reporting. Some methods to consider (or a combination of them) are the following: (1) Irrigated Acreage determined by aerial imagery; (2) Irrigated area hybrid determined by annual crop survey alongside aerial imagery; (3) Calibrated energy records; (4) Volumetric flow measurement; (5) Remote sensing of evapotranspiration; (6) Other.	✓		✓		Underway	District flyers, direct mail, public meetings	None	AEWSD completed their district-specific groundwater flow model and decision support tool. The GSA obtained satellite crop evapotranspiration (ET) data through LandIQ.	Refinements ongoing	2023-	0	0			✓		✓	NA	Authority of a GSA under SGMA to develop and implement a GSP	$0	$10,000	DWR Grant

KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.		✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	AEWSD General Fund
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2020-	0	0				✓	✓	NA	NA	$0	$25,000	AEWSD General Fund
AE-25	Education of Groundwater Use per Acre	This program would provide groundwater users an expected groundwater volume, as an education tool, prior to enforcement actions on groundwater allocations, with the goal of providing awarness of overdraft conditions. This information would be provided in an annual letter, along with average crop demand, GSA average extraction, GW overdraft, and reminders of GSA powers and authorities.	✓			Demand Reduction	To be implemented upon adoption of GSP	District flyers, direct mail, public meetings	None	In late 2023, AEWSD published an informational flier with information on District groundwater use	Ongoing	TBD	0	100						NA	None	$15,000	$5,000	AEWSD General Fund
AE-26	Incentives for Land Conversion	The District would provide subsidies to incentivize groundwater users to convert land to alternative land uses (e.g. solar farms) and reduce groundwater extractions. The District may consider a subsidy structure study to determine which subsidies would result in the greatest expected annual benefit in acre-feet per year.	✓		✓	Land Retirement	To be implemented upon adoption of GSP	District flyers, direct mail, public meetings	None	485 acres of solar conversion since 2015. District retained a consultant to develop Land Repurposing Program; Board to consider policy in late 2024. AEWSD provided financial incentives to landowners to conduct on-farm recharge (see AE-1).	2025	2015 (solar conversion) & 2030 (land repurposing)	0	11200						NA	Authority of a GSA under SGMA to develop and implement a GSP	$130,000	TBD	AEWSD General Fund
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	AEWSD General Fund
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓				When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2026	2025-	0	0				✓		NA	NA	$0	$45,000	AEWSD General Fund
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	###	✓				✓	NA	None	$0	$10,000	AEWSD General Fund

KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	AEWSD General Fund
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	AEWSD General Fund
AE-27	On-farm Water Conservation	The NRCS is offering landowner incentive programs to assist in implementing various conservation activities, including but not limited to: irrigation system improvements, water/nutrient/pest management, and pump engine replacement. Interested landowners can call (661) 336-0967 or visit the website (www.ca.nrcs.usda.gov) for more information.	✓			Water Conservation-Efficiency	Grant funding	District flyers, direct mail, public meetings	None	Not yet Initiated	TBD	1-3 years after initiation	0	250						NA	None	$10,000	$0	NCRS
AE-28	Groundwater Fee Increase	Increase GWSA costs to incentivize groundwater users to reduce groundwater extractions and take surface water when available. The District may consider modifying its fee structure study to determine the best strategy for curbing groundwater overdraft without causing inequitable economic impact.	✓		✓	Demand Reduction	As-needed to meet milestones	District flyers, direct mail, public meetings	Prop 218 or through District rate setting	Not yet Initiated	TBD	1-3 years after impleme ntation	0	TBD						NA	Authority of a GSA under SGMA to develop and implement a GSP	NS	NA	NA
AE-29	Groundwater Allocation per Acre	This program would provide a finite groundwater allocation on a per acre basis. The policy would identify and forecast the demands associated with existing water rights, domestic and environmental uses. The sustainable yield and ultimate groundwater allocation would take into consideration the applicable beneficial uses and users of groundwater. Once an individual groundwater allocation is determined, the District may adopt a policy which provides a gradual "ramp-down" wherein an allocation would decrease over time to arrive at the actual groundwater allocation to allow growers time to adjust to the concept of an allocation and, for some growers, a reduction in groundwater use. The policy would detail the number of years and amount of reduction each year.	✓		✓	Demand Reduction	To be implement ed upon adoption of GSP	District flyers, direct mail, public meetings	GSA adoption of resolution; potentially CEQA	Not yet Initiated	TBD	1-3 years after impleme ntation	0	TBD						NA	Authority of a GSA under SGMA to develop and implement a GSP	TBD	TBD	AEWSD General Fund
AE-30	Groundwater Marketing & Trading	Contingent on the GW extraction quantification and allocation programs, the District would pursue a groundwater market and trading program to provide uses and beneficial users more flexibility in utilizing a groundwater allocation. The District may adopt a policy to define a groundwater trading program, acknowledging that many complexities and considerations required to successfully initiate and manage a trading program may arise. Therefore the District should discuss any other water bank/credit systems in existence. The District may adopt a groundwater trading structure and consider a variety of structures including: (1) Bilateral contracts or "coffee shop" markets; (2) Brokerage; (3) Bulletin boards; (4) Auctions and reverse auctions; (5) Electronic clearing-houses or "smart markets" ; (6) Other trade structures.	✓		✓		Contingent on "Groundwa ter Extraction Quantificati on Method" and "Groundwa ter Allocation per Acre" Manageme nt Actions	District flyers, direct mail, public meetings	GSA adoption of resolution; potentially CEQA	Not yet Initiated	1-2 years after initiation by GSA Board	1-3 years after initiation	0	NA			✓			NA	Authority of a GSA under SGMA to develop and implement a GSP	TBD	TBD	AEWSD General Fund

Table 14-5. BVWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators: Groundwater Levels & Storage	Relevant Sustainability Indicators: Groundwater Quality	Relevant Sustainability Indicators: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
	Projects	Implemented / Functional / In-Process / As-Needed											Implemented	Functional	In-Process			As-Needed						
BV-1	Magnetic Flow Meter Installation	Magnetic flow meters have been installed on all production wells in BV. In addition to the approximately 200 wells now having magnetic flow meters, meters are being installed on all new and replacement wells constructed in the District.	✓		✓		Complete	NA	NA	Implemented and Operational	Ongoing	2016-	0	0			✓		✓	NA	None	$800,000	$1,600	BVWSD (water charges)
BV-2	Palms Recharge Project	The BVWSD/GSA has the 1,142-acre Palms Recharge Project. This facility is located at the southern tip of the District's Buttonwillow Service Area and was constructed on lands acquired by the District and retired from agricultural production.	✓	✓	✓	Land Retirement Supplemental Water Recharge	Complete	NA	NA	Implemented and operational	2019	2020-	8,700	3,340	✓	✓	✓		NA	Kern River and SWP water and occasionally Friant water	None	$26,000,000	$52,000	BVWSD (water charges)
BV-3	Corn Camp Recharge Project	In 2020 the BVWSD/GSA completed the 85-acre Corn Camp Recharge Project. This facility is located within the District and was constructed on land acquired by the District under a 20-year lease with eight 5-year options to extend the lease for a total of 60 years. The land has been retired from agricultural production.	✓	✓	✓	Land Retirement Supplemental Water Recharge	Complete	NA	NA	Implemented and operational	2021	2020-	470	250	✓	✓	✓		NA	Kern River and SWP water and occasionally Friant water	None	$1,750,000	$3,500	BVWSD (water charges)
BV-4	Annexation Demand Reduction Project	The District has purchased 900 acres of white lands and taken it out of production. This land is adjacent to the District and is in the process of being annexed.	✓	✓	✓	Land Retirement	Complete	NA	NA	Implemented and operational	2021	2020-	0	2,630	✓	✓	✓		NA	NA	None	$9,000,000	$18,000	BVWSD (assessment)
BV-5	Daley Ranch Recharge Project	The BVWSD/GSA purchased 91 acres that the District has used to develop the Daley Ranch Recharge Project. This facility is located within the District, and the property has been retired from agricultural production.	✓	✓	✓	Land Retirement Supplemental Water Recharge	Complete	NA	NA	Implemented and operational	2022	2021-	350	270	✓	✓	✓		NA	Kern River and SWP water and occasionally Friant water	None	$4,800,000	$9,600	BVWSD (water charges)
BV-6	Completed Pipelines	Completion of 83 miles of pipeline (36" to 54") to improve distribution of irrigation water by providing an alternative to unlined canals and installing new connections to the California Aqueduct. The pipelines give the District more discretion as to when recharge is performed. The pipeline system has been designed to operated on gravity flow in non-peak irrigation months. All construction has been performed since 2014. Projects include Northern Area, Northern Area - Southern Extension, Northern Area - Eastern Extension, and 7th Standard pipelines.	✓	✓	✓		Complete	NA	NA	Implemented and Operational	2022	2015-	0	0			✓		NA	Kern River and SWP water and occasionally Friant water	None	$72,000,000	$144,000	BVWSD (Capital Improvement Fund), Federal and State grants
BV-7	Completed Pump Stations	Three pump stations (two 1,200-hp and one 600-hp) have been completed to augment flow in the District's distribution system during peak months.	✓				Complete	NA	NA	Implemented and Operational	2023	2020-	0	0			✓		NA	Kern River and SWP water and occasionally Friant water	None	$6,000,000	$12,000	BVWSD (Capital Improvement Fund), Federal and State grants
BV-8	Future Pump Station	Design and environmental documentation of the 600-hp Brite Rd Pump Station is in progress.	✓				Completion of Project	NA		Design/Environmental Compliance	2026	2025-	0	0			✓		NA	Kern River and SWP water and occasionally Friant water	as required by CEQA	$2,450,000	$4,900	BVWSD (Capital Improvement Fund), Federal and State grants
BV-9	BV Future Pipelines	Construction of an additional 20 miles of pipeline to improve distribution of irrigation water by replacing open ditch laterals. Projects include the Belridge, Corn Camp Loop, Wasco Way, Elk Grove, and Brite Road pipelines. Important for delivering surface water to reduce reliance on marginal quality groundwater.	✓	✓	✓		Completion of Project	NA		Design/Environmental Compliance	2027	2026-	0	0			✓		NA	Kern River and SWP water and occasionally Friant water	as required by CEQA	$10,000,000	$20,000	BVWSD (Capital Improvement Fund), Federal and State grants
BV-10	McAlister Ranch Recharge Project	The BVGSA/BVWSD continues to work through regulatory hurdles in the development of a 2,072-acre water bank. BVWSD owns 86% the project and the remaining 14% is on the market. The DEIR is close to completion.	✓	✓	✓	Land Retirement Supplemental Water Recharge	Completion of Project	Completion of Project	In CEQA process	Design/Environmental Compliance	2028	2028-	18,000	5,600	✓	✓	✓		NA	Kern River	as required by CEQA	$35,000,000	$100,000	BVWSD (assessment)

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators: Groundwater Levels & Storage	Relevant Sustainability Indicators: Groundwater Quality	Relevant Sustainability Indicators: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	BVWSD (assessment)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process				As-Needed					
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.		✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	BVWSD (assessments)
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	BVWSD (assessments)
KSB-4	Coordination with Basin Study	Coordination with local GSAs to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	BVWSD (assessments)
KSB-5	Domestic Well Mitigation	Development of a Subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacement due to lowering of groundwater levels.	✓				When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2026	2025-	0	0				✓		NA	NA	$0	$45,000	BVWSD (assessments)
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	BVWSD (assessments)
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	BVWSD (assessments)
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	BVWSD (assessments)

Table 14-6. CWD GSP PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
	Projects	Implemented / Functional / In-Process / As-Needed											Implemented / Functional / In-Process / As-Needed											
CWD-1	New Water Supply Purchases	Implement programs that will acquire long-term new water contracts and/or establish a water purchase fund. The main goal would be to secure long-term water contracts and/or build a reserve fund for water purchases when supplemental water is available.	✓	✓	✓	Supplemental Water Supply	Functional	NA	NA	Implemented	Complete	2020-	5800	0	✓	✓	✓			State Water Project, Kern River, Central Valley Project	None		$8,000,000	Cawelo Water District (Assessments / Water Charges)
CWD-2	Friant Pipeline Project	Construct a pipeline, pump station, and turn-in/out structure to connect the CWD Famoso Recharge Basins directly to the Friant-Kern Canal. This project will allow for greater access to supplemental water and support additional banking programs.	✓	✓	✓	Supplemental Water Supply Supplemental Water Recharge Third-Party Banking	In-Process	Board Meetings Public Notice and Outreach	CEQA Construction Permits	Constuction	2024	2025-	2160	0	✓	✓	✓			Central Valley Project Third-Party Banking Partner	None	$9,000,000		Cawelo Water District (Assessments)
CWD-3	Increase Recharge Capacity	Implement programs and/or projects to increase water recharge capacity to capture and recharge additional wet year high flow waters to store for future use. CGSA will also consider to implement a program to incentivize landowners to use their land for recharge.	✓	✓	✓	Supplemental Water Recharge Land Retirement Demand Reduction	In-Process Implemented	Board Meetings Public Notice and Outreach	CEQA Construction Permits	In-Process (CWD increase water recharge capacity) Implemented (Landowner Banking Program)	2025	2025-	400	300	✓	✓	✓			State Water Project, Kern River, Central Valley Project	None	$9,000,000		Cawelo Water District (Assessments) CGSA Landowners
CWD-4	New Cawelo GSA Banking Partners	Modify existing CWD banking programs to increase the amount of water banked or intiate new banking programs and partners as a secondary priority.	✓	✓	✓	Third-Party Banking	In-Process	Board Meetings Public Notice and Outreach	CEQA Construction Permits	In-Process	2030	2025-	500	0	✓	✓	✓			Third-Party Banking Partner	None		$100,000	Third-Party Banking Partner Cawelo Water District
CWD-5	Poso Creek Flood Water Capture	Construct additional faciltiies to utilize existing appropriative rights to divert supplementary water from high flows from Poso Creek.	✓	✓	✓	Exercise of Rights	In-Process	Board Meetings Public Notice and Outreach	CEQA Construction Permits	Conceptual	2030	2030-	150	0	✓	✓	✓			Poso Creek	None	$3,900,000		Cawelo Water District (Assessments / Water Charges)
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-					✓	✓	✓	NA	None	Unknown	Unknown	Cawelo Water District (Assessments)
CWD-6	Water Treatment Facilities	Construct additional potential water treatment facilities/operations to acquire addtiional treated oilfield produced water that is safe for crop irrigation. When irrigation demands are low the water will be recharged for later use.	✓	✓	✓	New Local Supply	In-Process	Board Meetings Public Notice and Outreach	CEQA CVRWQCB WDR Contruction Permits	In-Process	2035	2025-	20000	0	✓		✓			Treated Oilfield Produced Water 9000 AF in 2025 to 20000 in 2040	None	$11,250,000		Cawelo Water District (Assessments / Water Charges)
CWD-7	Surface Water Storage	Construct a 5,000 AF reservoir to provide additional storage capacity during wet years to increase ability to capture available supplemental water during wet hydrological conditions.	✓	✓	✓	Supplemental Water Supply	As Needed	Board Meetings Public Notice and Outreach	CEQA Construction Permits	As Needed	2035	2035-	500	0		✓	✓			State Water Project, Kern River, Central Valley Project	None	$40,000,000		Cawelo Water District (Assessments)

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
CWD-8	Out of Cawelo GSA Banking	Evaluate additional groundwater banking projects outside the Cawelo GSA, both within and outside the Kern County Subbasin.	✓	✓	✓	Supplemental Water Supply Third-Party Banking	As Needed	Board Meetings Public Notice and Outreach	NA	As Needed	2035	2030-	1250	0	✓	✓	✓			State Water Project, Kern River, Central Valley Project	None		$500,000	Cawelo Water District (Assessments / Water Charges)
Management Actions		Implemented	Functional	In-Process	As-Needed							Implemented	Functional		In-Process		As-Needed							
CWD-9	Voluntary Land Conversion	Develop a program to incentivize landowners to reduce their total crop demand by converting farmed land to groundwater recharge areas.	✓	✓	✓	Demand Reduction	Complete	Board Meetings Public Notice and Outreach	CEQA	Implemented	Complete	2025-	0	2,000			✓	✓		Demand Reduction	None	$8,750,000	$0	Cawelo Water District (Assessments) CGSA Landowners
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	Cawelo Water District (Assessments)
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	Cawelo Water District (Assessments)
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	Cawelo Water District (Assessments)
CWD-10	Secure Access to Additional Monitoring Location	Pursue an access agreement for a monitoring well location in the southeastern portion of the GSA.	✓	✓	✓	Nor Applicable (monitoring)	In-Process	NA	NA	In-Process	2025	2025-	0	0					✓	NA	None	$0	$0	NA

KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	Cawelo Water District (Assessments) CGSA Landowners
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	Cawelo Water District (Assessments) CGSA Landowners
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	Cawelo Water District (Assessments) CGSA Landowners
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	Cawelo Water District (Assessments) CGSA Landowners
CWD-11	Crop Conversion and Irrigation Efficiency	Incentive programs for growers to convert to crops that require less water and to improve irrigation practices.	✓	✓	✓	Demand Reduction Water Use Efficiency	In-Process	Board Meetings Public Notice and Outreach	NA	In-Process	2040	2020-	0	3,800			✓	✓		Demand Reduction Water Use Efficiency	None	$0	Unknown	Cawelo Water District (Assessments) CGSA Landowners
CWD-12	Agriculture to Urban Land Use Conversion	Conversion of agricultural land use to urban/commercial land use due to urban expansion.	✓	✓	✓	Demand Reduction Land Retirement	In-Process	NA	NA	In-Process	2040	2025-	0	TBD			✓			Demand Reduction Land Retirement	None	$0	$0	NA
CWD-13	Land Acquisition	Program to acquire land that is actively farmed to reduce irrigated acreage within the Cawelo GSA.	✓	✓	✓	Demand Reduction Land Retirement	As Needed	NA	NA	As Needed	2040	2035-	0	2,400			✓			Demand Reduction Land Retirement	None	$20,000,000	$0	Cawelo Water District (Assessments)

Table 14-7. Eastside Water Management Area (EWMA) GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process		As-Needed							
EWMA-1	Produced Water Supply Project	Development of oilfield produced-water supplies to potentially reduce groundwater demand	✓			Supplemental Water Source	Completion of Design	Stakeholder Meetings, Board Meetings	WDR	Initiating Development	2035	2035-	900	0			✓			Oil & gas operations produced water	Possibly RWQCB WDR depending on WQ	$2,950,000	$50,000	EWMA landowners, future grants, potential Prop 218
EMWA-2	Surface Runoff Capture Project	Surface runoff capture and enhanced infiltration in impoundments	✓			Supplemental Water Recharge	Completion of favorable feasibility study; successful permitting application, completion of design	Stakeholder Meetings, Board Meetings	Legal review; SWRCB approval of diversion; CDFW approval of streambed alterations, others	Planning	2035	2035-	3220	0		✓	✓			Surface water runoff	Multiple Agencies	$800,000	$100,000	Future grants, potential Prop 218
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	EWMA assessments
P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process		As-Needed							
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	EWMA assessments

KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	EWMA assessments
EWMA-3	Groundwater Quality Investigation	Investigation of groundwater quality by collection and analysis of water quality data supplemented by borehole geophysical data where available		✓			Current Conditions (Implemented)	NA	NA	Implemented	2025	2025-	0	0	✓				✓	NA	NA	$5,000	$0	NA
EWMA-4	Local Native Yield Estimation Study	Improved estimation of local (EWMA) native yield by use of additional field-collected data and analysis	✓				Current Conditions (Implemented)	NA	NA	On-going	2025	2025-	0	0					✓	NA	NA	$30,000	$0	EWMA assessments
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	SGMA Implementation Grant, EWMA Assessments
EWMA-5	Aquifer-Specific Monitoring Wells Installation	Construction of aquifer-specific monitoring wells in locations with data gaps, to better understand hydraulic heads and gradients, particularly in confined bedrock units	✓	✓			Current Conditions	NA	Drilling Permit, WCRs	Planning	2025	2025-	0	0					✓	NA	DWR	$900,000	$0	DWR TSS funding
EWMA-6	Pressure Transducers Installation	Installation of pressure transducers in selected wells of the monitoring network, to collect high-resolution cost-effective data	✓				NA	NA	NA	Planning	2025	2025-	0	0					✓	NA	NA	$50,000	$2,000	DWR $7.6M grant
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	SGMA Implementation Grant, EWMA Assessments
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	SGMA Implementation Grant, EWMA Assessments
EWMA-7	Agricultural Demand Reduction	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	EWMA Assessments
EWMA-8	Groundwater Usage Fee Assessment	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	EWMA Assessments
EWMA-9	Transferrable Water Credit Program	Establish a system of transferrable water credits; including legal and administrative review: effects of CEQA and water law on joint management of native yield	✓			Demand Reduction	Program will be initiated once rules and regulations are finalized	Stakeholder Meetings, Board Meetings	TBD	Initiating Development	2030	2030-	0	0			✓			Surface water & groundwater	GSA	$80,000	$20,000	EWMA Assessments

Table 14-8. HMWD GSA PM/A

PMA Number	PMA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Expected Benefits – Primary (AFY): Demand Reduction	Expected Benefits – Secondary: Water Quality Improvement	Expected Benefits – Secondary: Flood Control	Expected Benefits – Secondary: Water Management Flexibility / Efficiency	Expected Benefits – Secondary: Mitigation Programs	Expected Benefits – Secondary: Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process / As-Needed										Implemented		Functional		In-Process			As-Needed					
HMWD-1	Demand Reduction due to Land Fallowing	The District irrigable lands now total less than 1/3 permanent crops, with over 2/3 of the lands being available to implement this project in future years as necessary to maintain sustainability over the long-term.	✓	✓	✓	Demand Reduction	Complete	NA	NA	Implemented	Complete	2020-	0	3600			✓		NA	NA	None	NA	NA	NA
HMWD-2	Maximize Water Banking during Wet Years	GSA will maximize water banking in wet years by using excess surface water supplies and purchasing water for the Pioneer Water Bank	✓	✓	✓	Third-Party Banking Supplemental Recharge	Complete	NA	NA	Implemented	Complete	2020-	0	0	✓	✓	✓		NA	SWP, Kern River, CVP, other surface supplies	None	NA	NA	HMWD (Water Charge)
HMWD-3	Recovery of Banked Supplies from the Pioneer Project	Recovery of banked surface water from the Pioneer Banking Project at times when the District has capacity, in order to reduce groundwater use within the District.	✓	✓	✓	Third-Party Banking	Complete	NA	NA	Implemented	Complete	2020-	250	0	✓		✓		NA	SWP, Kern River, CVP, other surface supplies	None	NA	$37,500	HMWD (Water Charge)
PMA Number	PMA Name	Summary Description	Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility / Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented / Functional / In-Process / As-Needed										Implemented		Functional		In-Process			As-Needed					
HMWD-4	Utilizing Surface Water In-Lieu of Groundwater During Wet Years	During years with above normal hydrology, the GSA will use surface water to satisfy water demands and minimize groundwater pumping to the greatest extent possible.	✓	✓	✓	Exercise of Rights	Complete	NA	NA	Implemented	Complete	2020-	0	0	✓	✓	✓		NA		None	NA	NA	NA
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	HMWD (Water Charge)

KSB-3	**Exceedance Policy**	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	**Implemented**	2024	2024-	**0**	**0**				✓	✓	NA		$0	$25,000	HMWD (Water Charge)
KSB-4	**Coordination with Basin Study**	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		NA	NA	NA	**Ongoing**	2025	2025-	**0**	**0**					✓	NA	NA	$25,000	$0	HMWD (Water Charge)
KSB-7	**Well Registry**	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	**Ongoing**	2024-	2024-	**0**	**0**				✓	✓	NA	NA	$0	$25,000	HMWD (Water Charge)
KSB-8	**Consumptive-Use Study**	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	**Ongoing**	2020-	2020-	**0**	**0**				✓	✓	NA	NA	$0	$25,000	HMWD (Water Charge)
HMWD-5	**Surface Water Transfer from El Rico GSA (Tulare-Lake Subbasin) to HMWD GSA**	HMWD has the ability to transfer surface water from the El Rico GSA to HMWD as an emergency supply in times of drought and can also be transferred in wet years for banking or correcting previous overdraft.	✓	✓	✓	Exercise of Rights	As Needed	NA	NA	**As Needed**	Complete	2023-	**550**	**0**	✓	✓	✓		NA	SWP, SVP, other surface supplies	None	NA	$5,000	HMWD (Water Charge)

Table 14-9. Kern River GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Expected Benefits – Primary (AFY): Demand Reduction	Expected Benefits – Secondary: Water Quality Improvement	Expected Benefits – Secondary: Flood Control	Expected Benefits – Secondary: Water Management Flexibility or Efficiency	Expected Benefits – Secondary: Mitigation Programs	Expected Benefits – Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
	Projects	Implemented / Functional / In-Process	As-Needed									Implemented		Functional	In-Process			As-Needed						
KRGSA-1	Water Allocation Plan	KDWD plans to use its full Kern River entitlement as prioritized in its Water Allocation Plan (WAP) for the Agricultural MA.	✓	✓	✓	Exercise of Rights	Complete	KDWD, Board Meetings & Website	CEQA (completed)	Implemented	2018	2018-	20,797	0			✓			Kern River Supplies	None	$0	$0	KDWD, Operating Budget
KRGSA-2	Kern River Optimized Conjunctive Use	The City plans to use its full Kern River entitlement, less current obligations, to mitigate undesirable results for water levels and water quality in the Urban MA.	✓	✓	✓	Exercise of Rights	Complete	COB, City Council Meetings & Website	CEQA (As Needed)	Implemented	2018	2018-	67,930	0			✓			Kern River Supplies	None	$0	$0	COB, Operating Budget
KRGSA-3	Lining of Pool #8	The Kern County Water Agency's (Agency) - Improvement District No. 4 (ID4) Cross Valley Canal (CVC) Extension Lining Project – Pool No. 8 (Project) includes installation of approximately 5,280 lineal feet of fiber-reinforced concrete lining on an existing earthen canal to reduce seepage and improve water delivery reliability. The lining will reduce seepage, increase water delivery reliability, reduce maintenance efforts and reduce the potential for canal breaches.	✓				Already being implemented	KCWA, UBAC, Board Meetings & Website	CEQA & NEPA (completed)	Implemented	2024	2024-	0	0			✓			Surface Supplies	KCWA, ID4	$7,000,000	$0	ID4 Grants Received
KRGSA-4	Urban Conservation	Future urban demand will be reduced from current modeled levels. The average urban demand for Metropolitan Bakersfield is reported by local UWMPs is 211 gallons per capita per day (gpcpd). Previous estimates for future demand were estimated at 248 gpcpd and basin wide GSP modelling included this estimate in all future model scenarios.	✓	✓	✓	Water Conservation-Efficiency	Already being implemented	COB, City Council Meetings & Website	None	Implemented	2040	2020-2040	0	21,299			✓			Demand Reduction	COB/Retail Urban Providers	NA	$0	COB, ENCSD, Lamont, Cal Water, Vaughn - Operating Budgets
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	KRGSA
KRGSA-5	ENCSD North Weedpatch Highway Water System Consolidation	Up to six small water systems in the northeast KRGSA will be consolidated into the ENCSD system for benefits to drinking water quality, including to disadvantaged communities (DACs). The project includes new water distribution systems, a new well (1,400 gpm capacity) with arsenic treatment, a storage tank, hydropneumatics tank, and a booster pump station. If TCP is detected in the new well, the grant will also fund a TCP treatment system. All wells with water quality violations will be properly abandoned according to Kern County Environmental Health regulations.		✓			In Progress	ENCSD, Board Meetings & Website	DDW	In-Process	2024	2024-	0	0	✓		✓				COB/Retail Urban Providers	$0	$0	ENCSD and potential SAFER Grants

KRGSA-6	South Kern and Old River Mutual Water System Consolidation	Two small mutual water systems in the southern KRGSA will be consolidated into the City of Bakersfield's domestic water system for benefits to drinking water quality, including to disadvantaged communities (DACs). The Project will include new water distribution systems connecting the mutual water systems with the City's water system, which improve drinking water quality for the DAC.		✓			In Progress	COB, City Council Meetings & Website	DDW	In-Process	2025	2025	0	0	✓		✓				COB, DDW	$7,500,000	$78,000	COB and potential SAFER Grants
KRGSA-7	Expand Recycled Water Use in the KRGSA	The City will increase recycled water use inside of the KRGSA from its WWTP No. 3 in 2026 when a contract for use outside of the KRGSA expires (about 72% is currently used outside of the KRGSA).	✓	✓	✓	New Local Supply	Already being implemented - Reallocates water	COB, City Council Meetings & Website	None	In-Process	2026	2026-	13,407	0			✓			Recycled Water	None	NA	$0	COB Operating Budget
KRGSA-8	Conversion of Agricultural Lands in Urban Use	Approximately 10,000 acres of current KRGSA agricultural lands is expected to be urbanized; this future urban demand is already included in the projected water budget, so 100% of this agricultural water use represents a demand reduction.	✓	✓	✓	Ag to Urban Conversion	Land use changes	COB/Planning Commission, Board Meetings & Website	CEQA (As Needed)	In-Process	2038	Total by 2038	0	27,000							None	NA	NA	NA
P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented	Functional	In-Process		As-Needed						Implemented	Functional		In-Process		As-Needed							
Phase 1																								
KRGSA-9	Implement Action Plan if Water Levels Fall Below Minimum Thresholds	A five-step action plan for addressing exceedance of GSP thresholds, including KRGSA Plan Manager coordination: 1. Identify the Well(s) and investigate the Area 2. Coordinate with KRGSA Plan Managers 3. Select Appropriate Management Actions or Projects for Mitigation 4. Consider Institutional Changes for Future Mitigation 5. Consider the Need for Improved Monitoring	✓			Supplemental Water Use	MT exceedance	KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0	✓		✓				None	$0	$0	KRGSA
KRGSA-10	Optimize Conjunctive Use in the KRGSA	Surface water sources available to the KRGSA will be prioritized for use when available, retaining the shared groundwater resources for periods when surface water is scarce. This balance of water use and higher reliance of groundwater during drought provides for increased reliability, higher groundwater levels to avoid undesirable results, and preservation of groundwater resources for other supplies are less available. Conjunctive management also encourages recharge of any excess surface water for storage and subsequent recovery to assist with drought management.	✓			Supplemental Water Use		KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0	✓		✓				None	$0	$0	KRGSA

KRGSA-11	Support California Delta Conveyance Project to Preserve Imported Water Supplies	In its UWMP, ID4 emphasizes the need for state-wide support in improving the availability and reliability of SWP supplies. On April 29, 2019, Governor Newsom announced that his administration will develop a water resiliency portfolio (Portfolio) intended to address a range of water-related challenges facing the state. The Portfolio will address unsafe drinking water, major flood risks, severely depleted groundwater aquifers, communities with uncertain water supplies and native fish populations.	✓	✓		Supplemental Water Use		KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0	✓						None	$0	$0	KRGSA
KRGSA-12	Incorporate Climate Change Adaptation Strategies	As noted in its 2015 UWMP (P&P, 2016), ID4 has identified strategies that can be adapted to fit within ID4 operations to address potential uncertainties associated with the reliability of imported water supplies. In brief, climate change may result in reduced surface water that will be even more unpredictable on a year-to-year basis. As listed in the UWMP, ID4 has identified the following measures for consideration: • Work with retail purveyors to identify impacts of demand management measures to improve the accuracy of overall ID4 future demands. New developments are incorporating the latest water conversation features and policies that may alter the current ID4 demand projections. • Continue water recharge activities to the extent practicable to increase reliability of supplies during dry-year conditions. • Explore options to capture excess runoff in off-stream recharge facilities to conserve additional water for beneficial use that might otherwise be lost from local supplies.	✓					KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0	✓						None	$0	$0	KRGSA
KRGSA-13	Support Sustainable Groundwater Supplies for KRGSA Disadvantaged Communities	The three founding KRGSA member agencies have established lines of communication and coordination with other agencies in the GSP Plan Area, many of whom provide water to DACs in the KRGSA Plan Area. In this manner, representation of these communities is considered in KRGSA actions and policies.	✓	✓				KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0				✓			None	$0	$0	KRGSA
KRGSA-14	Improve Groundwater Monitoring in the KRGSA Plan Area	It is the policy of the KRGSA to monitor groundwater for GSP compliance and to provide the understanding necessary for sustainable groundwater management. These actions will consist of: Improving documentation of well construction in the KRGSA Plan Area, coordinating water quality analysis through existing monitoring programs, securing inactive wells/dedicated monitoring wells, and obtaining access agreements for GSP monitoring network wells.	✓	✓				KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0				✓			None	$0	$0	KRGSA
KRGSA-15	Avoid Widespread Impacts to Domestic and Small Water System Wells in the Plan Area	This management action has been developed to provide clarity and more focused information on the issue of potential impacts to domestic and small water system wells. The new management action is based on an updated analysis of potential impacts to domestic and small water system wells throughout the entire Plan Area. It will consist of: Documenting Active Domestic and Small Water System Wells, Tracking the Potential for Impacts to Active Domestic and Small Water System Wells, Investigating Issues and Assisting Active Domestic and Small Water System Wells, Adjusting KRGSA Management Activities, (if Needed) and Updating Management Actions.	✓	✓				KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0				✓			None	$0	$0	KRGSA

KRGSA-16	Establish Well Metering Policy in the KRGSA	This policy will assist with monitoring groundwater extractions for ongoing water budget analyses and compliance with SGMA reporting requirements. (Add specific member updates)	✓			Water Conservation-Efficiency		KRGSA, Board Meetings & Website	None	Ongoing	2025	2020 -	0	0				✓			None	$0	$0	KRGSA
KRGSA-17	Implement Groundwater Extraction Reporting Program	As required by SGMA, the KRGSA will begin reporting extractions to DWR on an annual basis. In order to improve the accuracy of its reporting and to support the ongoing water budget analysis, KRGSA Plan Managers will implement a program for all well owners to report groundwater production to the GSA.	✓			Water Conservation-Efficiency		KRGSA, Board Meetings & Website	None	Ongoing	NA	2020 -	0	0				✓			None	$0	$0	KRGSA
Phase 2																								
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	KRGSA
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	KRGSA
KRGSA-18	Additional Urban Conservation Measures	To reduce urban demand, additional conservation measures could be considered by the City and other urban retail water purveyors. Such actions are documented in the UWMPs and strict adherence to permanent reductions in urban demand by 2020 are underway. A decrease in the long-term per capita water use is provided in UWMPs and embedded in the projected water budgets for the KRGSA.	✓			Water Conservation-Efficiency	New Legislation	KRGSA, Board Meetings & Website	None	Ongoing	2040	2020 -	0	0				✓			None	$0	TBD	KRGSA
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	KRGSA
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	KRGSA
KSB-6 (ID#4 only) (KDWD & Bakersfield not participating)	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	KRGSA

KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	KRGSA
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	KRGSA
KRGSA-19	Conversion of Agricultural Lands	Changes in land use may also result in a decrease in agricultural demand through urbanization. Some land conversion from agriculture to urban is anticipated in Phase One associated with growth projections for Metropolitan Bakersfield. Additional changes in land use to reduce water demand could be developed in Phase Two as needed.	✓			Ag to Urban Conversion	Urbanization	KRGSA, Board Meetings & Website	CEQA (As Needed)	Ongoing	2040	As needed	0	0				✓			None	$0	As needed	KRGSA
KRGSA-20	Additional Considerations for Adaptive Management	It is recognized that demand reduction projects could have a detrimental impact on the local economy, livelihood of residents and business owners, and the well-being of Metropolitan Bakersfield and Kern County. Therefore, large-scale reductions are not proposed in Phase One and may be unnecessary for achieving the sustainability goal. At a minimum, such actions are delayed until later in the implementation period to allow water supply projects the opportunity to sustainably support current and projected growth in the beneficial uses of groundwater.	✓	✓	✓	Supplemental Water Use	As needed	KRGSA, Board Meetings & Website	None	As Needed	NA	As needed	0	0				✓			None	$0	As needed	KRGSA
KRGSA-21	Possible Water Exchange	KRGSA member agencies can perform exchanges of surface water and groundwater for benefits to water quality, including to DACs.		✓		Supplemental Water Use	As needed	KRGSA, Board Meetings & Website	None	As Needed	NA	As needed	0	0							None	$0	As needed	KRGSA
KRGSA-22	Pumping Reductions and Allocation of Agricultural Groundwater Supply	If sustainable management cannot readily be achieved through increased and optimized supplies, then pumping allocations may a helpful management tool. If needed, KDWD will explore options and opportunities for equitable allocation scenarios and engage landowners to develop workable allocations. Adjacent water districts are already developing such programs and KDWD may benefit from lessons learned and strategies incorporated by others. Agricultural demand could also be achieved if needed by growing different crop types, fallowing portions of fields, district purchase and retirement of land (and possibly used for recharge if suitable), and other strategies.	✓			Demand Reduction	Continued MT exceedance	KRGSA, Board Meetings & Website	TBD	As needed	NA	As needed	0	0				✓			None	$0	As needed	KRGSA

Table 14-10. Kern-Tulare Water District GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects		Implemented / Functional / In-Process / As-Needed											Implemented / Functional / In-Process / As-Needed											
KTWD-1	Connect Rag Gulch and Ave 4 Systems	Construction of 0.5 miles of 15-inch pipeline between the Avenue 4 distribution system and the Rag Gulch distribution system increases the delivery capability to 2,089 acres in the Rag Gulch and Avenue 4 distribution systems from 4.0 to 4.9 gpm/acre. The project will increase surface water deliveries by an estimated 260 AF per year.	✓	✓	✓	Exercise of Rights		Stakeholder Meetings Board Meetings		Implemented	2023	2024-	260		✓		✓			CVP supplies	None	$180,000	$0	KTWD Water Charges
KTWD-2	Quinn Pumping Plant and Pipeline	Construction of the Quinn Pumping Plant and Pipeline includes a 400 HP pumping plant, 3.5 miles of distribution system piping, and 4 turnouts. The project will improve delivery capability to 3,544 acres to increase surface water deliveries and reduce groundwater pumping by an estimated 1,130 AF per year in years of adequate water supply.	✓	✓	✓	Exercise of Rights		Stakeholder Meetings Board Meetings Prop 218 Special Assessment	Complete	In-Process	2025	2025-	1130		✓		✓			CVP supplies	None	$2,500,000	$0	KTWD Special Assessment
KTWD-3	Improved Conveyance to Ave 24	Constructs the necessary improvements to the North distribution system to allow for 177 acres that are within the District and reliant upon groundwater to be added to the Service Area. The Project includes installation of 0.7 miles of 18-inch diameter pipeline and replacement of the 16-inch diameter pipeline crossing of Avenue 24 with a 30-inch pipeline. Project will increase surface water deliveries by an estimated 480 AF per year.	✓	✓	✓	Exercise of Rights		Stakeholder Meetings Board Meetings Prop 218 Special Assessment	Complete	In-Process	2025	2025-	480		✓		✓			CVP supplies	None	$600,000	$0	KTWD Special Assessment
KTWD-4	Replace Twin Pipes Pumping Plant	Increasing the horsepower at the Twin Pipes pumping plant from 200 HP to 400 HP will improve the delivery capability to 1,488 acres in the Twin Pipes service area from 3.8 gpm/acre to 5.2 gpm/acre. The project will increase surface water deliveries by an estimated 270 AF per year.	✓	✓	✓	Exercise of Rights		Stakeholder Meetings Board Meetings		In-Process	2025	2025-	270		✓		✓			CVP supplies	None	$400,000	$0	KTWD Water Charges
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	Unknown
KTWD-5	Provide Full Service to Southern Service Area	Replacement of Cecil Pumping Plant and Pipeline, construction of Intertie Pumping Plant and Pipeline, and construction of Grapefruit Pumping Plant and Pipeline to satisfy peak season irrigation demands to over 13,500 acres in the southern portion of the District. Project is estimated to increase the annual delivery capability of the District by 9,470 AF in wet and normal years.	✓	✓	✓	Exercise of Rights	Funding	Stakeholder Meetings Board Meetings Prop 218	CEQA/NEPA	As-needed	2035-2040	2040-	9470		✓					CVP supplies	None	$25,000,000	$0	KTWD; Grants
KTWD-6	Produced Water Project - Phase 2	The District has historically accepted produced water to provide surface water to the District and has the opportunity to obtain additional sources of produced water	✓		✓	New Local Supply	As needed	Stakeholder Meetings Board Meetings	WDR	As-needed	2025-2030	2030-	3000		✓		✓			Produced Water Supplies	None	$5,900,000	$0	KTWD; Private

KTWD-7	In-District Surface Storage	The District has selected two potential reservoir sites with a total capacity of 8,000 AF to capture wet year water.	✓	✓	✓	Supplemental Water Use	As needed	Stakeholder Meetings Board Meetings Prop 218	CEQA/NEPA	As-needed	2035-2040	2040-	2000		✓	✓	✓			CVP water, additional wet year water for purchase	None	$30,000,000	$0	KTWD; Grants

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions	Implemented	Functional	In-Process		As-Needed							Implemented	Functional		In-Process		As-Needed							
KTWD-8	Modify District Pricing Structure	Reduce groundwater pumping by providing a pricing mechanism that causes groundwater to cost more than surface water. Implement a "groundwater charge" for every acre-foot pumped and install meters on all ag wells.	✓	✓	✓	Demand Reduction	Complete	Stakeholder Meetings Board Meetings Majority Protest Hearing	Complete	Implemented	Complete	2024-		5580	✓		✓			CVP supplies	GSA Authority	$500,000	$10,000	Landowners
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	KTWD General Funds
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	KTWD General Funds
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	KTWD General Funds
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	KTWD General Funds; Water Charges
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	KTWD General Funds
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	KTWD General Funds
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	KTWD General Funds

Table 14-11. Kern Water Bank GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects		Implemented	Functional	In-Process	As-Needed							Implemented	Functional		In-Process			As-Needed						
KWBA-1	KWB Recharge and Recovery Enhancement Project	Construction of 3 wells and associated pipelines and 2 recharge basins (189 acres). Provides approx. 1730 AF/mo recharge capacity and 910 AF/mo recovery capacity.	✓			Supplemental Water Recharge	NA	Planned though IRWM Grant Process with basin stakeholders.	CEQA review completed with NOD in 1997.	Implemented	Completed	2018-	182	0	✓	✓	✓			SWP Table A, SWP Article 21, Kern River purchases and floodwater, Friant-Kern Section 215 purchases	None	$3,900,000	$1,000	IRWM Grant and KWBA Assessments
KWBA-2	KWB Recharge Enhancement Project	Construction of 4 pumping facilities on the Kern Water Bank Canal and 1025 acres of recharge basins. Capture of up to 107,900 AF/yr of wet period water.	✓			Supplemental Water Recharge	NA	Planned though IRWM Grant Process with basin stakeholders.	KWBA Addendum No. 1 to the 2016 Monterey Plus Revised EIR	Implemented	Completed	2020-	21,580	0	✓	✓	✓			SWP Table A, SWP Article 21, Kern River purchases and floodwater, Friant-Kern Section 215 purchases	None	$11,500,000	$3,000	IRWM Grant and KWBA Assessments
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	KWBA Assessments
Management Actions		Implemented	Functional	In-Process	As-Needed							Implemented	Functional		In-Process			As-Needed						
KWBA-3	Project Recovery Operations Plan	Domestic, small community, and irrigation well mitigation program to address impacts related to temporary lowering of water levels during prolonged droughts on adjacent lands.	✓				NA	Project websites, mailers, local well companies, newspaper articles.	NA	Implemented	Complete	2010-	0	0	✓	✓	✓			NA	NA	$0	$35,000	KWBA Assessments

KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	KWBA Assessments
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	KWBA Assessments
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	KWBA Assessments
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	KWBA Assessments
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	KWBA Assessments
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	KWBA Assessments
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	KWBA Assessments

Table 14-12. NKWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefit	Expected Benefits – Primary (AFY): Water Supply Augmentation	Expected Benefits – Primary (AFY): Demand Reduction	Expected Benefits – Secondary: Water Quality Improvement	Expected Benefits – Secondary: Flood Control	Expected Benefits – Secondary: Water Management Flexibility or Efficiency	Expected Benefits – Secondary: Mitigation Programs	Expected Benefits – Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process	As-Needed									Implemented	Functional		In-Process		As-Needed							
NKWSD-1	Beneficial Reuse of Oilfield Produced Water	Oilfield produced water of sufficient quality for beneficial reuse used as source water for groundwater recharge. 9,000 AFY expected annually, 6,500 of which will be transferred to RRID.	✓		✓	New Local Supply	Already being implemented	NKWSD, Board Meetings & Website	Waste Discharge Requirement Permit	Ongoing	2016	2014-	2,500	0			✓			Oilfield Produced Water	District / SGMA authorities	$300,000	$1,000,000	Water Tolls/ District
NKWSD-2	Allocation of Available NKWSD Supplies to RRID	Transfer a portion of groundwater banked oilfield produced water from NKWSD to RRID benefit.	✓			New Local Supply	Already being implemented	NKWSD, Board Meetings & Website	None	Ongoing	2023	2023-	6,500	0			✓			Oilfield Produced Water	District / SGMA authorities	$0	$650,000	RRID/Landowners
NKWSD-3	Landowner Subsurface/Surface Recharge Program	Implementation of joint Landowner and District program to expand District groundwater recharge using landowner owned facilities.	✓	✓		Supplemental Water Recharge	Already being implemented	NKWSD, Board Meetings & Website	CEQA	Ongoing	2024	2024-	1,000	320	✓		✓			Utilize Existing Water Right/ Landowner Acquisition	District / SGMA authorities	$1,400,000	$90,000	District/Landowners
NKWSD-4	SCADA Automation and Evapotranspiration Measurement Improvements	Develop automation and remote sensing for ET monitoring and improved management of surface water conveyance.	✓			Water Conservation-Efficiency	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Ongoing	2024	2021-	0	3,400			✓		✓	Demand Reduction	District / SGMA authorities	$160,432	$10,000	Grant/ District assessments and/or water tolls
NKWSD-5	Calloway Canal Improvements: Lining Snow Rd. to 7th Standard Rd.	Concrete lining of canal to increase surface water reliability and prevent loss from seepage.	✓	✓	✓	Water Conservation-Efficiency	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Ongoing	2024	2025-	0	0	✓		✓			Utilize Existing Water Right	District / SGMA authorities	$6,506,700	$5,000	Grant/ District assessments and/or water tolls
NKWSD-6	Calloway Canal Improvements: lining 7th Standard Rd. to 8-1 Pump Station	Concrete lining of canal to increase surface water reliability and prevent loss from seepage.	✓	✓	✓	Water Conservation-Efficiency	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Initiated	2026	2026-	0	0	✓		✓			Utilize Existing Water Right	District / SGMA authorities	$10,061,000	$5,000	Grant/ District assessments and/or water tolls
NKWSD-7	Groundwater Banking Conveyance Improvements to NKWSD Recharge and Recovery	Improvements to existing well network for return capacity of recharged water to District's banking partners.	✓	✓	✓	Third Party Banking	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Initiated	2026	2025-	4,000	0	✓	✓	✓			Third Party Banking Partner Sources	District / SGMA authorities	$15,350,000	$950,000	Grant/ District assessments and/or water tolls
NKWSD-8	Calloway Canal Improvements: lining Fruitvale Ave. to CVC Intertie	Concrete lining of canal to increase surface water reliability and prevent loss from seepage.	✓	✓	✓	Water Conservation-Efficiency	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Initiated	2028	2027-	0	0	✓		✓			Utilize Existing Water Right	District / SGMA authorities	$6,509,000	$5,000	Grant/ District assessments and/or water tolls
NKWSD-9	Calloway Canal Improvements: lining Case St. to Fruitvale Ave.	Concrete lining of canal to increase surface water reliability and prevent loss from seepage.	✓	✓	✓	Water Conservation-Efficiency	Already being implemented	NKWSD, Board Meetings & Website	CEQA, NEPA	Initiated	2029	2028-	0	0	✓		✓			Utilize Existing Water Right	District / SGMA authorities	$8,404,360	$5,000	Grant/ District assessments and/or water tolls

KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	District assessments and/or water tolls
NKWSD-10	RRID Groundwater Recharge Project	Construction and Implemetnation of water recharge basins for the RRID management area. Approximately 450 acres of crops will be removed and replace by recharge facilities.	✓	✓		Demand Reduction, Supplemental Water Recharge	Already being implemented	NKWSD, Board Meetings & Website	CEQA	Initiated	2036	2025-	7,200	1,300	✓	✓	✓			Utiilise Existing Contracts, Agreements, and Surplus Acquisition	District / SGMA authorities	$18,000,000	$400,000	Grant/RRID
NKWSD-11	Expanded Water Banking Program	Use of available capacity in existing facilities and development of additional recharge and recovery facilities	✓	✓	✓	Third Party Banking	Already being implemented	NKWSD, Board Meetings & Website	CEQA	Initiated	TBD	2025-	5,000	0	✓	✓	✓			Third Party Banking Partner Sources	District / SGMA authorities	TBD	TBD	Grant/ District assessments and/or water tolls
NKWSD-12	Poso Creek Weir	Installation of a concrete weir on Poso Creek to replace the earthen structure.	✓		✓	Water Conservation-Efficiency	Upon adoption of this project	NKWSD, Board Meetings & Website	CEQA, CDFW	Conceptual	TBD	2026-	TBD	0		✓	✓		✓	Poso Creek	District / SGMA authorities	TBD	TBD	Grant/ District assessments and/or water tolls

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefit	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented	Functional	In-Process	As-Needed							Implemented		Functional	In-Process			As-Needed						
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	Grant/ District assessments and/or water tolls
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	District assessments and/or water tolls
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	Grant/ District assessments and/or water tolls

KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	Grant/ District assessments and/or water tolls
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	District assessments and/or water tolls
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	District assessments and/or water tolls
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	District assessments and/or water tolls
NKWSD-13	Ongoing Evaluation of Groundwater Levels and Water Quality Trends	Monitor WQ to determine if a correlation for degradation develops as a result of declining water levels.	✓	✓			Already being implemented	NKWSD, Board Meetings & Website	None	Ongoing	TBD	Ongoing	0	0	✓				✓	Monitoring	District / SGMA authorities	$0	$75,000	District assessments and/or water tolls
NKWSD-14	Refinement of Water Budget Components	Improvement of monitoring and measurements to refine the accuracy of measurement or calculation of inflow and outflow components of district-level water budget. Will also refine Subbasin Model and water budget.	✓	✓	✓		Already being implemented	NKWSD, Board/GSA Meetings & Website	None	Initiated	TBD	2030-	0	0			✓		✓	Data Improvement	District / SGMA authorities	$0	$15,000	Grant/ District assessments and/or water tolls
NKWSD-15	Conversion of Agricultural Land to Urban Use in RRID	Conversion of agricultural land to urban use within the limits of each city to reduce groundwater use due to the decreased demand.	✓	✓		Demand Reduction	Already being implemented	Land Use & Planning	District, City & County	Initiated	TBD	2030-	0	9,600			✓			Demand Reduction	District / SGMA authorities	$0	$22,500	Landowners, Cities & Private
NKWSD-16	Urban Water Conservation Program	Implementation of urban indoor and outdoor usage cappage as required by SB 606 and AB 1668.	✓			Demand Reduction	Already being implemented	Urban Water Supplier & District	State Regulations, Local Ordinance	Ongoing	TBD	2030-	0	TBD	✓		✓			Demand Reduction	Cities	$0	$10,000	Grants/City/District
NKWSD-17	In-District Allocation Structure	Implementation of an groundwater credit allocation structure that would allow for the transfer of groundwater pumping credits within the district's jurisdiction.	✓	✓		Water Use Efficiency	As Needed	NKWSD, Board Meetings & Website	None	Conceptual	TBD	TBD	TBD	0			✓			Utilize Existing Water Storage	District / SGMA authorities	TBD	TBD	Grant/ District assessments and/or water tolls
NKWSD-18	Voluntary Land Fallowing	Development and implementation of a voluntary land fallowing program to reduce water demand.	✓	✓	✓	Demand Reduction	As Needed	NKWSD, Board Meetings & Website	None	Conceptual	TBD	TBD	0	TBD			✓			Demand Reduction	District / SGMA authorities	TBD	TBD	Grant/ District assessments and/or water tolls
NKWSD-19	Pumping Restrictions	Implement groundwater pumping allocations or limits.	✓	✓	✓	Demand Reduction	As Needed	NKWSD & GSA Board Meetings, Website, Direct Notices	Local Ordinance	Conceptual	TBD	TBD	0	TBD			✓	✓		Demand Reduction	District / SGMA authorities	TBD	TBD	District assessments and/or water tolls
NKWSD-20	In-Lieu Recharge Program	Implementation of fees for groundwater use when surface water is available.	✓	✓	✓	Water Conservation-Efficiency	As Needed	NKWSD, Board Meetings & Website	Prop 218	Conceptual	TBD	2035-	0	TBD	✓	✓	✓			Demand Reduction	District / SGMA authorities	None	None	None
NKWSD-21	On-Farm Efficiency/Deficit Irrigation Practices Incentive Program	Improvements to individual farming operations that address water use efficiency and/or groundwater protection through incentive programs.	✓	✓	✓	Water Conservation-Efficiency	As Needed	NKWSD, Board Meetings & Website	None	Conceptual	TBD	2035-	TBD	TBD	✓		✓			Demand Reduction - Water Use Efficiency	District / SGMA authorities	TBD	TBD	Grant/ District assessments and/or water tolls

Table 14-13. OWD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefit	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process / As-Needed										Implemented / Functional / In-Process / As-Needed												
Olcese-1	Shallow Monitoring Well Installation	Installation of a shallow monitoring well in the vicinity of Olcese Water District Well #2 for purposes of evaluating potential hydraulic connection between the Olcese Sand Aquifer Unit and the Shallow Alluvium.	✓	✓			Complete	NA	County well permit	Implemented	Complete	2019-	0	0					✓	NA	None	$40,000	$2,500	OWD
Olcese-2	Second Shallow Monitoring Well Installation	Installation of a second shallow monitoring well in the vicinity of Cottonwood Creek and conduct regular monitoring.	✓	✓			As-needed, contingent upon results of Project Olcese-1	NA	County well permit	Conceptual Design	2-3 years	2-3 years	0	0					✓	NA	None	$40,000	$2,500	OWD
Management Actions		Implemented / Functional / In-Process / As-Needed										Implemented / Functional / In-Process / As-Needed												
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	OWD
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	OWD
Olcese-4	Olcese Sand / Shallow Alluvium Hydraulic Connection Study	Conduct a study of the potential hydraulic connection between the Olcese Sand Aquifer Unit and the Shallow Alluvium	✓	✓	✓		Installation of shallow monitoring well	NA	None	In Progress	3 years	2025-	0	0					✓	NA	none	$50,000	$5,000	OWD

KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	OWD
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	OWD
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	OWD
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	OWD
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	OWD

Table 14-14. Pioneer GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process	As-Needed									Implemented	Functional		In-Process			As-Needed						
Pio-1	Install Monitoring Well in North Pioneer	Installation of a cluster monitoring well in the north portion of the Pioneer Project	✓	✓	✓	NA	Data Gap	NA	Well Permit from KCPHSD	Complete	Completed	2021-	0	0			✓		✓	NA	NA	$320,000	$0	Pioneer Participant's capital improvement budget
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	Pioneer Participant's capital improvement budget
Management Actions		Implemented / Functional / In-Process	As-Needed									Implemented	Functional		In-Process			As-Needed						
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	Pioneer Participant's capital improvement budget
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	Pioneer Participant's capital improvement budget

KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	Pioneer Participant's capital improvement budget
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	Pioneer Participant's capital improvement budget
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	Pioneer Participant's capital improvement budget
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	Pioneer Participant's capital improvement budget
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	Pioneer Participant's capital improvement budget
Pio-2	Continued Participation in Basin-Wide Coordination	Coordinate with all other GSA's within the Kern Subbasin to address regulatory requirements and determination.	✓	✓	✓	Exercise of Rights	NA	Stakeholder Meetings Board Meetings	NA	In-Process	2040	2020-	0	0	✓	✓	✓	✓	✓	NA	NA	$0	$150,000	Pioneer Participant's capital improvement budget
Pio-3	Continued Balanced Pumping and	Continued balanced pumping and recharge is the standard operating procedure for the Pioneer GSA.	✓	✓	✓	Efficiency	As-needed	NA	NA	In-Process	NA	NA	0	0	✓		✓			NA	NA	$0	$0	NA
Pio-4	Adaptive Management: Increase Surface Spreading Losses from 6 to 10 Percent	This adaptive management strategy would explore the feasibility of increasing the fixed loss rate from 6 percent to a fixed loss rate of 10 percent.	✓	✓	✓	Efficiency	NA	Stakeholder Meetings Board Meetings	NA	As-Needed	NA	NA	0	0	✓	✓	✓	✓	✓	NA	NA	$0	$0	NA

Table 14-15. RRBWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
	Projects	Implemented / Functional / In-Process	As-Needed									Implemented / Functional / In-Process	As-Needed											
RRB-1	Stockdale East Water Storage and Recovery Project	Acquisition and retirement of 200 acres of irrigated ag lands and development of 200 acres of new recharge ponds. For conjunctive-use and 2:1 third party banking.	✓	✓	✓	Land Retirement Third-Party Banking	Complete	NA	NA	Implemented	Complete	2019-	1103	578	✓	✓	✓		NA	Kern River Flood, SWP Table A, SWP Article 21 , Friant-Kern Flood, 2:1 Exchanges, Kern River Purchase Contract	None	$2,950,000	$88,500	RRBWSD (Water Charge)
RRB-2	McCaslin Recharge Improvements	Acquisition and retirement of 175 acres of irrigated ag lands and development of 175 acres of new recharge ponds. For conjunctive-use and 2:1 third party banking.	✓	✓	✓	Land Retirement Third-Party Banking	Complete	NA	NA	Implemented	Complete	2024-	630	530	✓	✓	✓		NA	Kern River Flood, SWP Table A, SWP Article 21 , Friant-Kern Flood, 2:1 Exchanges, Kern River Purchase Contract	None	$6,500,000	$118,000	RRBWSD (Water Charge) USBR Grants
RRB-3	Kern Fan Water Storage Project Phase 1	Acquisition and retirement of 350 acres of irrigated ag lands, and development of 350 acres of new recharge ponds. For conjunctive-use and 2:1 third party banking.	✓	✓	✓	Land Retirement Third-Party Banking	Completion of Design	Stakeholder Meetings Board Meetings Hearing	NA	Design and Construction	2025	2025-	1260	1059	✓	✓	✓		NA	Kern River Flood, SWP Table A, SWP Article 21 , Friant-Kern Flood, 2:1 Exchanges, Kern River Purchase Contract	None	$13,000,000	$236,000	RRBWSD (Water Charge) CA WSIP Funding USBR Small Storage Grant
RRB-4	Onyx Ranch Water Acquistion	Acquisition of 4109 acres of land with water rights from the South Fork of the Kern River. Fallowing of ranches and change of point of diversion to Kern Subbasin for groundwater recharge.	✓	✓	✓	Exercise of Rights	Complete	NA	NA	CEQA Litigation	Complete	2025-	6000	0	✓	✓			NA	Kern River Pre 1914 Appropriative	None	$33,000,000	$450,000	RRBWSD (Water Charge)
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	RRBWSD (Assessments)
RRB-5	Sites Reservoir	New reservoir to capture flood runoff for later recharge in District	✓	✓	✓	Supplemental Water Recharge	Completion of Project	Stakeholder Meetings Board Meetings Hearing	NA	Environmental Design	2031	2031-	500	0					NA	Post 1914 Appropriation	None	$9,700,000	$98,000	RRBWSD (Increased Assessment)
RRB-6	Kern Fan Groundwater Storage Project Phase 2	Acquisition and retirement of 850 acres of irrigated ag lands and development of 850 acres of new recharge ponds. For conjunctive-use and 2:1 third party banking. Construction of approximately 400 cfs of conveyance capacity from the California Aqueduct	✓	✓	✓	Land Retirement Third-Party Banking	As Needed	Stakeholder Meetings Board Meetings Hearing	NA	Feasibility	2035	2035-	3780	3177	✓	✓	✓		NA	Kern River Flood, SWP Table A, SWP Article 21 , Friant-Kern Flood, 2:1 Exchanges, Kern River Purchase Contract	None	$65,000,000	$944,000	RRBWSD (Water Charge) CA WSIP Funding USBR Small Storage Grant
RRB-7	Ten Section Water Recharge Project	Development of 200 acres of new recharge ponds for conjunctive-use.	✓	✓	✓	Third-Party Banking	As Needed	NA	NA	Feasibility	2035	2035-	500	0	✓	✓	✓		NA	Unknown	Unknown	Unknown	Unknown	Private
RRB-8	Land Acquistion and Retirement	Acquisition and retirement of 500 acres of irrigated ag lands.	✓	✓	✓	Land Retirement	As Needed	Stakeholder Meetings Board Meetings Hearing	NA	Feasibility	2036	2035-	0	1300					NA	NA	None	$14,500,000	$125,000	RRBWSD (Water Charge)

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
RRB-9	Western Rosedale In-Lieu Service Area	Constuction of In-Lieu Service Area Project in order to provide surface water to agricultural water users within a portion of RRBWSD service area located westerly of Interstate 5.	✓	✓	✓	Third-Party Banking	As Needed	Stakeholder Meetings Board Meetings Hearing	NA	Design Complete On-Hold	2035	2040-	1126	0	✓	✓	✓		NA	Kern River Flood, SWP Table A, SWP Article 21, Friant-Kern Flood, 2:1 Exchanges, Kern River Purchase Contract	None	$5,000,000	$152,000	RRBWSD (Water Charge) CA WSIP Funding USBR Small Storage Grant
RRB-10	Delta Conveyance Project	Participation in the DCP. Alternative under Delta tunnels.	✓	✓	✓	Exercise of Rights	Completion of Project	Stakeholder Meetings Board Meetings Hearing	NA	Environmental Design	2045	2045-	3600	0					NA	SWP Table A, Article 21	None		$3,000,000	RRBWSD (Increased Assessment)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process		As-Needed							
RRB-11	Project Recovery Operations Plan	Domestic, small community, and irrigation well mitigation program to address impacts related to temporary lowering of water levels during prolonged droughts on adjacent lands.	✓				NA	Project websites, mailers, local well companies, newspaper articles.	NA	On-going	On-going	2010-						✓	✓		None	$0	$45,000	RRBWSD (Assessments)
RRB-12	White Land Water Budget/Demand Imbalance Reduction	White Lands (non-RRBWSD lands in RRBWSD GSA) not used for groundwater banking will correct the water supply imbalance by setting water budgets and a linear reduction of 5% per year over the planning period of 2020-2040.	✓	✓	✓	Demand Reduction	NA	Stakeholder Meetings Board Meetings Hearing	NA	Implemented	2020	2020-	0	5200	✓					NA	None	$100,000	$25,000	RRBWSD (Assessments)
RRB-13	District Land Water Budget/Water Charge Demand Reduction	Setting of a Sustainable Water Budget and collection of a Groundwater Use Charge assisting with project financing and creating approximately a 2.5% demand reduction.	✓	✓	✓	Demand Reduction	NA	Stakeholder Meetings Board Meetings Hearing	NA	Implemented	2023	2024-	0	2000	✓					NA	None	$100,000	$25,000	RRBWSD (Assessments)
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	RRBWSD (Assessments)
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	RRBWSD (Assessments)
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	SGMA Implemetnation Grant RRBWSD (Assessments)

KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	RRBWSD (Assessments)
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	RRBWSD (Assessments)
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	RRBWSD (Assessments)
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	RRBWSD (Assessments)
RRB-14	Land Retirement for Solar Power Production	Conversion of 1500 acres of irrigated agricultural lands into solar array field.	✓	✓	✓	Land Retirement	Final Approval of Solar Power Project	NA	NA	Feasibility and Design	2030	2035-	0	3900						NA	NA	NA	NA	Private

Table 14-16. SSJMUD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility or Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects		Implemented / Functional / In-Process / As-Needed										Implemented		Functional		In-Process		As-Needed						
SSJMUD-1	Exercising Existing Water Rights	The USBR, SLDMWA, FWA, and SJREC have entered into a MOU to collectively identify projects and potential actions aimed at improving drought resiliency South of the Delta, including SSJMUD deliveries from the Friant-Kern Canal (FKC). The South of Delta Drought Resiliency Framework allows participating entities to voluntarily conserve and securely store a portion of their CVP south of Delta deliveries for subsequent use with the goal of providing at least a 5% allocation to CVP south of Delta agricultural water service/repayment contracts, reducing reliance on Delta exports in drought years.	✓			Exercise of Rights	Underway	NA	NA	MOU effective March 2024	2024	2024-	4850	0			✓			Increased reliability of SSJMUD's CVP supplies	Signed MOU	-	-	-
SSJMUD-2	Subbasin Banking Partnerships	Partners with neighboring water district to bank up to 15,000 AFY in existing banking facilities when excess surface water supplies are available. This partnership provides a "leave behind" volume of water to the banking partner, and retuns previously banked water when requested.	✓			3rd Party Banking	Implemented	NA	NA	Implemented	Complete	2018 with return capacity increase as of 2024-	5000	0			✓		NA	Friant-Kern Supply and Class I/II Unreleased Restoration Flows (URF), and Section 215	None	$1,200,000	$180,000	Grants and SSJMUD Water Charge
SSJMUD-3	Pandol Spreading Grounds	Acquisition and retirement of 30 acres of irrigated ag lands and development of 30 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	NA	NA	Implemented	Complete	2017-	434	72	✓	✓	✓		NA	Friant-Kern Supply, URF, and Section 215	None	$660,000	$2,550	Grants and SSJMUD Water Charge
SSJMUD-4	City of Delano Spreading Grounds	Acquisition and retirement of 40 acres of irrigated ag lands and development of 40 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	NA	NA	Implemented	Complete	2017-	578	14	✓	✓	✓		NA	Friant-Kern Supply, URF, and Section 215	None	$880,000	$3,400	Grants and SSJMUD Water Charge
SSJMUD-5	In-District Spreading Grounds	Acquisition and retirement of 32 acres of irrigated ag lands and development of 32 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	NA	NA	Implemented	Complete	2019-	462	11	✓	✓	✓		NA	Friant-Kern Supply, URF, and Section 215	None	$704,000	$2,720	Grants and SSJMUD Water Charge
SSJMUD-6	Giumarra Spreading Grounds	Acquisition and retirement of 78 acres of irrigated ag lands and development of 78 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	NA	NA	Implemented	Complete	2022-	1156	158	✓	✓	✓		NA	Friant-Kern Supply, URF, and Section 215	None	$1,716,000	$6,800	Grants and SSJMUD Water Charge
SSJMUD-7	Regan Spreading Grounds	Acquisition and retirement of 80 acres of irrigated ag lands and development of 80 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	Board Meetings IS/MND Noticing	CEQA / NEPA	Functional	2023	2024-	1084	187	✓	✓	✓		NA	Friant-Kern Supply, URF, and Section 215	None	$1,650,000	$6,375	Grants and SSJMUD Water Charge
SSJMUD-8	Giumarra Additional Spreading Grounds	Acquisition and retirement of 80 acres of irrigated ag lands and development of 80 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Complete	Board Meetings IS/MND Noticing	CEQA / NEPA	Functional	2024	2025-	1156	171	✓	✓	✓			Friant-Kern Supply, URF, and Section 215	None	$1,760,000	$6,800	Grants and SSJMUD Water Charge
SSJMUD-9	Land Conversions	Based on General Plans and Urban Water Management Plans, urban sprawl from the cities of Delano and McFarland will cause agricultural land to be taken out of production and converted to rediential and commercial developments. Demand reduction is calculated based on an average change in ET.	✓	✓	✓	Ag to Urban Conversion	Anticipated	NA	NA	Functional	2020	2020	-	2656			✓			NA	None	-	-	NA

SSJMUD-10	Caratan Spreading Grounds	Acquisition and retirement of 160 acres of irrigated ag lands and development of 160 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Preliminary Design, Pre-Construction Bidding	Board Meetings IS/MND Noticing	CEQA / NEPA	Design and Construction	2025	2025-	2312	315	✓	✓	✓			Friant-Kern Supply, URF, and Section 215	None	$3,520,000	$13,600	Grants and SSJMUD Water Charge
SSJMUD-11	Additional Caratan Spreading Grounds	Acquisition and retirement of 505 acres of irrigated ag lands and development of 505 acres of new recharge ponds.	✓	✓	✓	Land Retirement, Supplemental Water Recharge	Grant Funding Application, CEQA/NEPA	Board Meetings IS/MND Noticing	CEQA / NEPA	Property Purchased	2026	2026-	7297	1078	✓	✓	✓			Friant-Kern Supply, URF, and Section 215	None	$11,110,000	$42,925	Grants and SSJMUD Water Charge
SSJMUD-12	White Land Demand Reduction	White Lands (non-SSJMUD lands) will correct the water supply imbalance by setting water budgets and a linear reduction that corrects overdraft by 2040.	✓		✓	Demand Reduction	NA	Stakeholder Meetings Board Meetings Hearing	NA	Planning	2026	2026-	0	3400			✓			NA	None	-	-	NA
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	SSJMUD Water Charge
SSJMUD-13	Land Acquisition and Retirement	Acquisition and retirement of irrigated ag lands.	✓		✓	Demand Reduction	NA	Stakeholder Meetings Board Meetings Hearing	NA	As-Needed	2035	2035	0	1219			✓			NA	None	$13,475,000	$116,500	SSJMUD Water Charge

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented	Functional	In-Process			As-Needed							
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	SSJMUD Assessments
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	SSJMUD Assessments

KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	SSJMUD Assessments
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	SSJMUD Assessments
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	SSJMUD Assessments
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	SSJMUD Assessments
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	SSJMUD Assessments

Table 14-17. SWID GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
	Projects	Implemented	Functional	In-Process	As-Needed								Implemented	Functional	In-Process		As-Needed							
SWID-1	Kimberlina Recharge Project	Conversion of 280 acres of farmland to recharge basins.	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Complete	NA	NA	Implemented	Complete	2016-	6,000	998	✓	✓				CVP, Supplemental	None	$11,200,000	$30,000	SJRRP, USBR, District Water Rates
SWID-2	Bell Recharge Project and Pump Station	Conversion of 35 acres of farmland to recharge basins, and a pipeline modification to maximize water deliveries to the project	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Complete	NA	NA	Implemented	Complete	2019-	1,000	123	✓	✓				CVP, Supplemental	None	$1,400,000	$20,000	USBR, District Water Rates
SWID-3	Farmers Coop and Pipeline	Conversion of 25 acres of farmland to recharge basins, and a pipeline modification to maximize water deliveries to the project	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Complete	NA	NA	Implemented	Complete	2023-	530	88	✓	✓				CVP	None	$3,125,000	$20,000	USBR, District Water Rates
SWID-4	Grower Recharge and Subsurface Recharge Program	Implementation of policy that encourages landowners to install subsurface recharge systems and/or recharge water on fallowed acreage during wet years.	✓	✓	✓	Supplemental Water Recharge	Complete	NA	NA	Implemented	Complete	2016-	750	0	✓	✓				CVP	None	$0	$0	NA
SWID-5	Diltz/Leonard Interties with SWSD	Installation of two interties to allow for 2-way movement of water to and from SWSD, to enable both Districts to fully maximize wet year supplies when available.	✓	✓	✓	Utilize Existing Water Rights	Complete	NA	NA	Implemented	Complete	2015-	0	0			✓			NA	None	$3,000,000	$0	USBR, District Water Rates
SWID-6	Southeast Recharge	Conversion of 35 acres of farmland to recharge basins.	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Completion of Design	Stakeholder Meetings Board Meetings Hearing	CEQA/NEPA	In-Process	2024	2024-	700	123	✓	✓				CVP	None	$2,305,000	$20,000	USBR, District Water Rates
SWID-7	Dresser Recharge	Conversion of 112 acres of farmland to recharge basins	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Completion of Design	Stakeholder Meetings Board Meetings Hearing	CEQA/NEPA	In-Process	2025	2025-	2,400	392	✓	✓				CVP, Supplemental	None	$7,600,000	$30,000	USBR, District Water Rates
SWID-8	Poplar Recharge	Conversion of 77 acres of farmland to recharge basins	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Completion of Design	Stakeholder Meetings Board Meetings Hearing	CEQA/NEPA	In-Process	2026	2026-	1,750	270	✓	✓				CVP	None	$4,500,000	$30,000	USBR, District Water Rates
SWID-9	Jack Recharge	Conversion of 118 acres of farmland to recharge basins	✓	✓	✓	Supplemental Water Recharge; Land Retirement	Completion of Design	Stakeholder Meetings Board Meetings Hearing	CEQA/NEPA	In-Process	2026	2026-	2,655	413	✓	✓				CVP	None	$5,000,000	$30,000	USBR, District Water Rates
SWID-10	Southern Calloway Turnout	Installation of a turnout to enable the SWID southern FKC turnout to deliver water to the Calloway, which will feed Poplar, Dresser, Bell, and Jack Recharge. This will enable SWID to maximize the use of those facilities.	✓	✓	✓	Exercise of Rights	Completion of Design	Stakeholder Meetings Board Meetings Hearing	CEQA/NEPA	In-Process	2026	2026-	0	0			✓			NA	None	$2,600,000	$0	USBR, District Water Rates

SWID-11	Improved Water Level Measurement	Installation of a monitoring well at the Kimberlina Recharge facility to ensure that banking operations do not contribute to localized impacts.	✓	✓	✓		Completion of Design	NA	NA	In-Process	2027	2027-	0	0					✓	NA	None	$500,000	$0	USBR, District Water Rates
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	USBR, District Water Rates

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented / Functional / In-Process / As-Needed										Implemented		Functional		In-Process		As-Needed						
SWID-12	2:1 Recharge Programs	SWID has signed four 2:1 programs, where partners import 2 AF and SWID returns to them 1 AF at a future year. This will be a water supply benefit for SWID	✓	✓	✓	3rd Party Banking	Complete	None	None	Implemented	Complete	2023-	3,000	0	✓		✓			CVP, SWP, Supplemental	None	$0	NA	NA
SWID-13	2:1 SLR Program	SWID has historically had access to roughly 1250 AFY in San Luis Reservoir as a result of the SJRRP Restoration Program and more specifically the water management goal. SWID has agreements to begin to double that water through 2:1 exchange programs, and import it into the District. This will be a water supply benefit for SWID.	✓	✓	✓	Exercise of Rights	Complete	None	None	Implemented	Complete	2023-	2,500	0	✓		✓			San Joaquin River Restoration Program	None	$0	NA	NA
SWID-14	Water Quality Mitigation	The recently signed Water Quality Guidelines of the Friant Kern Canal will give SWIID additional water annually for Reclamation Leaching based on the water quality throughout the year. This will be a water supply benefit for SWID	✓	✓		Exercise of Rights	Complete	None	None	Implemented	Complete	2024-	500	0	✓		✓			CVP	None	$0	NA	NA
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.		✓			NA	NA	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	USBR, District Water Rates
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		NA	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	USBR, District Water Rates
SWID-16	FWA Drought Plan MOU	Execution of a Drought Plan that will reduce the number of "Call on Friant", which have historically decreased the Class 1 Friant Allocation in dry years. Under this Drought Plan MOU, USBR, Exchange Contractors, Friant Contractors and Westside Contractors will work together to bolster dry year supplies	✓	✓	✓	Exercise of Rights	Complete	None	None	Implemented	Complete	2024-	2,500		✓		✓			CVP	None	NA	NA	NA

SWID-15	Well Mitigation Policy	SWID will adopt a well mitigation policy that is consistent with basin-wide efforts to mitigate effects from lowering groundwater levels.	✓				Will be implemented with Basin efforts	Outreach	None	In-Process	2024	2024-	0	0				✓		NA	None	$0	$45,000	USBR, District Water Rates
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		NA	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	USBR, District Water Rates
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓				NA	NA	NA	Initiating Development	2026	2025-	0	0				✓		NA	NA	$0	$45,000	USBR, District Water Rates
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	NA	Stakeholder Meetings Board Meetings Hearings	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	USBR, District Water Rates
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	USBR, District Water Rates
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	USBR, District Water Rates
SWID-17	Ag to Urban Conversion	As the cities expand, they will retire agricultural land and it'll be converted to urban land, with a substantially lower demand for water.	✓	✓		Ag to Urban Conversion	Will be implemented based on Cities of Shafter and Wasco activities	None	None	In-Process (will be through 2024)	2040	2020-2040 linear increase to 2600 AFY in 2040	0	2,600	✓		✓			NA	None	$0	NA	NA
SWID-18	WQ Trend Study/Program Coordination	Filling data gap on water quality, and the impact of groundwater management activities on the groundwater quality. Also coordinating with WQ Programs (CVSALTS, etc.) if and when impacts occur		✓			Will be implemented	Outreach and Coordination	None	In-Process	TBD	2020-	0	0				✓	✓	NA	None	$0	NA	NA
SWID-19	ET Allocations/Pumping Restrictions/Voluntary Land Fallowing	If needed, SWID will implement ET allocations, pumping restrictions, and encourage land fallowing to reduce demand if the aforementioned projects are not successful	✓	✓	✓	Demand Reduction	As needed (Other projects Fail)	None	None	As-Needed	TBD	2033-	0	0			✓				None	$0	NA	NA

Table 14-18. SWID 7th Standard Annex PM/A

PMA Number	PMA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects	Implemented	Functional	In-Process		As-Needed							Implemented		Functional	In-Process			As-Needed						
7th Stnd Annex-1	Purchase Supplemental Water Supplies	7TH Standard Annex collects assessments and will use them to purchase water supplies during wet years for recharge in adjacent Districts, most often in SWID. As these supplies accumulate, they will increase the quantity that can be sustainably pumped in 7th Stnd Annex.	✓	✓	✓	Supplemental Water Use	Availability of Supplemental Supplies	None	None	Implemented	Complete	2020-	TBD	0	✓	✓	✓			CVP, SWP, Supplemental	None	TBD	Unknown	Property Assessments
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	Property Assessments

PMA Number	PMA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions	Implemented	Functional	In-Process		As-Needed							Implemented		Functional	In-Process			As-Needed						
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	NA
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	NA

7th Stnd Annex-3	Well Mitigation Policy	SWID will adopt a well mitigation policy that is consistent with basin-wide efforts to mitigate effects from lowering groundwater levels.	✓				Will be implemented with Basin efforts	Outreach	None	In-Process	2024							✓			None	$0	NA	NA
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	NA
7th Stnd Annex-2	ET Limitations/Water Budget	7th Standard Annex has done rotational fallowing since 2020, and in 2025 will begin implementing a Water Budget that ramps down allowable ET from 3 AF/Acre to 0.57 AF/Acre by 2040, or a higher number if 7th Stnd Annex is successful in purchasing supplies for recharge.	✓	✓	✓	Demand Reduction	Will be implemented	Letter sent to growers	None	In-Process	2025	2025-	0	23,153	✓		✓			NA	None	$0	NA	NA
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	NA
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	NA
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	NA
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	NA
7th Stnd Annex-4	WQ Trend Study/Program Coordination	Filling data gap on water quality, and the impact of groundwater management activities on the groundwater quality. Also coordinating with WQ Programs (CVSALTS, etc) if and when impacts occur		✓			Will be implemented	Outreach and Coordination	None	In-Process	TBD							✓	✓		None	$0	NA	NA

Table 14-19. SWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects		Implemented	Functional	In-Process	As-Needed							Implemented	Functional		In-Process		As-Needed							
SWSD-1	Monitoring Network Improvement Plan	Assess and identify monitoring network requirements for full compliance with SGMA and development of an implementation plan for achieving full compliance. Additional wells leverage existing network of monitoring wells.	✓	✓	✓		Upon approval by SWSD BOD	Semitropic GSA Board Meetings & Website	Site specific (CEQA)	Implemented	Complete	2023-	0	0					✓		District authorities	$10,000	$0	District
SWSD-2	Leonard Avenue System	Conveyance capacity to support delivery of surface water for groundwater recharge. Interconnection with Shafter-Wasco Irrigation District.	✓		✓		Complete	Semitropic GSA Board Meetings & Website	CEQA	Implemented	Complete	2023-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$16,100,000	$0	District
SWSD-3	Diltz Intertie	Conveyance capacity to support delivery of surface water for groundwater recharge. Interconnection with Shafter-Wasco Irrigation District.	✓		✓		Complete	Semitropic GSA Board Meetings & Website	CEQA	Implemented	Complete	2020-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$3,200,000	$0	District
SWSD-4	Cox Canal Pump Station	Conveyance capacity to support delivery of surface water for groundwater recharge. Interconnection with Buena Vista Water Storage District.	✓		✓		Complete	Semitropic GSA Board Meetings & Website	CEQA	Implemented	Complete	2022-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$3,600,000	$0	District
SWSD-5	Water Market Acquisitions	Increased participation in state-wide water markets for spot market and long-term water transfers. And maximize acquisition of wet year water supplies for recharge.	✓		✓	Supplemental Water Supplies	Upon approval by SWSD BOD	Semitropic GSA Board Meetings & Website	CEQA / DWR	Implemented/ Ongoing	On-going	2020-	19,000	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$0	$9,500,000	District
SWSD-6	Stored Water Recovey Unit-XYZ	Development of water storage to expand in-lieu service areas.	✓		✓	Exercise of Rights	Upon approval by SWSD BOD and identification of funding	Semitropic GSA Board Meetings & Website	None	Completed	2018	2022-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$17,000,000	$0	District
SWSD-7	Pond-Poso Spreading Grounds, Phase II	Development of spreading facililiteis to increase groundwater recharge capacity.	✓		✓	Supplemental Water Recharge	Upon approval by SWSD BOD and identification of funding	Semitropic GSA Board Meetings & Website	CEQA	Construction	2025	2025-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$32,000,000	$0	District
SWSD-8	Schuster Spreading Grounds	Development of spreading facililiteis to increase groundwater recharge capacity.	✓		✓	Supplemental Water Recharge	Upon approval by SWSD BOD and identification of funding	Semitropic GSA Board Meetings & Website	CEQA	Design	2026	2026-	0	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	$1,200,000	$0	District
SWSD-9	Poso Creek MAR	Development of floodwater capture and recharge program from Poso Creek flood flows.	✓		✓	Supplemental Water Recharge	Upon completion of feasibility and permitting requirements	Semitropic GSA Board Meetings & Website	CEQA	Feasibility	2028	2028-	2800	0		✓	✓			Poso Creek & Friant-215	District authorities	$17,700,000	$0	District

SWSD-10	Pond-Poso Entrance Ponds	Development of spreading facilities to increase groundwater recharge capacity.	✓		✓	Supplemental Water Recharge	Upon approval by SWSD BOD and identification of funding	Semitropic GSA Board Meetings & Website	CEQA	Design	2028	2028	0	0	✓	✓	✓			Poso Creek & Friant-215	District authorities	$8,000,000	$0	District
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	District
SWSD-11	Tulare Lake Project	Development of conveyance facilities to divert Kings River flood flows for direct use and recharge in the SWSD.	✓	✓	✓	Supplemental Water Recharge	Upon competion of water rights determination	Semitropic GSA Board Meetings & Website	CEQA / State Board / Regulatory	Feasibility/ Water Rights	2035	2035-	35000	0	✓	✓	✓			Kings River flood flows	District authorities	$270,000,000	$1,000,000	District
SWSD-12	Enhanced Groundwater Recharge	Development of surface and subsurface recharge projects underlying developed agricultural lands to increase groundwater recharge capacity.	✓			Exercise of Rights/ Supplemental Water Recharge	Upon approval by SWSD BOD and identification of funding	Semitropic GSA Board Meetings & Website	Site Specific (CEQA)	In-Process	2040	2020-	0	0	✓		✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District authorities	TBD	$25,000	District
SWSD-13	Evaluation and Assessment of GDEs within the Semitropic Area	Conduct additonal analysis to verify the presence and extend fo GDE's in the Semitropic and, if present, develop appropriate monitoring protocols.	✓				As needed	Semitropic GSA Board Meetings & Website	TBD	As needed	2030	2030-	0	0					✓		District authorities	$50,000	bank	District
SWSD-14	Brackish Water Desalination	Development of a brackish water treatment facility to treat locally sourced brackish water for District use.	✓			New Local Supply	Upon completion of environmental and regulatory requirements As needed	Semitropic GSA Board Meetings & Website	CEQA	As needed	2040	2040-	1,800	0	✓		✓			Local brackish water	District authorities	$0	$900,000	District
SWSD-15	In-District Water Markets and Transfers	District will allow for the development of market for in-district transfers.	✓			Exercise of Rights Supplemental Water Use	As needed	Semitropic GSA Board Meetings & Website	TBD	As needed	2040	2040-	TBD	0			✓			SWP, Friant, Kern River, CVP and other imported and local sources.	District / SGMA authorities	TBD	$25,000	District
P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented	Functional	In-Process	As-Needed							Implemented	Functional		In-Process			As-Needed						
SWSD-16	Landowner Water Budgets	Establish individual water budgets for landowners by landowner classes. Implemented to reduce District's demand to	✓	✓	✓	Demand Reduction	Establish water budgets by landowner	Semitropic GSA Board Meetings & Website	CEQA	Implemented	Complete	2017	0	132,000			✓	✓		NA	District / SGMA authorities	$0	$250,000	District

KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	District
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	District
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	District
SWSD-17	Tiered Pricing for Groundwater Pumping	Develop pricing structure to incentivize groundwater users to manage groundwater extractions to SWSD-16 landowner budgets.	✓	✓	✓	Demand Reduction	Implementation of SWSD-16	Semitropic GSA Board Meetings & Website	218 Process	Ongoing	2025	2025-	0	33,000			✓	✓		NA	District / SGMA authorities	$100,000	$25,000	District
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	District
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	District
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	District
SWSD-18	District Fallowing Program	Support land fallowing as a District action and by individual landowners or groups of landowners.	✓	✓	✓	Demand Reduction	Implementation of SWSD-16	Semitropic GSA and District Board CEQA compliant process	CEQA	As needed	2040	2040-	0	TBD			✓	✓			District authorities	TDB	$0	District

Table 14-20. TCWD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Primary (AFY)		Secondary					Source(s) of Water	Legal Authority Required	Estimated Costs		
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process		As-Needed							
TC-1	Recharge of Carrot Wash Water	Tejon Ranch Company (TRC) recharges carrot wash water generated at a nearby carrot processing facility to a 75.5-acre parcel located just outside of the Tejon-Castac Management Area (Township 32S Range 30E Section 6). The site, which has been in operation since 2016, receives carrot wash water from a nearby carrot processing facility which is discharged to a set of recharge ponds. A total of over 1,000 AF has been recharged at these ponds between 2016 and early 2019. This project is anticipated to continue in the future, and results in a local recharge benefit. A production well may be installed in the future at the site to allow for recovery of recharged groundwater.	✓			Supplemental Water Recharge	Underway	NA	WDR No. 5-01-22; well construction permit from Kern County	Complete; new recovery well may be constructed in the future.	2016	2016-	300	0	✓		✓			Carrot wash water from processing facility	None	$4,500	$0	Carrot Processing Facility; TCWD
TC-2	Conversion of Granite Quarry to Sycamore Ranch	The Granite Co. quarry, located upstream of the Sycamore Spreading Basins, is approaching the end of its operational life and could be converted into a balancing / detention / spreading reservoir. Excess flows in the North Canal could be pumped into the quarry reservoir, so the detained water could be recirculated for irrigation demands in-lieu of groundwater pumping and/or recharged.	✓	✓		Supplemental Water Use	To be implemented upon adoption of GSP / Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; DMR SMARA permit closure; NEPA requirements if grant funds are used	Geotechnical study complete; AEWSD and TCWD have participated in several meetings to discuss the permitting process for this project	Construction duration TBD	2030	1500	0	✓		✓			Additional wet-year imported water supplies	Property acquisition or land use agreement with quarry owner	$15,000,000	TBD	AEWSD, TCWD, grants
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	TCWD, subsidized by landowner (TRC)

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
													Primary (AFY)		Secondary									
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented	Functional		In-Process		As-Needed							
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	TCWD, subsidized by landowner (TRC)
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	TCWD, subsidized by landowner (TRC)
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	TCWD, subsidized by landowner (TRC)
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	TCWD, subsidized by landowner (TRC)
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	TCWD, subsidized by landowner (TRC)
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	TCWD, subsidized by landowner (TRC)
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	TCWD, subsidized by landowner (TRC)

Table 14-21. WDWA GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Expected Benefits – Primary (AFY): Demand Reduction	Expected Benefits – Secondary: Water Quality Improvement	Expected Benefits – Secondary: Flood Control	Expected Benefits – Secondary: Water Management Flexibility or Efficiency	Expected Benefits – Secondary: Mitigation Programs	Expected Benefits – Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
	Projects	Complete / Functional / In-Process	As-Needed									Implemented		Functional	In-Process				As-Needed					
WDWA-1	Long-Term Supplemental Water Programs	WDWA GSA is a Joint Powers Authority comprised of Belridge Water Storage District, Berrenda Mesa Water District, and Lost Hills Water District. Between 2015 and 2023, the three districts have successfully purchased over 1.6 million acre feet from State Water Contractors, Central Valley Project Contractors, pre-1914 water rights holders, and the SWP Dry-Year transfer program. Several of these purchases are multi-year long term agreements valid until 2030, with first right of refusal to renew.	✓	✓	✓	Supplemental import secured by existing contract	Complete	Board meetings, CEQA EIR review period, other DWR/SWRCB public noticing requirements	CEQA EIR, DWR SWAPO approval, CVP Bureau of Reclamation approval, Kern County Water Agency approval, SWRCB water rights petition of change of place of use	Implemented and Continuously Ongoing	Complete	Implemented	80,000	0			✓			State Water Project (Table A, Article 21, Article 56), CVP, Pre-1914 appropriative rights, local Kern River supplies, SWP Dry-Year program	None	$0	$10,000,000	Participating landowner assessments
WDWA-2	Conjunctive Reuse of Naturally Degraded Brackish Groundwater	Phased project that will integrate the modular treatment and conjunctive use of brackish groundwater and oil field produced water. A Phase I project engineering feasibility study for has been completed. Negotiations with project partners, financing options, and development of a Front-End Engineerng & Design (FEED) report are the next phase of project implementation.	✓	✓		New Local Supplies	Results of feasibility study indicate viable project	To be determined by feasibility study	CEQA, additional regulatory requirements to be determined by feasibility study	In-Process	2035	2035-	50,000	0	✓				✓	Treated brackish groundwater and oilfield produced water	None	$60,000,000	$2,000,000	Landowner assessments, federal and state grant programs
WDWA-3	Delta Conveyance Project	Via KCWA's status as a State Water Contractor, WDWA GSA's JPA members (BMWD, BWSD, and LHWD) participate in funding the Delta Conveyance Project. DCP aims to modernize the aging water infrastructure and improve the reliability of water transported through the Delta. It seeks to address the challenges posed by climate change, seismic risks, and environmental concerns.	✓	✓		Exercise of Rights	Completion of Project	Stakeholder Meetings, Board Meetings, CEQA EIR review period, other DWR/SWRCB public noticing requirements	All permitting and regulatory processes are being managed by DWR	Environmental Design	2045-	2045-	17,806	0	✓					SWP Table A, Article 21	None	$12,465,349	$4,000,000	District contributions to KCWA DCP funding costs (gathered via District landowner assessments)

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected			Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits							Source(s) of Water	Legal Authority Required	Estimated Costs		
			Groundwater Levels & Storage	Groundwater Quality	Land Subsidence								Primary (AFY)		Secondary									
													Water Supply Augmentation	Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring			One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Management Actions		Implemented / Functional / In-Process	As-Needed									Implemented	Functional		In-Process				As-Needed					
WDWA-4	Net Zero Well Drilling Moratorium within Close Proximity to Critical Infrastructure	To ensure no net increase of groundwater extraction capacity within the California Aqueduct Subsidence Program (CASP) 5 mile CA Aqueduct "Buffer Zone", new well drilling is prohibited within the Buffer Zone unless explicitly approved by the Board of Directors, which may allow replacements only if an existing well within the Buffer Zone is abandoned.	✓		✓		Complete	Impacted stakeholder meetings (4) and public Board of Directors meeting (2/20/24)	NA	Implemented	Complete	2024-	0	0					✓	NA	None	$2,500	$1,000	WDWA GSA via landowner assessments
WDWA-5	Mandatory Well Registration	To further supplement Kern County Subbasin Well Registry (KSB-7) management action, WDWA GSA has implemented a mandatory well registration program that requires all currently existing and future wells drilled within WDWA GSA register with the GSA and provide well construction reports and water quality analyses, if available. The policy also requires new wells have a flowmeter installed, well owners allow the GSA to use the well for monitoring (if located in a data gap area), and well owners provide annual status updates for each well (active, inactive, damaged, abandoned, etc.).	✓	✓	✓		Complete	Impacted stakeholder meetings (4) and public Board of Directors meeting (2/20/24)	NA	Implemented	Complete	2024-	0	0					✓	NA	None	$5,000	$1,000	WDWA GSA via landowner assessments
WDWA-6	Well Extraction Volume Reporting within Close Proximity to Critical Infrastructure	All well owners within the CASP 5-mile Buffer Zone of the CA Aqueduct are required to report annual groundwater extraction volume (measured by flowmeter) by February 1 of the following year.	✓		✓		Complete	Impacted stakeholder meetings (4) and public Board of Directors meeting (2/20/24)	NA	Implemented	Complete	2024-	0	0					✓	NA	None	$2,500	$1,000	WDWA GSA via landowner assessments
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	WDWA GSA via landowner assessments
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	WDWA GSA via landowner assessments

KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	WDWA GSA via landowner assessments
WDWA-7	CA Aqueduct CASP Collaboration and Data Sharing Agreement	To address subsidence along Mileposts 195-215 of the CA Aqueduct and fill data gaps, WDWA GSA is developing a collaboration and data sharing agreement with CASP. Components of the agreement may include (1) quarterly coordination meetings between WDWA GSA and CASP, (2) share well location and extraction volume within the CA Aqueduct Buffer Zone data with CASP, and (3) reviewing annual subsidence rates and CASP collected well and extensometer data.			✓		In-Process	NA	NA	In-Process	2025	2024-	0	0					✓	NA	None	$5,000	$2,500	WDWA GSA via landowner assessments
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	WDWA GSA via landowner assessments
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	WDWA GSA via landowner assessments
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	WDWA GSA via landowner assessments
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	WDWA GSA via landowner assessments
WDWA-8	As-Needed Land Fallowing	Since 2015, WDWA GSA landowners have fallowed over 13,000 acres of permanent crops. Due to naturally high salinity levels, WDWA GSA's groundwater cannot be used for agricultural beneficial use without blending or other prohibitively expensive treatment. Thus, WDWA GSA landowners are 98% reliant on imported surface water supplies (on average between 2015 to 2023) to meet irrigation demand. In dry years where irrigation demand exceeds the Table A allocation provided by the SWP, WDWA GSA landowners utilize their robust supplemental surface water purchase and storage program (P/MA WDWA-1) rather than increase groundwater pumping and risk permanent crop damage or death due to salt stress.	✓			Demand Reduction	Complete	NA	NA	As Needed	Ongoing	As-Needed	0	39,000 cumulative since 2015						NA	None	Landowner asset losses of more than $400,000,000 in market value	N/A	None required, landowners absorb revenue losses

Table 14-22. WRMWSD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects		Implemented / Functional / In-Process / As-Needed										Implemented		Functional	In-Process			As-Needed						
WRM-1	Increase Out-of-District Banking Operations	Increase size/participation in out-of-District banking facilities (i.e., Kern Water Bank and Pioneer Project). Increased banking of wet year supplies outside of the District would support deliveries of imported water into the District in normal/dry years.	✓	✓		Third-Party Banking	Underway	Regular District Board meetings	CEQA	Implemented	Complete	2020-	6730	0	✓		✓			Combination of lower Kern River water supplies and article 21	None	$1,000,000	$100,000	District water charges
WRM-2	Purchase Additional Supplies	Continue purchase of additional supplies, as available, for banking outside of the District or direct delivery within the District.	✓	✓	✓	Supplemental Water Use	Underway	Regular District Board meetings	CEQA	Implemented	Complete	2020-	5000	0	✓		✓			Combination of lower Kern River water supplies and article 21	District authority as a Water Storage District	NA	$2,500,000	District water charges
WRM-3	On-Farm Recharge	A Landowner Recharge Program was established in April 2023 and pays participating landowners $75/AF to spread certain low-cost water supplies available to WRMWSD on private lands.	✓	✓		Supplemental Water Recharge	Underway	Regular District Board meetings	CEQA	Implemented	Complete	2023-	3600	0	✓		✓			Combination of lower Kern River water supplies and article 21	None	$0	$1,350,000	District water charges
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	GSA Admin Charge (to be implemented)
WRM-4	"Thru Delta" Facility	Particpation in a "Thru Delta" Facility to increase access to contracted (SWP) supplies.	✓	✓	✓	Exercise of Rights	State-led effort underway	Prop 218	CEQA	Design & Permitting	2045	2045-	5000	0	✓					State Water Project	None	$311,000,000	TBD	District water charges
WRM-5	In-District Recharge Facilities	Program to promote private and/or District-owned recharge facilities within the District.	✓	✓		Supplemental Water Recharge	To be implemented upon adoption of GSP	Regular District Board meetings	CEQA	Feasiblity Study	2030	2030-	2000	0	✓		✓			Combination of lower Kern River water supplies and article 21	None	$3,200,000	$100,000	District water charges; GSA Admin Charge (to be implemented)
WRM-13	Capture of Imported Water Return Flows from White Wolf Subbasin	WRMWSD has provided imported water deliveries to landowners within the White Wolf Subbasin. Return flows of imported water flow across the White Wolf Fault into Wheeler-Ridge Maricopa GSA. Wheeler-Ridge Maricopa GSA would capture the proportion of Subbasin inflows attributed to WRMSD's imported water return flows for distribution and use within the surface water service area.	✓			Exercise of Rights	Underway	GSA Board meetings	NA	Wheeler-Ridge Maricopa GSA has initiated discussions and negotiations with Subbasin GSAs and White Wolf GSA	2025	2025-	4500	0						Imported water return flows	None	$0	$0	NA
WRM-6	Expand District Distribution System	Project to expand District distribution system into area currently using only private groundwater.	✓	✓	✓	Supplemental Water Use	Upon modification of water service contracts	Regular District Board meetings	CEQA	Not yet Initiated	TBD	TBD	2000	0	✓		✓			Additional wet-year imported water supplies	District as a water storage authority	$18,000,000	$100,000	District water charges; grants

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Relevant Sustainability Indicators Affected: Groundwater Quality	Relevant Sustainability Indicators Affected: Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary (AFY): Water Supply Augmentation	Expected Benefits: Primary (AFY): Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibilityor Efficiency	Expected Benefits: Secondary: Mitigation Programs	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
WRM-7	Desalination Facilities	Desalination facilities to allow for use of additional poor quality groundwater for agricultural use, easing demand on principal aquifer.	✓	✓	✓	New Local Supply	Localized pumping lowering GW levels near MT	Regular District Board meetings	CEQA	Feasiblity Study	TBD	TBD	0	0	✓					poor-quality (currently unused) groundwater	None	NA	$2,400,000	District water charges; GSA Admin Charge (to be implemented)
Management Actions	Implemented	Functional	In-Process	As-Needed								Implemented		Functional		In-Process			As-Needed					
WRM-8	Acerage Assessment	Set policy to implement an acreage assessment to fund purchase of additional supplies, purchase of land for fallowing, and other investments to support SGMA compliance.	✓		✓	Demand Reduction	To be implemented upon adoption of GSP	Prop 218	CEQA	Implemented	Complete	2024-	0	2000						NA	District authority as a Water Storage District	$200,000	$50,000	District water charges
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	GSA Admin Charge (to be implemented)
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	GSA Admin Charge (to be implemented)
KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	GSA Admin Charge (to be implemented)
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	GSA Admin Charge (to be implemented)

KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	GSA Admin Charge (to be implemented)
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	GSA Admin Charge (to be implemented)
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	GSA Admin Charge (to be implemented)
WRM-9	Groundwater Allocation and Market	Develop a groundwater pumping allocation methodology, including a market system for trading and/or transfering of allocations.	✓		✓	Demand Reduction	To be implemented upon adoption of GSP	Regular District Board Meetings	CEQA	By end of WY 2023, allocation policy in early stages of development	TBD	2035-	0	21000			✓			NA	Authority of a GSA under SGMA to develop and implement a GSP	$50,000	$50,000	GSA Admin Charge (to be implemented)
WRM-10	Voluntary Pumping Limitation	Set non-binding pumping limitations in conjunction with a fee for pumping above limits.	✓		✓	Demand Reduction	To be implemented upon adoption of GSP	Prop 218	CEQA	In coordination with WRM-9	TBD	2035-	0	0						NA	Authority of a GSA under SGMA to develop and implement a GSP	$200,000	$50,000	GSA Admin Charge (to be implemented)
WRM-11	Mandatory Pumping Limitation	Set binding pumping limitations in conjunction with a fee for pumping above limits.	✓		✓	Demand Reduction	if other P/MAs are insufficient	Peop 218	CEQA	In coordination with WRM-9	TBD	2035-		5000					✓	NA	Authority of a GSA under SGMA to develop and implement a GSP	$200,000	$50,000	GSA Admin Charge (to be implemented)
WRM-12	Land Retirement	Conversion of ag lands to solar. Purchase and permanently fallow previously irrigated acreage within District to reduce overall water demand and groundwater extractions.	✓		✓	Land Retirement	if other P/MAs are insufficient	Prop 218	CEQA	Feasiblity Study	TBD	2030-	0	10000 (increase by 2500 after 2030)						NA	Authority of a GSA under SGMA to develop and implement a GSP	$0	$10,000	GSA Admin Charge (to be implemented)

Table 14-23. WKWD GSA PM/A

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
	Projects	Implemented / Functional / In-Process	As-Needed									Implemented		Functional		In-Process		As-Needed						
WKWD-1	Automatic Meter Reading Project	This includes the installation of Automatic Meter Readers on all residential and commercial customers in the WKWD.	✓	✓	✓	Water Conservation-Efficiency	Pre-SGMA, supports SGMA goals	Notices and WKWD Board Meetings	NA	Complete	2023	2023-	0	191	✓		✓			NA	NA	$1,500,000	$0	Grant
KSB-1	Friant-Kern Canal Capacity Mitigation	1) Collaborate with FWA to develop costs estimates for the Lower Reach Capacity Correction, 2) develop an attribution analysis of post-2020 subsidence impacts, 3) participate in developing a value of water analysis in cooperation with FWA and 4) develop and implement a funding mechanism to pay for post-2020 conveyance impacts on the FKC attributable to subsidence.	✓		✓		Completion of Design and Impact Analysis	Stakeholder Meetings Board Meetings	NA	Feasiblity Study	2030	2030-	0	0			✓	✓	✓	NA	None	Unknown	Unknown	Rate Payers, Grants
WKWD-2	Participation in Delta Conveyance Facility	Participation in the DCP. Alternative under Delta tunnels.	✓	✓	✓	Exercise of Rights	Completion of Project	Stakeholder Meetings Board Meetings Hearing	NA	Environmental Design	2045-	2045-	3100	0						SWP Table A, Article 21	None		$700,000	Water Rates
WKWD-3	Buena Vista Recreation Area Water Supply Management Coordination	Coordination with Kern County on the operations and extractions required for BVARA.	✓			Exercise of Rights	Fill data gap	NA	NA	In-Process	TBD	TBD	0	0	✓	✓	✓	✓	✓	NA	NA			NA

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Overdraft Correction Description Category	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits – Primary (AFY): Water Supply Augmentation	Demand Reduction	Secondary: Water Quality Improvement	Flood Control	Water Management Flexibility or Efficiency	Mitigation Programs	Data Gap Filling/ Monitoring	Source(s) of Water	Legal Authority Required	Estimated Costs: One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
	Management Actions	Implemented / Functional / In-Process	As-Needed									Implemented		Functional		In-Process		As-Needed						
KSB-2	Coordination with Groundwater Regulatory Programs	Coordination with various water quality regulatory programs by local, state, and federal agencies. Some of these programs include the Irrigated Lands Regulatory Program, SAFER projects, Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), as well as local Groundwater Banking MOU's.	✓	✓			When domestic or small community wells require assistance maintaining access to safe and reliable water supplies.	Refer to Subbasin Outreach and Engagement Plan	NA	Implemented	2020	2020-	0	0	✓				✓	NA	NA	$0	$25,000	Rate Payers, Grants
KSB-3	Exceedance Policy	Subbasin wide policy to provide protocols for groundwater GSAs to investigate exceedances. This policy is developed in conjunction with the Subbasin Well Mitigation Program which identifies mitigation strategies for vulnerable communities.	✓	✓	✓		When an MT exceedance occurs for any sustainability indicator.	NA	NA	Implemented	2024	2024-	0	0				✓	✓	NA		$0	$25,000	Rate Payers, Grants

KSB-4	Coordination with Basin Study	Coordination with local GSA's to gain a better understanding of the Kern Subbasin and how best to manage for sustainability, native yield, subsurface flow, and evapotranspiration. The further development of the data management system to improve data access and transparency.	✓	✓	✓		Supporting data collection, reviewing and validating results with GSA-specific data.	NA	NA	Ongoing	2025	2025-	0	0					✓	NA	NA	$25,000	$0	Rate Payers, Grants
KSB-5	Domestic Well Mitigation	Development of a subbasin domestic and small community well mitigation program to assist with financial aspects of emergency water supplies and well improvement and replacment due to lowering of groundwater levels.	✓	✓			When declining groundwater levels impact domestic or small community wells.	Refer to Subbasin Outreach and Engagement Plan	NA	Initiating Development	2025	2025-	0	0				✓		NA	NA	$0	$45,000	Rate Payers, Grants
KSB-6	White Land Demand Management	Development of governance structure and demand reduction action for Subbasin white lands (lands not within a district or management area). Correct the water supply imbalance by setting water budgets and a linear reduction of 10% per year over the planning period of 2030-2040.	✓	✓	✓	Demand Reduction	Subbasin-wide overdraft correction.	Stakeholder Meetings Board Meetings Hearings Public Outreach & Engagement	NA	Initiating Development	2030	2030-	0	20,410	✓				✓	NA	None	$0	$10,000	Rate Payers, Grants
KSB-7	Well Registry	Maintain and improve 2024 Subbasin well inventory in the DMS platform with added data from field surveys, current beneficial use determinations, and coordination with Kern County Environmental Health and DWR to track new wells, etc.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2024-	2024-	0	0				✓	✓	NA	NA	$0	$25,000	
KSB-8	Consumptive-Use Study	Maintain and improve existing Subbasin consumptive-use study (ITRC Metric/LandIQ) for accurate estimates of water use by parcel within GSA's.	✓	✓	✓			Refer to Subbasin Outreach and Engagement Plan	NA	Ongoing	2020-	2020-	0	0				✓	✓	NA	NA	$0	$25,000	
WKWD-4	Continued Participation in Basin-Wide Coordination	Coordinate with all other GSA's within the Kern Subbasin to address regulatory requirements and determination.	✓	✓	✓	Exercise of Rights	NA	Stakeholder Meetings Board Meetings	NA	In-Process	2040	2020-	0	0	✓	✓	✓	✓	✓	NA	NA	$0	$100,000	Rate Payers, Grants
WKWD-5	Continued Balanced Pumping and Recharge	Continued balanced pumping of groundwater and recharge of imported supplies has and will continue to be the operational norm for WKWD. Under this management action, recharge and recovery activity will continue to be monitored closely by WKWD to maintain balanced conditions.	✓	✓	✓		As-needed	NA	NA	As-Needed	NA	NA	0	0	✓		✓			NA	NA	$0	$0	NA
WKWD-6	Implement Water Shortage Response Plan	Implement conservation measures during drought periods	✓	✓	✓	Demand Reduction	As-needed	Stakeholder Worskhops, Board meeting, customer communications	NA	As-Needed	NA	NA	0	2500			✓	✓		NA	NA	$0	$0	NA
WKWD-7	Taft Recycled Water Program	The Taft Recycled Water Program could potentially generate 423 AFY of tertiary recyceld water for Title 22 approved applicaitons.	✓	✓	✓	New Local Supply	As-needed	Stakeholder Worskhops, Board meeting, customer communications	Construction permits, General Waste Discharge Requirement Permit,.	As-Needed	NA	NA	423	0	✓		✓	✓		Recycled Water	NA	$14,455,000	$415,000	Rate Payers, Grants
WKWD-8	Shift Balance of Pumping between North and South Wellfields	Shifting and balancing pumping between the North Wellfield and South Wellfield entails WKWD increasing the proportion of groundwater pumped at the wellfield that is experiencing the least decline in groundwater levels. This strategy would allow local recovery of groundwater levels in the other wellfield.	✓	✓	✓		As-needed	NA	NA	As-Needed	NA	NA	0	0	✓		✓			NA	NA	$0	$0	NA
WKWD-9	Implement Permanent Demand Management Measures	This adaptive management strategy would convert the Response Level 1 actions in the WSRP from voluntary to mandatory. These water restrictions would require a 25 percent reduction in large landscape watering from 2007 levels, prohibit water waste, and reduce non-contracted industrial water use by 15 percent from 2007 levels.	✓	✓	✓	Demand Reduction	As-needed	Stakeholder Worskhops, Board meeting, customer communications	NA	As-Needed	NA	NA	0	2500			✓	✓		NA	NA	$0	$0	NA

This page intentionally left blank.

15. MONITORING NETWORK

§ 354.32. *Introduction to Monitoring Networks*
This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

☑ **23 CCR § 354.32**

The following sections delineate the established monitoring network for the four relevant sustainability indicators. This network is designed to characterize groundwater conditions within the Subbasin and assess changes in these conditions over time.

15.1 Monitoring Network Objectives

§ 354.34. *Monitoring Network*

(a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.

(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

- *(1) Demonstrate progress toward achieving measurable objectives described in the Plan.*
- *(2) Monitor impacts to the beneficial uses or users of groundwater.*
- *(3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.*
- *(4) Quantify annual changes in water budget components.*

☑ **23 CCR § 354.34(a)**
☑ **23 CCR § 354.34(b)**

The monitoring network for the Kern County Subbasin was designed to gather representative data pertinent to the four applicable sustainability indicators:

- Chronic Lowering of Groundwater Levels
- Reduction of Groundwater Storage, using groundwater levels as proxy
- Degraded Groundwater Quality
- Land Subsidence

The evaluation of minimum thresholds and measurable objectives for the applicable sustainability indicators is accomplished through groundwater level, groundwater quality, and subsidence monitoring. The GSP Regulations require the establishment of a network of representative monitoring wells to depict groundwater occurrence, groundwater conditions, flow direction, and hydraulic gradients between principal aquifers and surface water features (GSP Reg. § 354.32). The objectives of the monitoring program include:

Enhancing understanding of groundwater occurrence and movement by monitoring local and regional groundwater levels, including seasonal and long-term trends, and identifying vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, particularly in areas designated for short-term and long-term groundwater resource development.

Evaluating progress towards the Subbasin sustainability goal and measurable objectives outlined in this Plan.

- Assessing impacts to beneficial uses and users of groundwater.
- Collecting data to improve characterizations of groundwater conditions and assess the availability and reliability of current and future water supplies, while revising analyses such as the groundwater model and water budget as additional data becomes available.
- Improving understanding of groundwater quality conditions throughout the Subbasin by monitoring Constituents of Concern (COCs) to identify long-term trends and changes in groundwater quality.
- Generating data to refine estimates of groundwater basin conditions and evaluate local current and future water supply availability and reliability, updating analyses such as the groundwater model and water budget as additional data becomes available.

Detecting and monitoring land subsidence caused by GSA activities to provide information to help mitigate potential infrastructure damage and land-use impacts.

- Supporting decision-making processes related to groundwater management, including the development and implementation of Projects and Management Actions (P/MAs).

It should be noted that portions of the basin have been monitored extensively for water levels, water quality, and subsidence for decades, especially in the Kern River HCM.

15.2 Description of Monitoring Network

§ 354.34. *Monitoring Network*

(d) *The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.*

(e) *A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.*

(f) *The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:*

(1) *Amount of current and projected groundwater use.*

(2) *Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.*

(3) *Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.*

(4) *Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.*

(g) *Each Plan shall describe the following information about the monitoring network:*

(1) *Scientific rationale for the monitoring site selection process.*

(2) *Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.*

(3) *For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.*

(h) *The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.*

Table 15-1 provides an overview of the number and type of sites corresponding to each sustainability indicator. More detailed tables, including measurement frequency and site locations, are provided within the individual sections dedicated to each sustainability indicator.

Table 15-1. Summary of Monitoring Sites

Sustainability Indicator	Type of Site	Number of Sites
Chronic Lowering of Groundwater Levels	Well	185
Reduction in Groundwater Storage	Well (water levels as a proxy)	185
Degraded Groundwater Quality	Well	51
Land Subsidence	Extensometer GPS Benchmarks Survey Locations InSAR	145

Site Density in the Monitoring Network

Sites for all sustainability indicators were strategically chosen to ensure adequate spatial coverage across the Subbasin, with data collected at intervals conducive to detecting temporal trends. The density of monitoring sites was influenced by the presence of beneficial users, with higher densities allocated to locations with more beneficiaries.

Groundwater level monitoring sites were distributed across the Subbasin to accommodate variations in pumping. Higher densities of monitoring sites were established in areas with intensive pumping to monitor for potential impacts to agriculture, domestic and municipal and industrial (M&I) beneficial users. Similarly, water quality monitoring sites were also selected to monitor potential impacts to the most vulnerable users. More water quality monitoring sites were selected in areas with higher density of domestic wells or small community water systems. Sites were also chosen to overlap with wells monitoring for groundwater levels to provide the Subbasin the ability to analyze both groundwater level and quality data to determine if degradation is caused by changes in groundwater levels. Monitoring site density for land subsidence is greater in areas with critical infrastructure experiencing historical and ongoing subsidence.

Further details regarding the monitoring networks and site density are provided in Sections 15.2.1 through 15.2.6.

Rationale for Site Selection

Groundwater level monitoring sites were selected based on several factors including location to ensure distribution across the Subbasin relative to pumping, accessibility, availability of existing water level records, representativeness of water level conditions, and considerations for discrete monitoring of principal aquifers in the East Margin HCM Area where multiple aquifers are present as previously described Section 7.2.2.4 and further discussed in Section 15.2.1.

Groundwater quality sites were chosen based on their inclusion in existing programs, accessibility for sampling, and capability to represent aquifer conditions. All wells will monitor effects from changes in groundwater levels. Select sites within this network are designated to correlate groundwater quality to other sustainability indicators - Other sites within this network designated to also monitor potential effects of subsidence and water banking projects. As previously stated, sites were selected to ensure a higher density of wells in areas with vulnerable beneficial users.

Land subsidence monitoring sites were selected based on their proximity to critical infrastructure, with consideration given to existing monitored sites for ease of data collection. All sites for sustainability indicators were chosen to protect beneficial users and to monitor current and future conditions within the Subbasin.

Consistency with Data Reporting Standards

Quantitative values for Measurable Objectives (MOs), Minimum Thresholds (MTs), and Interim Milestones (IMs) for each monitoring site are discussed in Section 13.

Adherence to Data Quality Objective (DQO) Process

DWR recommends employing the DQO process (EPA, 2006) for establishing a monitoring network. The following table (Table 15-2) outlines how the Subbasin implemented the steps within this process.

Table 15-2. Summary of DQO Process Implementation

Steps	Implementation by the Subbasin
1. State the problem – Define sustainability indicators and planning considerations of the GSP and sustainability goal.	Sustainability indicators and sustainability goal are defined in Sections 12 and 13
2. Identify the goal – Describe the quantitative MOs and MTs for each sustainability indicators.	MOs and MTs for each sustainability indicator are described in Section 13.
3. Identify the inputs – Describe the data necessary to evaluate the sustainability indicators and other GSP requirements (i.e. water budget).	Data required for the evaluation of the sustainability indicators is described in Section 13.
4. Define the boundaries of the study- This is commonly the extent of the Bulletin 118 groundwater basin or Subbasin, unless multiple GSPs are prepared for a given basin. In that case, evaluation of the coordination plan and specifically how the monitoring will be comparable and meet the sustainability goals for the entire basin.	The boundary of the study area is defined as the Kern County Subbasin, as described in Section 6.
5. Develop an analytical approach – Determine how the quantitative sustainability indicators will be evaluated (i.e. are special analytical methods required that have specific data needs).	The evaluation of sustainability indicators is described in Section 13.
6. Specify performance or acceptance criteria – Determine what quality the data must have to achieve the objective and provide some assurance that the analysis is accurate and reliable.	Protocols for data collection and monitoring are described in Section 15.
7. Develop a plan for obtaining data – Once the objectives are known determine how these data should be collected. Existing data sources should be used to the greatest extent possible.	Data collection procedures, timing, and frequency are described in Section 15.

15.2.1 Monitoring Network for Chronic Lowering of Groundwater Levels

> ***§ 354.34**. Monitoring Network*
> *(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
> *(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:*
> *(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.*
> *(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.*

☑ 23 CCR § 354.34(c)(1)

Development of the groundwater level monitoring network aimed to fulfill the objectives presented in Section 15.1 and assess the Subbasin's progress toward its sustainability goal. Throughout the network's establishment, the DWR Best Management Practices (BMPs) served as guiding principles. These BMPs played a crucial role in determining the optimal density of monitoring wells suitable for the Subbasin. Table 15-3 provides the recommend monitoring well density that was adopted from the California Statewide Groundwater Elevation Monitoring (CASGEM) guidelines (DWR, 2010, 2016).

Table 15-3 Monitoring Well Density Considerations

Reference (Hopkins 1984)	Monitoring Well Density (wells per 100 square miles)
Basins pumping more than 10,000 acre-feet/year per 100 square miles	4.0
Basins pumping between 1,000 and 10,000 acre-feet/year per 100 square miles	2.0
Basins pumping between 250 and 1,000 acre-feet/year per 100 square miles	1.0
Basins pumping between 100 and 250 acre-feet/year per 100 square miles	0.7

To ascertain the necessary number of wells for the Kern County Subbasin, the average total pumping from 1995 through 2022 was computed. The Hopkins methodology, outlined in Table 15-3, was employed to derive the minimum number of representative monitoring sites, using the following subbasin values:

- Average Total Pumping: 1,470,139 AFY
- Total Area: 2,785 square miles
- Calculated number of wells: 111

A total of 111 wells were calculated as a minimum for monitoring groundwater levels. Subsequently, following the determination of the appropriate number of monitoring wells for the Subbasin through the Hopkins method, a hexagonal tessellation was generated over the Subbasin area as illustrated in Figure 15-1. This tessellation comprised 111 cells spanning 25 square miles each. Initially, a uniform approach was considered, assigning one monitoring well to each grid cell to ensure equal distribution across the Subbasin.

However, this method failed to account for variations in pumping across the Subbasin. To better align the monitoring network with pumping distribution, recommendations from Table 15-3 were adjusted to a 25 square mile scale, as shown in Table 15-4. Each pumping category (pumping per 25 square miles) was assigned a pumping group, as shown in Table 15-4.

Table 15-4 Scaled Monitoring Well Density

Pumping Group	Pumping per 25 square miles (AFY)	Wells per 25 square miles
1	0 - 25	0
2	25 – 62.5	0.175
3	62.5 - 250	0.25
4	250 - 2500	0.5
5	2500+	1.0

This page intentionally left blank.

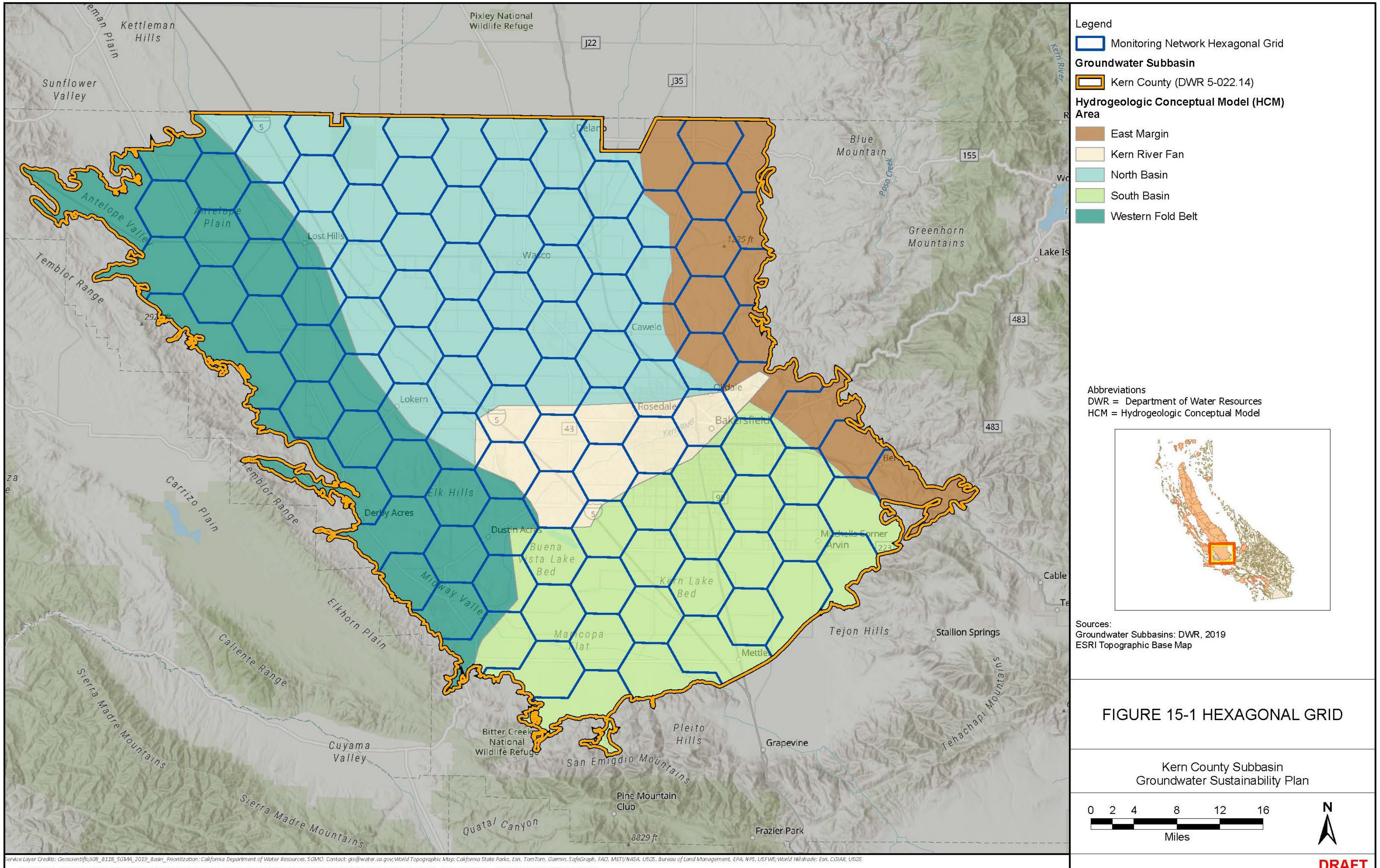


Figure 15-1 Hexagonal Grid

This page is blank intentionally.

To apply the scaled monitoring densities to each grid cell, rasters of groundwater pumping from the groundwater model were analyzed for pumping distribution across the Subbasin. Figure 15-2 shows a heat map depicting the average (2016-2023) pumping distribution of pumping across the Subbasin. This heat map was utilized to assign pumping values to each grid cell in Figure 15-1. As indicated on this heat map, minimal to no pumping was observed in the Western Fold Belt HCM Area. This observation is consistent with degraded water quality and Basin Plan de-designations in this HCM Area, limiting the ability to beneficially use groundwater (Table 15-5. Western Fold Belt HCM Groundwater Beneficial Exceptions[1]). Rather than extract groundwater, water users import surface water and/or recovered banked surface water supplies into the GSA to meet demand. The Basin Setting (Section 6) provides additional background information on how Subbasin boundaries, water quality, and other factors contribute to the lack of groundwater extraction within the Western Fold Belt HCM Area.

Table 15-5. Western Fold Belt HCM Groundwater Beneficial Exceptions[1]

Exception Area	Area Description[2]	DAU#
2	Groundwater and spring water within ½ mile radius of the McKittrick Waste Treatment (formerly Liquid Waste Management) site in Section 29, T30S, R22E, MDB&M, are not suitable, or potentially suitable, for municipal or domestic supply (MUN).	259
3	Ground water in the San Joaquin, Etchegoin, and Jacalitos Formations within one-half mile of existing surface impoundments P-1, P-2, P-3, P-4, P-4 ½, P-5, P-6, P-7, P-8, P-9, P-10, P-11, P-12/12A, P-13, P-14, P-15, P-16, P-17, P-18, P-19, and P-20, and proposed surface impoundments P-21, P-24, P-25, P-27, P-28, and P-29 at the Kettleman Hills Facility (Sections 33 and 34, T22S, R18E, and Section 3, T23S, R18E, MDB&M) of Chemical Waste Management is not a municipal or domestic supply (MUN).	N/A

1 Table adopted from Table 2-3 in Amendments to the Water Quality Control Program for the Tulare Lake Basin, May 2018. Link: tularelakebp_201805.pdf (ca.gov)

2 In addition to the identified areas listed, on November 7, 2023, the State Water Resources Control Board approved Resolution 2023-0040 amending the Water Quality Control Plan for the Tulare Lake Basin to remove the municipal and domestic supply (MUN) and agricultural supply (AGR) beneficial uses from groundwater within a designated horizontal and vertical portion of the Southern Region of the Lost Hills Oilfield. Resolution 2023-0040 is pending final approval by the Office of Administrative Law.

Minimal pumping also occurs in most portions of the East Margin HCM Area. As described in Section 7.2.2.4, this HCM area is impacted by geologic features impeding groundwater flow. Furthermore, the saturated thickness of the Principal Alluvial Aquifer decreases toward the Sierra Nevada and Bakersfield Arch due to the aquifer bottom rising in this direction. This decrease in saturated thickness limits pumping, resulting in the majority of wells pumping from the Santa Margarita or Olcese Sands Principal Aquifer.

Pumping in the North Basin and South Basin HCM Areas is more extensive than in the Western Fold Belt and East Margin HCM Areas. Pumping in the North and South Basin HCM areas occurs in the Principal Alluvial Aquifer. Groundwater in both HCM Areas flows to areas of high groundwater pumping. In the North Basin HCM Area, groundwater also flows to the north into the Tule and Tulare Lake Subbasins. In the

Kern River Fan HCM Area, banking and recovery operations influence groundwater levels. Pumping in this area also occurs from the Primary Alluvial Principal Aquifer. A detailed discussion regarding groundwater flow and pumping is presented in Section 8.

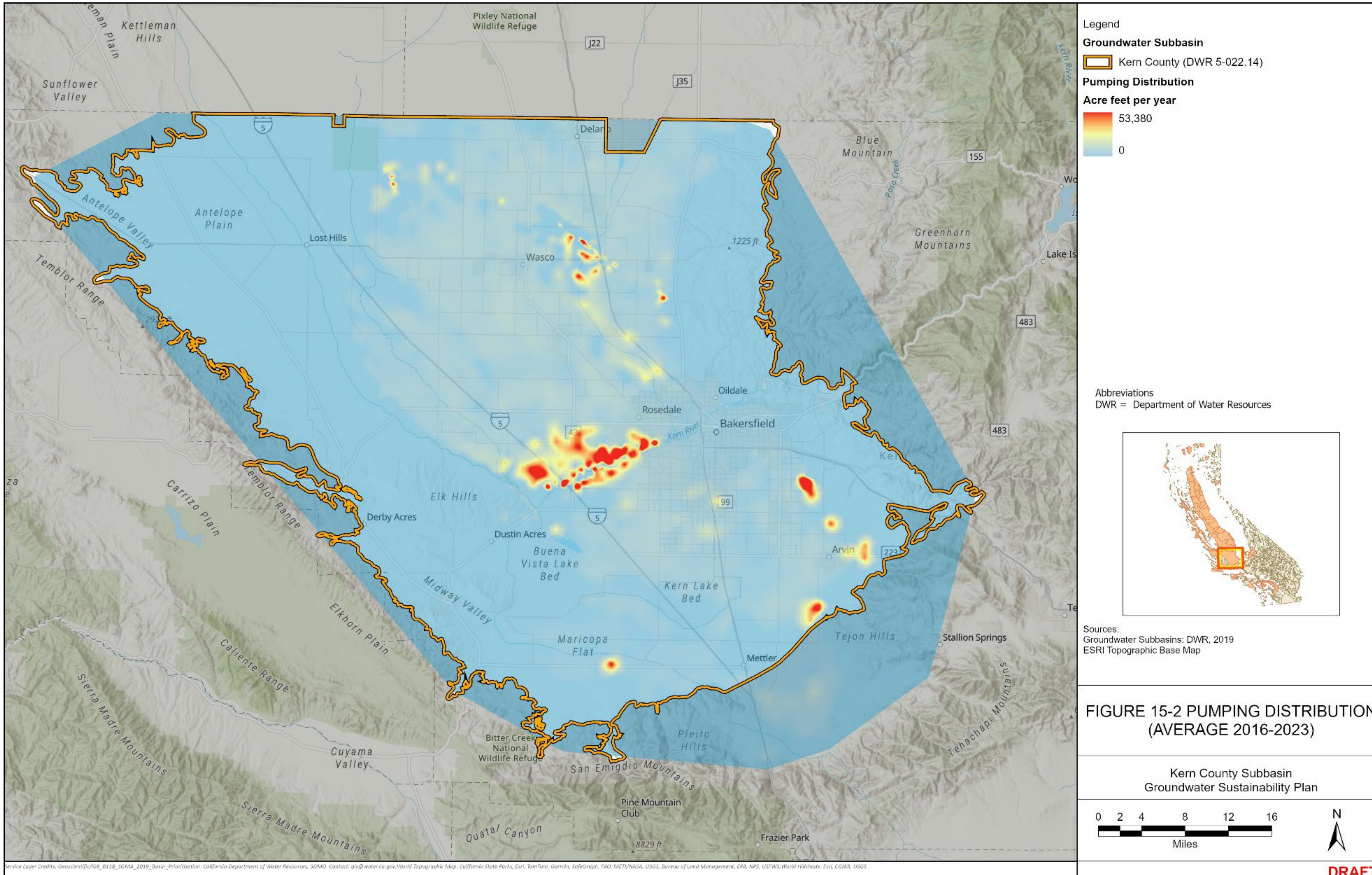


Figure 15-2 Pumping Distribution (Average 2016-2023)

This page is blank intentionally

Using Table 15-4, each grid cell was assigned to a pumping group based on the average pumping amount within the grid cell. The grid cells belonging to the same pumping groups were merged to generate a modified distribution grid as depicted in Figure 15-3. The previously calculated 111 wells were distributed across this new grid based on the area and amount of pumping for each pumping group. This distribution resulted in the Calculated Minimum Number of Wells column in Table 15-6.

Table 15-6. Distribution of Minimum Number of Wells Across Pumping Groups

Pumping Group	Well Density Category	Calculated Minimum Number of Wells
1	0	0
2	0.7	0.5
3	1	8
4	2	91
5	4	11

In addition to this analysis, the Subbasin was analyzed to ensure monitoring of the three principal aquifers (the Primary Alluvial Principal Aquifer, Santa Margarita Principal Aquifer, and Olcese Sand Principal Aquifer) as described in Sections 6 through 8. Wells monitoring the Santa Margarita and Olcese Sand Principal Aquifers are primarily located in the East Margin HCM Area. These considerations are depicted in Figure 15-4.

This page intentionally left blank.

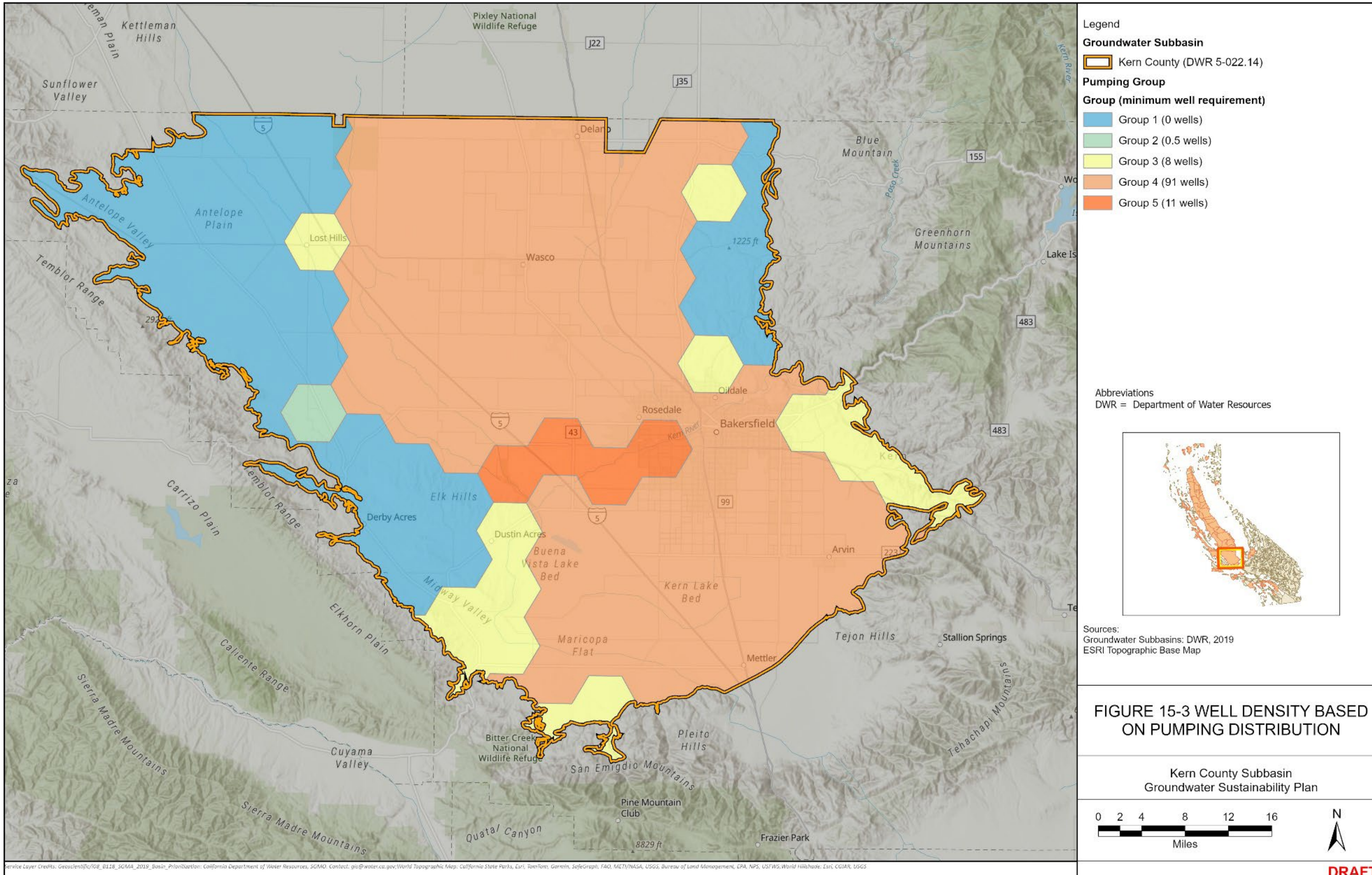


Figure 15-3. Well Density Based on Pumping Distribution

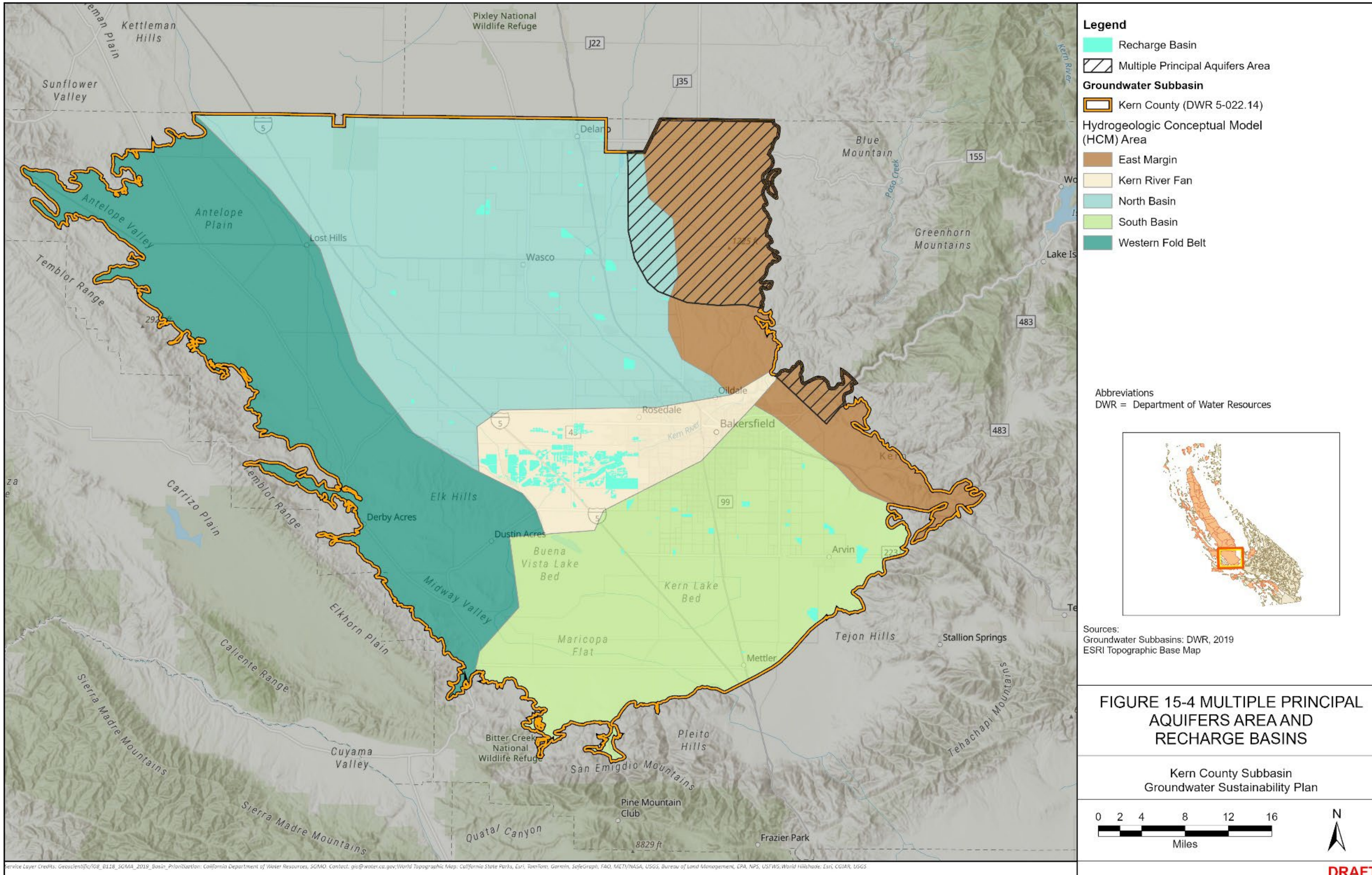


Figure 15-4. Multiple Principal Aquifers Area and Recharge Basins

Monitoring wells were also selected near the boundary between the Western Fold Belt HCM Area and the North Basin HCM Area. Groundwater quality is naturally degraded in the Western Fold Belt HCM. The subject wells are strategically placed to monitor groundwater levels and quality in the transition between the Western Fold Belt HCM and the adjacent down gradient North Basin HCM. Figure 15-5 shows the monitoring network in relation to the geologic structures in the Subbasin. The three wells monitoring the boundary between the Western Fold Belt HCM Area and the North Basin HCM Area are also highlighted as WDWA Sentinel Wells on Figure 15-5.

The monitoring network was also re-examined by GSAs and all routine monitoring network changes (due to lack of well access, well destruction, etc.) were also incorporated into the new monitoring network. The resulting monitoring network was subsequently evaluated against this grid to ensure an adequate number of wells for monitoring. The results of this evaluation are presented in Table 15-7.

Table 15-7. Comparison of Existing Network to Calculated Well Density

Pumping Group	Well Density Category	Calculated Minimum Number of Wells	Existing Number of Wells
1	0	0	5
2	0.7	0.5	0
3	1	8	3
4	2	91	160
5	4	11	17

Overall, the groundwater level monitoring network for the Kern County Subbasin comprises 185 wells, as illustrated in Figure 15-6 and summarized in Appendix X and Table 13-2. An assessment of the monitoring network is provided in Section 15.5. This assessment includes a discussion of the discrepancy between the calculated minimum number wells and existing number of wells for pumping group 3.

This page intentionally left blank.

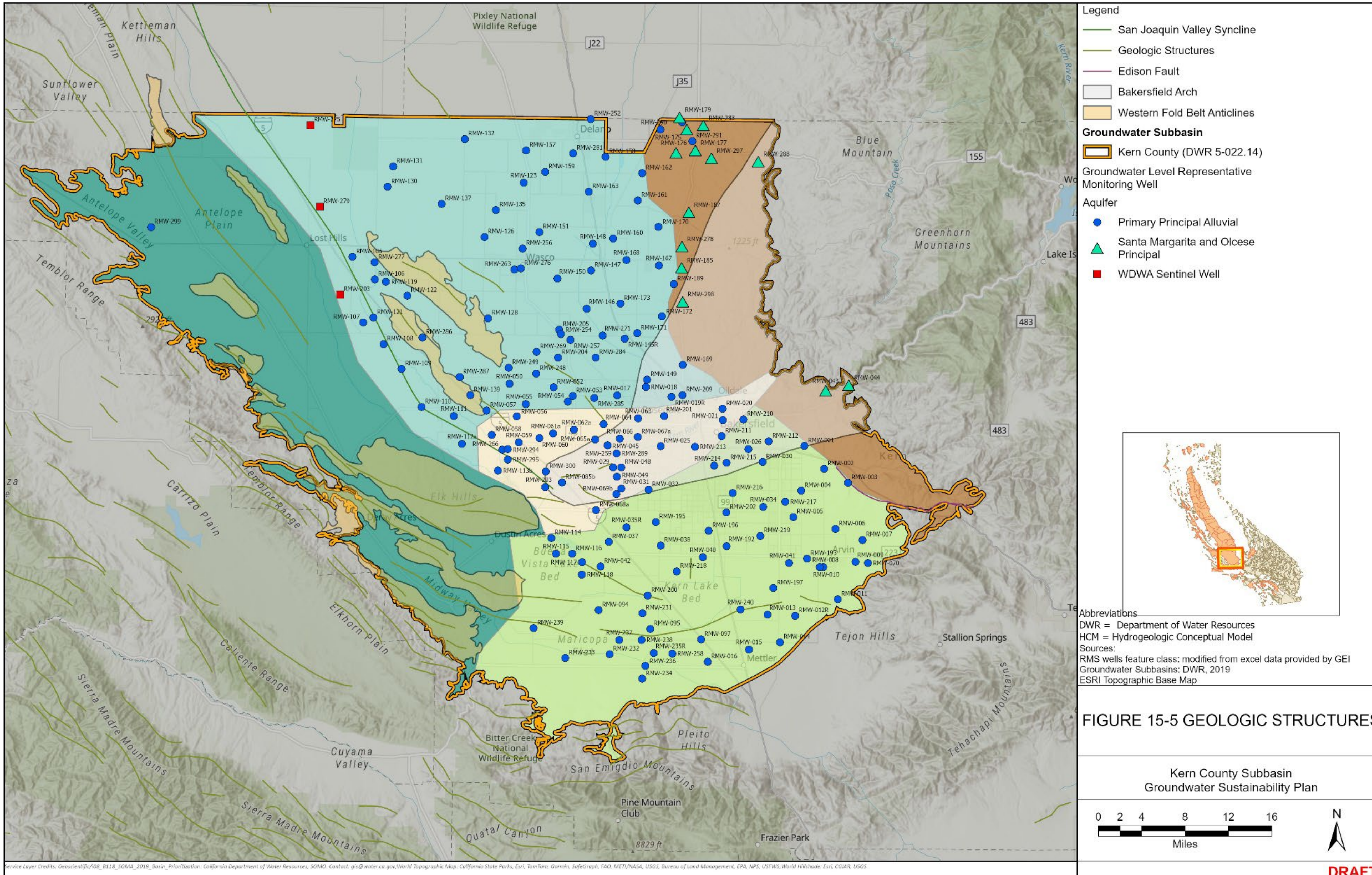


Figure 15-5. Geologic Structures

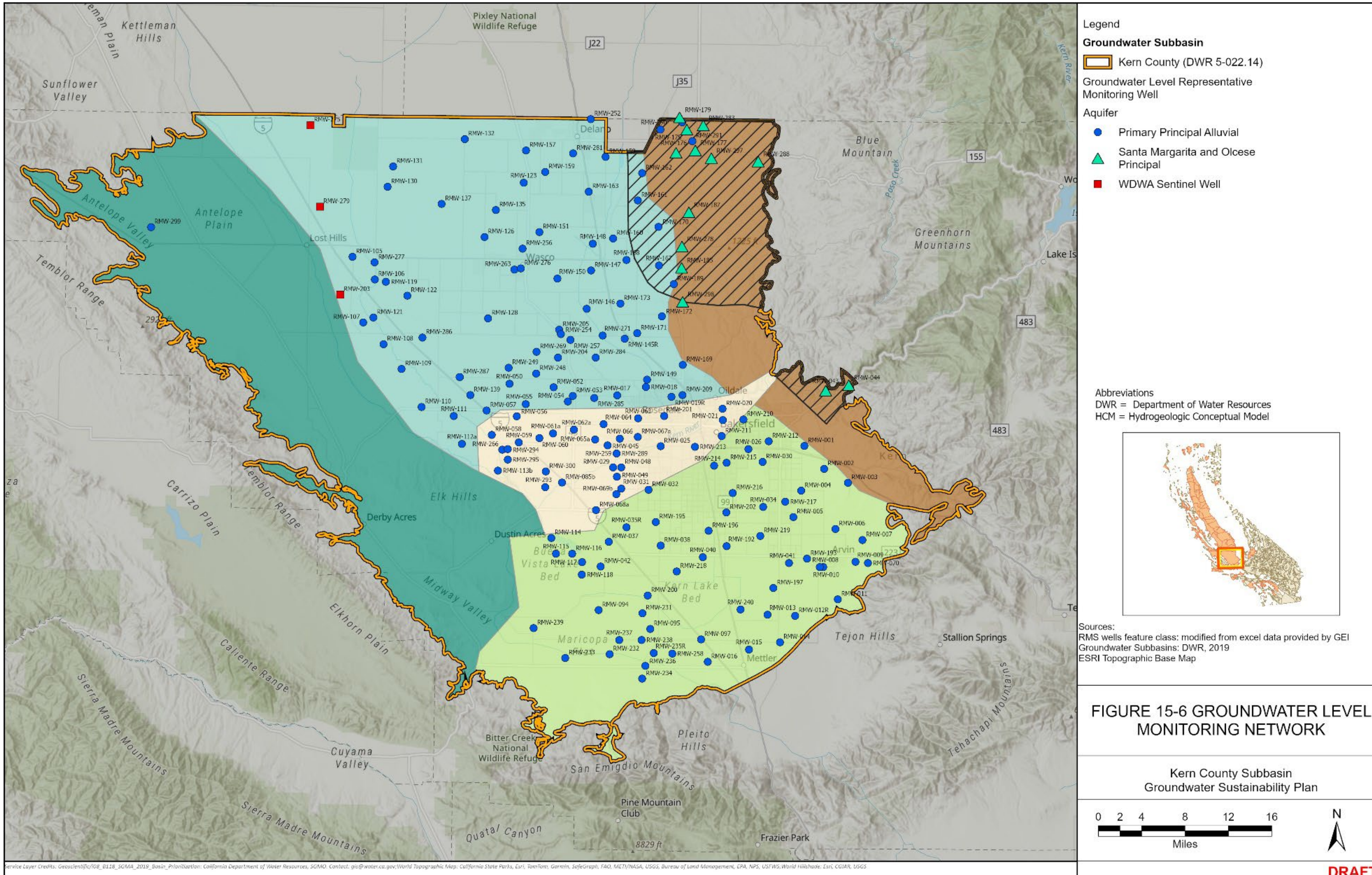


Figure 15-6. Groundwater Level Monitoring Network

15.2.2 Monitoring Network for Reduction in Groundwater Storage

> ***§ 354.34.*** *Monitoring Network*
>
> *(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.*

☑ 23 CCR § 354.34(c)(2)
☑ 23 CCR § 354.36(b)(1)
☑ 23 CCR § 354.36(b)(1)

As detailed in Section 13.2, the amount of groundwater storage is directly related to groundwater levels, and the minimum thresholds (MTs) for Chronic Lowering of Groundwater Levels are used as a proxy for the Reduction of Groundwater Storage. Consequently, the groundwater level monitoring network will be used as a proxy and serve as the monitoring network for the Reduction of Groundwater Storage Sustainability Indicator.

15.2.3 Monitoring Network for Seawater Intrusion

> ***§ 354.34.*** *Monitoring Network*
>
> *(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.*
>
> *(j) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.*

☑ 23 CCR § 354.34(c)(3)
☑ 23 CCR § 354.34(J)

As described in Section 13.4, this sustainability indicator is not applicable to the Subbasin and thus no monitoring network has been established.

15.2.4 Monitoring Network for Degraded Water Quality

> ***§ 354.34.*** *Monitoring Network*
> *(a) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
> *(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.*

☑ 23 CCR § 354.34(c)(4)

As described in Section 8.4, current groundwater quality conditions within the Subbasin were characterized following the State Water Resources Control Boards (SWRCB) methodology for high and medium priority Subbasins. Sample results were downloaded from various databases to represent groundwater quality from domestic, irrigation, municipal and industrial, and other water supply well types. The applied methodology evaluates a list of constituents of concern then uses screening criteria to develop the Subbasin's list of constituents to be monitored based on the prevalence of exceedances that occurred between 2010 and 2023. Monitoring wells representative of conditions across the Subbasin were identified and selected for the assignment of sustainable management criteria and included in the monitoring network.

In addition to characterizing groundwater quality, the well inventory was utilized to determine locations with high densities of domestic wells and small community water systems (Figure 15-7). A higher density of representative monitoring wells is identified in these regions to monitor groundwater quality and potential impacts on these beneficial users. A subset of the wells was also identified to monitor subsidence and the effects of Projects and Management Actions. For example, wells in the vicinity of recharge basins and in areas with mapped clay units and historical subsidence will be used to monitor the relationship between sustainability indicators (Figure 15-8).

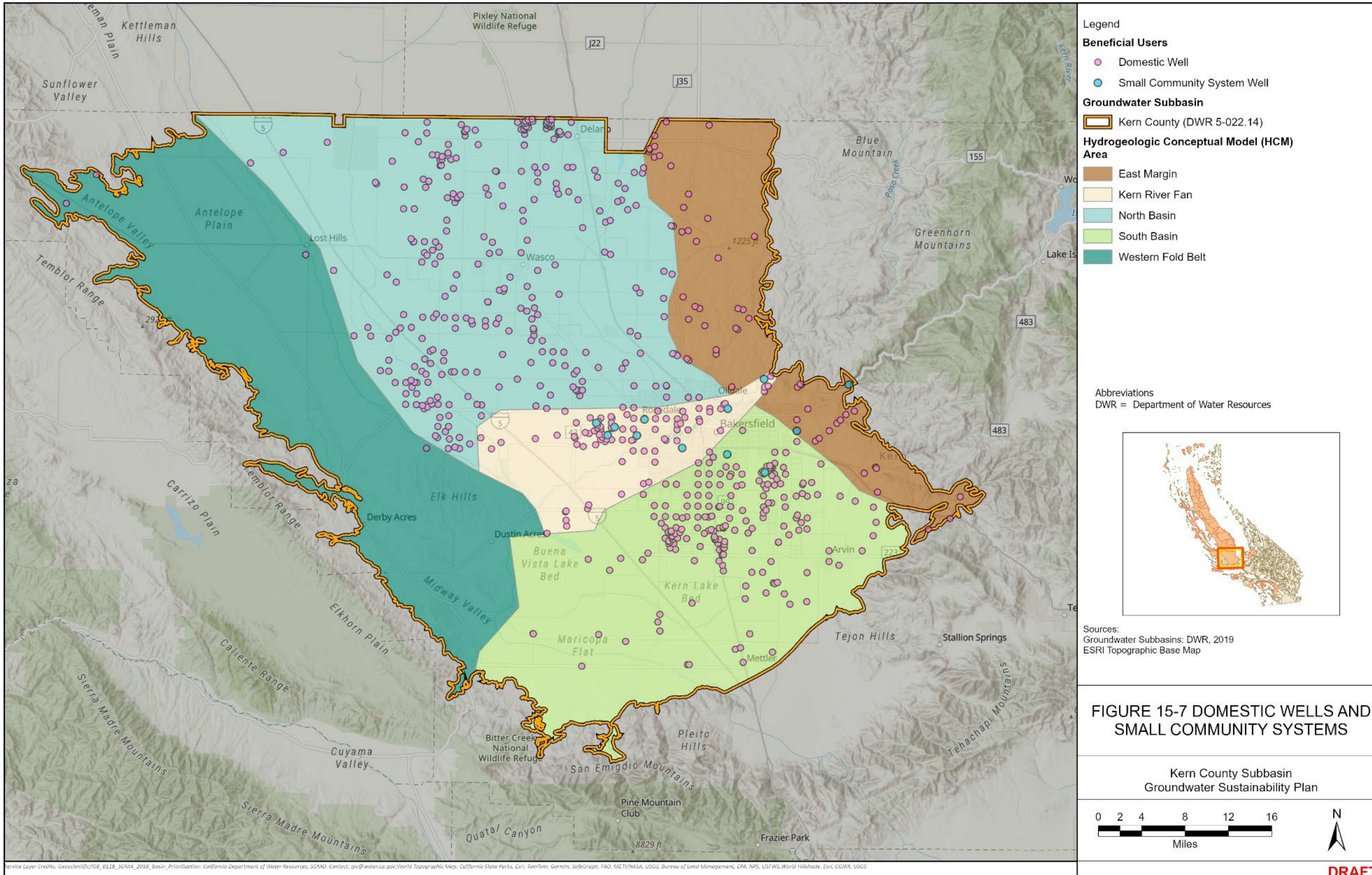


Figure 15-7. Domestic Wells and Small Community Systems

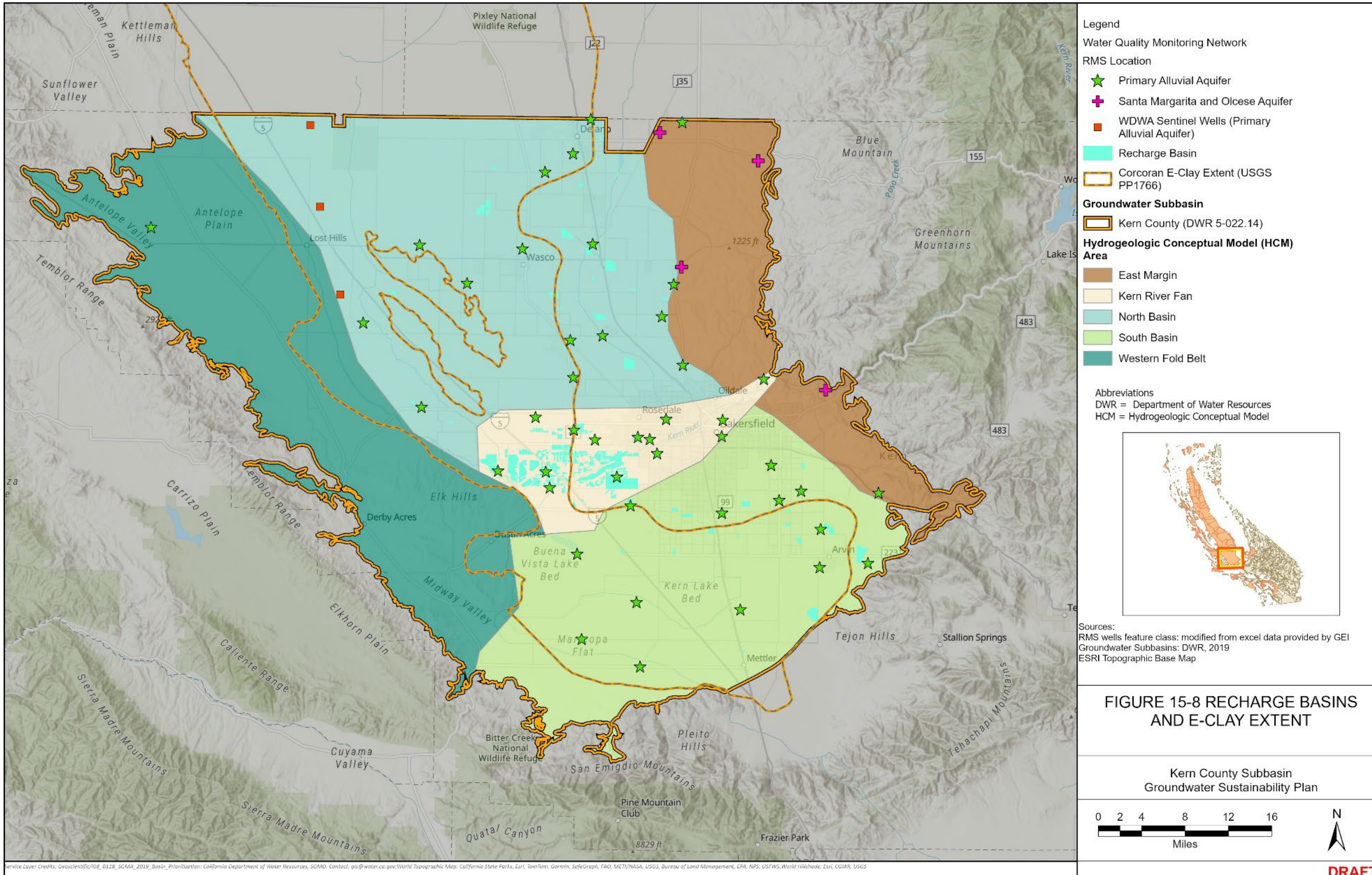


Figure 15-8. Recharge Basins and E-Clay Extent

Additional well location criteria include spatial distribution across the Subbasin and representation of various land uses with at least one groundwater quality monitoring well in each GSA. In cases where a GSA spans more than one HCM area, a monitoring well was identified for that GSA/Management Area in each HCM. A minimum of one well was also included for each HCM area. An exception to the monitoring network criteria is applied to the Western Fold Belt HCM area, due to minimal pumping, there are limited wells available to include in the monitoring network. This limitation in well availability is partly due to water quality issues (natural and anthropogenic) in this HCM Area as discussed in Sections 7.2.2.5 and 8.4. Several wells in the Western Fold Belt HCM Area in Figure 15-10 were found to be inactive after validation through the well inventory process. More information is provided about these wells in Section 5.6. One well near the northern boundary was identified, but all other production wells identified through the well inventory were verified to be inactive and unavailable for sampling. Figure 15-10 also shows one ILRP well in the center of the Western Fold Belt HCM Area. This ILRP well is classified as a monitoring well and thus is not utilized to produce water.

During monitoring well selection, every effort was made to include monitoring wells from existing water quality regulatory programs such as the Irrigated Lands Regulatory Program (ILRP) and public supply wells regulated by Division of Drinking Water (DDW).

The groundwater quality monitoring network consists of a total of 51 monitoring wells designated as Representative Monitoring Wells (RMWs). These wells are summarized in Appendix X and Table 13-2 and illustrated on Figure 15-9. In addition to these monitoring wells, the Subbasin will continue to evaluate data and water quality reports from ILRP and public supply monitoring programs (Figure 15-10). This data will help the GSAs comprehensively assess groundwater quality conditions across the Subbasin.

This page is blank intentionally.

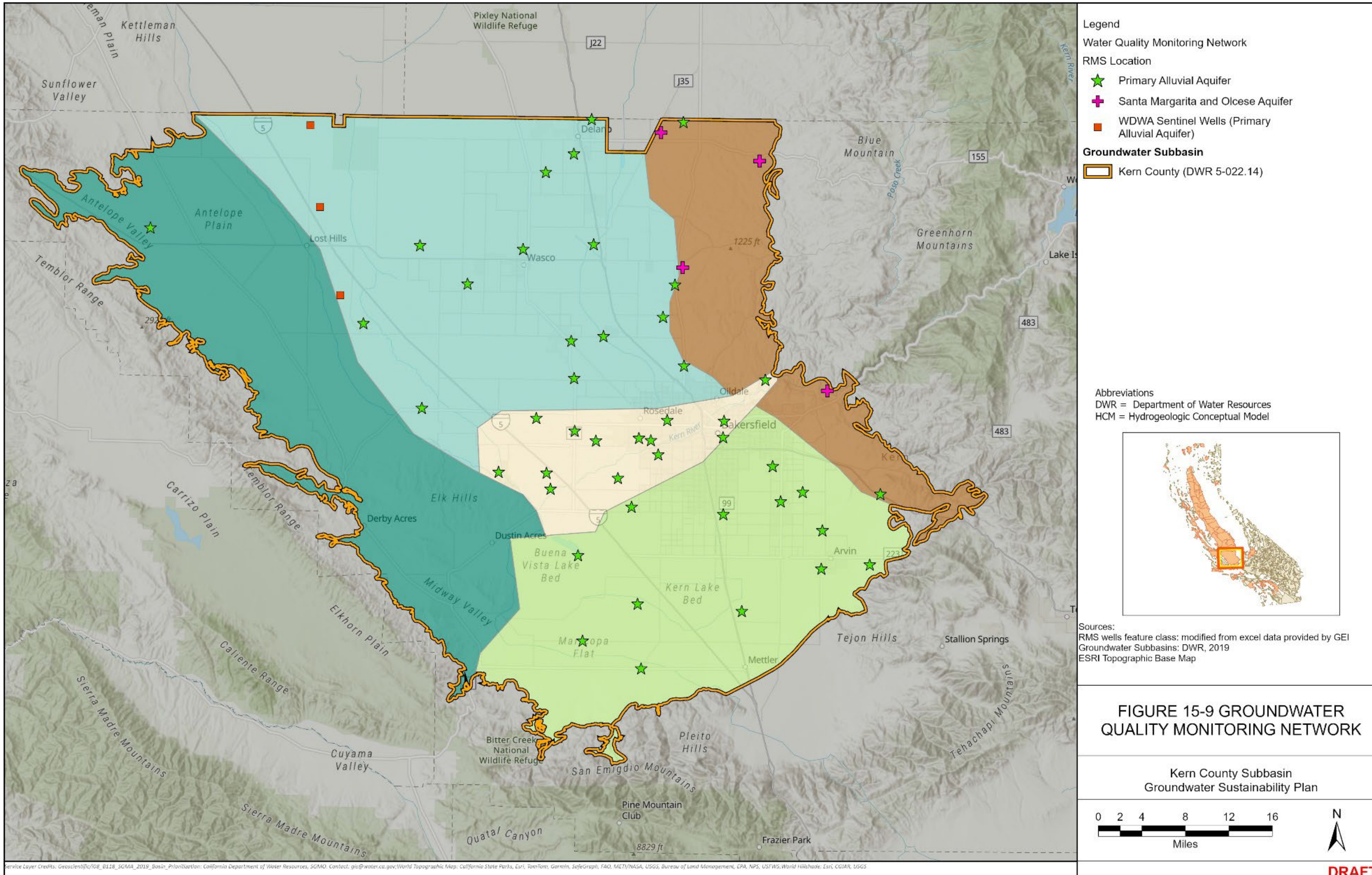


Figure 15-9. Groundwater Quality Monitoring Network

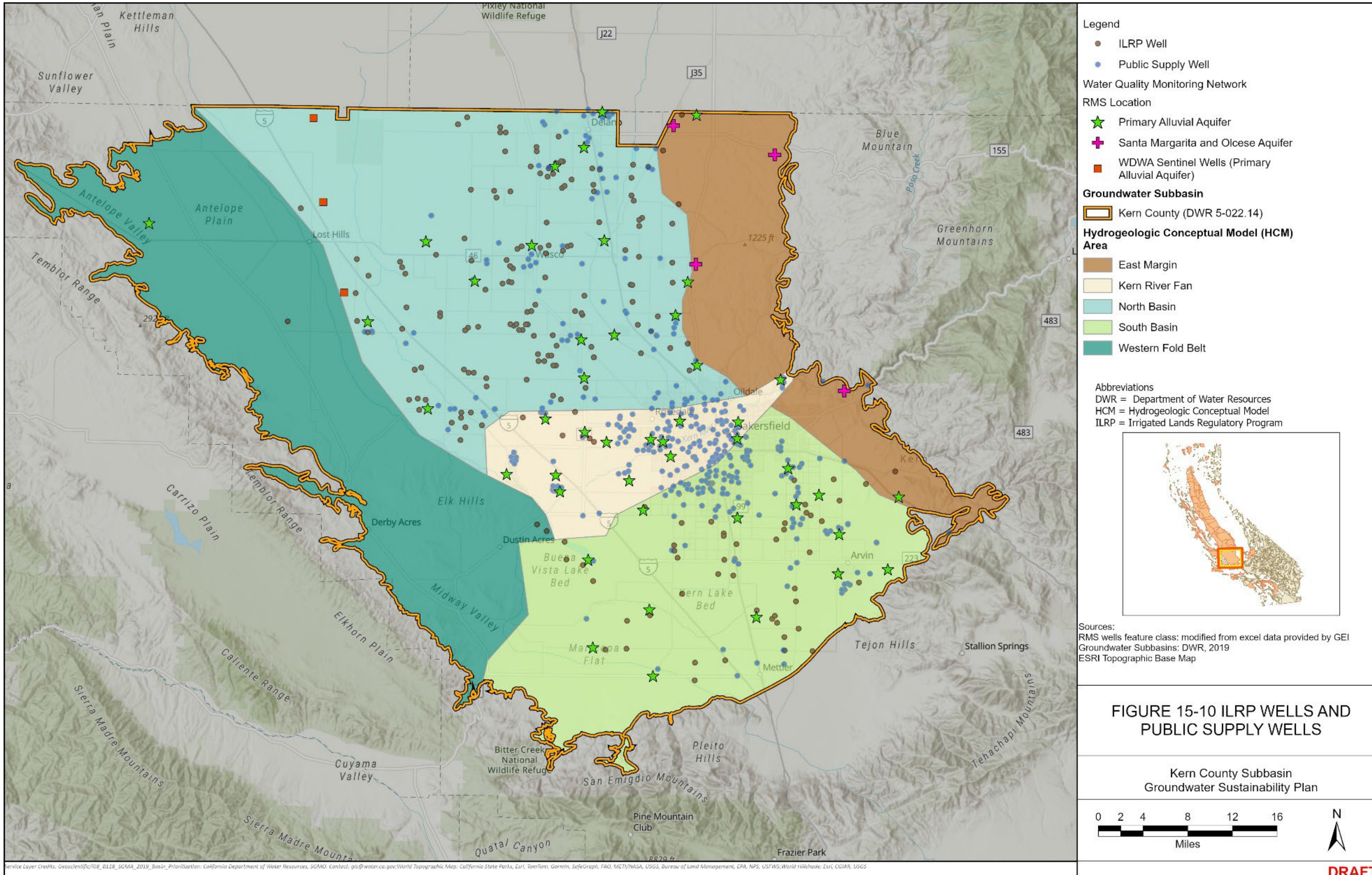


Figure 15-10. ILRP Wells and Public Supply Wells

15.2.5 Monitoring Network for Land Subsidence

***§ 354.34.** Monitoring Network*

(c) *Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*

(5) *Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.*

☑ 23 CCR § 354.34(c)(5)

The monitoring network for land subsidence was devised to ensure sufficient monitoring coverage of critical infrastructure within the Subbasin and to anticipate future subsidence issues. Section 13.5 delineates the locations of identified critical infrastructure and corresponding Sustainable Management Criteria (SMC). Land subsidence monitoring network sites were chosen to monitor subsidence both in proximity to this critical infrastructure and across the Subbasin.

Evaluation of the sustainability indicator for land subsidence entails monitoring land surface elevation via a network of subsidence monitoring programs in the Subbasin. This spatially extensive monitoring network encompasses several data collection programs:

- The Subbasin will continue acquiring InSAR data from DWR. This InSAR data will undergo verification through comparisons with various benchmarks and GPS stations. Additionally, it will be used to prepare various subsidence time series and monitor overall subsidence across the Subbasin and to identify rates and extent of subsidence.
- Both NKWSD and NOAA collect subsidence data from surveyed benchmarks adjacent to and surrounding the Friant-Kern Canal from 21 and 15 surveyed locations, respectively.
- California Aqueduct Subsidence Program (CASP) surveyed benchmark data and new extensometer data along the Aqueduct will be utilized to ground-truth InSAR data annually. CASP also plans to install additional monitoring wells and extensometers along the Aqueduct between 2023 and 2025. The Subbasin will work to incorporate these new sites into the monitoring network. The Subbasin GSAs will request the updated surveyed benchmark data from CASP annually.
- USGS gathers subsidence data from 2 historical extensometer locations in the Subbasin, with an additional extensometer currently under construction adjacent to the Friant-Kern Canal at Kimberlina Road.
- UNAVCO maintains continuous GPS subsidence data from 5 GPS subsidence stations in the Subbasin, while SOPAC collects data from 7 GPS stations.

- DWR gathers subsidence data from 67 GPS survey locations within the Subbasin, which will augment extensometers, surveyed benchmarks from NKWSD and National Oceanic and Atmospheric Administration (NOAA), and continuous GPS monitoring stations.
- DWR also monitors subsidence at an extensometer located at well T30S/R25E-16L MDB&M within the Kern Water Bank.
- Arvin Edison Water Storage District monitors 5 survey locations along its canal.

InSAR data coverage for the Subbasin is depicted on Figure 15-11. The individual monitoring locations are summarized in Appendix X and Section 13.5 and illustrated on Figure 15-12.

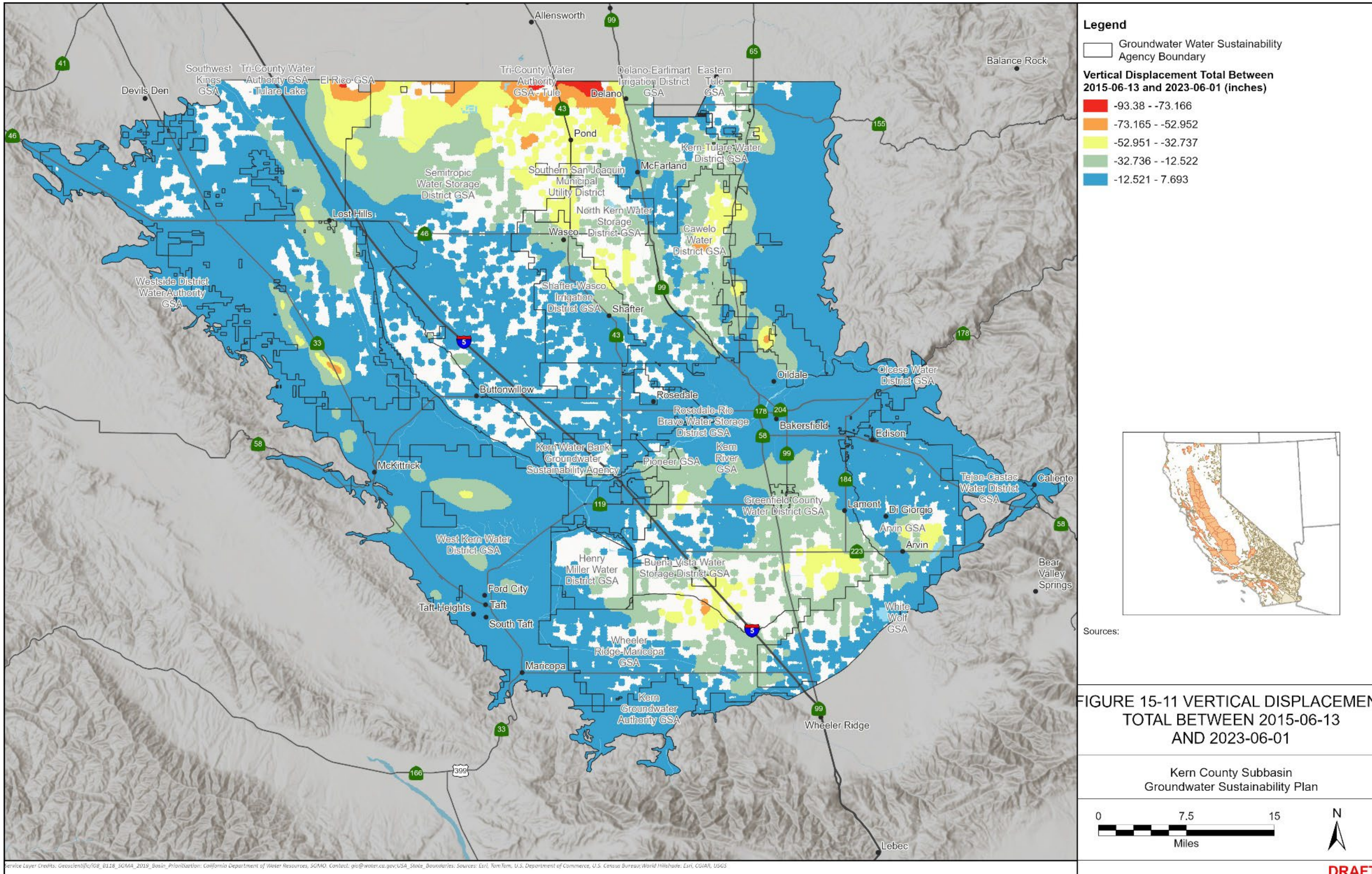


Figure 15-11. Vertical Displacement Total Between 2015-06-13 and 2023-06-01

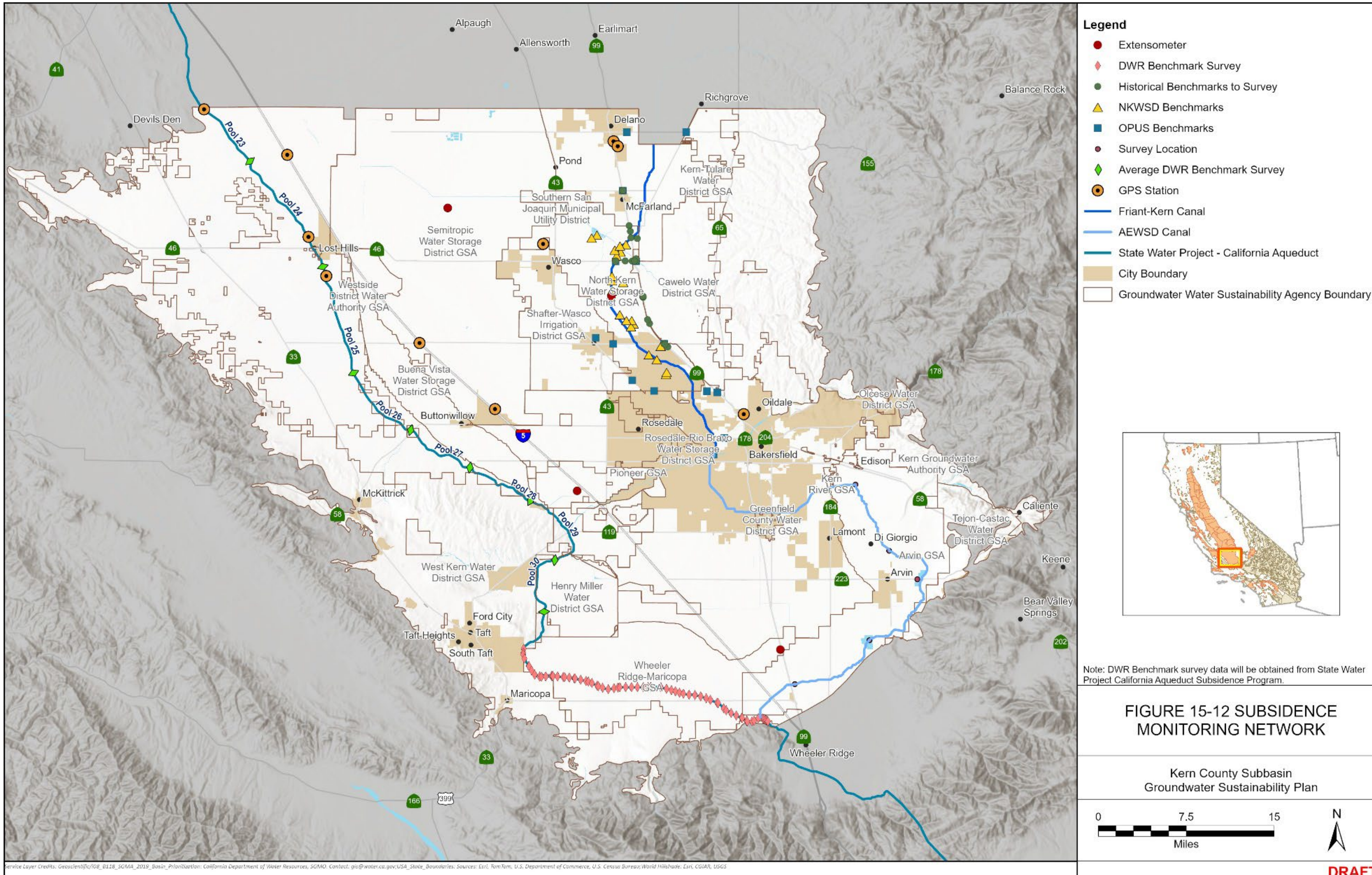


Figure 15-12. Subsidence Monitoring Network

15.2.6 Monitoring Network for Depletions of Interconnected Surface Water

§ 354.34. *Monitoring Network*

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:

(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.

(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.

(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.

(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

☑ **23 CCR § 354.34(c)(6)**
☑ **23 CCR § 354.34(j)**

As detailed in Section 8.6, there are no identified interconnected surface water or groundwater dependent ecosystems in the Subbasin. If needed, the Subbasin may reevaluate the necessity for a Subbasin-wide ISW monitoring network in future periodic evaluations.

15.3 Monitoring Protocols for Data Collection and Monitoring

§ 352.2. *Monitoring Protocols*

Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§ 354.34. *Monitoring Network*

(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

☑ **23 CCR § 352.2**
☑ **23 CCR § 354.34(i)**

The monitoring protocols outlined for all sustainability indicators were formulated to reflect the guidance in the *Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites* document drafted by DWR (2016). These protocols are designed to facilitate accurate data collection necessary for monitoring the minimum thresholds and measurable objectives associated with each sustainability indicator. The following protocols apply to all monitoring sites:

- Long-term access agreements should incorporate year-round site access to accommodate increased monitoring frequency.
- Every site must have a unique identifier consisting of a comprehensive written description detailing the site's location, date of establishment, access instructions, point of contact (if applicable), type of information to be collected, latitude, longitude, and elevation. Furthermore, each monitoring location should maintain a modification log to record all changes made to the site.

GSAs are currently working to establish access agreements with landowners for monitoring wells that were added to the groundwater quality and groundwater level monitoring networks. Consequently, some well locations may change between the approved public Plan and the adopted version.

15.3.1 Protocols for Groundwater Level Measurements

Groundwater level data will be collected, at minimum, on a semi-annual basis across the Subbasin. This frequency of measurement will allow the Subbasin to account for seasonal high and low water levels. The data collected will be used to generate potentiometric surfaces across the Subbasin. The collected data will also be compared against the measurable objectives and interim milestones to document the Subbasin’s progress toward reaching its sustainability goal. The data collected will also be entered into the DMS and included in the Annual Reports.

Groundwater levels should be collected during the following time frames for consistency across the Subbasin:

- January to March
- August to November

Additional protocols applicable to groundwater level measurements are described in Appendix Y.

15.3.2 Protocols for Reduction in Groundwater Storage

As the groundwater level monitoring network also serves as proxy to monitor reductions in groundwater storage, the protocols for reducing groundwater storage align with those outlined for chronic lowering of groundwater levels. The procedure for utilizing groundwater level data to determine change in storage is provided in the Subbasins Standard Operating Procedures.

15.3.3 Protocols for Water Quality Sampling

Water quality samples will be collected to represent groundwater conditions across the Subbasin. Sample results will be compared against baseline conditions presented in Section 8.4 of this Plan and used to assess the effects of SGMA implementation. To correlate groundwater levels with water quality, sampling schedules will be coordinated with groundwater level measurements. GSAs will sample each WQ RMW for the full set of identified constituents and submit the results to a Subbasin-wide data management system (DMS), which will also be uploaded to the SGMA Portal. Additionally, an assessment of groundwater conditions that compares current results against baseline conditions will be provided in each Annual Report to DWR. Detailed protocols for water quality sampling, including field procedures and laboratory methods, are included as Appendix Z. Water quality sampling procedures are consistent with the USGS National Field Manual for the Collection of Water Quality Data (USGS 2019). Key points of the water quality Standard Operating Procedure (SOP) include:

- Sampling should be conducted within a 2-week timeframe of water level measurements.
  - If samples are collected from a production well (agricultural or municipal), they should only be collected when the well is actively pumping to ensure the samples are representative of aquifer conditions. In order to determine when the well is sufficiently purged and representative of the aquifer, the sampler will monitor temperature, pH, specific conductance, and turbidity. Laboratory samples will only be collected when the field tests are stable.
  - In the Kern Subbasin, many production wells are not operated during wet or above normal water years. In this situation, samples will not be collected from the wells that are inactive (no active power supply).
  - The Water Quality Sampling SOP provides guidance for collecting representative samples from agricultural, municipal, and dedicated monitoring wells.
- Field log sheets and other documentation of well operation during the sampling period will be maintained. In the instance that representative samples cannot be collected, an explanation will be provided in the Annual Report to DWR.
- Constituents of concern are detailed in Section 8.4, with SMCs in Sections 11 through 13.

15.3.4 Protocols for Land Subsidence Measurements

Land subsidence measurements will adhere to protocols set by respective agencies overseeing data collection. The Subbasin will download data for all sites within the monitoring network at the following frequencies:

- InSAR data will be acquired on a quarterly basis.
- Benchmark survey data along the California Aqueduct will be acquired from CASP on a yearly basis.

15.4 Representative Monitoring

§ 354.36. *Representative Monitoring*
Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

(a) Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.
(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:
(1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.
(2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.
(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

☑ **23 CCR § 354.36**

15.4.1 Designated Representative Monitoring Sites

☑ **23 CCR § 354.36(a)**

All monitoring sites identified for the groundwater level monitoring network have SMCs assigned and are representative of Subbasin conditions. The groundwater level monitoring network consists of 185 wells with SMCs established at all of these monitoring wells.

Groundwater quality monitoring sites were selected to represent groundwater quality conditions throughout the Subbasin. As described in Section 15.2.1, SMCs were set at 51 wells. These wells were chosen based on existing groundwater quality conditions and locations of vulnerable users.

In addition, all monitoring sites identified for land subsidence have established SMCs. These sites represent areas vulnerable to subsidence and are in the vicinity of critical infrastructure.

15.5 Assessment and Improvement of Monitoring Network

***§ 354.38.** Assessment and Improvement of Monitoring Network*

(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.
(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.
(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:
   (1) The location and reason for data gaps in the monitoring network.
   (2) Local issues and circumstances that limit or prevent monitoring.
(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five- year assessment, including the location and purpose of newly added or installed monitoring sites.
(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:
   (1) Minimum threshold exceedances.
   (2) Highly variable spatial or temporal conditions.
   (3) Adverse impacts to beneficial uses and users of groundwater.
   (4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

☑ 23 CCR § 354.38

A thorough evaluation of the diverse monitoring networks outlined above was conducted to confirm that the objectives of the monitoring network (Section 15.1) were being met and that sufficient temporal and spatial data could be obtained to assess SMCs. Evaluations for each of the sustainability indicator monitoring networks are provided below.

15.5.1 Groundwater Levels Monitoring Network

As explained in Section 15.2.1, the BMPs provided by DWR were utilized to determine the appropriate well density for the Subbasin. The current monitoring network surpasses the minimum recommended number of monitoring wells. Consequently, this network offers adequate spatial and temporal coverage to capture groundwater level trends. Moreover, the network addresses vertical variability by monitoring multiple aquifers in the East Margin HCM area. However, 83 monitoring wells currently lack construction information. GSAs will continue efforts to address this data gap by striving to collect construction information for these monitoring wells. This data gap will be reassessed during the Five-Year GSP update.

The analysis used to determine the number of monitoring wells and their locations is based on pumping data from the C2VSim-FG Kern model. GSAs are attempting to gather more information on groundwater extraction through the metering of wells. More information about well metering is provided in Section 16. In addition to utilizing existing models, the Subbasin is in the process of developing an updated model that upon completion, will be utilized to reassess the pumping distribution and corresponding distribution of wells across the Subbasin. Data gaps in the monitoring network, specifically pumping group 3, as presented in Table 15-5, will be reassessed at this time in conjunction with updated pumping distribution values.

Currently, the Western Fold Belt HCM Area and parts of the East Margin HCM Area have few monitoring wells. As described in Section 15.2.1, minimal pumping occurs in the Western Fold Belt HCM Area and parts of the East Margin HCM Area. However, the Subbasin has taken steps to ensure both HCM Areas are monitored adequately. Specifically:

- The monitoring network includes 14 monitoring wells within the East Margin HCM Area to monitor the areas where pumping does occur. Two new representative monitoring wells were identified to represent Non-districted Lands the East Margin HCM Area. RMW-301 represents small community water systems that border the East Margin and Kern River Fan HCM Areas. The Subbasin is also identifying another well in the Caliente area (southernmost region of the East Margin) to represent a small, groundwater dependent community. Refer to Section 15.2.1, Jurisdictional Boundary of the Kern Non-Districted Lands Authority for background information.

- In the Western Fold Belt HCM Area, the Subbasin will ensure that any future development of water and water movement due to existing gradients is monitored. As described in Section 15.2.1, three sentinel wells exist in areas of groundwater flow from the Western Fold Belt HCM area into the adjacent down gradient North Basin HCM Area. These wells will monitor for transitions in groundwater level and quality. Furthermore, any new wells drilled in the Westside District Water Authority will be required to register with the GSA and, if located within a data gap area, are also required to participate in the monitoring program (Appendix S -WDWA PMA Table). However, if the new well is within 1 mile from an existing monitoring well, the new well will not be required to participate in the monitoring program. This process will ensure that the monitoring network evolves to track changes in water use in this HCM Area.

The monitoring network will undergo continuous evaluation during annual reports to ensure accessibility of all monitoring sites and facilitate data collection. Additionally, the network will be appraised for its capacity to provide sufficient information to detect temporal and spatial trends in groundwater levels. Based on these assessments, monitoring sites may be adjusted to ensure the monitoring network remains aligned with its objectives as stated in Section 15.1. Furthermore, as part of their projects and management actions, several GSAs are attempting to identify additional monitoring locations that can be added to the existing monitoring network.

15.5.2 Groundwater Quality Monitoring Network

For the groundwater quality monitoring network, the GSAs have established SMCs at 51 wells throughout the Subbasin. In addition to these wells, the Subbasin will assess publicly available data from ILRP and public water supply wells. This data will enable the Subbasin to evaluate the current monitoring network to ensure that groundwater quality trends captured by the network are representative of conditions within the Subbasin.

The Subbasin has also attempted to add additional monitoring wells in the Western Fold Belt HCM Area. The Subbasin is in the process of locating and verifying existing wells in the HCM Area. To date, the wells investigated have been destroyed or are no longer operational. The lack of wells in this HCM Area is reflective of the lack of pumping occurring here as described in Sections 15.2.1 and 15.5.1. However, as outlined in Section 15.5.1, the Westside District Water Authority has implemented a plan to require new wells located in data gap areas to participate in monitoring. This process will ensure groundwater is being monitored if usage levels change in the future.

Furthermore, as depicted in Table 15-5 and described in Section 15.2.1, large portions of the aquifers in the Western Fold Belt and East Margin HCM Areas have been de-designated due to naturally degraded water quality. Further development of groundwater in these areas is not anticipated due to the existing water quality issues.

15.5.3 Land Subsidence Monitoring Network

The critical infrastructure matrix outlined in Section 13.5 establishes the framework for SMCs and monitoring land subsidence within the Subbasin. The GSAs will continue to evaluate InSAR and site-specific data annually to detect shifts in infrastructure risk. The monitoring network will undergo assessment and modification to ensure coverage of all critical infrastructure. Land subsidence monitoring will continue to be conducted in close consultation with DWR, CASP and the FWA.

15.5.4 Depletion of Interconnected Surface Water Monitoring Network

Because no ISWs or GDEs were identified, there is no Subbasin-wide ISW monitoring network. The Subbasin will reevaluate the necessity for such a network in future periodic evaluations.

15.6 Reporting Monitoring Data to the Department

§ 354.40. *Reporting Monitoring Data to the Department*
Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

☑ **23 CCR § 354.40**

The Kern Subbasin DMS is capable of housing information related to each sustainability indicator. Through the Subbasin coordination agreement, each GSA is obligated to report data collected for SGMA compliance through the DMS, which is then compiled and reported to DWR. Data is also available to the public through a web-based data visualization map viewer.

This collected data will undergo QA/QC procedures at the GSA level before being uploaded to the shared DMS. The DMS will serve as the platform for generating copies of monitoring data to be incorporated into both Annual Reports and Five-Year GSP updates.

16. PLAN IMPLEMENTATION

§ 351(y) Plan Implementation
Refers to an Agency's exercise of the powers and authorities described in the Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities.

☑ 23 CCR § 351(y)

This chapter describes the ongoing and planned activities that have been and will be performed by the Groundwater Sustainability Agencies (GSAs) of the Kern County Subbasin (Subbasin) as part of the implementation of this Plan, with a focus on the period extending through 2030. Key ongoing and planned implementation activities to be undertaken by each GSA include:

- Annual reporting.
- Monitoring and data collection.
- Data gap filling.
- Projects and/or Management Actions (P/MA) implementation, including policy development to support Plan implementation.
- Technical and non-technical coordination with other water management entities within the Subbasin.
- Continued outreach and engagement with stakeholders.
- Enforcement and response actions.
- Evaluation and updates of this Plan as part of the required periodic evaluations (i.e., "five-year updates").

The Subbasin's coordinated approach to implementing these activities is briefly described in this section, with references to the Plan sections where details are provided. Status updates on Plan Implementation activities of each of the participating GSAs are presented in Section 14 and detailed in the GSA P/MA (Appendix S). Each GSA in the Subbasin provides updates on their P/MAs that have been fully implemented since the passage of the Sustainable Groundwater Management Act (SGMA), P/MAs that are in the process of being implemented and P/MAs proposed for implementation should it become apparent that these activities will be necessary to bring the Subbasin into sustainability.

Collectively, the P/MAs described in Section 14 demonstrate that the Subbasin's GSAs have been actively implementing specific P/MAs to reach sustainable groundwater management with consideration for all beneficial uses and users. Actual results will be provided in annual reports to the California Department of Water Resources (DWR).

16.1 Plan Implementation Activities

16.1.1 Monitoring and Data Collection

As discussed in Section 15 Monitoring Network, sustainable groundwater management relies on data-driven decision making. As such, collecting data that is representative of the applicable Sustainability Indicators is key to Plan implementation. These efforts include collecting data from the networks of Representative Monitoring Sites (RMS), as well as other information required for annual reporting. Table 16-1 summarizes the Subbasin's data collection and reporting.

Table 16-1. Summary of Data Collection

Sustainability Indicator	Data	Start Date	Frequency	Reporting
Groundwater Levels	Field Measurements	WY 1993	Semi-annual	DMS, SGMA Portal, Annual Reports
Groundwater Storage	Simulated from the numerical model	WY 1995	Annual	Annual Reports
Subsidence	InSAR Benchmark Surveys	WY 2016	Annual	DMS, Annual Reports
Water Quality	Collect Samples	WY 2024*	Semi-annual	DMS, SGMA Portal, Annual Reports
Interconnected Surface Water	Not Applicable			
Seawater Intrusion	Not Applicable			

*Historic data is available from public databases with a limited amount of data available from Water Districts. Semi-annual monitoring for the Subbasin defined Constituents of Concern (COCs) aligned with groundwater levels began in WY 2024.

<u>Monitoring of Applicable Sustainability Indicators</u>

Section 15 discusses the monitoring networks (i.e., RMS) and protocols used for monitoring the applicable sustainability indicators across the Subbasin. Monitoring protocols for each applicable sustainability indicator are defined through Subbasin-wide Standard Operating Procedures (SOPs), which are used to support consistent and coordinated efforts among the GSAs (e.g., as part of Annual Reports; see Section 16.2). Data will be entered and stored in the Subbasin-wide Data Management System (DMS).

Monitoring results will be routinely evaluated against applicable Sustainable Management Criteria (SMCs, i.e., Undesirable Results, Minimum Thresholds, and Measurable Objectives) to evaluate efficacy of P/MAs by each of the GSAs. To support GSA awareness of groundwater conditions across the Subbasin, the DMS is programmed to send email notifications to all GSA Manager's and other selected staff to advise when a Minimum Threshold (MT) Exceedance occurs. Additionally, the MT Exceedance Policy (Appendix W) established protocols for GSA action when an exceedance occurs.

The GSAs anticipate that within the period of Plan implementation extending through 2030, the following efforts related to monitoring will be performed:

- Refinement of the Subbasin-wide DMS.
- Refinement of the SGMA Monitoring Network, including adding, replacing or constructing new dedicated monitoring wells and/or video-logging to collect missing screen/depth information on the RMS to fill existing data gaps and to continually update the well registry (see Section 15.5 Assessment and Improvement of Monitoring Networks).
- Semi-annual monitoring of water levels at the RMS in the monitoring network for Chronic Lowering of Groundwater Levels is described in Section 15.2.1. Data collected from this network will also be used to monitor reductions of groundwater storage as noted in Section 15.2.2. A Groundwater Monitoring Protocol SOP is provided in Appendix Y.
- Semi-annual monitoring for Degraded Water Quality at a subset of the groundwater level RMS, identified as the water quality monitoring network, is described in Section 15.2.4. A Water Quality Sampling SOP, including Quality Assurance/Quality Control (QA/QC) procedures, is provided in Appendix Z. An SOP for data interpretation and reporting will be developed and attached to the Kern Subbasin Coordination Agreement.
- Compilation and review of InSAR subsidence data, benchmark, and survey results from the California Aqueduct Subsidence Program (CASP) and the Friant Water Authority (FWA) and continued monitoring of land subsidence is described in Section 15.2.5.
- As described in Section 15.2.6, no interconnected surface waters (ISW) have been identified in the Subbasin. Therefore, at present no Subbasin-wide monitoring program has been established. If needed, the Subbasin may reevaluate the necessity for a Subbasin-wide ISW monitoring network in future periodic reviews.

<u>Collecting Other Required Information</u>

Besides the data on Sustainability Indicators described above, collection and reporting of other types of information is required under SGMA (see further discussion below in Section 16.2 Annual Reporting). These other types of information include:

- Groundwater extraction information
- Surface water supply data

Groundwater extraction information will be quantified for inclusion in the Annual Reports through methods described in the Groundwater Monitoring Protocol (Appendix Y). In addition, consumptive use of water will be monitored through methods described in an SOP to be implemented across the Subbasin.

All surface water delivered into the participating GSAs is reported and identified by source (e.g., SWP, Kern River, CVP, or other) in the DMS to facilitate local and Subbasin-wide accounting of these supplies in water budgets.

Data Gap Filling

The GSAs will prioritize and begin to fill the key data gaps identified in the Plan related to the Hydrogeological Conceptual Model, water budgets, monitoring networks and other topics. As of October 1, 2024 (i.e., through WY 2023), completed and/or ongoing data-gap filling efforts performed by individual GSAs will have included:

- Development of numerical groundwater flow models and decision support tools.
- Installation of meters on selected wells and ground truthing efforts to refine estimates of agricultural groundwater pumping derived from satellite evapotranspiration data.
- Conducting additional outreach to public water systems to refine estimates of industrial groundwater demands.
- Installation of stream gauging dataloggers to quantify surface water inflows from intermittent creeks.
- Installation of an extensometer.
- Planned installation of dedicated monitoring wells.

Continuing efforts to fill data gaps include completion of the Basin Study, installation of new monitoring wells through DWR's Technical Support Services grant, on-going verification of satellite evapotranspiration data, subsidence analysis and modeling and maintenance of the DMS and well registry.

16.1.2 Project and Management Action Implementation

A major element of Plan implementation is development and operation of P/MAs that will correct overdraft conditions and address and prevent potential Undesirable Results. Section 14 presents a portfolio of P/MAs, which fall into two general categories:

- P/MAs supported and funded collectively by the GSAs to be implemented to address Subbasin-wide concerns, and
- P/MAs developed and funded by individual GSAs to address groundwater overdraft and to demonstrate compliance with the applicable sustainability indicators within their GSA.

Section 14 describes how, collectively, the combination of demand reduction and water supply augmentation benefits anticipated from these P/MAs compares with the minimum P/MA target assigned to each GSA based on the 2010-2019 water supply and demand conditions and increased by the 2030 climate change scenario. Section 14 and

Appendix S also present glide paths for the Subbasin and for each of the GSAs indicating the schedule to attain sustainability on a Subbasin--wide and GSA scale.

The initial steps for implementing both categories of P/MAs may require performing various studies or analyses to refine the concepts into actionable projects and/or policies[1]. These efforts may include, but are not limited to, the following:

- Initiating California Environmental Quality Act (CEQA) and/or National Environmental Protection Act (NEPA) studies and documentation.
- Initiating engineering feasibility studies and preliminary design reports.
- Performing financial and/or economic analysis such as Proposition 218 studies and exploring opportunities to secure grant funding to support costs for engineering and environmental studies and construction costs.
- Performing legal analyses.

Once the necessary initial studies are completed, P/MAs will undergo, as necessary, final engineering design (in the case of infrastructure projects) and final drafting (in the case of policy-based actions). At that point, construction of projects and/or adoption of programs/policies will occur, followed by ongoing operations and maintenance (O&M).

Each implemented P/MA will have a monitoring and evaluation plan to allow for performance assessment and, if necessary, modification and results will be provided in the Subbasin's annual report.

As of the date of submittal of this Amended Plan, many of the Subasin-wide and individual GSA P/MAs have already been initiated and/or implemented. Refer to the Kern County Subbasin Fifth Annual Report for status and results through WY 2023.

16.1.3 Intrabasin Coordination

Just as this Plan has been developed as part of a coordinated process in the Kern County Subbasin, coordination among all water management entities involved in SGMA will continue through the implementation period. This coordination will include both technical and non-technical matters, as described in the following sections.

<u>Technical Coordination</u>

Continued technical coordination is critical to ensure that all entities in the Subbasin approach local groundwater management using a robust shared framework of data, information, and technical methods. GSAs and water management entities coordinate on technical matters including, but not limited to:

- DMS development and maintenance.

[1] Studies conducted in support of P/MA implementation will be based on the best available data and science.

- Groundwater model refinement and updates.
- Water budget refinement and collection of supporting data including evapotranspiration (ET) estimates.
- Basin-wide monitoring and reporting efforts.

Non-Technical Coordination

Non-technical coordination involves matters related to policy, advocacy, and governance. GSAs in the Subbasin have entered into a Coordination Agreement (Appendix C) that establishes a governance structure for how the collective groundwater management entities will cooperate and coordinate in exercising their authorities under SGMA to develop and implement the Plan, and in other matters related to sustainable groundwater management.

Additionally, these entities actively coordinate with other Kern County stakeholder groups as appropriate. Other non-technical coordination activities will be pursued, as necessary.

16.1.4 Stakeholder Engagement

To fulfill notice and communication requirements, each GSA has developed a Stakeholder Communication and Engagement Plan (SCEP); see Appendix H). The SCEP is a key part of the Plan, and will continue to be refined, updated, and executed during implementation. Refer to Section 5.10 for details on stakeholder engagement activities and opportunities. Anticipated stakeholder engagement activities during Plan implementation include, but are not limited to:

- Regular SGMA updates during GSA Board meetings.
- Hosting stakeholder workshops, as needed.
- Posting relevant announcements and information on GSA websites.
- Conducting informational discussions and meetings with interested stakeholders, as needed.
- Engagement with stakeholders and domestic well owners through public events.
- Coordination and engagement with cities consistent with agreements between the GSA and cities it covers.

Any implementation actions that relate to establishment of allocations of groundwater pumping or “native yield” on a landowner level will be conducted through a robust stakeholder engagement process.

16.2 Annual Reporting

☑ **23 CCR § 356.2(b)(1)(2)(3)**

An annual report on Subbasin conditions and SGMA implementation status is required to be submitted to DWR by April 1 of each year following Plan adoption. To date, the Subbasin GSAs have submitted five annual reports covering WY2020 through WY2023. These annual reports are prepared on the Subbasin-level using information uploaded to the DMS and require input from each local entity. The annual reports include each GSA's progress towards achieving interim milestones and identifies whether any MT exceedances have occurred. Activities required at the GSA- and Subbasin-level are described in the following sections.

GSA-Level Activities

In support of the annual reporting requirements, the GSAs submit all monitoring data from the RMS to the Subbasin's DMS, which is available to the public. All necessary information to evaluate compliance status for the various SMC is available after each seasonal monitoring period. Each Sustainability Indicator and its monitoring network and applicable SMC is accessible through the public Map Viewer. Other non-public information that is required for annual reporting is also uploaded to the DMS and available for the Subbasin Plan Manager to extract. All groundwater management entities review and comment on the draft annual reports to ensure that local information is properly incorporated into the Subbasin-level reports.

Subbasin-Level Activities

An entity will be designated at the Subbasin-level to compile and consolidate all local information into annual reports that meet the requirements of the GSP Emergency Regulations (23 CCR § 356.2) or updated reporting requirements released by DWR.

16.2.1 Enforcement and Response Actions

Part of successful management involves the ability to adapt and respond to unforeseen or uncertain circumstances. To the extent possible, methods to address foreseeable problems should be developed before those problems arise. It is anticipated that there may need to be actions taken to enforce Plan compliance and any policies adopted thereunder. Such actions, if necessary, are taken in accordance with applicable laws and authorities.

MT Exceedance Policy

This Amended Subbasin Plan fundamentally defines sustainability under SGMA as managing water supplies to mitigate overdraft conditions and avoiding Undesirable Results (URs). While a single or isolated MT exceedance may not, by itself, cause an UR, such an exceedance may be indicative of future or trending exceedances which could result in URs that have the potential to adversely impact nearby beneficial users. For these reasons, all GSAs in the Subbasin adhere to the Kern County Subbasin Minimum Thresholds Exceedance Policy presented in Appendix W.

16.2.1.1 Impacted Well Mitigation Program

As described in Section 13.1.2 Minimum Threshold for Chronic Lowering of Groundwater Levels and consistent with the human right to water specified under California Water Code (CWC) §106.3(a)[2], all GSAs in the Kern County Subbasin with domestic and small community wells within their boundaries have committed to mitigating impacts to these wells that occur as a result of groundwater management activities. This is accomplished by participating in the Subbasin's Well Mitigation Program and implementing it within the respective GSAs. This program has been developed in partnership with Self-help Enterprises and aims to evaluate the cause of well or pump failures, or degraded water quality, and provides an appropriate remedy well owners who have been impacted by groundwater conditions, as defined within the policy. While the final program is still under development, the policy and the supporting Letter of Intent between the Subbasin and Self-Help Enterprises is presented in Appendix K. The Well Mitigation Program is anticipated to begin implementation January 1, 2025.

Funding for the Impacted Well Mitigation Program is sourced from each of the GSAs within the Subbasin with the level and mechanism for funding determined by the individual GSAs. The program has been developed in coordination with and in consideration of the interests of local stakeholders within the Subbasin.

16.2.2 Periodic Evaluations of the Plan

☑ **23 CCR § 356.4**

Participating groundwater management entities will conduct a periodic evaluation of the Plan at five-year intervals and will modify the Plan as necessary to ensure that the Sustainability Goal defined for the Kern County Subbasin (see Section 12 Sustainability Goal) is achieved.

The periodic evaluation represents a progress report for each five-year evaluation cycle. The evaluation summarizes basin conditions in relation to sustainable management criteria, the implementation of projects and management actions, and other specified information. The purpose of the evaluation is to assess whether Plan implementation is meeting interim milestones and is on track to meeting measurable objectives and the sustainability goal for the Subbasin.

[2] CWC §106.3(a) specifies that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes."

Plan elements covered in the periodic evaluation include:

- **Sustainability Evaluation** evaluates current groundwater conditions for each applicable Sustainability Indicator within the Subbasin, including progress toward achieving Interim Milestones and Measurable Objectives (MOs).
- **Plan Implementation Progress** evaluates performance of established P/MAs and describes the status of P/MAs in the process of implementation. The section also provides updated project implementation schedules and descriptions of new projects that were not previously presented.
- **Reconsideration of Plan Elements** provides a current evaluation of the Basin Setting, URs, MTs, and MOs, and revisions as needed.
- **Evaluation of Monitoring Networks and DMS** updates the status of the SGMA Monitoring Networks and DMS. The update will describe efforts to identify and fill data gaps, assess monitoring network performance, identify actions necessary to improve the monitoring networks and DMS, and describe the status of plans to fund and implement needed improvements.

As described in Section 15, the functions of the monitoring networks and DMS are to provide and manage data needed to evaluate progress toward the Subbasin's sustainability goal and MOs outlined in the Amended Subbasin Plan. Review of the monitoring networks and DMS will focus on their performance with respect to each of the following objectives:

- Assessing impacts to beneficial uses and users of groundwater.
- Collecting data to improve characterizations of groundwater conditions and assess the availability and reliability of current and future water supplies, while revising analyses such as the groundwater model and water budget as additional data becomes available.
- Improving understanding of groundwater quality conditions throughout the Subbasin by monitoring Constituents of Concern (COCs) to identify long-term trends and changes in groundwater quality.
- Generating data to refine estimates of groundwater basin conditions and evaluate local current and future water supply availability and reliability, updating analyses such as the groundwater model and water budget as additional data becomes available.
- Detecting and monitoring land subsidence caused by activities related to GSA-related pumping to provide information to help mitigate potential infrastructure damage and land-use impacts.
- Supporting decision-making processes related to groundwater management, including the development and implementation of P/MAs.

- **New Information** provides a description of significant new information that has become available since the adoption or amendment of the Plan, or the last five-year update, including data obtained to fill identified data gaps. As discussed above under *Reconsideration of Plan Elements,* if evaluation of the Basin Setting, MOs, MTs, or URs definitions warrant changes to any aspect of the Plan, this new information would also be included.
- **Regulations or Ordinances** describes each GSAs legal authority to implement regulations or ordinances related to the Plan and relevant actions taken by each GSA, including a summary of related regulations or ordinances.
- **Legal or Enforcement Actions** summarizes legal or enforcement actions taken by each GSA in relation to the Plan, along with how such actions support sustainability in the Subbasin.
- **Plan Amendments** describes proposed or completed amendments to the Plan.
- **Coordination** describes coordination activities relevant to the Plan Area (i.e., the Kern County Subbasin).

16.2.3 Plan Implementation Costs

☑ **23 CCR § 354.6(e)**
☑ **23 CCR § 354.44(b)(8)**

This section provides estimates of the costs to each groundwater management entity to implement this Plan and potential sources of funding to meet those costs.

16.2.4 Estimated Costs

Costs to participating GSAs to implement this Plan can be divided into the following two groups:

- Costs for Subbasin-wide groundwater management activities.
- Costs to individual GSAs to implement P/MAs within their jurisdictions, including capital/one-time costs and annual operation and maintenance costs.

Most costs for Subbasin-wide groundwater management activities are shared by the Subbasin's 22 participating entities. Estimates of P/MA implementation costs by individual GSAs and the sources of funding to support these costs are presented in Appendix S. This appendix also presents timing and magnitude of the benefits, including contributions toward deficit reduction, expected of these P/MAs.

P/MAs described in Section 14 include management actions which benefit the Subbasin and P/MAs being developed and funded by individual GSAs to achieve or maintain sustainability in their GSA area. The highest priority P/MAs are for demand reduction measures, which are the actions expected to make the greatest contribution to correcting the Subbasin's overdraft conditions. Supply augmentation or enhancement measures are also included in the portfolios of many GSAs.

16.2.5 Plan Implementation Schedule

This section discusses an estimated schedule for Plan implementation. The GSP Emergency Regulations do not require that a schedule for Plan implementation over the 20-year implementation period (i.e., 2020 through 2040) be provided, and any such schedule is subject to considerable uncertainty. However, the following factors and constraints inherent to the Plan process guide the schedule for implementation:

- GSP Emergency Regulations require achievement of the Sustainability Goal (i.e., manage water supply within sustainable yield and avoidance of URs) within 20 years of Plan adoption, which in the case of the Kern County Subbasin means by 2040.
- The P/MA implementation glide path presented in Section 14.1.1 Implementation Glide Path illustrates the general schedule and expected benefits from P/MAs. Benefits attributable to these P/MAs started accruing as early as 2020 and will continue through 2040 across the Subbasin.
- Assessment of the Subbasin's progress towards achieving sustainability will be conducted annually, with results posted to the SGMA Portal for DWR and public review. Annual reports are due on April 1 of the following year.
- Periodic evaluations are required at least every five years, meaning the Kern Subbasin Plan will be updated no later than January 31, 2030.

This page intentionally left blank.